A payment strategy to improve the supply chain performance

by

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Submitted for the Degree of Doctor of Philosophy

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April 2016

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This thesis is dedicated to my parents.

For their endless love, support and encouragement
Abstract

One of the main objectives of a firm is to add value to the firm and to earn more profit; therefore, the financial performance of a firm in a supply chain has to be managed and modelled properly. The aim of this thesis is to devise a payment strategy to improve the financial performance of a firm in a supply chain through evaluating the effects of the supply chain operation including demand variation, delivery time, customer satisfaction and horizontal and vertical integration on the financial performance of the firm. In fact, it aims to develop an optimisation mathematical model to maximise the aggregated cash flow of a firm within a time horizon through prioritising the cash outflow invoices and optimising the payment strategy parameters such as penalty rate and customer discount.

To represent the cash flow of a firm as well as the movement of customers through the firm in different time periods, a cascade diagram is developed where the cash flow of a firm in each period is the summation of cash available from the previous period received from the satisfied customers plus the amount of cash received from the new customers minus the amount of cash which has to be paid to the upstream partners. Since the cash inflow of a firm in each time period is directly related to the number of satisfied customers in the previous period; therefore, the firm tries to ensure that the maximum number of satisfied customers are transferred to the next period in order to have the maximum amount of cash inflow in each period.

In addition, the effects of demand variation and delivery time as a result of the supply chain operation, usually known as logistic bullwhip, on the financial performance of a firm in a supply chain are investigated in different time periods. In fact, the effects of the supply chain operation on the financial performance of a firm are formulated through introducing additional costs to the firm in each period. However, the cash outflow invoices in each period are scheduled and prioritised based on the available amount of cash in the firm and the penalty rate is applied to the customers who receive the invoices and suppose to pay the amount of invoices in each period on late payments, while the optimum penalty rate in each period is correlated to the amounts supposed to be received in the next periods and the penalty rate of the competitors. Additionally, the optimum customer discount can be applied to compensate the cost of customer dissatisfaction due to the late delivery of products to the customers. Also, horizontal and vertical integration between supply chain partners can improve the supply chain operation and, consequently the financial performance of a firm in a supply chain.
Acknowledgments

One of the joys of completion is to look over the journey past and remember all the individuals who have helped and supported me along this long but fulfilling road as I would never have been able to finish my PhD thesis without their help and support. I would like to express my gratitude to my supervisor, Dr Franjo Cecelja, for his excellent guidance and providing me with his careful and instructive comments. Also, I would like to thank my ex-supervisor Dr Ali Hosseini.

My sincere and special thanks to my dear true friends, Dr Vahid Heydari, Dr Amir Tabatabaei, Dr Siavash Adhami, Dr Farhad Azarmi, Mr Shahin Shariat and Mr Masoud Hassanpour who kindly participated in my long and tiring past days and gave me a home away from home, thank you for all your support and encouragement. I would like to thank Mr Paul and Mrs Fran Handrick who always supported and encouraged me within the last year of my PhD life.

I would not have contemplated this road if not for my parents, who inspired within me a love of science, courage to face the difficulties and hope for a better future, all of which finds a place in this thesis. My lovely parents, words cannot express the thanks I owe you.

Also, this thesis would not have been possible without the love and support of my siblings. To my sisters, Hoda and Faezeh, you were always there, ready to help and sacrifice in my hardest days. I would like to thank you from the bottom of my heart my brothers, Amir and Hesam who encouraged me to look forward and wisely advised me through this journey. Finally, special mention goes to Parsa, my lovely nephew you have a very special place in my heart.
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Chapter One

Introduction

This chapter discusses a brief introduction to the supply chain and its flows, followed by the problems associated with a firm’s cash flow in the supply chain and the importance of managing cash flow. It continues by introducing the aim and objectives of the thesis. This chapter finishes with the outline of the thesis.

1.0. Introduction

A supply chain consists of numerous business partners working and cooperating together to achieve a common goal. These partners usually work to deliver products or services from the point of raw materials suppliers to the point of final customers, while transferring cash from the final customers to the suppliers for the delivered products. This cooperation among partners in the supply chain happens under three major flows: product flow, information flow and cash flow (Figure 1) (Li-na and Qi, 2010). The product flow is the downstream movement of goods from a supplier to a customer, cash flow, which flows inversely to the product flow, is the flow of cash from the customer to the manufacturer and ends up with the supplier, while the information flow is the sharing of information, transmitting orders and informing the status of delivery from the customer as well as supplier (Jiang and Zhu, 2008).

Figure 1 Supply Chain Partners and Three Main Flows

Generally, cash flow comprises of the amount of cash flowing in and out of any entities. Therefore, the cash flow from any firm’s point of view in a supply chain can be classified into two types: the cash inflow
and the cash outflow. The cash inflow includes the amount of cash received from the downstream partners in the supply chain for purchased products plus the amount of cash received from other sources such as financial institutions for possible financial aids like loan, while the cash outflow includes the amount of cash paid to the upstream partners for delivered materials plus the amount of cash which has to be paid to other sources such as financial institutions for the repayment of loan (He et al., 2010). In order to avoid any interruption to the production or operation processes and to improve the financial performance of a firm in a supply chain, accurate and up-to-date information in terms of all cash inflow invoices, pending invoices to prioritise the cash outflow are essential for the manager (Sharma and Kumar, 2011).

A firm in a supply chain usually defines payment strategy attributes such as penalty rate, customer discount, quality of delivery (demand fulfilment) and delivery time to deliver products or services to the downstream partners. In this thesis, an optimisation mathematical model to improve the financial performance of a firm in a supply chain through optimising the payment strategy attributes and prioritising the cash outflow invoices is developed. In addition, the effects of supply chain operation such as demand variation and delivery time, customer satisfaction and merger and acquisition are evaluated.

1.1. Problem Statement

One of the main objectives of the firm in the supply chain is to add value to the firm, to ensure the employees are paid and the products are produced and delivered to ensure sufficient amount of cash is available to cover the day-to-day operating expenses, and finally, more profit is being earned. In consequence, cash flow has to be managed and quantified carefully and properly (Bertel et al., 2008). Despite the similarity of the product flow and cash flow in terms of ‘fluidity’ behaviour, there are significant differences between them. One of the main differences between cash flow and product flow happens within the normal operation where the products flow and operate normally within the supply chain partners, while the cash flow may not, since the time and amount of cash inflow and outflow invoices may not be received or paid as normal. In addition, keeping products in stock increases the holding cost, while keeping cash leads to earning more interest (Gupta and Dutta, 2011).

In addition, there is an overlap between product and cash flow in a supply chain in some aspect; therefore, any weakness in the management of one side will threaten the accretion of the supply chain; thus, to ensure business sustainability, the management of the cash flow is as important as the management of the product and information flows (Gupta and Dutta, 2011). The optimisation of the product flow of a firm in the supply chain was the topic of interest to the previous academic research studies, while very little
attention has been given to the cash flow of a firm in the supply chain; therefore, there is a big gap in the cash flow literature (Pfohl and Gomm, 2009). Numbers of models or methods are proposed in the previous works to measure, review and improve the performance of cash flow of firm in a supply chain, while some of these studies (Stewart, 1995, Bhagwat and Sharma, 2007, Kroes and Manikas, 2014) try to improve the cash flow by considering only one side of cash flow, either cash inflow or outflow; thus, do not optimise the cash flow in the supply chain. In fact, previous research tries to model payment strategy but not to optimise it.

A firm in the supply chain desires to maximise cash flow and profit through scheduling and paying pending invoices. The pending invoices need to be paid from the amount received from each issued invoice and also the available amount of cash in the firm. The actual time and value the firm receives from its downstream partners for each invoice are unknown and uncertain, and this uncertainty not only affects the firm’s profit but is also propagated through its upstream supply chain partners.

Unforeseen events in the supply chain operation such as demand variation and delivery time as a result of product flow, known as “logistic bullwhip”, affect the firm’s cash flow. The “bullwhip” effect, as the biggest problem in the supply chain, gets amplified as it propagates through all the supply chain partners.

Previous research (Cachon et al., 2007, Campuzano and Mula, 2011, Aprile and Garavelli, 2007, Sucky, 2009) studies on the BWE have focused on demonstrating its existence, identifying its cause and providing methods for reducing its impact on the product flow. One of the most critical problems in a supply chain is how to quantify and measure the effects of bullwhip on the cash flow of a firm in the supply chain (Shao et al., 2008).

One of the main obstacles for each firm in the supply chain is how to deal with the customers in order to have more satisfied customers, and how satisfaction affects a firm’s cash flow; therefore, customer satisfaction has to be measured and quantified with the hope of improving the cash flow, while the relationship between satisfaction and a firm’s cash flow is still an unsolved problem for a firm in a supply chain (Hansemak and Albinsson, 2004). Despite the reviewed approaches or models about customer satisfaction in Chapter 2 Section 2.3, there is no approach to quantify the customer satisfaction and consequently to maximise the cash flow of the firm in a supply chain.

However, there is still very little known about the payment strategies and supply chain operation related with the financial performance of a firm in a supply chain, which needs further investigations.
1.2. Aims and Objectives

The aim of this PhD thesis is to investigate effects of supply chain operation on the firm’s cash flow and formulate a payment strategy to maximise the financial performance of a firm in a supply chain. In fact, an optimisation mathematical model is developed to improve the financial performance of a firm in a supply chain by formulating the effect of supply chain operation. In order to achieve the aim, objectives are defined as follows:

- Review the existing financial models and payment strategies which are both researched and implemented in a firm within a supply chain;

- Evaluate the effects of a supply chain operation on the cash flow of a firm in a supply chain, through developing a mathematical model, including:
  - Effect of logistic bullwhip as result of product flow;
    - Formulate the effect of demand variation and delivery time on the firm’s cash flow;
  - Effect of customer satisfaction including customer satisfaction management;
    - Develop a new approach to model, measure and quantify customer satisfaction;

- Devise the payment strategy to maximise the firm’s performance in a given operational and financial environment;
  - An optimisation model for the firms’ cash flow through optimising the payment strategy attributes;

- Evaluate the effects of vertical and horizontal integration, as a way to improve the performance of firms in a supply chain, within a supply chain partners on the supply chain operation, and consequently on the financial performance of a firm in a supply chain;

- Verify the proposed payment strategy using a case study.

1.3. Structure of the Thesis

The research starts with a brief introduction to the supply chain and the problems associated with a firm’s cash flow in the supply chain (Chapter 1). The research continues with reviewing the existing literature on the financial models, supply chain operation, logistic bullwhip, customer satisfaction and horizontal and
vertical integration (Chapter 2). In Chapter 3, the mathematical model for the firm’s cash inflow and outflow are developed, while the aggregated cash flow of a firm is formulated through a cascade diagram. Then, Chapter 4 starts with evaluating the effects of the supply chain operation such as demand variation and delivery time, usually known as logistic bullwhip, on the firm’s cash flow. Also, the effect of customer satisfaction on the firm’s cash flow is quantified and modelled based on the defined payment strategy attributes. In addition, the effect of the firm’s vertical and horizontal integration on the financial flow of the firm is studied and investigated. On the following chapter the optimisation model for a firm in a supply chain is presented to improve the financial performance of a firm through optimising the payment strategy attributes (Chapter 5). Then, the work continues by testing the model through a numerical example in Chapter 6. For the sake of illustration in Chapter 7, the proposed method and model will be evaluated and tested using real data from an Iranian company as a case study. Finally, the conclusion and future work are presented in Chapter 8.

1.4. List of Publication


3. JAHANGIRI, M. H. & CECELJA, F. Year 2016. Modelling customer satisfaction in the supply chain (Submitted)

Chapter Two

Literature Review

This chapter starts with reviewing the available literature on the cash flow, then the existing work on the supply chain operation such as the bullwhip effect, customer satisfaction and mergers and acquisitions are reviewed. Then, the provided models for the firm’s cash flow and customer satisfaction in the literature are studied. Finally, the concept of mergers and acquisitions and metrics to measure the performance of a firm before and after merger is reviewed.

2.0. Introduction

In order to devise a payment strategy and to improve the financial performance of a firm within a supply chain, firstly the available literature on the cash flow of firms in supply chains need to be reviewed to reveal potential gaps and areas not covered by the existing research; then the studies on the effect of “bullwhip” in the supply chain have to be checked in order to evaluate the effect of “logistic bullwhip” as a result of product flow on the financial performance of a firm. To calculate the effects of “logistic bullwhip” and to evaluate the effect of the supply chain operation on financial performance, customer satisfaction measurement methods and techniques have to be studied and analysed. Finally, previous studies of merger and acquisition concepts, and metrics as a strategy for improving the financial and operational performance of a firm, need to be checked. Therefore, the available literature is being reviewed to find areas not previously examined in order to develop a proper payment strategy. The objectives introduced in Section 1.2 of Chapter 1 are defined to address these gaps and areas. The available literature was reviewed in the following order:

- Cash flow in the supply chain
- Bullwhip effect in the supply chain as a result of product flow
- Customer satisfaction measurement methods and techniques
- Mergers and Acquisitions (M&A) concepts and metrics

2.1. Cash Flow in the Supply Chain

Cash flow runs in the opposite direction to the product flow and is a consequence of the product flow operations. A firm’s cash flow comprises of the amount of cash flowing in and out of any organization. Cash inflow is the amount of cash received from either upstream partners or other external sources, while
the outflow is the amount of cash to be paid either to the downstream partners for the delivered materials or to other external institutions. Researchers (Bertel et al., 2008, Gupta and Dutta, 2011, He et al., 2010, Kroes and Manikas, 2014, Tangsucheeva and Prabhu, 2013, Sweeney, 2004) believe that it is vitally important for a firm to manage cash inflow and outflow at the same time in order to have operational and financial success.

Gupta et al. (2011) divided the work which has been done on the financial side of the supply chain in the existing literature into the following three categories:

1. Methods and technologies to improve the cash flow

Different financial metrics systems such as Return On Equity (ROE), Days of Sales Outstanding, Days of Inventory Outstanding, Days of Payables Outstanding and Operating Cash Cycle were proposed in the previous literature to improve and model the cash flow process of a firm in the supply chain and to evaluate the day-to-day business operation (Stewart, 1995, Bhagwat and Sharma, 2007, Kroes and Manikas, 2014). However, these studies consider only one side of cash flow, either cash inflow or outflow; thus, do not optimise the cash flow in the supply chain.

2. Models for cash management

Mathematical models were developed based on the concept of inventory to predict the cash flow in the supply chain and to balance the amount of cash in hand. In fact, the firms maintain a portfolio of assets; thus, the optimal cash policy for these organizations is to minimize the cost of holding cash and transaction costs (Baumol, 1952, Sethi, 1971, Premachandra, 2004, Feinberg and Lewis, 2007). However, the papers on the cash balance usually deal with the management of the internal cash, the amount of cash used internally within a firm, while the external cash, the amount of cash received from the downstream partners, is not usually considered.

3. Models to integrate manufacturing and finance decision

Researchers believe that in order to optimise the cash flow, integrating the cash flow and the product flow in the supply chain is essential; thus, they combine the profit and the cost of making a profit to maximize the cash position (Badell et al., 2004, Badell et al., 2005, Guillen et al., 2007).

On the other hand, numbers of models or methods are proposed in the previous works to measure, review and improve the performance of cash flow of a supply chain. The most cited ones are explained in the following sections.
Cash Conversion Cycle, CCC, is defined as an important financial metric describing the length of time to turn a dollar invested in raw materials into a dollar received from the downstream partners. In fact, this metric calculates the time necessary to convert inventories into available cash (Özbayrak and Akgün, 2006). CCC is mathematically represented by Eq. (1) by using the inventory days of supply (INV) to represent the efficiency of production and inventory management, accounts receivable cycle time (ARD) to measure a firm’s ability to manage downstream partners, and accounts payable cycle time (APD) to indicate the efficiency of upstream supply chain management (Farris II and Hutchison, 2002).

\[ CCC = INV + ARD - APD \]  \hspace{1cm} (1)

Moreover, Pate-Cornell et al. (1990) proposed a stochastic method based on the decision analysis and Bayesian updating to manage the cash flow and in order to make a short term decision when a liquidity squeeze appears, while timing of payments is a major source of uncertainty in financial decision. This method aims to compute the probability distribution of the cash balance for the time \( t_0 + \Delta t \). Due to the uncertainties about time of outstanding bills received from each customer, the time of cash inflow invoices is considered as a random variable, while the distribution of this random variable can vary among businesses and customers (Pate-Cornell et al., 1990). The amount of cash in hand denoted by \( C(t_0 + \Delta t) \) at time \( t_0 + \Delta t \) is:

\[ C(t_0 + \Delta t) = C(t_0) - 0_1 + \sum_{j=1}^{n} l_j x_j \]  \hspace{1cm} (2)

where:

\[ x_j = \begin{cases} 
0 & \text{if the invoice is not received by } t_0 + \Delta t \\
1 & \text{if the invoice is received by } t_0 + \Delta t 
\end{cases} \]

where \( 0_1 \) is the first future payable invoice, \( l_j \) is the amount of future receivable invoices at time \( t_0 \) and \( C(t_0) \) represents the amount of cash in hand at time \( t_0 \). If there is nonzero probability that \( C(t_0 + \Delta t) < 0 \) (essentially \( C(t_0) < 0_1 \)) then the firm faces a potential cash flow problem.

On the other hand, (Bertel et al., 2008) developed a model showing the connection between product flow and cash flow of a firm in the supply chain. The goal of this model is to find out the optimal solution during liquidity and satisfying customers. In fact, he proposed a mixed integer linear program (MILP) to formulate the supply chain problem through combining the cash flow with the scheduling problem and to determine an optimal level of cash position. The objective function of the model is to maximise the
average cash position, where cash position is the amount of available cash for the whole supply chain, are represented as:

$$\text{Max(AverageCashFlow)} = \text{Max} \left( \frac{\sum_{p=1}^{P} \text{Cash}_p}{P} \right) \quad (3)$$

$$\text{Cash}_p = \text{Cash}_{p-1} - A_p - CP_p - Cstock_p + E_p \quad \forall p \quad (4)$$

where, $P$ is the number of periods, $\text{Cash}_p$ represents cash position available for period $p$, $A_p$ the amount of payment for the supplier during period $p$, $CP_p$ production cost for period $p$, $Cstock_p$ inventory cost for period $p$ and $E_p$ is the amount of cash provided from all customers during period $p$.

Gupta and Dutta (2011) developed an integer programming model to minimise the net present value of the cash outflow of the firm to schedule all payments within the constraints of the cash received. In fact, they tried to schedule and give priority to the invoices based on the credit terms. The model is developed from the point of view of the wholesaler who receives finished products from the manufacturers and then distributes the products to the retailers. The amount of payable invoices can take three different values based on the time of payment: i) paid with discount rate before a specific date, ii) paid with the normal face value before or on the due date, and iii) paid with a certain penalty rate after the due date. However, the main source of the cash inflow is the amount received from the downstream partners for the issued invoices, while the main source of the cash outflow is the amount needs to pay to the upstream partners for the provided materials. The amount paid for any given invoices could be written as:

$$A_k(t) = \begin{cases} 
L_k \left(1 - u_k\right) & \text{if } s_k \leq t \leq b_k \\
L_k & \text{if } b_k \leq t \leq d_k \\
L_k(1 + v_k)^{(t-d_k)} & \text{if } d_k < t 
\end{cases} \quad (5)$$

Where $A_k$ denotes the amount of invoice $k$ supposed to be paid, $L_k$ is the face value of invoice $k$, $u_k$ shows the discount rate applied on the invoice $k$ when it is paid before the due date, $v_k$ is the penalty rate applied if the invoice $k$ is paid after the due date, $s_k$ is the time of issuing invoice $k$, $b_k$ represents the time before which the invoice $k$ needs to be paid to get the discount, $d_k$ is the due date of invoice $k$, $k \in K$ is the set of all invoices, and $t$ is the time that invoices are paid. However, the wholesaler’s objective is to minimise the total present value of the payments to reduce the amount paid to the upstream partners; thus, the present value of $A_k$ denoted by $PV_k$ is represented as:
where \( r \) is the interest rate, while the objective function of the wholesaler is:

\[
P(V_k) = \frac{A_k}{(1 + r)^t} \quad (6)
\]

Minimize \( \sum_{\forall k \in K} PV_k \)

Minimize \( z = \sum_{\forall k \in K} \left[ \sum_{t = s_k}^{b_k} \frac{L_k(1 - u_k)}{(1 + r)^t} X_{kt} + \sum_{t = b_k+1}^{d_k} \frac{L_k}{(1 + r)^t} X_{kt} + \sum_{t = d_k+1}^{T} \frac{L_k(1 + v_k)^{(t-d_k)}}{(1 + r)^t} X_{kt} \right] \quad (7)

\[
X_{kt} = \{0,1\} \quad \forall k \in K, \quad \forall t \in T
\]

\[
\sum_{t = s_k}^{T} X_{kt} = 1
\]

The objective function in Eq. (7) composed of three statements; the first statement represents the present value of invoices on the discount rate, payment to be done earlier than the specified date, the second statement represents the present value of invoices on the normal rate, payment to be done before the due date, and third statement shows the present value of invoices on the penalty rate, payment to be done after due date. The decision variable \( X_{kt} \) is used to show whether the invoice \( k \) is paid either at the discount rate or the normal rate or even the penalty rate, while \( T \) is the end of time horizon.

Comelli et al. (2009) proposed an approach to share the value, preserving liquidity and satisfying customers, between firms within a supply chain regarding the link between product flow and cash flow in a supply chain. In fact, they proposed two MILP models chained together (Figure 2); the first model (Model A) is used to maximise the cash flow of the supply chain, while the second model (Model B) aims to share value between supply chain partners. These two models are chained together, which means the variables of the first model become the parameter of the second model.
In the first part of this approach model A, a programming mathematical model to find the best solution is developed by integrating the cash management with the physical limitations, while in the second part of the approach, a mathematical model to share the value among entities in a supply chain is proposed. The variables of the first model are the quantity of item $i$ sold, the quantity of item $i$ bought by the entity $j$ and the resource cost consummated in entity $j$, while the variables of the second model are market price, purchase price, cash flow and cash position (Comelli et al., 2009).

The objective function of Model A can be written as:

$$
\text{Max } z = \sum_{t=1}^{T} \sum_{j=1}^{I} \left[ \sum_{k=1}^{K} \left( QV_{i,j,k,t-h_{ij}} \cdot PV_{i,j,k,t-h_{ij}} + QA_{i,j,k,t-l_{ij}} \cdot PA_{i,j,k,t-l_{ij}} \right) - \sum_{z} R_{j,t-g_{1kz}} \right] \tag{8}
$$

where $I$ is number of items, $J$ is number of business unit in supply chain, $K$ is number of external and internal entities, $T$ is number of resources, $PV_{i,j,k,t}$ is market price for item $i$ sold by an business unit $j$ to a business unit $k$ in period $t$, $PA_{i,j,k,t}$ is purchase price for item $i$ bought by an business unit $j$ from $k$ in period $t$, $QV_{i,j,k,t}$ is quantity of an item $i$ sold by the unit $j$ to the business unit $k$ in period $t$, $QA_{i,j,k,t}$ is quantity of item $i$ to be bought by unit $j$ from unit $k$ in period $t$ and $R_{j,t-g_{1kz}}$ is resource $z$ consummated in unit $j$ in period $t$. The objective function of model B is presented as:

$$
CF_{j,t} = \sum_{k=1}^{K} \sum_{l} \left( QV_{i,j,k,t-h_{l_{ij}}} \cdot PV_{i,j,k,t-h_{l_{ij}}} - QA_{i,j,k,t-l_{ij}} \cdot PA_{i,j,k,t-l_{ij}} \right) - \sum_{z} R_{j,t-g_{1kz}} \tag{9}
$$
One of the important elements in supply chain design and analysis is the introduction of appropriate performance measures to gauge the efficiency of an existing system or to design a proposed system by defining the decision variables. Based on the existing literature, the defined supply chain performance measures can be either qualitative, such as customer satisfaction, flexibility and supplier performance; or quantitative, such as cost minimization and profit maximization. The performance measures are expressed as functions of different decision variables, such as production/distribution scheduling, inventory level, number of echelons or product assignment to the plant, to optimise one or more performance measures. The decision variable “inventory level” is used to determine the amount of raw materials in storage, while “production/distribution scheduling” is used to schedule manufacturing and distribution. Table 1 summarizes the criteria used in supply chain modelling in the previous literature through different decision variables. Table 1 illustrates that different models use different performance measures and decision variables to optimise the associated performance measure (Beamon, 1998).

<table>
<thead>
<tr>
<th>Basis</th>
<th>Performance Measures</th>
<th>Author(s)</th>
<th>Decision Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Minimise cost</td>
<td>(Lee et al., 1997)</td>
<td>Inventory level</td>
</tr>
<tr>
<td>Cost</td>
<td>Minimise cost</td>
<td>(Williams, 1981)</td>
<td>Production/Distribution scheduling</td>
</tr>
<tr>
<td>Cost</td>
<td>Maximise profit</td>
<td>(M.A Cohen, 1989)</td>
<td>Inventory level</td>
</tr>
<tr>
<td>Customer responsiveness</td>
<td>Minimise stockout probability</td>
<td>(Altiok and Ranjan, 1995)</td>
<td>Inventory level</td>
</tr>
<tr>
<td>Cost and Activity time</td>
<td>Minimise the number of activity days and total cost</td>
<td>(Arntzen et al., 1995)</td>
<td>Production/Distribution scheduling, Inventory level</td>
</tr>
</tbody>
</table>

### 2.2. Bullwhip Effect in the Supply Chain as Result of Product Flow

A supply chain consists of partners working together to deliver products or services from the suppliers to the point of final customers and transferring cash from the final customers to the suppliers instead of delivered products. Therefore, supply operation usually depends on the performance of product flow and cash flow. The product flow in a supply chain affects the cash flow performance. In fact, unforeseen events such as demand variation and delivery time as a result of supply chain operation, usually known as
logistic bullwhip, affect not only the product flow but also the cash flow performance at the same time. Logistic bullwhip affects cash flow by imposing additional costs such as storage cost and customer dissatisfaction cost to the firm while these costs oscillate higher within the supply chain partners. Managing the cash flow supply chain is difficult due to the complex nature and also the effect of many uncertainty factors of the supply chain like time of payment and product delivery time. These uncertainty factors, known as bullwhip, fluctuate within the supply chain as they move up through the chain. Based on the definition, the bullwhip effect, BWE, is defined as an unforeseen event happening to a firm in the supply chain which propagates through the supply chain partners (Tangsucheeva and Prabhu, 2013). Bullwhip refers to a phenomenon in which orders to the supplier tend to have larger fluctuations than sales to the buyer, and the resulting distortion is increasingly amplified within a supply chain. The amounts ordered by the customers from the upstream partners may have very little variation, and this variation becomes larger and larger when it propagates through the supply chain (Baganha and Cohen, 1998). Two primary definitions of the BWE measurement are used in the literature. The first one is the information distortion measured by comparing the order variance with the demand variance, whereas the second definition is the material flow which goes downstream to compare the variance of order receipts with the variance of sales (Chen and Lee, 2012).

![Bullwhip Effect of Material Flow in the Supply Chain](image)

Figure 3 Bullwhip Effect of Material Flow in the Supply Chain (Tangsucheeva and Prabhu, 2013)

Figure 3 represents the bullwhip effect created by the materials flow within the supply chain. The graphs in Figure 3 represent the order quantity of each supply chain member over time. The horizontal axis in Figure 3 represents time, whereas the vertical axis shows the order quantity of each partner within a supply chain. As it is apparent from Figure 3, the rightmost graph, customer demand, has little variation
of the order quantity, while this variation becomes larger when propagated through the upstream partners, where the furthest upstream partner in the supply chain has the worst variations.

Bullwhip effect, known as the biggest problem in the supply chain, moves upstream through all the supply chain partners. Previous research studies (Cachon et al., 2007, Campuzano and Mula, 2011, Aprile and Garavelli, 2007, Sucky, 2009) on the BWE have focused on demonstrating its existence, identifying its cause and providing methods for reducing its impact on the product flow. Regarding the supply chain management, one of the most critical problems is how to quantify the bullwhip effect to reduce such a phenomenon in the cash flow of a firm in the supply chain (Shao et al., 2008). However, the problems of quantifying the bullwhip effect are remaining unsolved due to the complex nature of the problem.

The existing literature on the bullwhip effect mostly emphasizes the existence of the bullwhip effect, the reasons for it and the possible ways to reduce its effects, while the recent research studies on the bullwhip effect can be divided into six general categories: (i) quantifying the bullwhip effect (ii) analysing and identifying the causes of bullwhips (iii) observing the effect of bullwhip on the numerous industries and companies (iv) proposing methods to reduce the effect of bullwhips (v) simulating the system behaviour and (vi) validation of the bullwhip effect (Luong, 2007).

In order to measure and quantify the effect of bullwhip on the supply chain performance, first of all the cause of this phenomenon has to be distinguished, then the effect of bullwhip has to be measured and modelled to reduce its cause on the supply chain performance. Previous studies have identified five main causes of the bullwhip effect, such as follows (Lee et al., 1997):

1. Demand forecasting: Forecasting of demand is inaccurate by nature, and hence the gap between the forecast demand and the reality introduces excess/shortage in the inventory.

2. Order batching: Companies usually place orders in batches to reduce the cost of production and transportation; thus, incorporating the information on batches into the forecast leads to misperception of feedback.

3. Price fluctuation: Promotions or cutting prices may not only encourage customers to purchase large quantities of products but also result in erratic future purchase forecasts.

4. Supply shortage: Whenever the firm thinks there is product shortage, it will increase the size of orders to the suppliers to secure the amount of products needed, while only some parts of order will be filled.
5. Lead time: Increasing lead time leads the inventory level required to increase; thus, the variability of demand increases.

Based on the causes mentioned for the bullwhip effect, four suggestions are identified to reduce the bullwhip effect: i) share information to reduce uncertainty, ii) cut promotions and use a consistent price system to reduce variability, iii) adopt lean manufacturing to reduce the lead time, and iv) use effective inventory management through the supply chain (Simchi-Levi et al., 1992).

Five different approaches, or five routes to connect the real world problem to the real world solution, are defined to measure the bullwhip effect as follows (Geary et al., 2003): operational research, the filter theory, the control theory, systems dynamics and ad-hocacy based on the problems and solutions. The operational research helps the firm to formulate the problem using a differential equation approach, while the solution is a mathematical formula to minimise a cost function. The ratio between orders variance and demand variance is used for this formula. The filter theory explains the problem in the frequency domain where value judgments are made on the spectrum widths or based on the amplitudes of the noise or the disturbances, while the solution is gained by shaping the system frequency response to suit the needs of the user. The control theory models the problem in a transfer function form and focuses on the system structure to ensure stability and to shape the desired response. System dynamics is a type of modelling to make simulation and study through cause and effect diagrams and studied via test demands. Ad-hocacy is an approach based on practical experience to observe the amplification created by an echelon. Hence, the subsequent action is to redesign the supply chain based on knowledge of the bullwhip.

Chen et al. (2000) formulated a model to quantify the bullwhip effect for a simple supply chain based on two factors assumed to cause the bullwhip effect: demand forecasting and order lead times. It is quantified that the bullwhip effect as the variance of orders received from the retailer relative to the variance of demand faced by the retailer. He determined that the increase in the variability is an additive function of the lead time and the lead time squared in the supply chain with centralized information, while for the supply chain without centralized information the increase in the variability is the multiplicative. Thus, the centralized information reduces the effects of demand forecasting on the bullwhip. The variance of the order over the variance of the demand without centralized information is represented in Eq. (10), while Eq. (11) shows the variance of the order over the variance of the demand with centralized information as (Chen et al., 2000):

\[
\frac{\text{Var}(q)}{\text{Var}(D)} = 1 + \frac{2L}{p} + \frac{2L^2}{p^2} \quad (10)
\]
\[
\frac{Var(q^k)}{Var(D)} = \prod_{i=1}^{k} \left( 1 + \frac{2L}{p} + \frac{2L^2}{p^2} \right) \quad (11)
\]

where, \( q \) represents the variance of orders received from the retailers, \( D \) denotes the variance of demand sent to the retailers, \( k \) is the number of stages in the supply chain, while \( L \) shows the lead time and the average demand observation is denoted by \( p \).

In addition, Kim et al. (2006) tried to extend the Chen’s model by developing a model in a stochastic environment and lead time with and without information sharing. He found that the bullwhip effect increases linearly with information sharing but exponentially without information sharing (Kim et al., 2006).

Moreover, Tangsucheeva et al. (2013) believe the bullwhip phenomenon in the product flow may also happen to the cash flow through the supply chain. The bullwhip effect not only has a tremendous effect on the supply chain efficiencies but also on the cash flow of the supply chain. Cash Flow Bullwhip (CFB) is defined as a similar phenomenon to the logistic bullwhip except that it happens on the cash flow. They developed a mathematical and simulation model to analyse the relationship between inventory and cash flow bullwhip through using a metric such as cash conversion cycle. Also, they found that the CFB is an increasing function of expected inventory and a decreasing function of expected demand. In addition, they found CFB is a function of parameters such as lead time of the order placement and the arrival of goods, expected value of inventory and expected value of order quantity. Besides, they found that whenever the amplified order does not match the actual demand, the products will pile up in the inventory; thus, the firm will be faced not only with a high inventory holding cost but also a high opportunity cost and working capital (Tangsucheeva and Prabhu, 2013).

2.3. Customer Satisfaction Concept, Measurement Methods and Techniques

In order to sustain competitiveness and long term profitability, firms in the supply chain have to endeavour not only to attract new customers but also to retain the existing and loyal customers through the process of increasing customer satisfaction (Yang, 2005). Customer satisfaction with conceptual and experimental evidence can be defined as a feeling or judgement that features of a product or service provide a pleasurable level of consumption related to its fulfilment (Oliver, 2010). Similarly, customer satisfaction is viewed as the perception of the products’ performance in relation to the expectation, and is often used as an indicator of whether customers will return to repurchase or not; satisfied customers are likely to purchase again, whereas dissatisfied customers are likely to leave and to try elsewhere. The firms
with dissatisfied customers surrender the market to its rivals who offer better products and services (Tripathi, 2014). Based on the definition presented by Webster (2000), a customer is an individual or business entity that buys and pays for the product to acquire it. Since the customers who pay for the products or services are the biggest source of cash inflow for a firm, a higher rate of customer satisfaction leads the firm to have a greater number of satisfied or loyal customers, and concomitantly greater cash inflow. Maximizing the number of satisfied customers and also maximizing cash inflow is the primary aim of every firm (Fecikova, 2004). With this in mind, customer satisfaction has become the central concept of modern marketing. Such a marketing concept emphasizes delivering satisfaction to the customers who pay for the products or services to obtain a profit in return; hence, measuring customer satisfaction is becoming an importance issue in business practices today. Customer satisfaction as the key factor of indicating a firm’s success is attracting the attention of all firms in a supply chain. One of the main obstacles for each firm in the supply chain is how to deal with the customers in order to have more satisfied customers, and how satisfaction affects a firm’s cash flow; therefore, customer satisfaction has to be measured and quantified with the hope of improving the cash flow, while the relationship between satisfaction and a firm’s cash flow is still an unsolved problem for a firm in a supply chain (Hansemark and Albinsson, 2004).

The models to review and to explain customer satisfaction are divided into two different groups: i) macro models, which aim to integrate the concept of satisfaction such as value, quality and loyalty, and ii) micro models, which include elements that explain the composition of the customer satisfaction concept such as disconfirmation of the expectations, perceived performance, equity and attribution. Macro models are subsets of micro models with some possible overlaps. Figure 4 represents the traditional macro model of customer satisfaction still much used in research today, which includes perceived performance, comparison standard, perceived disconfirmation, satisfaction feeling and outcomes (Hom, 2000).

To evaluate satisfaction, the perceived performance of the products or services is compared with a set of comparison standards. The comparison standards can vary widely by individual, situation and by product type. Perceived disconfirmation reflects the level of mismatch between the perceived performance and comparison standard, and results in satisfaction feeling as an attitude which emerges as an outcome of intention to repurchase.
Previous research (Anderson and Mittal, 2000) indicates that there is a positive correlation between attribute performance of products, customer satisfaction and profitability of a firm. In fact, improved product attribute performance increases customer satisfaction, while increased satisfaction leads to greater profitability. Conversely, poor attribute performance of products, below expectation, may have a deteriorating effect on the profitability of the firm.

The relationship between product attribute performance, customer satisfaction and profitability is known as the chain of Satisfaction-Profit (Figure 5). Improving the product attribute performance leads to higher customer satisfaction, which in turn increases customer retention and leads to greater profitability (Simon and Gómez, 2014).
The heart of the satisfaction process is the comparison of what was expected from the products or services’ performance with the perceived performance of the products or services. Pereira defined satisfaction as a result of the customers’ attitude regarding the interaction with the products. This attitude, called perceived quality \((PQ)\), is described as a mathematical ratio between the customers’ needs met by the product \(m\) and the total customers’ needs \(n\) (Pereira, 1998, Fecikova, 2004). Perceived quality is coincident with satisfaction of any particular customer. The mathematical model is represented as:

\[
PQ \equiv S = \frac{m}{n} \quad (12)
\]

where, perceived quality ranges from 0 to 1 and consequently satisfaction \(S\) belongs to the interval \([0, 1]\) with 1 indicating complete satisfaction and 0 indicating complete dissatisfaction.

Fecikova (2004) proposed a general formula to make a quantitative measurement of customer satisfaction based on factors such as level of product importance, types of customer and method used to interact with the customers as represented in Eq. (13). Regarding the product importance, an evaluation scale from 0 for not important to 10 for most important is used, while an interval \([0, 10]\) is defined to evaluate the level of satisfaction, 0 for dissatisfaction to 10 for ultimate satisfaction. The type of customers is defined based on each customer’s share of the firm’s profit, while the validity of method used for each customer is defined based on the types of method such as structured interview with a validity of 100 percent, interview by phone with a validity of 70 percent and questionnaire with a validity of 40 percent (Fecikova, 2004).

\[
CS = ((\text{Level of satisfaction}) - (\text{Level of importance})) \ast (\text{Types of customers}) \ast (\text{Types of method used})
\]

\[
a > 1: \text{sufficient satisfaction of customers}
\]

\[
a < 1: \text{insufficient understanding of customers' demands}
\]

\[
b: \text{index that represents customer and method used}
\]

The disconfirmation theory model is created by comparing the perceived performance and the expected performance of the products to measure customer satisfaction (Ekinci and Sirakaya, 2004). To measure satisfaction, the following steps should be considered: i) customers form expectations of the performance
of a product or service prior to purchasing, and ii) the perceived performance of the products or services and experience of using them is compared with the expected performance (Figure 6).

![Disconfirmation Theory Model](image)

As it is apparent from Figure 6, if the perceived performance $P$ is equal to or greater than the expected performance $E$, then the customer expectations are fulfilled and satisfaction has occurred, while if the perceived performance lags behind the expectations, the opposite occurs and the customers become dissatisfied (Ekinci and Sirakaya, 2004).

Kano (1984) has proposed a widely used two-dimensional model which establishes a relationship between customer satisfaction and product attributes performance. For this, the attributes of a product are characterised based on how well they are able to satisfy the customer’s needs and hence to help the businesses to classify all potential customers’ requirement to prioritise efforts towards issues that most influence satisfaction (Figure 7). The model is defined based on the three types of product attributes: i) basic needs or expected attributes, ii) performance factors, and iii) delighter. The presence of surprise attributes or delighters creates satisfaction for the customers, while their absence does not necessarily lead to dissatisfaction. Customers become satisfied by the achievement of performance factors and become dissatisfied if these attributes are not achieved. Also, the basic needs make the customers dissatisfied if they are not fulfilled, while the absence of these features or attributes does not necessarily make the customers satisfied. The relationship between product attributes and satisfaction/dissatisfaction as
experience is not necessarily linear and symmetric; instead, that relationship could be nonlinear, positive and negative asymmetric (Tsiotsou et al., 2010).

The Kano model has a defect that prevents firms from accurately assessing the quality attributes, and the degree of importance of quality attributes is neglected; therefore, a refined Kano model is developed by (Shahin et al., 2013) considering the quality attributes of products in more precise categories. In the refined model, the categories of Kano model, Performance factor, Delighter and Basic needs, are divided into six categories: highly attractive, less attractive, high-added value, low added-value, necessary and critical (Figure 8). With respect to performance factor attributes in Kano model, increasing such attributes will raise customer satisfaction. Therefore, it is possible to define some performance factor attributes with high importance as high value-added attributes, whereas others can be defined as low value-added attributes. For the delighter attributes, the one with high importance can be categorized as highly attractive attributes, while those with lesser importance can be classified as less attractive attributes. On the other hand, the basic needs attributes also can be divided into two categories; critical or necessary for high and lesser importance attributes respectively (Yang, 2005).
2.4. Mergers and Acquisitions within Firms

The main objective of every firm is to get maximum profit to increase the wealth of shareholders. Regarding globalisation and economic growth, every firm adopts different techniques and methods to maximise profit and also to survive in the fast growing market. Thus, every firm tries to achieve the optimum market share and dominate the market in the competitive market. The firm thinks about growing the business and market via various ways and two ways are usually defined as: internal expansion or external expansion. Internal expansion is defined as when a firm grows gradually over time via acquisition of new assets and substitution of obsolete equipment, whereas external expansion is defined as when a firm instantly combines with an operating business in the form of a merger, acquisition or takeover (Ransariya, 2010). Generally speaking, merging different firms within supply chain significantly affects the supply chain operation and consequently the financial performance of firm; therefore, the effect of merger and acquisition on the financial performance of a firm in a supply chain needs to be evaluated.

Mergers and acquisitions, M&A, are defined as when two companies operating separately combine into one new company. ‘Merger’ is defined as a combination of two or more firms into a new firm with the new firm gaining the assets and liabilities of the merged companies, whereas ‘acquisition’ is a takeover of a company by another company in which no new firm is formed (Van Dijk, 2012). Similarly, Abbas et al. defined ‘merger’ as the agreement of two firms to move forward as a single or joint entity, while
‘acquisition’ is defined as purchasing of some assets, plants, equipment and business units of an entity by a firm (Abbas et al., 2014). In fact, the main difference between a merger and an acquisition lies in the way the two firms are combined. Although, ‘merger’ and ‘acquisition’ are not the same terminology they are; however, often used interchangeably.

Mergers and acquisitions are very important tools for the expansion of businesses in different countries; thus, the use of mergers and acquisitions is increasing due to the globalised economy, to improve competitiveness through gaining greater market share, earning new markets and capitalising on economies of scale (Mantravadi and Reddy, 2008). Mergers and acquisitions as a global business strategy enable firms to enter into new potential markets or to a new business area. Also, mergers and acquisitions are probably a very easy way and the only option for small or less profitable firms to survive in the emerging markets (Malik et al., 2014).

Rationales and drivers are two types of reason mentioned for mergers and acquisitions. The rationales reasoning, known as high level, includes the condition under which a decision to merger is made out of financial necessity, while the drivers decision, known as mid-level, includes merger justification such as globalization and diversification (Roberts et al., 2003). A firm can achieve more resources, such as financial resources; therefore, the competitiveness of firms is increased due to better productivity, better economies of scope, better market power, more product and technology categories and also efficiency gains through mergers and acquisitions. Three main objectives or motives are mentioned for mergers and acquisitions: i) maximizing profit and revenues, ii) faster growth in scale and iii) acquisition of new technology (Frantslikh, 2005, Akinbuli and Kelilume, 2013).

2.4.1. Types of Mergers and Acquisitions

Three basic types of mergers and acquisitions used by firms within a supply chain were introduced in the literature as follows (Hoang, 2008):

**Vertical Integration**

Vertical integration is a combination of firms involved in different stages of the production or distribution within a supply chain. In fact, vertical integration is defined as the process of merging the manufacturers with the suppliers or retailers. Vertical integration is an attempt to reduce the risk associated with the suppliers and to improve the performance of firm through internalising all transactions between a supplier and a manufacturer. The mergers between an internet search, Google, and Internet advertising, DoubleClick is an example of vertical integration.
**Horizontal Integration**

Horizontal merger is a combination of firms operating in the same business and producing the same products and services to obtain more economies of scale through reducing cost and eliminating the duplication facilities. In fact, the companies in the horizontal integration are usually direct competitors. The benefit of a horizontal merger is the elimination and reduction of competition through increasing market share and economies of scale. The combination of Daimler-Benz and Chrysler is a popular example of a horizontal merger.

**Conglomerate Integration**

A conglomerate merger is a process of joining of two firms from different areas of business in order to diversify the business activities and to spread the business risk across different sectors. In fact, conglomerate merger happens between unrelated firms or firms without a seller/buyer relationship, or firms which are not in the competition with each other. However, due to the lack of knowledge and technology of the new product and market introduced, the business risk may increase. One example of a conglomerate merger was the merger between the Walt Disney Company and the American Broadcasting Company.

2.4.2. **Process of Mergers and Acquisitions**

The process of mergers and acquisitions usually starts with an idea to add value to the current business within different steps. The steps to describe the process of the mergers and acquisitions are defined differently by different authors. A typical mergers and acquisitions process goes through three phases or steps: i) planning phase to cover operational, ii) implementation phase to cover a range of activities to carry out a merger and deal closure, and finally iii) integration phase which is concerned with post-deal (Picot, 2002). In addition, the acquisition process is described as a linear process consisting of two main parts, the pre-acquisition and post-acquisition process. The pre-acquisition process is the decision-making process categorized into value creation, target selection and valuation, and the essential factor in the pre-acquisition process is the importance of finding the right acquisition target and evaluating the target. Different critical success factors such as evaluation of the strategic partner, paying the price of the partner, size mismatches and communication before the merger, are defined during the pre-merger process. The post-acquisition process includes the implementation phase of the acquired firm with the aim of increasing the efficiency of the existing capabilities, while the goal in the post-acquisition process is to increase the efficiency of the use of the existing capabilities. Integration strategies, post-acquisition
leadership, culture and speed of implementation are mentioned as critical success factors for the post-merger process (Gomes et al., 2013, Haspeslagh and Jemison, 1991).

Haspeslagh et al. (1991) mentioned that the process of merger and acquisition goes through four stages (Figure 9): i) idea, ii) acquisition justification, iii) acquisition integration, and iv) result. The first two stages are referred to as the pre-acquisition phase or decision-making phase, while the last two stages are referred to as the post-acquisition phase or integration process phase (Risberg, 2003).

![Figure 9 Mergers and Acquisitions Process](image)

The acquisition process starts with the idea phase to find out the potential acquisition and evaluate the eventual partners; then, the acquisition should be justified before the company reaches a deal. The integration phase starts when the deal is done. However, there are no clear boundaries between the defined phases, while the possible overlap may happen between phases.

Although there is no documented process for the mergers and acquisitions planning and decision-making, Galpin introduced a framework for conceptualising the fundamental processes of the deal process known as the deal flow model. The deal flow model consists of five stages: formulate, locate, investigate, negotiate and integrate process. The first three stages belong to the pre-merger phase, while the negotiate stage represents the deal phase and the integration phase represents the post-deal phase (Galpin and Herndon, 2008). After finishing and finalising the merger deal, the performance of the new firm formed after the mergers and acquisitions has to be measured and quantified in different areas such as customer satisfaction and financial performance through defining different metrics to compare the performance of the firm before and after the merger.

Table 2 maps the stages and phases of the deal flow model.
Table 2 Map of Merger and Acquisition Process

<table>
<thead>
<tr>
<th>Stages</th>
<th>Description</th>
<th>Phase</th>
</tr>
</thead>
</table>
| Formulate | • Set Business strategy  
|          | • Define acquisition criteria                   |           |
| Locate | • Identify target market and companies  
|         | • Select target  
|         | • Issue letter of intent                      | Pre deal  |
| Investigate | • Decide negotiation parameters  
|             | • Summarize findings                          |           |
| Negotiate | • Set deal terms  
|          | • Close deal                                   | Deal      |
| Integrate | • Finalize and execute integration plan  
|          | o Process                                      | Post deal |
|          | o People                                       |           |
|          | o System                                       |           |

In fact, the comparison of the metrics before and after the merger helps to determine how successful the merger was and how it affects the firm’s performance. Different types of performance measures have been used to characterise and measure the performance of a system. Financial performance as the most important performance is used by firms to measure the performance of a system (Wu and Song, 2005).

Based on financial performance, Saboo et al. (2009) have studied the impact of the merger on the operating and financial performance of a firm aiming for expansion through using financial metrics such as debt-equity ratio, current ratio, fixed assets and return of capital employed, while the data of these metrics are compared before and after merger. They test the metrics for two types of firms: domestic and cross-border firms. The results show that most of the metrics and ratio were improved after merger for domestic firms, while the metrics and ratio deteriorated after merger on the cross-border firms (Saboo and Gopi, 2009).

Mantravadi et al. (2008) investigated the effect of merger and acquisition on the operating performance of the acquiring firm in different industries through financial ratio such as operating profit margin, gross profit margin and debt-equity ratio for three years prior to and three years after a merger. The comparative results of the pre-merger and post-merger of the financial performance ratio for the sample of Indian firms show that there was a significant decline in terms of profitability and return on investment in the chemical sectors, with a slightly positive impact on profitability of firms in the banking and finance sectors. (Mantravadi and Reddy, 2008). By contrast, the study on the financial statement of twenty-two firms from Oklahoma to investigate the success of a merger in improving the financial performance of a firm was
proposed by Kenkel (2003) through using five different financial ratios such as current ratio, debt to asset ratio, ROA, ROE and sales growth for each firm annually. The comparison of ratios of the merged firm before and after merger indicated that the merger can improve the overall performance of a firm. In fact, the results showed that the financial performance of new firm was enhanced after the merger (Kenkel et al., 2003).

To conclude, the existing and current literature has shown mixed results in terms of the operating and financial performance of the firms before and after merger. Thus, it would be really difficult to conclude that the merger and acquisition can be used as a catalyst to improve the performance of a firm, especially the financial performance. However, Table 3 summarizes the results of the financial performance of an acquired firm based on the different metrics which have been done in the previous literature.

Table 3 Financial Performance of the Acquired Firm

<table>
<thead>
<tr>
<th>Authors</th>
<th>Metrics</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Healy et al., 1992)</td>
<td>Cash flow margin on sale, Asset turnover</td>
<td>Significant improvements in operating cash flow returns</td>
</tr>
<tr>
<td>(Ahmed and Ahmed, 2014)</td>
<td>Probability, Efficiency, Liquidity</td>
<td>Insignificantly improved on profitability and liquidity, insignificant decline in efficiency</td>
</tr>
<tr>
<td>(Pillania and Kumar, 2009)</td>
<td>Return on capital employed</td>
<td>No significant changes</td>
</tr>
<tr>
<td>(Kemal, 2011)</td>
<td>Liquidity ratio, Profitability ratio</td>
<td>Quite satisfactory before the merger deal</td>
</tr>
<tr>
<td>(Abbas et al., 2014)</td>
<td>Profitability &amp; Efficiency, Leverage,</td>
<td>No improvement in the financial performance of banks after merger and acquisition</td>
</tr>
</tbody>
</table>

As can be seen from the Table 3, different authors used different metrics to analysis the impact of merger and acquisition on the performance of a firm. The studies focus on the analysis of changes in operation performance of firms through different financial performance metrics. The changes are examined by comparing the metrics value before and after merger (Rani et al., 2015). However, there is not a convergence to conclude of whether a merger and acquisition is wealth-enhancing or value-destroying.

2.5. Conclusion

Considering the studies have been reviewed in this chapter on cash flow in the supply chain, bullwhip effect in the supply chain as a result of product flow, customer satisfaction measurement methods and techniques and mergers and acquisitions (M&A) concepts and metrics, there is still very little known about the payment strategies and supply chain operation related with the financial performance of a firm
in a supply chain, which highlights the needs for further investigations. Thus, the objectives of this thesis, which are presented in Section 1.2 in Chapter 1, are defined to address the research gaps reviewed in this chapter. In fact, a mathematical model which is more concise and practically relevant is developed to maximise the financial performance of a firm in a supply chain through evaluating the effects of supply chain operation on the cash flow of a firm in a supply chain and also evaluating the effects of vertical and horizontal integration within a supply chain on the supply chain operation, and consequently on the financial performance of a firm in a supply chain.
Chapter Three

Modelling Cash Flow of a Firm in a Supply Chain

In this chapter, a mathematical model for the firm’s cash flow is developed through a framework representing the firm’s aggregated cash flow; then, mathematical models for the firm’s cash inflow and outflow are formulated in specified time period. In addition, random numbers to reduce the uncertainties in cash inflow are generated to understand the amounts of available cash in the firm.

3.0. Introduction

The supply chain consists of different firms working and cooperating to deliver products, services or information from the suppliers of raw materials to the final customers. From the point of view of any firm in a supply chain, three flows can be defined as in Figure 10. Product flow goes from those partners furthest upstream, the suppliers, to the partners furthest downstream, the customers, while cash flow moves inversely and information flows in both directions. As can be seen from Figure 10, the cash flow of a firm in a supply chain is in the opposite direction of product flow.

Figure 10 depicts a supply chain containing four echelons: suppliers who provide raw materials, firms which turn raw materials into final products, distributors who send the products to their various destinations and customers who pay for the final products or services.
The main objectives of a firm in a supply chain are to add value to the products or services and to earn more profit. From the firm’s point of view, two kinds of cash flow are defined: i) the cash inflow coming to the firm from numerous sources e.g. downstream partners and financial institutions, as receivables, and ii) cash outflow going from the firm to the many sources e.g. upstream partners, overhead cost and financial institutions as payables. The main source of the cash inflow are invoices received from the downstream partners, while the main source of the cash outflow are invoices paid to the upstream partners for the provided materials (He et al., 2010).

The aim of the PhD thesis is to devise a payment strategy to improve the financial performance of a firm in a supply chain through investigating the effects of supply chain operation on the firm’s cash flow. The aim of this chapter is to develop mathematical models for the firm’s cash inflow and outflow by defining a cash flow diagram.

Regarding cash inflow, two different scenarios, best-case and worst-case, where the receivables are obtained as soon as possible and as late as possible respectively, are defined by generating a sample of data with any distribution based on the payment records of customers within previous periods to reduce the effects of cash inflow uncertainties. In fact, the time each payment is received can be considered as a sample distributed around the due date. The best scenario is the time which is the minimum point in the sample, whereas the worst scenario is the time which is furthest from the due date, the maximum point in the sample. Therefore, the expected time of receiving payment from each customer is related to their payment history and deviation from the due date of invoices.

3.1. Modelling the Firm’s Cash Flow

In order to improve the financial performance of a firm in a supply chain over a particular time instance or period, a framework representing the flow of cash inflow as receivables and cash outflow as payables of a firm in different time periods is proposed. More precisely, the cash flow of a firm in a supply chain can be defined based on the different types of cash flow of a firm: i) the amount of cash received from the immediate downstream partners, ii) the amount of cash available in the firm as cash in hand and iii) the amount of cash which has to be paid to the immediate upstream partners.

A mathematical model for the firm’s cash inflow and outflow is developed based on the cascade cash flow model as presented in Figure 11. This framework as cascade diagram is proposed as a part of this thesis to show the firm’s cash flow and to formulate the model for firm’s cash flow. In Figure 11, the time horizon $T$, usually a period of one year, where all firm’s cash flow is happened, consists of ‘n’ time periods, while the cash flow in each time period affects the cash flow in the next period.
As it is apparent from Figure 11, the amount of cash flow at the end of each time horizon affects the cash flow on the next time horizon. In fact, the amount of cash at the end of time horizon is the initial amount of cash for the first time period of the next time horizon.

The mathematical presentation of the firm’s cash flow for the period $tn$ is:

$$ CF(tn) = IN(tn) + CF(tn - 1) - OUT(tn) $$

where $IN(tn)$ represents the overall amount of cash entering the firm during period $tn$ as cash inflow, $OUT(tn)$ represents the overall amount of cash going out of the firm as cash outflow during period...
tn, \( CF(tn - 1) \) represents the amount of cash available from the previous period or previous time horizon and \( CF(tn) \) represents the cash flow of the firm at the end of period \( tn \). The framework is used to represent how cash flows in each time period and how cash transfers from one period to the next period. As shown in Figure 11, the present value of cash received from the customer with invoice \( i \) at period \( tn \) is indicated by \( PV(tn, i) \), while the present value of cash paid to the supplier with invoice \( j \) at period \( tn \) is depicted by \( PV'(tn, j) \).

The cash inflow of the firm in each period, e.g. \( IN(tn) \), is composed of the sum of present value of all cash received from the different customers at the specific times based on the due date of each issued invoice, while the cash outflow in each period, e.g. \( OUT(tn) \), is composed of the present value of cash that has to be paid to the different suppliers for the delivered materials at various times.

In addition, the amount of upstream flow of cash (the amount of cash paid by the downstream partners to the upstream partners in the supply chain) will depend on the terms of payment including discount rate, due date and penalty rate. In fact, the firm in a supply chain issues the invoices with a certain value for the downstream partner for the purchased products, and also receives the invoices with a certain value from the upstream partners for delivered raw materials, whilst the amount paid or received for each invoice can take three values based on the time of invoice payment: i) discount value, ii) normal value, and iii) penalty value (Gupta and Dutta, 2011). In general, the discounts and penalties are respective mechanism to encourage the downstream partners to pay the payment as soon as possible and to penalise the downstream partners for late payments.

In order to present the time and amount for each invoice, an invoice life time, e.g. one month, as a period of time in the time horizon \( T'' \), is developed consisting of the time at which the invoice is issued \( T_1 \), the time at which the payment gets a discount on or before \( T_2 \) and the time at which the payment is due \( T_3 \). Consequently, the invoices are paid at a penalty rate if they are paid after the due date and before the end of invoice life time \( T_4 \) where the new period in the time horizon starts (Figure 12). It is also assumed that after \( T_4 \) other courses of action may be taken, such as using a debt collection agency to collect payments due from invoices sent to the downstream partners. However, payments which are not received before time \( T_4 \) lead to the firm being unable to schedule payments for the next period properly; thus, the cash flow of the firm over the next period is affected by late receivables.
Gupta et al. (2011) defined the amount $A_k(t)$ paid for invoice $k$ at time $t$ for the delivered products or materials as:

$$
A_k(t) = \begin{cases} 
  L_k(1 - u_k) & \text{if } T_1 \leq t \leq T_2 \\
  L_k & \text{if } T_2 \leq t \leq T_3 \\
  L_k(1 + p_k)^{(t-T_3)} & \text{if } T_3 < t \leq T_4
\end{cases}
$$

(15)

where $k$ is set of all invoices during a time period, $L_k$ is the face value of invoice $k$, $u_k$ is a discount rate applied to invoice $k$ if it is paid at the proper time, $p_k$ indicates a penalty value applied to invoice $k$ if it is paid after the due date and $t$ is the time of paying invoice $k$.

### 3.1.1. Cash Inflow

Based on the cascade diagram (Figure 11) developed for the firm’s cash flow, all cash inflow invoices are received from the downstream partners within the supply chain in each time period. Therefore, an integer mathematical model has been developed for the cash inflow of the firm in the supply chain within different time periods. Considering $i \in I$ is a set of receivables invoices and $F(tn,i)$ is the face value of invoice $i$ at period $tn$ then, the amount received for invoice $i$ at period $tn$, $a(tn,i)$, is:

$$
a(tn,i) = \begin{cases} 
  F(tn,i)(1 - v(tn))^{(du(tn,i) - d(tn,i))} & s(tn,i) \leq d(tn,i) < du(tn,i) \\
  F(tn,i) & d(tn,i) = du(tn,i) \\
  F(tn,i)(1 + p(tn))^{(d(tn,i) - du(tn,i))} & du(tn,i) < d(tn,i) \leq T(tn)
\end{cases}
$$

(16)
Early receiving of cash from customers helps firm to invest the cash in order to use daily interest rate. Moreover, it is considered that the customers can use a certain discount rate that depends on \( d(tn,i) \). In fact, if the amount of invoices is paid before due date, the discount or the interest starts accruing daily to the due date; thus, daily discount rate is added to the cash flow model in comparison with Eq. (15).

The parameters of the model in Eq. (16) are given in Table 4.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( I )</td>
<td>Set of all customer’s invoices</td>
</tr>
<tr>
<td>( F(tn,i) )</td>
<td>Face value of invoice ( i ) at period ( tn )</td>
</tr>
<tr>
<td>( p(tn) )</td>
<td>Daily penalty rate at period ( tn )</td>
</tr>
<tr>
<td>( v(tn) )</td>
<td>Daily discount rate period ( tn )</td>
</tr>
<tr>
<td>( du(tn,i) )</td>
<td>Due date of invoice ( i ) at period ( tn )</td>
</tr>
<tr>
<td>( s(tn,i) )</td>
<td>Time of generating invoice ( i ) at period ( tn )</td>
</tr>
<tr>
<td>( d(tn,i) )</td>
<td>Time of receiving invoice ( i ) at period ( tn )</td>
</tr>
<tr>
<td>( r )</td>
<td>Daily interest rate</td>
</tr>
<tr>
<td>( T(tn) )</td>
<td>End of period ( tn )</td>
</tr>
</tbody>
</table>

The present value of \( a(tn,i) \) denoted by \( PV(tn,i) = \frac{a(tn,i)}{(1+r)^{d(tn,i)}} \) is the formulated as:

\[
PV(tn,i) = \sum_{d(tn,i)=s(tn,i)}^{du(tn,i)-1} \left( u(tn,i) \frac{F(tn,i)(1-v(tn))^{(du(tn,i)-d(tn,i))}}{(1+r)^{d(tn,i)}} \right)
+ \sum_{d(tn,i)=du(tn,i)}^{T(tn)} \left( u(tn,i) \frac{F(tn,i)}{(1+r)^{d(tn,i)}} \right)
+ \sum_{d(tn,i)=du(tn,i)+1}^{T(tn)} \left( u(tn,i) \frac{F(tn,i)(1+p(tn))^{(d(tn,i)-du(tn,i))}}{(1+r)^{d(tn,i)}} \right)
\]

\[ u(tn,i) = \{0,1\} \]

\[ \sum_{d(tn,i)=s(tn,i)}^{T(tn)} u(tn,i) = 1 \quad \forall i \in I \quad (18) \]

As represented in Eq. (18), \( u(tn,i) \) is used here as a binary variable to show invoice \( i \) needs to be paid once either on the discount value, normal value or penalty value during the period \( tn \).
The first statement on the right hand side of Eq. (17), 
\[
\frac{F(t_{n,i})(1-v(t_{n,i}))^{d(u(t_{n,i})-d(t_{n,i}))}}{(1+r)^{d(t_{n,i})}},
\]
shows the present value of invoice \( i \) at period \( t_{n} \) received from customers before the due date on the discount value, the second statement, 
\[
\frac{F(t_{n,i})}{(1+r)^{d(t_{n,i})}},
\]
represents the present value of the invoice \( i \) at period \( t_{n} \) received from customers on the due date on the normal value, while the third statement, 
\[
\frac{F(t_{n,i})(1+p(t_{n,i}))^{d(t_{n,i})-d(u(t_{n,i}))}}{(1+r)^{d(t_{n,i})}},
\]
shows the present value of the invoice \( i \) at period \( t_{n} \) received from customers after the due date with a delay on the penalty value.

On the other hand, it is apparent that the time of receiving cash from the downstream partner in the supply chain is unknown and uncertain, since it is significant for the firm to know the time and the amount of cash received in order to manage cash outflow. In order to understand the time of cash inflow invoices and reduces the effect of cash inflow uncertainties on the firms’ cash flow, a sample of numbers distributed over the due date of payment is generated according to the data taken from the payment history of each customer during previous periods. However, there are maximum and minimum points in the sample during the time periods representing the numbers of days on which the invoices are paid with the greatest delay and the numbers of days on which they are paid in the quickest time respectively. In fact, the maximum and minimum points for payment receipts represent the greatest deviation from the due date during the different periods in opposite directions. The maximum point can be considered as a worst scenario for cash inflow, while the minimum point has been assigned as the best scenario, and a firm can schedule payments due after defining these two scenarios based on the customer’s historic data of payments accordingly. Generating best-case and worst-case scenarios helps the firm to forecast the probable date on which customers may pay, and is useful for calculating the amount of cash available at any moment during the lifetime of an invoice (Figure 12) for which all payments must be made.

The amount of available cash in the firm at time \( \beta \), smaller units of time e.g. a day forming a time period, for period \( t_{n} \) is therefore defined as:

\[
A(t_{n}, \beta) = \sum y(t_{n}, i) * PV(t_{n}, i) \quad (19)
\]

\[
y(t_{n}, i) = \begin{cases} 
1 & \beta \geq d(t_{n}, i) \\
0 & \beta < d(t_{n}, i) \\
1 \leq \beta \leq T(t_{n})
\end{cases} \quad (20)
\]

where \( A(t_{n}, \beta) \) is the total amount of available cash in the firm in the time \( \beta \) at period \( t_{n} \), i.e. a month, received from customers, while \( y(t_{n}, i) \) is a variable to show whether the issued invoice \( i \) is paid on or
before the time $\beta$ or not, $T(tn)$ is the end of time period, $\beta$ is the unit of time in each time period, e.g. a day and $PV(tn, i)$ is the present value of issued invoice $i$ during period $tn$ as presented in Eq. (17).

The aggregate firm’s cash inflow, the total amount that the firm receives from the downstream partners, at the end of period $tn$ as presented in cascade diagram (Figure 11) can be formulated as the summation of present value of cash received from customer with invoice $i$ during period $tn$:

$$IN(tn) = \sum_{i \in I} PV(tn, i) \quad (21)$$

### 3.1.2. Cash Outflow

Unlike the cash inflow, cash outflow can be classified into two groups: i) the amount of cash the firm used internally such as overhead costs, and ii) the amount of cash used externally to pay to the upstream partners for the supplied raw material. Similar to the cash inflow, the amount of cash outflow invoice has three options to take: i) discount value to get discount, ii) normal value to avoid penalties, and iii) penalty value for late payments (perhaps to earn interest through investing cash). Considering $j \in J$ to be set of cash outflow invoices, three different scenarios for the value of cash outflow invoice $j$ in the period $tn$ represented as:

$$b(tn, j) = \begin{cases} F'(tn, j)(1 - v'(tn))^{(du'(tn, j) - d'(tn, j))} & s'(tn, j) \leq d'(tn, j) < d'u'(tn, j) \\ F'(tn, j) & d'(tn, j) = d'u'(tn, j) \\ F'(tn, j)(1 + p'(tn))^{(d'(tn, j) - du'(tn, j))} & du'(tn, j) \leq d'(tn, j) \leq T(tn) \end{cases} \quad (22)$$

where $F'(tn, j)$ denotes the face value of invoice $j$ at period $tn$, and $b(tn, j)$ indicates the amount of invoice $j$ paid at period $tn$. Table 5 represents all parameters of the firm’s cash outflow model in Eq. (22). The present value of $b(tn, j)$ denoted by $PV'(tn, j) = \frac{b(tn, j)}{(1+r)^{d'(tn, j)}}$ is represented as:
The first part of the right hand side of Eq. (23), 
\[ PV'(tn,j) = \sum_{d'(tn,j)=s'(tn,j)}^{d'(tn,j)=d'(tn,j)-1} \left( u'(tn,j) \frac{F'(tn,j)(1-v'(tn))^{(d'(tn,j)-d'(tn,j))}}{(1+r)^{d'(tn,j)}} \right) \]
+ \[ \sum_{d'(tn,j)=d'(tn,j)}^{T(tn)} \left( u'(tn,j) \frac{F'(tn,j)}{(1+r)^{d'(tn,j)}} \right) \]
+ \[ \sum_{d'(tn,j)=d'(tn,j)+1}^{T(tn)} \left( u'(tn,j) \frac{F'(tn,j)(1+p'(tn))^{(d'(tn,j)-d'(tn,j))}}{(1+r)^{d'(tn,j)}} \right) \]
(23)

\[ u'(tn,j) = \{0, 1\} \]

\[ \sum_{d'(tn,j)=s'(tn,j)}^{T(tn)} u'(tn,j) = 1 \]  
(24)

The first part of the right hand side of Eq. (23), 
\[ \frac{F'(tn,j)(1-v'(tn))^{(d'(tn,j)-d'(tn,j))}}{(1+r)^{d'(tn,j)}} \], shows the present value of invoice \( j \) at period \( tn \) paid to the suppliers before the due date at the discount value; the second statement, 
\[ \frac{F'(tn,j)}{(1+r)^{d'(tn,j)}} \] shows the present value of invoice \( j \) at period \( tn \) when it is paid on the due date and the third statement, 
\[ \frac{F'(tn,j)(1+p'(tn))^{(d'(tn,j)-d'(tn,j))}}{(1+r)^{d'(tn,j)}} \], shows the present value of the invoice \( j \) at period \( tn \) when it is paid after the due date with a penalty.

Table 5 Parameters of the Firm’s Cash Outflow

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( J )</td>
<td>Set of supplier’s invoice</td>
</tr>
<tr>
<td>( F'(tn,j) )</td>
<td>Face value of invoice ( j ) at period ( tn )</td>
</tr>
<tr>
<td>( d'u'(tn,j) )</td>
<td>Due date of invoice ( j ) at period ( tn )</td>
</tr>
<tr>
<td>( s'(tn,j) )</td>
<td>Generating time of invoice ( j ) at period ( tn )</td>
</tr>
<tr>
<td>( p'(tn) )</td>
<td>Daily penalty rate at period ( tn )</td>
</tr>
<tr>
<td>( v'(tn) )</td>
<td>Daily discount rate at period ( tn )</td>
</tr>
<tr>
<td>( d'(tn,j) )</td>
<td>Time of paying invoice ( j ) at period ( tn )</td>
</tr>
<tr>
<td>( r )</td>
<td>Daily interest rate</td>
</tr>
<tr>
<td>( T(tn) )</td>
<td>End of period ( tn )</td>
</tr>
</tbody>
</table>
The decision variable \( u'(tn,j) \) is used to determine whether the invoice \( j \) is paid at the discount value, normal value or at the penalty value. Moreover, Eq. (24) shows that invoice \( j \) needs to be paid once during the period \( tn \).

In order to manage the cash outflow and schedule the payment, the firm needs to have enough cash in hand at the time of paying each invoice, which means the firm has to make sure enough cash is available in the firm at the time of each payment. However, the firm can borrow money from the financial institution but with an interest rate in order to have enough cash to pay the payments. The amount of available cash at the time of paying invoice \( j \) at period \( tn \), denoted by \( cash(tn,j) \), is formulated as:

\[
cash(tn,j) = \sum_{i \in I} (w(tn,j,i) * PV(tn,i)) + CF(tn - 1) - \sum_{j' \in J} \lambda(tn,j,j') * PV'(tn,j')
\]

where \( PV'(tn,j') \) represents the present value of invoice \( j' \) during period \( tn \), while \( j' \) is indexed to all the payable invoices except invoice \( j \). The variable \( w(tn,j,i) \) is defined to distinguish at the time of paying invoice \( j \) at period \( tn \) whether the invoice \( i \) has been received or not. Also, the binary variable \( \lambda(tn,j,j') \) is used to show that at the time of paying invoice \( j \) at period \( tn \) whether the invoice \( j' \) has been paid or not. In fact, two variable \( w(tn,j,i) \) and \( \lambda(tn,j,j') \) are defined to show the amount of cash received from invoice \( i \) and the amount of cash paid for invoice \( j' \) at period \( tn \) respectively to find out the amount of available cash to pay invoice \( j \).

\[
w(tn,j,i) = \begin{cases} 1 & d'(tn,j) \geq d(tn,i) \\ 0 & Otherwise \end{cases} \quad (26)
\]

\[
\lambda(tn,j,j') = \begin{cases} 1 & d'(tn,j') < d'(tn,j) \\ 0 & otherwise \end{cases}, j \neq j' \in J \quad (27)
\]

Eventually, the aggregate firm’s cash outflow, the total amount that the firm pays to the upstream partners, at period \( tn \) as presented in cascade diagram (Figure 11) can be formulated as the summation of present value of cash paid to the supplier with invoice \( j \) at period \( tn \):

\[
OUT(tn) = \sum_{j \in J} PV'(tn,j)
\]

\[
(28)
\]
3.2. Conclusion

In this chapter, the cascade diagram is developed to represent the cash flow of a firm in a supply chain, while the cash flow of a firm in each time period consisting of cash inflow, the amount of cash received from the downstream partners, cash outflow, the amount of cash needs to pay to the upstream partners and the amount of cash available from the previous period. The firms in a supply chain usually use a discount and a penalty rate as a mechanism to control that the invoices are received as early as possible. In addition, a mathematical model for the firm’s cash inflow and cash outflow in each time period is develop to calculate the overall firm’s cash flow. Moreover, the historical data from customers’ payment time leads to generate a sample representing the number of days the cash inflow is received from customers; thus, the expected time of receiving the invoice can be calculated in order to reduce the cash inflow uncertainties. In addition, the amount of available cash in the firm in each day of time period needs to calculate in order to prioritise the cash outflow. In fact, the firm’s require knowing the amount of available cash in the firm on each day within a time period to understand whether enough cash is available in the firm to pay the invoices or not. However, the optimum time of payment in each time period is a relative function of cash inflow, amount of available cash in the firm and the rate of penalty rate. The finding and results of this chapter are provided in Chapter 6, Section 6.1.

On the following chapter, the effects of supply chain operation such as demand variation and delivery time, usually known as logistic bullwhip effect and customer satisfaction as result of payment strategy on the financial performance of a firm in a supply chain in each time period is evaluated and modelled. In addition, the effects of horizontal and vertical integration as form of mergers and acquisitions on the supply chain operation, and consequently on the financial performance of a firm in a supply chain is investigated.
Chapter Four

Evaluate the Effects of a Supply Chain Operation on the Cash Flow of a Firm in a Supply Chain

In this chapter, the effects of supply chain operation such as demand variation and delivery time, known as logistic bullwhip, customer satisfaction and vertical and horizontal integration on the financial performance of a firm in a supply chain are evaluated and mathematically modelled.

4.0. Introduction

The firms in a supply chain work together to deliver products or services from the upstream toward the downstream partners, and in consequence transfer cash from the downstream toward the upstream partners. Therefore, supply chain operation depends on the performance of product flow and cash flow. The product flow in a supply chain affects the progress of the cash flow. In order to improve the financial performance of a firm, the effects of supply chain operation, including i) delivery time and demand variation as a result of product flow known as cause of bullwhip effect, ii) customer satisfaction including customer satisfaction management as a result of payment strategy, and iii) horizontal and vertical integration within supply chain partners, on the financial performance of a firm in a supply chain should be evaluated and mathematically modelled.

This chapter starts with evaluating and modelling the effect of logistic bullwhip on the financial performance of a firm. Afterwards, a new method for measuring and modelling the customer satisfaction is proposed. In addition, customer satisfaction related payment strategy and concomitant model are defined. Meanwhile, mathematical models to improve the cash inflow of a firm regarding the customer satisfaction are proposed through developing a pool-based-model which represents the movement of customers through the firm. Finally, the effects of horizontal and vertical integration, as forms of mergers and acquisitions, on the supply chain operation and concomitantly on the financial performance of a firm are evaluated.

4.1. Effects of Delivery Time and Demand Variation as a Result of Product Flow on the Firm’s Cash Flow

Logistic bullwhip affects the cash flow of a firm through imposing additional costs, while these costs oscillate higher within the supply chain partners. The effects of delivery time and demand variation, known as cause of logistic bullwhip, on the financial performance of a firm in a supply chain have to be analysed due to introducing a cost to the firm in the form of excess cost.
Regarding the demand variation, a firm’s operations depend on the demand trend; therefore, every company in a supply chain regularly does product forecasting for its production scheduling, inventory control, and operation (Berk and DeMarzo, 2007). In fact, the firm in the supply chain usually has a prediction of the market to adjust its financial needs for operation, while this prediction is transferred within the partners in the supply chain; thus, accurate demand forecasting is essential for the firm. If the firm’s prediction is not properly accurate, additional costs may be imposed on the firm due to the forecast error of demand; thus, the financial performance of a firm is affected.

Delivery time is defined as the time that products or services are supplied and delivered from the upstream partners to meet the downstream partners’ expectation in the supply chain (Rao et al., 2011). Whenever a customer places an order, a fixed promise date is given to the customer to deliver and receive the products, while the actual delivery time can happen as early delivery, on time delivery and late delivery. Any deviation in the delivery time, both earliness and lateness, from the promised date has to be analysed in the supply chain due to introducing a cost to the firm (Figure 10), and consequently affecting the financial performance of the firm. Early delivery leads to excess inventory cost to the firm, who planned to deliver the products or services to the downstream partners as shown in Figure 10, whereas late delivery lead to loss of goodwill and customer dissatisfaction, whilst on time delivery incurs the normal cost to the firm (Guiffrida and Jaber, 2008, Guiffrida and Nagi, 2006).

However, in this research, it is assumed that no early delivery is allowed between the partners in a supply chain, which means the upstream partners are not allowed to deliver the products to the downstream partners earlier than the promised date, thus they have to pile the products in the storage if they are prepared earlier than the promised delivery date.

Figure 13 summarizes the effect of logistic bullwhip as a supply chain operation on the firm’s cash flow. As it is apparent from Figure 13, the delivery time and demand variation affects the firm’s cash flow through introducing storage cost, customer discount and customer dissatisfaction. In general, customer discount is defined as a mechanism to improve the level of customer satisfaction affected due to the late delivery of products. In fact, customer discount can be applied to compensate the cost of customer dissatisfaction.
4.1.1. Demand Variation

Demand forecasting not only helps a firm to understand the customers’ demands for products or services to increase operation accuracy, but also makes a firm more competitive in the market (Ott et al., 2013). Generally, historical data and purchasing history of the customers are used to determine the potential demand for products or services; however, the forecasted demand is not usually accurate and does not match with the actual demand. The nature of demand variation is the difference between actual and forecast demand. Any difference between actual customer demand and forecast demand imposes an additional cost either for storage or as a consequence of dissatisfaction with the firm, as explained in Figure 13.

Previously, a time horizon consisting of different time periods are defined to represent the cash flow of a firm (Figure 12). It is assumed that the firm in a supply chain predicts the forecasted demand for products or services for each time period at the beginning of time horizon, defined in the previous chapter for the firm’s cash flow (Chapter 3).

The imbalance between actual and forecasted customers’ demand, both underestimation and overestimation, affects the financial performance of a firm (Figure 14). Whenever the actual customers’ demand decreases to below of forecasted demand, the underestimation of customers’ demand happens
and the firm’s cash flow is affected through the storage cost. On the other hand, increasing actual demand to the above of forecasted demand leads to the sales can be lost due to lack of supply of goods and customers may become dissatisfied; thus, firm’s cash flow is affected through the customer dissatisfaction (Buchmeister et al., 2013). In fact, the revenue of firm in forecasted demand is compared with the revenue in actual demand; thus, the revenue decreases as cash flow decreases due to the imbalance between actual and forecasted demand.

Figure 14 Effect of Imbalance between Actual and Forecasted Customers’ Demand on the Firm’s Cash Flow

4.1.1.1. Overestimation of Customers’ Demand

The firm based on its prediction of the market orders raw materials from the suppliers to produce the products. Whenever the actual demand received from the downstream partners becomes less than the forecasted demand, this discrepancy between actual and forecasted customers’ demand (known as overestimation) forces the firm to store the spare products in the stock; thus, the firm’s cash flow and financial performance are influenced by the storage cost.

The firm decides to produce the products based on the customers’ forecasted demand. The unsold products at each time period and the remaining products from the previous period are stored in the storage and affect the firm’s cash flow. Therefore, similar to the cash flow, a cascade diagram is developed to represent the product flow of a firm within time periods in a time horizon e.g. one year (Figure 15). Here, the time horizon T, usually a period of one year, where all firm’s product flow is happened, consists of ‘n’ time periods. As it is apparent from Figure 15, the amount of product at the end of time horizon is the initial amount of product for the first time period of the next time horizon.
In fact, Figure 15 shows the amount of inventory, which has to be transferred from one period to another. This graph can be related to the cascade diagram of financial flow, Figure 11, explained in Section 3.1 of Chapter 3, as the expected demand, $ED(tn, i)$ in each time period forms the cash outflow of the firm in that period, whereas the cash inflow in each time period will be formed based on the actual customers’ demand, $RD(tn, i)$.

\[
egin{align*}
q'(tn - 1) & \rightarrow ED(tn, i) \rightarrow RD(tn, i) \\
q'(tn) & \rightarrow ED(tn + 1, i) \rightarrow RD(tn + 1, i) \\
q'(tn + 1) & \rightarrow ED(tn + 2, i) \rightarrow RD(tn + 2, i) \\
& \vdots \\
q'(tn + (n - 1)) & \rightarrow ED(tn + n, i) \rightarrow RD(tn + n, i) \\
q'(tn + n) & \rightarrow \quad
\end{align*}
\]

Figure 15 Cascade Diagram for the Product Flow

The mathematical presentation of the firm’s product flow for period $tn$ is:
\[
q'(tn) = \begin{cases} 
0 & \text{if } ED(tn, i) + q'(tn - 1) \leq RD(tn, i) \\
\sum_{i} (ED(tn, i) - RD(tn, i)) + q'(tn - 1) & \text{otherwise} 
\end{cases}
\]

(29)

where \(q'(tn)\) is the amount of unsold product which has to be stored in period \(tn\), \(I\) is the set of customer's invoices, \(ED(tn, i)\) and \(RD(tn, i)\) are the forecasted and the actual demand for customer with invoice \(i\) at period \(tn\) respectively, \(q'(tn - 1)\) are the amount of unsold products remains from the previous period and \(M\) is the number of invoices. As Eq. (29) shows, whenever the actual customer’s demands are not completely fulfilled by the firm, no products will be stored in the storage.

The cascade diagram for the product flow (Figure 15) is related to the cascade diagram developed for the cash flow (Figure 11). The firm in each period is supposed to pay the issued invoices to the upstream partners based on the expected demand, while it has to receive the issued invoices from the downstream partners based on the actual demand, also the unsold products in each period affects the cash flow of firm in that period.

In order to formulate the storage cost or inventory cost, with the use of Economic Order Quantity model when a shortage is not allowed, two costs are defined: i) setup cost or unit cost which is constant and does not depend on the amount of the products being stored including overhead costs of the storage, and ii) holding cost which is the cost of storing one unit of a product in storage (Zappone, 2014).

It is assumed that the orders are received at the beginning of each time period; thus, the excess products have to be stored until the end of that time period. The present value of the storage cost for the firm at period \(tn\) is represented as:

\[
ST'(tn) = \frac{h + d \cdot q'(tn)}{(1 + r)^{T(tn)}}
\]

(30)

where \(ST'(tn)\) represents the present value of the storage cost applied in the period \(tn\), \(h\) is the setup cost or unit cost during a period, \(dd\) is the holding cost per unit of product, \(r\) is the daily interest rate, \(q'(tn)\) are the amount of unsold products at period \(tn\) and \(T(tn)\) is the end of period \(tn\).

However, whenever the aggregation of customers’ forecasted demand and the remaining product from the previous period becomes less than the customers’ actual demand; thus, no products are stored in the storage and the customers’ requirement do not fulfil.
4.1.1.2. Underestimation of Customers’ Demand

Whenever the aggregation of customers’ forecasted demand and the remaining product from the previous period becomes less than the customers’ actual demand (known as underestimation), no products are stored in the storage, $q'(tn) = 0$, the firm not being able to meet the extra demand and fulfil all customers’ demands. Thus, the customers may become dissatisfied and do not repeat their purchase, and consequently the financial performance of a firm is affected.

Unfulfilling the customers’ demand imposes a customer dissatisfaction cost on the firm, which means the customers not only intend to do not repurchase but also intend to purchase from elsewhere next time; thus, the firm may lose the customers and market and consequently the cash inflow reduces. The mathematical model for customer satisfaction and underestimation of customers’ demand is explained in Section 4.2.

4.1.2. Delivery Time

Delivery time as a result of product flow, known as cause of logistic bullwhip, affects a firm’s cash flow and financial performance of a firm in a supply chain. Whenever an order is placed by a customer, a fixed promise date, due date of delivery, is given to the customer to deliver and receive the products, while the actual delivery time happen as early, on time and late delivery. Early delivery leading to excess inventory cost, whereas late delivery may lead to loss of goodwill and customer dissatisfaction, whilst on time delivery incurs the normal cost to the firm (Rao et al., 2011).

To understand the effects of delivery time on the financial performance of a firm, a time period where the products have to be delivered to the downstream partners is defined (Figure 16). This time period consists of the due date of delivery $T'(tn)$, the time the products are expected to deliver to the downstream partners, and $T(tn)$, end of time period, the time that all the products have to be delivered to the downstream partners even with delay.
If the products are delivered after the end of period, first of all the customer become dissatisfy and may not repeat their purchase, and also the customer can complain in order to penalise the suppliers. In addition, the actual time of delivery is set with the due date of payment, which means if the products are delivered with delay the due date of payment is shifted to the actual time of delivery. On the other hand, if the product is prepared earlier than the due date of delivery, since it is not allowed to deliver the products to the downstream partners before the due date; thus, it has to be stored in the storage and consequently the cash flow is affected.

The delivery time is composed of a series of internal delivery time such as production time and manufacturing and external delivery time such as distribution found at the various stages of the supply chain (Bushuev and Guiffrida, 2012). Therefore, the expected due date of delivering the products from the supplier point to the final customers at period \( tn \) denoted by \( T'(tn) \) depends on three different times: i) the expected time of delivering all materials from the suppliers to the firm at period \( tn \), \( d_{sm}(tn) \), ii) the time of production at period \( tn \), \( d_{m}(tn) \) and iii) the expected time of delivering the products from the firm to the customers at period \( tn \), \( d_{mc}(tn) \) as:

\[
T'(tn) = d_{sm}(tn) + d_{m}(tn) + d_{mc}(tn) \quad (31)
\]

In fact, the expected time of delivering a product from the supplier point to the customer with invoice \( i \) is the summation of longest delivery time from supplier \( j = 1, ..., N' \) to the firm, where \( N' \) represents the number of suppliers provides materials for the firm, production time and the expected time of delivering products from the firm to the customer as presented in Figure 17.

![Figure 16 Effects of Delivery Time on the Financial Performance of a Firm](image-url)
In the supply chain various suppliers provide the materials for the firm, while each material complements the other parts to produce a product; therefore, the manufacturer cannot start production until all materials are received. Thus, as represented in Figure 17, the expected time of receiving all raw materials from the suppliers to the firm in period $tn$, depicted by $d_{sm}(tn)$, is equal to the longest expected time, Maximum expected time, of delivering raw materials from supplier $j$ at period $tn$ to the firm, signified by $d_s(tn,j)$, as:

$$d_{sm}(tn) = Max(d_s(tn,j)) \quad \forall j \quad \text{(32)}$$

Any imbalance between the actual and expected time represented in Figure 17 leads to make a difference between the actual time and expected time of delivery; thus, the cash flow of firm is affected either with storage or customer dissatisfaction cost as shown in Figure 16. The earliness of delivery, the products are prepared earlier than the expected time, is explained in Section 4.1.2.1, whereas lateness of delivery, the products are delivered later than the expected time, is explained in Section 4.1.2.2.

Since, several suppliers may provide materials for the firm; therefore, late delivery of materials from one supplier or any inequality between the suppliers’ delivery times will force the firm to postpone the production process and store the parts of the delivered materials until all raw materials are received from all suppliers. The present value of the storage cost at period $tn$ mathematically represented as:

$$ST(tn) = \sum_{\forall j \in J} h * (Rd_{sm}(tn) - Rd_s(tn,j)) + dd * qq(tn,j) \left(1 + r\right)^{-T(tn)}$$

\text{(33)}
where \( ST(tn) \) represents the present value of the storage cost at period \( tn \), \( h \) signifies the overhead costs for daily storage, \( dd \) is the holding cost per product, \( T(tn) \) is the end of period \( tn \), \( Rd_{sm}(tn) \) represents the actual time of delivering materials from the suppliers to the firm at period \( tn \), while \( Rd_s(tn,j) \) shows the actual time of delivering materials from the supplier with invoice \( j \) at period \( tn \), \( qq(tn,j) \) indicates the quantity of products supposed to be received from the supplier with invoice \( j \) at period \( tn \).

Alternatively, in order to investigate the effect of delivery time on the firm’s cash flow properly, the delivery time created by the upstream partners and the delivery time created by the downstream partners should be considered at the same time. Thus, the firm can set its own delivery time based on the upstream partners delivery time in order to achieve the maximum cash flow. In fact, the firm can choose the best strategy to maximise the cash flow when the upstream partners delivery time is known, through finding out the best time for its own delivery time.

However, as explained earlier, delivering products to the downstream partners affects the financial performance of a firm in a supply chain under two different scenarios: lateness or earliness.

### 4.1.2.1. Earliness of Delivery Time

With respect to the delivery time of the firm, whenever the products are prepared earlier than the due date to deliver, the products need to be stored in the storage until due date of delivery. The present value of this storage cost is presented as:

\[
ST''(tn) = \sum_{i \in I} \frac{h * (T'(tn) - TT'(tn)) + dd * RD(tn, i)}{(1 + r)^T(tn)}
\]  

(34)

where \( ST''(tn) \) is the present value of storage cost applied for early preparation of products at period \( tn \), \( h \) is the overhead costs for daily storage, \( T'(tn) \) and \( TT'(tn) \) are the promised and actual time for delivering the product to the customers at period \( tn \) respectively, \( dd \) is the holding cost per product, \( T(tn) \) is the end of period \( tn \), \( RD(tn, i) \) is the actual demand have to be delivered to the customer with invoice \( i \) at period \( tn \).

### 4.1.2.2. Lateness of Delivery Time

On the other hand, the actual delivery time of the product to the customers might become greater than the due date and the product is delivered with a delay to the customers. This delay, either created by the firm or the suppliers, leads to the customers become dissatisfied and consequently the firm’s cash flow is affected. Moreover, in order to compensate the cost of customer dissatisfaction, the firm in the supply
chain may apply customer discount for each day late delivery. The mathematical model for the effects of a product’s late delivery on the financial performance of a firm in a supply chain and its link with customer satisfaction and customer discount is explained in Section 4.2.

Finally, the parts of the effects of demand variation and delivery time as supply chain operation, mostly storage costs, are added on the cash flow model of a firm in a supply chain, explained in Eq. (14), as:

\[
CF(tn) = IN(tn) + CF(tn - 1) - OUT(tn)
- \left( \sum_{v_j} [n(tn, j)ST(tn)] + \sum_{v_t} [(m(tn)ST''(tn)) + (m'(tn, i)ST'(tn))] \right)
\]  

where \( IN(tn) \) represents the amount of cash entering the firm in period \( tn \) as cash inflow, \( OUT(tn) \) represents the amount of cash going out of the firm as cash outflow in period \( tn \), \( CF(tn - 1) \) represents the amount of cash available from the previous period or previous time horizon, \( CF(tn) \) represents the cash flow of the firm in period \( tn \), \( ST(tn) \) represents the present value of the storage cost at period \( tn \) for inequality between the suppliers’ delivery times, \( ST'(tn) \) represents the present value of the storage cost applied in the period \( tn \) for demand variation, \( ST''(tn) \) is the present value of storage cost applied for early preparation of products at period \( tn \), while \( n(tn, j), m(tn), m'(tn, i) \) are the binary variables to add the effect of storage costs on the cash flow model.

\[
\begin{align*}
Rd_{sm}(tn) \neq Rd_s(tn, j) & \quad & n(tn, j) = \begin{cases} 1 & \text{Otherwise} \\ 0 & \end{cases} \\
T'(tn) < TT'(tn) & \quad & m(tn) = \begin{cases} 1 & \text{Otherwise} \\ 0 & \end{cases} \\
T'(tn) \geq TT'(tn) & \end{align*}
\]

\[
\begin{align*}
ED(tn, i) + q' (tn - 1) \leq RD(tn, i) & \quad & m'(tn, i) = \begin{cases} 0 & \text{Otherwise} \\ 1 & \end{cases} 
\end{align*}
\]

Moreover, in order to manage the cash outflow and schedule the payment, the firm needs to have enough cash in hand at the time of paying each invoice, while storage cost leads to the amount of available cash in the firm decreases as:
\[ \forall j \in J \quad \text{cash}(t, j) = \sum_{i \in I} (w(t, j, i) \times PV(t, i)) + CF(t, i - 1) - \sum_{j' \in J} (\lambda(t, j, j') \times F'(t, j')) - \left(\sum_{j' \in J} [n(t, j)ST(t, j)] + \sum_{i \in I} [(m(t, i)ST''(t, i)) + (m'(t, i)ST'(t, i))]\right) \]  

(37)

\[ w(t, j, i) = \begin{cases} 1 & \text{if } d'(t, j) \geq d(t, i) \\ 0 & \text{otherwise} \end{cases} \]  

(38)

\[ \lambda(t, j, j') = \begin{cases} 1 & \text{if } d'(t, j') < d'(t, j) \\ 0 & \text{otherwise} \end{cases} \]  

(39)

where \( F'(t, j') \) represents the face value of all invoices at period \( t \) except invoice \( j \), while \( j' \) is indexed to all the payable invoices except invoice \( j \) and \( n \) and \( n' \) are the number of invoices issued for the customers and suppliers respectively. The decision variable \( w(t, j, i) \) is defined to distinguish at the time of paying invoice \( j \) at period \( t \) whether the invoice \( i \) has been received or not. Also, the decision variable \( \lambda(t, j, j') \) is used to show that at the time of paying invoice \( j \) at period \( t \) whether the invoice \( j' \) has been paid or not.

Therefore, as the amount of available cash in the firm decreases, the optimum time of payment invoices might be changed.

4.2. Customer Satisfaction Management

A firm in a supply chain defines payment strategies such as penalty rate, delivery time, customer discount and quantity of order fulfilment regarding the invoices issued for the products ordered by the customers, whilst these payment strategies affect the cash flow of a firm through changing the level of customer satisfaction and number of satisfied customers. In fact, how to deal with customers in order to have more satisfied customers and how satisfaction affects the firm’s financial performance and cash flow is one of the main obstacles of each firm in the supply chain.

In order to measure customer satisfaction at a particular time instance or period, a pool-based-model of customers representing the movement of customers through the firm is developed. More precisely, the movement of customers in a firm in a supply chain is defined based on the different groups of customers of a firm: i) new customers, i.e. customers entering the firm in a particular period and who have decided
to buy from the firm for the first time, ii) dissatisfied customer, i.e. customers who are not satisfied with the performance of products or services and are leaving the firm and going elsewhere, and iii) satisfied customer, i.e. customers who are satisfied with the performance of products or services and intend to stay loyal to the firm and repurchase again in the next period. It is a fact that the movement of customers in each period never ceases to exist, and also the movement of customers in one-time period affects the movement of customers in the next period.

The mathematical presentation of the aggregated firm’s customer movement for the period $tn$ is:

$$
\text{Period } tn: C(tn) = C_{\text{new}}(tn) + C(tn - 1) - C_{\text{dis}}(tn) 
$$

(40)

where, $C(tn)$ is the number of satisfied customers in period $tn$, $C_{\text{new}}(tn)$ is the number of new customers entering the firm in the period $tn$, $C(tn - 1)$ is the number of satisfied customers staying with the firm from the previous period, $C_{\text{dis}}(tn)$ is the number of dissatisfied customers leaving the firm in the period $tn$.

To represent the movement of customers, a cascade model or diagram is developed as represented in Figure 18. In fact, the movement of customers shows the number of satisfied/dissatisfied customers in each period within a time horizon.

As it is apparent from Figure 18, the firm has $N$ number of customers in the first period of a time horizon, while the number of satisfied customers transfers to the next period. Here in Figure 18, the time horizon consists of time periods with $C_{\text{new}}(tn)$ representing the number of new customers entering the firm, $C_{\text{dis}}(tn)$ representing the number of dissatisfied customers leaving the firm and $C(tn)$ representing the number of satisfied customers staying with the firm in the next time period. Since the number of satisfied customers in each period directly affects the amount of cash received to the firm, Figure 18 can be linked to the cascade diagram (Figure 11) developed for the firm’s cash flow. This link will be presented in Chapter 5 (Figure 26).
As explained in Chapter 2, previous research (Simon and Gómez, 2014, Anderson and Mittal, 2000, Fecikova, 2004) indicates that a strong relationship between customer satisfaction and profitability of a firm exists. In fact and regardless of the number of new customers, dissatisfied customers who do not intend to repeat their purchase from the firm in the next period may lead to the firm receiving smaller amounts of receivables compared to the previous period, while satisfied customers are more likely to return and repurchase more often. Moreover, based on the linear equation developed by Anderson et al. (1994) for the relationship between profitability and customer satisfaction, it is assumed that the
relationship between customer satisfaction and the amount of cash that a firm receives from customers is linear. Also, the firm’s cash inflow from customers is linked linearly with the firm’s market share; thus, a lower level of customer satisfaction leads to a decrease in the amount of cash received by the firm, and consequently its market share decreases as well. On the other hand, if all customers were to order the same quantity of the firm’s products in each period, decreasing the firm’s cash inflow would be equivalent to decreasing the firm’s market share and consequently decreasing the number of customer orders to the firm. As a result, the number of satisfied customers and customer satisfaction is linearly linked.

Hence, the number of satisfied customers in each time period is:

\[ C(tn + 1) = C(tn) \times CS(tn + 1) + C_{new}(tn + 1) \quad (41) \]

where \( C(tn + 1) \) and \( C(tn) \) represent the number of satisfied customers at period \( tn + 1 \) and \( tn \) respectively, while \( CS(tn + 1) \) represents customer satisfaction at period \( tn + 1 \). It is assumed here that customer satisfaction has no direct impact on new customers since the new customers have no prior experience to compare. In addition, the amount of cash received to the firm at each period comes from two sources; the satisfied customers and new customers. In fact, the amount of cash the firm receives at period \( tn + 1 \) consists of the amount of cash received from the satisfied customers, which is the multiplication of number of satisfied customers with the average amount of cash that the firm is expected to receive from the satisfied customers at period \( tn + 1 \), and also the amount of cash received from new customers as Eq. (42).

\[ IN(tn + 1) = C(tn) \times AVGln(tn + 1) + \theta(tn + 1) \quad (42) \]

where \( IN(tn + 1) \) signifies the amount of cash at the end period \( tn + 1 \) received from customers, \( C(tn) \) represents the number of satisfied customers in period \( tn \), \( AVGln(tn + 1) \) represents the average amount expected to be received from each customer in period \( tn + 1 \) and \( \theta(tn + 1) \) indicates the amount that are expected to be received from the new customers in period \( tn + 1 \). In fact, \( AVGln(tn + 1) \) represents the average amount of cash that the firm is expected to receive from the customers who order at the beginning of the time horizon, if they continue to purchase from the firm at period \( tn + 1 \), and new customers who enter to the firm on the previous periods as:

\[ AVGln(tn + 1) = \frac{\sum_{i=1}^{N+C_{new}(tn)} PV(tn + 1,i)}{(N + C_{new}(tn))} \quad (43) \]
where $PV(tn + 1, i)$ is the present value of cash that customer with invoice $i$ is supposed to pay in period $tn + 1$, $N$ is the number of customers at the beginning of the time horizon and $C_{new}(tn)$ is the number of new customers who enter to the firm at period $tn$.

Customers place their orders with the firm for products or services at the beginning of each period within a time horizon. The firm then generates invoices for each customer according to the different payment strategy attributes that it can manipulate; this data can then be used to form the variables of the optimisation model devised in this thesis. In this PhD thesis, the attributes of payment strategy include: i) the penalty rate used to penalise customers, ii) order fulfilment or quality of delivery related to the number of products or quantity of products that a firm can provide and deliver in each period to fulfil customer demand and meet orders (the quality of products is not considered in this research), and iii) the due date of delivery as a promised time that products are supposed to be delivered to the customer which is defined to model customer satisfaction.

As a part of this PhD, customer satisfaction is modelled and measured based on the above features or attributes of payment strategy; hence, the relationship between customer satisfaction and attributes of payment strategy are formulated for each time period. A mathematical optimization model is proposed to maximise the firm’s cash inflow and consequently to maximise the number of satisfied customers by optimising the attributes of payment strategy in each period, as well as in the observed time horizon.

The overall satisfaction of customers in period $tn$ is related to the satisfaction followed by the penalty rate, delivery time, and order fulfilment. As all payment strategy attributes are important for the customers but not equally, which means some of the payment strategy attributes may more important than the others attributes for customers; thus, the overall satisfaction of customers in period $tn$ can be defined as the weighted average of customers satisfaction extracted from each of the three defined attributes of payment strategy separately. The overall satisfaction of customers in the period $tn$ is defined as:

$$CS(tn) = \text{Weighted Average} \left(CS_{penalty}(tn), CS_{delivery}(tn), CS_{demand}(tn)\right)$$

(44)

where $CS(tn)$ indicates the overall customer satisfaction in the period $tn$, $CS_{penalty}(tn)$ shows the customer satisfaction derived from the penalty rate, while $CS_{delivery}(tn)$ represents the customer satisfaction linked to delivery time and $CS_{demand}(tn)$ shows the customer satisfaction related to the demand variation.
4.2.1. Customer Satisfaction and Penalty Rate

The products are produced and delivered to the downstream partners by the firm to obtain cash in return. However, the upstream cash flow, i.e. the amount of cash to be paid by the downstream partners, depends on the terms of payment including discount rate for early payments and penalty rate for late payment. In fact, the firm issues the invoices to the downstream partners for the purchased products, which can be effected in three ways based on the time of payment: i) discount value, ii) normal value and iii) penalty value (Gupta and Dutta, 2011). The firm prefers to receive cash from the customer as quickly as possible; thus, the penalty rate and discount rate are the respective mechanisms to control that. However, based on the empirical data from Iranian companies the discount rate for early payment is considered to be a fixed number during the whole periods of time horizon; thus it does not affect the level of customer satisfaction.

Naturally, there is a relationship between the amount of payment and the penalty rate, which means that a greater penalty rate leads the amount of payment to increase over time, based on the Eq. (10) explained in Chapter 2. However, too high a penalty rate changes the level of customer satisfaction and consequently forces customers to switch to a competitor, who offer better penalty rate, while too low a penalty rate encourages customers to pay the invoices with a delay.

The penalty rate is usually set at the beginning of each period, thus the customers know the rate of penalty they have to pay for late payment before (or in the course of) purchasing. Knowing the penalty rate in each period and comparing it with the penalty rate for the previous period for the customers who purchased from the firm, helps customers to make a decision to stay loyal or leave the firm. Consequently, if the penalty rate increases in each period in comparison to the previous period, satisfaction decreases, whereas if the penalty rate decreases in each period in comparison to the previous period, satisfaction does not change.

In the competitive market, different firms produce the same products with different payment strategy; thus, customers can make a decision to purchase from other firms and to switch to a rival who offers a better payment strategy, however, the firms set a proper switching cost in order to convince customers to do not switch. Here, it is assumed that a better payment strategy can encourage customers to ignore the switching cost.

Homburg et al. (2005) mentioned that the relationship between customer satisfaction and the price that the customers are willing to pay is nonlinear and follows an inverse S-shaped function (Homburg et al., 2005); thus, the correlation between customer satisfaction and the penalty rate can be modelled nonlinearly.
In order to model and measure customer satisfaction, three different areas are identified: fully satisfied area, fully dissatisfied area and the area in between which is the partially satisfied area. The level of satisfaction in each period is related to the penalty rate of each period in comparison with the penalty rate of the previous period. In addition, Kano (1984) defines the basic and delighter attributes for the products explained in Chapter 2, which are related to the level of satisfaction nonlinearly (Bayus, 2010). In order to model the nonlinear relationship between customer satisfaction and penalty rate in the ‘partially satisfied’ area, two different relationships are defined: i) Logarithmic and ii) Exponential (Figure 19).

![Figure 19 Relationship Between Customer Satisfaction and Penalty Rate](image)

In Figure 19, the vertical axis represents the level of customer satisfaction ranges from 0 for least satisfaction and 1 for most satisfaction, while the horizontal axis represents the penalty rate of firm at period $tn + 1$. As can be seen from Figure 19, $p'(tn + 1)$ is the penalty rate of the competitor in period $tn + 1$ and $p(tn)$ is the penalty rate at period $tn$. In total, whenever the penalty rate in each period decreases and becomes less than the penalty rate of the previous period, customers are satisfied and stay in the ‘fully satisfied’ area, while increasing the penalty rate to more than the previous period drops satisfaction to the ‘partially satisfied’ area. However in the partial satisfied area, the rate of decreasing customer satisfaction could be non-linear, logarithmic or exponential. Finally increasing the penalty rate to more than the penalty rate of the competitor may lead the satisfaction level to the ‘fully dissatisfied’ area and also may force them to leave the market and switch to the competitors. The exponential relationship between satisfaction and penalty rate shows that increasing the penalty rate is not significantly important for a firm because payments received from customers do not have a significant effect on its cash flow, whereas the logarithmic relationship between satisfaction and penalty rate shows that increasing the penalty rate is significantly important for a firm because payments received from customers have an important effect on its cash flow as those customers have a bigger portion of firm’s share in the market. Moreover, the exponential relationship shows that a small increase in the penalty rate
does not change the level of satisfaction considerably; however, significant changes take place in the logarithmic relationship, and this is what the firm needs to have in mind when deciding to increase its penalty rate. Regarding the exponential relationship, this relationship is presented in Eq. (45) mathematically:

$$
CS_{\text{penalty}} (tn + 1) = \begin{cases} 
1 & \text{if } p(tn + 1) \leq p(tn) \\
\frac{a + b e^{\left(\frac{p(tn+1)}{p(tn)}\right)}}{p(tn) < p(tn + 1) \leq p'(tn + 1)} & \\
0 & \text{if } p(tn + 1) > p'(tn + 1)
\end{cases}
$$

where $CS_{\text{penalty}} (tn)$ represents customer satisfaction at period $tn$ based on the penalty rate, while $a, b$ are real numbers, known as scaling factors or scaling coefficients, to scale the level of satisfaction properly in the border of areas based on the different penalty rates. For instance, if the penalty rate in each period is set equal to the penalty rate of the previous period, then $a, b$ are used to scale the satisfaction level in the ‘fully satisfied’ area as shown in Eq. (46)

$$
\begin{cases}
\frac{a + b e^{\left(\frac{p(tn+1)}{p(tn)}\right)}}{p(tn) = p'(tn + 1)} = 1 & \text{if } p(tn + 1) = p(tn) \\
\frac{a + b e^{\left(\frac{p(tn+1)}{p(tn)}\right)}}{p(tn) = p'(tn + 1)} = 0 & \text{if } p(tn + 1) = p'(tn + 1)
\end{cases}
$$

On the other hand, the logarithmic relationship is presented mathematically in Eq. (47).

$$
CS_{\text{penalty}} (tn + 1) = \begin{cases} 
1 & \text{if } p(tn + 1) \leq p(tn) \\
\frac{a' + b' \log \left( \frac{p(tn+1)}{p(tn)} \right)}{p(tn) < p(tn + 1) \leq p'(tn + 1)} & \\
0 & \text{if } p(tn + 1) > p'(tn + 1)
\end{cases}
$$

In Eq. (47) $a', b'$ are real numbers, known as scaling factors, to put the satisfaction level in the proper area based on the different penalty rates as shown in Eq. (48).

$$
\begin{cases}
\frac{a' + b' \log \left( \frac{p(tn + 1)}{p(tn)} \right)}{p(tn) = p'(tn + 1)} = 1 & \text{if } p(tn + 1) = p(tn) \\
\frac{a' + b' \log \left( \frac{p(tn + 1)}{p(tn)} \right)}{p(tn) = p'(tn + 1)} = 0 & \text{if } p(tn + 1) = p'(tn + 1)
\end{cases}
$$

### 4.2.2. Customer Satisfaction and Demand Variation

It is the fact that a firm’s operations depend on the demand trend and hence, every firm in a supply chain regularly does product forecasting for its production scheduling, inventory control, and operation (Berk and DeMarzo, 2007). Demand forecasting not only helps a firm to understand the customers’ demands for
products or services to increase operation accuracy, but also makes a firm more competitive in the market (Ott et al., 2013). However, demand forecasting depending on the historical data and purchasing history of the customers is used to determine the potential demand for a product or services.

The forecast demand is not always accurate and match with the actual demand; thus, this error in demand forecasting, the mismatch between actual demand and forecasted demand (either overestimation or underestimation), can affects the firm’s cash flow and profit (Campuzano-Bolarín et al., 2013). In fact, if the demand is underestimated, then sales can be lost due to lack of supply of goods and customers may become dissatisfied, while overestimated demand leads to surplus and inventory cost (Ott et al., 2013). The effects of overestimation of customers’ demand on the firm’s cash flow are modelled and explained previously in Section 4.1.1.1.

In this section, the effect of underestimation of customers’ demand on customer satisfaction is investigated and modelled. In order to understand the relationship between customers’ demand and customer satisfaction, first of all, three different areas - fully satisfied, fully dissatisfied and partially satisfied - are defined, and then a mathematical model representing customer satisfaction in these areas are developed. Obviously, the number of products the customers are going to order in each period is limited with the production capacity of the firm which means the maximum number of orders should not be exceed the production capacity of a firm. The production capacity of a firm in a supply chain is the amount of product that a firm can produce based on the resources available and in this thesis it is considered constant over the specified time horizon. Therefore, the relationship between customer satisfaction and customers’ order fulfilment is defined based on the manufacturer’s production capacity and the forecasted demand.

Based on the model developed by Kano (1984) (Figure 7), three features- basic needs features, performance factors and delighter features- are defined for the products to model the customer satisfaction. Kano describes that the features classified as performance factors of the products are linearly related to the level of satisfaction where the absence or weakness of this features leads satisfaction to decrease, and conversely, presence of this features will improve customer satisfaction. The number of orders fulfilled by the firm and deliver to the customers (known as quality of delivery) as a feature of payment strategy is considered as a performance attribute of the payment strategy; thus, the correlation between satisfaction and customers’ order fulfilment according to the Kano model can be considered linear.
Figure 20 represents the relationship between customer satisfaction and demand variation in three different areas, where $RD(tn)$ denotes the actual customers’ demand in period $tn$, $ED(tn)$ is the forecasted customers’ demand in period $tn$ and $C$ represents the production capacity of a firm which is constant over the time horizon. In Figure 20, the vertical axis represents the level of customer satisfaction ranges from 0 for fully dissatisfaction and 1 for fully satisfaction, while the horizontal axis represents the actual customers’ demand in period $tn$.

Figure 20 Relationship Between Customer Satisfaction and Demand Variation

As it is apparent from the Figure 20, whenever the actual customers’ demand of products in each time period increases and moves toward, but not above, the forecasted demand in the same time period then, the firm meets all the customers’ demand and the customers become satisfied. If the actual customers’ demand increases and goes beyond the forecasted demand, where the excess demand cannot be supplied by the firm, then satisfaction decreases further and moves toward the ‘partially satisfied’ area, whilst increasing of actual demand to greater than the firm’s production capacity leads satisfaction to the ‘fully dissatisfied’ area and the customer may decides to leave the firm and switch to the competitors. Here, it is assumed that the customers intend to purchase all the products from one supplier, not to split purchases between more than one supplier. In fact, the customers prefer to switch to the competitors who fulfil the customers’ demand completely.

In addition, in the ‘partially satisfied’ area of Figure 20, the actual demand can take any values with equal probability in an interval $[ED,C]$; thus, the actual customers’ demand can be considered as uniform distribution which is a distribution with constant probability (Weisstein, 2003). Therefore, linear dependency of customer satisfaction to the customers’ demand is mathematically presented as:
where $CS_{demand}(tn)$ is satisfaction of customers in period $tn$, $ED(tn)$ is the forecasted demand for period $tn$, $RD(tn)$ is the actual demand received from customers in period $tn$ and $C$ represents the production capacity of the firm.

### 4.2.3. Customer Satisfaction and Delivery Time

Delivery time as a result of product flow affects a firm’s cash flow and financial performance of a firm in a supply chain; thus, to improve the financial performance of a firm, the effects of delivery time on the firm’s cash flow is evaluated and modelled within a supply chain partners. Whenever a customer places an order, a due date is given to the customer to deliver the products, while the actual delivery time can happen early, on time and late. Any deviation from the promised date time, whether earliness or lateness, is analysed in the supply chain through the cost to the firm in the form of excess cost of storage for early delivery, while late delivery leads to loss of goodwill and customer satisfaction. In this research, it is assumed that no early delivery is allowed between partners which means the upstream partners is not allowed to deliver the products or services to the downstream partners earlier than the due date. However, the effect of earliness delivery time on the financial performance of a firm is investigated and modelled previously in Section 4.1.2.1. In this section only the effects of late delivery of products to the customers are investigated.

At the time an order is placed by the customers, the invoice including the due date of payment, penalty rate and due date of delivery time is issued. However, delivery time as an attribute of payment strategy affects the due date of invoice payment. In fact, it is assumed that the due date of invoice payments is set with the time of delivery. The time line relates delivery time to the payment time is shown in Figure 21.

This time line is consists of the due date of delivery $T'(tn)$, which is equal to the time of issuing the invoices and $T(tn)$, end of time period, the time that all the products have to be deliveried to the downstream partners even with delay and all invoices need to be paid. It is not allowed to deliver the products to the customers earlier than due date, whereas the customers are encouraged to pay the invoices earlier than due date of payment by applying a discount rate. However, delivering the product after due date with delay leads to the customer dissatisfaction cost and consequently customer discount.
Clearly, the relationship between customer satisfaction and delivery time is significantly related to the type of products; different types of products affect satisfaction differently. Therefore, the products are classified into different groups based on the importance to the customers. In the product category, some products are very important to be delivered on time since they affect profit and production process of the customers significantly, while some products are less important to be delivered on time since they do not have a significant effect on the customer’s profit. As such the products are categorized in the range $a_1, a_2, a_3$ for less important, important and very important respectively, all from the customer’s points of view. The level of customer satisfaction is related to the time of delivery of products and the level of products’ importance.

As Explained earlier in Chapter 2, Kano (1984) defined three attributes for the products- basic, performance and delighter-, while these attributes are correlated to the customer satisfaction in different ways: logarithmic, exponential and linear. Similarly, delivery time as an attribute of payment strategy affects customer satisfaction in three ways, while the effects of delivery time on the customer satisfaction depend on the level of products’ importance.

Two different areas for satisfaction are defined: the partially satisfied and fully dissatisfied area, as early delivery, earlier than due date, is not allowed between partners the fully satisfied area is replaced with the full satisfaction point, which is the point that the products are delivered on time. It is assumed that the
products have to be delivered to the customers at the latest at the end of each time period; therefore, if the products are not delivered until the end of the time period, the customers become fully dissatisfied and do not repeat their purchase in the next period.

Figure 22 illustrates the relationship between delivery time and customer satisfaction for different types of product.

![Figure 22 Relationship Between Customer Satisfaction and Delivery Time](image)

In Figure 22, the vertical axis represents the level of customer satisfaction ranges from 0 for least satisfaction and 1 for most satisfaction, while the horizontal axis represents the actual time of delivering the products at period $t_n$. In Figure 22, $T'(t_n)$ is the promised time of delivering products to the customers at period $t_n$, $TT'(t_n)$ denotes the actual time of delivering and $T(t_n)$ represents the end date of period $t_n$. Since new orders are received at the beginning of each period; therefore, undelivered products after finishing the observation period leads to the customers become fully dissatisfied. The rate of decreasing customer satisfaction on the partial satisfied area is related to the level of product importance. It is assumed that products are delivered to all customers at the same time.

The mathematical equation of customer satisfaction and delivery time for the ranges of product denoted by $\lambda$ in different areas is presented as:
where $CS_{\text{delivery}}(tn)$ represents customer satisfaction at period $tn$ based on the delivery time, while $a''(tn), b''(tn)$ and $a'''(tn), b'''(tn)$ are real numbers, known as scaling factors or scaling coefficients, to put the satisfaction level in the proper area based on the ratio of actual delivery time and end of time period as:

\[
CS_{\text{delivery}}(tn) = \begin{cases} 
1 & \text{if } T'(tn) = T'(tn) \\
 a''(tn) + b''(tn)e^{\frac{T'(tn)}{T'(tn)}} & \text{if } T'(tn) < T''(tn) \leq T(tn) \\
 a'''(tn) + b'''(tn)\log\left(\frac{T'(tn)}{T'(tn)}\right) & \text{if } TT'(tn) > T(tn) \\
0 & \text{if } TT'(tn) > T(tn)
\end{cases}
\]

As explained above, late delivery of the product to customers affects the level of customer satisfaction and consequently the level of the firm’s receivables. However, customer discounts as a mechanism to improve the level of satisfaction can be applied. Regarding the customer discount and in order to understand the effect of customer discount on the level of satisfaction, the term ‘future value of products or cash’ is used. Actually, future value is defined as the value of an asset or cash for the customers at a specific date in the future (Berk and DeMarzo, 2007). If the products are delivered to the customers on the due date, then the value of product in the due date is calculated as:

\[
\begin{align*}
& a''(tn) + b''(tn)e^{\frac{T'(tn)}{T'(tn)}} = 1 & \text{if } TT'(tn) = T'(tn) \\
& a''(tn) + b''(tn)e^{\frac{T'(tn)}{T'(tn)}} = 0 & \text{if } TT'(tn) = T(tn) \\
& a'''(tn) + b'''(tn)\log\left(\frac{T'(tn)}{T'(tn)}\right) = 1 & \text{if } TT'(tn) = T'(tn) \\
& a'''(tn) + b'''(tn)\log\left(\frac{T'(tn)}{T'(tn)}\right) = 0 & \text{if } TT'(tn) = T(tn)
\end{align*}
\]

\[FV(tn) = B(tn) \ast (1 + r)^{T'(tn)} \quad (52)\]

where $FV(tn)$ denotes the expected future value of product for customers at period $tn$ when the products are delivered on time, $B(tn)$ indicates the overall face value of the products sold at period $tn$, $T'(tn)$ represents the due date of delivering the products at period $tn$ and $r$ is the daily interest rate. The overall
face value of products sold at period $tn$ where the face value of invoice $i$ at period $tn$ is denoted by $F(tn,i)$ calculated as:

$$B(tn) = \sum_{i} F(tn,i) \quad (53)$$

In addition, the future value of the products at the actual time of delivery, if they are not delivered on due date, is calculated as:

$$FV'(tn) = B(tn) \ast (1 + r)^{TT'(tn)} \quad (54)$$

where $FV'(tn)$ denotes the future value of product at period $tn$ on the actual time of delivery and $TT'(tn)$ represents the actual time of delivering the products in period $tn$.

Therefore, late delivery of products to the customers, $TT'(tn)$ becomes greater than $T''(tn)$, not only leads the customer satisfaction to decrease but also leads the future value of products to increase. The difference between $FV(tn)$ and $FV'(tn)$ shows how late delivery changes future values and how this change affects customer satisfaction. In order to improve customer satisfaction, customer discount $x(tn)$ is applied. Applying customer discount concomitantly decreases the future value of the products as:

$$FV'_{new}(tn) = FV'(tn) \ast (1 - x(tn)) \quad (55)$$

where $FV'_{new}$ is the new future value of products after applying a customer discount at period $tn$, $FV'(tn)$ is the future value of product at period $tn$ and $x(tn)$ is a discount rate ranges between 0% and 100%. In addition, $FV'_{new}$ shows the future value of products at the specific time, $D(tn)$, as:

$$FV'_{new}(tn) = B(tn) \ast (1 + r)^{D(tn)} \quad (56)$$

To calculate $D(tn)$, the exponential expression in Eq. (56) has to be converted to the logarithm expression as:

$$D(tn) = \log_{(1+r)} \frac{FV'_{new}(tn)}{B(tn)} \quad (57)$$

New customer satisfaction and concomitantly the new number of satisfied customers have to be calculated based on $D(tn)$ and Eq. (50).

Finally, the discount directly affects the amount of cash received from the customers as:
In period $tn + 1$, the variable $\alpha(tn + 1)$ is used to show whether the products are delivered to the customers on time or with delay in order to apply customer discount.

In fact, a high customer discount leads the amount of cash received from the customers to decrease, whereas a low customer discount may not affect satisfaction properly to compensate the cost of dissatisfaction; therefore, the optimum level of customer discount should be found out. The customer discount ranges between 0 and 100% annually. The range values for customer discount rate are taken from Iranian companies working in the area of home appliance industries.

4.3. Mergers and Acquisitions

Mergers and acquisitions usually start with an idea to add value to the current business or to improve the financial and operational performance of the firm in a supply chain. Therefore, mergers and acquisitions are not only a way to expand a business but also to improve the firm’s financial and operational performance. In order to evaluate the effect of mergers and acquisitions on the financial performance of a firm in a supply chain, first of all different financial metrics such as gross profit margin (GPM) and current ratio (CR) are evaluated and compared before and after vertical and horizontal integration to find out how successful a merger or acquisition was, and how the financial performance of a firm improves after vertical and horizontal integration. Afterwards, the effect of mergers and acquisitions on the supply chain operation, such as demand variation, delivery time and customer satisfaction as a result of payment strategy, and concomitantly on the financial performance of a firm, has to be evaluated (Ahmed and Ahmed, 2014).

GPM, which is an indicator of a business’s financial health, is used to evaluate the financial performance of a firm and to show whether or not a firm is using its materials and labour in the production process efficiently. Eq. (59) represents the mathematical ratio for GPM while the cost of goods sold is defined as direct cost attributes to the production of the product or goods by a firm (Berk and DeMarzo, 2007).

$$GPM = \frac{S - CGS}{S}$$  (59)

where $S$ represents the sales of firm and $CGS$ is the cost of goods sale.
On the other hand, the current ratio, used to measure a firm’s ability to pay its short-term obligations, is mathematically presented as:

\[ CR = \frac{CA}{CL} \]  

(60)

where CA is the current assets, the cash or other forms of assets that can be turned into cash within one year, whereas CL is the current liabilities, the debt that the manufacturer has to pay within one year (Berk and DeMarzo, 2007).

For example, two supply chains produce the same products and compete in a market comprising: a number of suppliers one firm and various customers are considered. Also, two flows are defined within the supply chain’s partners: cash flow and product flow (Figure 23).

![Figure 23 Two Supply Chain Partners before Merger](image)

As can be seen from Figure 23, the cash outflow of firm in supply chain 1 in period \( t_n \), \( OUT(t_n) \), is the cash inflow of the suppliers in supply chain 1 in period \( t_n \), whereas \( O_j(t_n) \) represents the cash outflow of supplier \( j \) in supply chain 1 in period \( t_n \). Also \( O''_j(t_n) \) represents the cash outflow of supplier \( j \) in supply chain 2 in period \( t_n \).
The total cash flow of the firm in supply chain 1 and supply chain 2 in period $tn$ as explained earlier in Chapter 3 in Eq. (12) can be formulated as:

\[ \text{supply chain 1: } CF(tn) = IN(tn) - OUT(tn) + CF(tn - 1) \quad (61) \]

\[ \text{supply chain 2: } CF''(tn) = IN''(tn) - OUT''(tn) + CF''(tn - 1) \quad (62) \]

where $CF(tn)$ and $CF''(tn)$ are the total cash flow of the firm in supply chain 1 and 2 in period $tn$ respectively, $IN(tn)$ and $IN''(tn)$ denote the overall firm’s cash inflow coming from the customers in the supply chain 1 and 2 in period $tn$ respectively, $OUT(tn)$ and $OUT''(tn)$ are the overall firm’s cash outflow going to the suppliers in supply chain 1 and 2 in period $tn$ respectively and $CF(tn - 1)$ and $CF''(tn - 1)$ are the amount of the firm’s cash in supply chain 1 and 2 in period $tn - 1$ respectively, while $tn$ as explained in Figure 11 is a period of time within which the firm’s cash flow has happened.

On the other hand, the total cash flow of the supplier 1 in supply chain 1 and supply chain 2 in period $tn$ can be formulated as:

\[ \text{supply chain 1: } F_1(tn) = OUT_1(tn) + F_1(tn - 1) - O_1(tn) \quad (63) \]

\[ \text{supply chain 2: } F''_1(tn) = OUT''_1(tn) + F''_1(tn - 1) - O''_1(tn) \quad (64) \]

where $F_1(tn)$ and $F''_1(tn)$ are the total cash flow of the supplier 1 in supply chain 1 and 2 in period $tn$ respectively, $OUT_1(tn)$ and $OUT''_1(tn)$ denote the supplier 1’s cash inflow coming from the firm in the supply chain 1 and 2 in period $tn$ respectively, $O_1(tn)$ and $O''_1(tn)$ are the supplier 1’s cash outflow going to the upstream partners in supply chain 1 and 2 in period $tn$ respectively and $F_1(tn - 1)$ and $F''_1(tn - 1)$ are the amount of supplier 1’s cash in supply chain 1 and 2 in period $tn - 1$ respectively.

In this section, it is assumed that the only source of cash inflow is the cash received from the downstream partners, while the only source of cash outflow is the cash paid to the upstream partners. However, the firm’s overall cash inflow in supply chain 1, the total amount that the firm receives from the downstream partners and, at period $tn$ as presented earlier can be formulated as:

\[ IN(tn) = \sum_{i=1}^{n} PV(tn,i) \quad (65) \]
Eventually, the firm’s overall cash outflow in supply chain 1, the amount of cash the firm has to pay to the upstream partners, in period $tn$ is presented earlier as:

$$OUT(tn) = \sum_{j=1}^{n'} PV'(tn, j)$$  \hspace{1cm} (66)

Also, the supplier 1’s overall cash outflow in supply chain 1, the amount of cash the supplier 1 has to pay to the upstream partners, in period $tn$ is:

$$O_1(tn) = \sum_{i'=1}^{m} P(tn, i')$$  \hspace{1cm} (67)

where $i$ is the set of invoices issued by the firm for each downstream partner, $PV(tn, i)$ is the present value of the amount received for invoice $i$ at period $tn$, while $j$ is the set of invoices issued by each upstream partner, $PV'(tn, j)$ is the present value of the amount needs to be paid for invoice $j$ at period $tn$, $n$ and $n'$ are the number of invoices issued for the customers and suppliers respectively, $i'$ is the set of invoices issued by supplier 1 for each upstream partner, $P(tn, i')$ is the present value of the amount the supplier 1 received for invoice $i'$ at period $tn$, $m$ is the number of invoices issued for the upstream partners.

4.3.1. **Vertical Merger**

Regarding the vertical merger, the firm is merged with the supplier 1 within supply chain 1 (Figure 24). As it is apparent from Figure 24, the product flow still exist between the firm and supplier 1 after a vertical merger, while there is no cash flow as a form of external cash between the firm and Supplier 1. However, Supplier 1 is required to pay an amount of cash to the upstream partner for materials provided even after a vertical merger. Also, the new firm formed after a vertical merger may have to pay some money not only to the other suppliers but also to its upstream partners as supplier of the supplier. In this PhD thesis, the external cash flow that takes place between partners in a supply chain is considered but internal cash flows are not.
Since the number of customers purchasing from the firm both before and after a vertical merger are the same, it means the firm’s cash inflow is not changed after the vertical merger in comparison with its cash inflow before. Moreover, there is no cash flow from the firm toward Supplier 1 after a vertical merger; thus, the firm’s cash outflow decreases. As explained earlier, there is a cash outflow from Supplier 1 as part of the new company to the upstream partners which affects the firm’s cash flow. Eq. (68) represents the firm’s cash outflow after a vertical merger at period $tn$.

$$\text{OUT}(tn) = \sum_{j=2}^{m} PV'(tn,j) + \sum_{i'=1}^{m} P(tn,i') \quad (68)$$

However, in order to show the overall firm’s cash flow after a vertical merger, Eq. (69) is used.

$$\text{CF}(tn) = \sum_{i=1}^{n} PV(tn,i) - \sum_{j=2}^{n'} PV'(tn,j) + \text{CF}(tn-1) - \sum_{i'=1}^{m} P(tn,i') \quad (69)$$

Regarding the financial metrics, whenever two firms are merged, the assets and liabilities of the new firm are the summation of assets and liabilities of each firm; however, the rate of increasing and decreasing assets and liabilities depends on the types and performance of the firms before the merger. In addition,
since the vertical merger does not necessarily increase the sales of products, while decreases the cost of goods sales; thus, the GPM seems to increase after a vertical merger.

Regarding the demand variation, demand variation, both underestimation and overestimation, affects a firm’s cash flow (Section 4.1.1 and 4.1.2); however, vertical merger does not have a significant effect on the demand variation, and consequently firm’s cash flow, since the number of customers and customers’ demand does not change after a vertical merger.

Subsequently several suppliers provide materials for the firm; therefore, late delivery of the materials from one supplier or any inequality between the suppliers’ delivery time will force the firm to postpone the production process and store the parts of the delivered materials until all raw materials are received from all suppliers. The expected time of receiving all raw materials from the suppliers at period $tn$ before and after a vertical merger is defined as:

$$\text{Before Merger: } d_{sm}(tn) = \max(d_{s}(tn,j)) \quad \forall j \in 1,2,3 \ldots n' \quad (70)$$

$$\text{After Merger: } d_{sm}(tn) = \max(d_{s}(tn,j)) \quad \forall j \in 2,3 \ldots n' \quad (71)$$

where $d_{sm}(tn)$ depicts the expected time of receiving all raw materials from the suppliers at period $tn$, while $d_{s}(tn,j)$ is the expected time of delivering raw materials from supplier $j$, $j$ is the set of invoices issued by each upstream partner and $n'$ is the number of invoices issued for the suppliers. As Eq. (71) shows the expected time of receiving raw materials from the suppliers at period $tn$ is equal to the maximum of the expected time of delivering raw materials from supplier $j$. Since after vertical merger, one supplier is merged with the firm; thus, the expected time of receiving all raw materials is probably improved as the number of supplier decreases.

The storage cost introduced to the firm due to the late delivery from suppliers after vertical merger is represented as:

$$ST(tn) = \sum_{j=2}^{n'} h'(Rd_{sm}(tn) - Rd_{s}(tn,j)) + dd'q(tn,j) \quad (1 + r)^T(tn) \quad (72)$$

where $ST(tn)$ represents the present value of storage cost created by the suppliers at period $tn$, $h'$ is the overhead costs for the daily storage, $dd'$ is the holding cost which is the cost of storing one quantity of product in the storage, $T(tn)$ is the end of period $tn$, $Rd_{sm}(tn)$ represents the actual time of delivering materials from the suppliers to the firm at period $tn$, while $Rd_{s}(tn,j)$ shows the actual time of delivering
materials from the supplier $j$ to the firm at period $tn$ and $q(tn, j)$ is the quantity of products supposed to be received from the supplier $j$ at period $tn$.

On the other hand, customer satisfaction as a dependent variable of penalty rate, demand variation and delivery time, as explained in Section 4.2, does not change significantly, since these attributes do not change due to the vertical merger. However, the effects of a vertical merger on the supply chain operation are quantified through a case study in the Chapter 6.

### 4.3.2. **Horizontal Merger**

The firm in supply chain 1 is merged with the firm in supply chain 2 as a horizontal merger to form a new firm (Figure 25), while these two supply chains are producing same product and competing in the market. However, the number of customers and suppliers of the new firm, after a horizontal merger, are increased concomitantly; the amount of cash inflow received from the customers and the amount of cash outflow paid to the suppliers are increased as presented by Eq. (73) and (74) respectively.

\[ IN(tn) = \sum_{k=1}^{m} PV(tn, k) \]  

---

**Figure 25** Horizontal Merger
\[ OUT(tn) = \sum_{k' = 1}^{m'} PV'(tn, k') \quad (74) \]

where \( IN(tn) \) and \( OUT(tn) \) are the firm’s overall cash inflow and outflow after a horizontal merger in period \( tn \) respectively, \( PV(tn, k) \) and \( PV'(tn, k') \) are the present value of cash received from customer with invoice \( k \) and the present value of cash paid to the supplier with invoice \( k' \) in period \( tn \) respectively, \( k' \in K' \) is the set of all suppliers in the supply chain after a horizontal merger, \( k \in K \) is the set of all customers after a horizontal merger \( m \) and \( m' \) are the number of invoices issued for the customers and suppliers respectively. However, the cash flow of the new firm after a horizontal merger in period \( tn \) is presented as:

\[ CF(tn) = \sum_{k = 1}^{m} PV(tn, k) - \sum_{k' = 1}^{m'} (PV'(tn, k')) + CF(tn - 1) \quad (75) \]

The firm does product forecasting based on the customers’ demand; thus, the horizontal merger has a significant effect on the demand variation, and consequently firm’s cash flow. When the demands are overestimated, the present value of the storage cost calculated based on the orders received from customer \( k \) at time period \( tn \) is:

\[ ST'(tn) = \sum_{k = 1}^{m} \frac{h + dd(ED(tn, k) - RD(tn, k))}{(1 + r)^T(tn)} \quad (76) \]

where \( ST'(tn) \) represents the present value of the storage cost applied in the period \( tn \), \( h \) is the overhead costs or unit cost during a period, \( dd \) is the holding cost per product, \( ED(tn, k) \) and \( RD(tn, k) \) are the forecasted and the actual demand of customer with invoice \( k \) at period \( tn \) respectively, \( r \) is the daily interest rate and \( T(tn) \) is the end of period \( tn \).

Regarding the delivery time, a horizontal merger affects the storage cost of the firm as the numbers of customers and suppliers increases. As explained in Section 4.1.2, two storage cost can be applied by the firm in a supply chain due to the delivery time, the storage cost applied for inequality between the suppliers’ delivery time and the storage cost applied for early preparation of products to deliver to the customers. The storage cost created due to the supplier delivery time after horizontal merger in period \( tn \) is represented as:
\[ ST(tn) = \sum_{k' = 1}^{m'} \frac{h'(Rd_{sm}(tn) - Rd_s(tn,k')) + dd'q(tn,k')}{(1 + r)t(tn)} \]  

(77)

where \( ST(tn) \) represents the present value of the storage cost created by the suppliers at period \( tn \), \( h \) is the overhead costs for daily storage, \( dd \) is the holding cost per product, \( T(tn) \) is the end of period \( tn \), \( Rd_{sm}(tn) \) represents the actual time of delivering materials from the suppliers to the firm at period \( tn \), while \( Rd_s(tn,k') \) shows the actual time of delivering materials from the supplier \( k' \) at period \( tn \) and \( q(tn,k') \) indicates the quantity of products supposed to be received from the supplier \( k' \) at period \( tn \).

On the other hand, the storage cost of applied for early preparation of product to deliver to the customers after horizontal merger in period \( tn \), equal to Eq. (34) before horizontal merger, is represented as:

\[ ST''(tn) = \sum_{k = 1}^{m} \frac{h''(T'(tn,k) - TT'(tn,k)) + dd''RD(tn,k)}{(1 + r)t(tn)} \]  

(78)

where \( ST''(tn,k) \) is the present value of storage cost applied for delivering the product to the customer \( k \) period \( tn \), \( h \) is the overhead costs for daily storage, \( T'(tn,k) \) and \( TT'(tn,k) \) are the promised and actual time for delivering the product to the customer \( i \) at period \( tn \) respectively, \( dd \) is the holding cost per product, \( T(tn) \) is the end of period \( tn \) and \( RD(tn,k) \) is the actual demand have to be delivered to the customer \( i \) at period \( tn \).

Regarding the customer satisfaction, it is assumed that customers purchase the same amount of the products from the firm after horizontal merger. In order to understand the effect of customer satisfaction on the firm’s cash flow, the average amount expected to be received from each customer after a horizontal merger in period \( tn \) is calculated as:

\[ AVGIn'(tn + 1) = \frac{\sum_{k=1}^{N' + C_{new}(tn)} PV'(tn + 1,k)}{(N' + C_{new}(tn))} \]  

(79)

where \( PV'(tn,k) \) is the present value of cash that customer \( k \) is supposed to pay in period \( tn \), \( N' \) is the number of customers at the beginning of the time horizon after a horizontal merger and \( C_{new}(tn) \) is the number of new customers who enter to the firm at period \( tn \).

As a horizontal merger leads the production capacity of the new firm to increase; thus, customer satisfaction would be improved, while customers’ demand increases as:
\[
CS_{demand}(tn) = \begin{cases} 
1 & \text{if } RD(tn) \leq ED(tn) \\
\frac{RD(tn) - C}{ED(tn) - C} & \text{if } ED(tn) < RD(tn) \leq C \\
0 & \text{if } RD(tn) > C
\end{cases}
\]

where \(CS_{demand}(tn)\) is satisfaction of customers in period \(tn\), \(ED(tn)\) is the forecasted demand supposed to be received from the customers in period \(tn\), while \(RD(tn)\) is the actual demand received from customers in period \(tn\), \(C\) is the production capacity of a firm after a horizontal merger, \(C_p\) and \(C_{p'}\) are the production capacity of firms in supply chain 1 and 2 respectively before a horizontal merger. In order to evaluate the effect of horizontal merger on the level of customer satisfaction, while the customers’ demand increases, Eq. (80) and Eq. (49) are compared. Due to increasing the production capacity of firm after horizontal merger, the numerator of Eq. (80) increases when the customers’ demand grows; thus, by keeping the number of expected demand constant after horizontal merger, the level of customer satisfaction improves.

4.4. Conclusion

In this chapter, the effects of supply chain operation including demand variation and delivery time, known as logistic bullwhip, on the financial performance of a firm are modelled. Overestimation of customers’ demand affects the cash flow of the firm through the storage cost, while underestimation of demand variation affects the cash flow of the firm through customer dissatisfaction cost. On the other hand, earliness of delivery time affects the cash flow of a firm by imposing storage cost to the firm, while lateness of delivery time affects the cash flow of a firm by customer dissatisfaction cost. However, the storage costs as result of logistic bullwhip are added to the firm’s cash flow model.

Besides, the effect of customer satisfaction on the financial performance of a firm and firm’s cash inflow is modelled and distinguished. Regarding the customer satisfaction, a cascade diagram to represent the movement of customers of a firm within different time period is developed, while satisfaction is linked to the payment strategies attributes. Different payment strategy attributes such as penalty rate, customer discount, delivery time and quality of delivery (demand fulfilment) are defined to link to the satisfaction. Customer discount as a mechanism to improve the satisfaction level due to the late delivery of products or services are defined, while it affects the cash inflow of a firm at the same time. The optimum level of
customer discount relates to the number of days that the products are delivered with delay and the amount supposed to be received from the downstream partners.

In addition, the effects of horizontal and vertical merger as form of mergers and acquisitions on the supply chain operation and consequently on the financial performance of a firm in a supply chain is studied, while it seems that the effects of supply chain operation on the financial performance of a firm in a supply chain improves after horizontal and vertical merger. The finding and results of this chapter are provided in Chapter 6, Section 6.1.

In the next chapter, the optimisation model as an objective function for the firm’s cash flow to improve the financial performance through optimising the payment strategies and scheduling the payments with certain constraints is developed.
Chapter Five

The payment Strategy for a Firm in a Supply Chain

In this chapter, an optimisation mathematical model for the firm’s cash flow to maximise the overall cash flow through optimising the payment strategies and prioritising the cash outflow invoices is developed.

5.0. Introduction

This PhD thesis focuses more on the financial side of a supply chain and the cash flow of a firm in a supply chain, while the main goal of this research is to devise a payment strategy to improve the financial performance of a firm in a supply chain. Therefore, an optimisation mathematical model is developed to maximise the cash flow of a firm at each particular time period within a time horizon through optimising the payment strategy and prioritising the cash outflow invoices based on the amount of available cash in the firm in each period with certain constraints.

5.1. An Optimisation Mathematical Model

In order to devise a mathematical model for the firm’s cash flow, first of all a cascade diagram as explained in Figure 11 is proposed, then a mathematical equation representing the firm’s cash flow in each time period is developed. The cash flow of a firm in a supply chain in period $t_n + 1$ is:

$$CF(t_n + 1) = IN(t_n + 1) + CF(t_n) - OUT(t_n + 1) \quad (81)$$

After developing a mathematical model for the firm’s cash flow, the effects of the supply chain operation, including customer satisfaction, on the financial performance of a firm in a supply chain are mathematically modelled and linked to the associated payment strategy attributes. Therefore, the effect of customer satisfaction on the cash inflow of the firm in period $t_n$ is presented by Eq. (42) in Chapter 4 as:

$$IN(t_n + 1) = C(t_n) \times AVGIn(t_n + 1) + \theta(t_n + 1) \quad (82)$$

where $IN(t_n + 1)$ is the aggregated amount of cash received from customers in period $t_n + 1$, $C(t_n)$ represents the number of satisfied customers in period $t_n$, $AVGIn(t_n + 1)$ represents the average amount expected to be received from each customer in period $t_n + 1$, $\theta(t_n + 1)$ is the amounts that expected to be received from the new customers in period $t_n + 1$. However, the effects of customer satisfaction on the firm’s cash flow are proposed through developing a cascade diagram (Figure 26).
As is apparent from Figure 26, the time horizon $T$, usually a period of one year, in which all the firm’s cash flow and customer movement has happened, consists of ‘n’ time periods, while the cash flow and satisfaction in each time period affects the cash flow in the next period. The cash flow of the firm in each time period is composed of cash inflow (the summation of the cash to be received from satisfied customers who stayed loyal from the previous period and the cash received from new customers), cash
outflow (the amount of cash to be paid to the upstream partners) and the amount of cash available from
the previous period.

As explained in Chapter 4 and Eq. (58), the firm can apply customer discounts as a means of improving
the level of customer satisfaction, which would also affect the firm’s cash inflow. The effect of customer
discounts on the amount of cash received from customers in period \( tn + 1 \) is added to Eq. (82) as:

\[
IN(tn + 1) = \left[ 1 - (\alpha(tn + 1) \times x(tn + 1)) \right] \times \left( C(tn) \times \text{AVGln}(tn + 1) \right) + \theta(tn + 1) \quad (83)
\]

where \( x(tn + 1) \) is a discount rate applied by the firm to compensate for the cost of dissatisfaction due to
late delivery and \( \alpha(tn + 1) \) is a binary variable to show whether the discount rate is applied or not. The
other parameters of the model are explained in Eq. (82). The mathematical presentation of the firm’s cash
flow for the period \( tn + 1 \) after applying the effect of customer satisfaction and customer discounts can
be written as:

\[
CF(tn + 1) = \left[ 1 - (\alpha(tn + 1) \times x(tn + 1)) \right] \times \left( C(tn) \times \text{AVGln}(tn + 1) + \theta(tn + 1) \right) + CF(tn) - OUT(tn + 1) \quad (84)
\]

In addition, the effects of the supply chain operation on the cash flow model of a firm within the chain,
including demand variation and delivery time which cause “logistic bullwhip”, are evaluated and
mathematically modelled by adding storage costs to the firm, as explained in Chapter 4, Eq. (35).
Therefore, storage costs as a result of overestimating customer demand and early delivery are added to
Eq. (84) as:

\[
CF(tn + 1) = \left[ 1 - (\alpha(tn + 1) \times x(tn + 1)) \right] \times \left( C(tn) \times \text{AVGln}(tn + 1) + \theta(tn + 1) \right) + CF(tn) - OUT(tn + 1) - \left( \sum_{v_j \in J} \left[ n(tn + 1, j) \times ST(tn + 1) \right] \right) + \left( \sum_{v_i \in I} \left[ m(tn + 1) \times ST''(tn + 1) + m'(tn + 1, i) \times ST'(tn + 1) \right] \right) \quad (85)
\]

where \( CF(tn + 1) \) is the cash flow of the firm in period \( tn + 1 \), \( OUT(tn + 1) \) is the amount of cash
going out of the firm in period \( tn + 1 \) as cash outflow, \( CF(tn) \) is the amount of cash available from the
previous period or previous time horizon, \( ST(tn + 1) \) represents the present value of the storage cost at
period \( tn + 1 \) for inequality between the suppliers’ delivery times, \( ST'(tn + 1) \) represents the present
value of the storage cost applied in the period $tn + 1$ for demand variation, $ST''(tn + 1)$ is the present value of storage cost applied for early preparation of products at period $tn + 1$, while $n(tn + 1)$, $m(tn + 1)$ and $m'(tn + 1, i)$ are the binary variables to show whether the storage costs needs to be added on the cash flow model or not.

In the first statement on the right-hand side of Eq. (85), $C(tn)$ represents the number of satisfied customers in period $tn$ who decide to continue purchasing from the firm in the next period, while the number of satisfied customers in period $tn + 1$ can be calculated as:

$$C(tn + 1) = C(tn) * CS(tn + 1) + C_{new}(tn + 1) \quad (86)$$

where $C(tn + 1)$ and $C(tn)$ represent the number of satisfied customers in period $tn + 1$ and $tn$ respectively, $CS(tn + 1)$ represents customer satisfaction in period $tn + 1$, while $C_{new}(tn + 1)$ is the number of new customers entering the firm in the period $tn + 1$. Customer satisfaction in each period is related to their satisfaction followed by the penalty rate, delivery time, and order fulfilment. The relationship between penalty rate and customer satisfaction could be defined as either exponential or logarithmic in the partially satisfied area as explained in Section 4.2.1. This relationship is mathematically presented in Eqs. (87) and (88).

$$CS_{penalty}(tn + 1) = \begin{cases} 
1 & p(tn + 1) \leq p(tn) \\
\alpha + \beta \frac{p(tn + 1)}{p(tn)} & p(tn) < p(tn + 1) \leq p'(tn + 1) \\
0 & p(tn + 1) > p'(tn + 1)
\end{cases} \quad (87)$$

$$CS_{penalty}(tn + 1) = \begin{cases} 
1 & p(tn + 1) \leq p(tn) \\
\alpha' + \beta' \log\left(\frac{p(tn + 1)}{p(tn)}\right) & p(tn) < p(tn + 1) \leq p'(tn + 1) \\
0 & p(tn + 1) > p'(tn + 1)
\end{cases} \quad (88)$$

where $CS_{penalty}(tn + 1)$ represents customer satisfaction in period $tn + 1$, $p'(tn + 1)$ is the penalty rate of the competitor in period $tn + 1$; $p(tn + 1)$ and $p(tn)$ are the penalty rates in period $tn + 1$ and $tn$ respectively; and $\alpha, \beta, \alpha'$ and $\beta'$ are real numbers, known as scaling factors or scaling coefficients, which scale the level of satisfaction in the border areas based on the different penalty rates. Moreover, the relationship between order fulfilment and customer satisfaction in the partially satisfied area as explained in Section 4.2.2 is formulated linearly. Eq. (89) shows this relationship mathematically.
where $CS_{demand}(tn + 1)$ is satisfaction of customers in period $tn + 1$, $ED(tn + 1)$ is the forecast demand for period $tn$; $RD(tn + 1)$ is the actual demand received from customers in period $tn + 1$; and $C$ represents the production capacity of the firm. Finally, the relationship between delivery time and customer satisfaction as explained in Section 4.2.3 can be formulated in a linear, exponential or logarithmic form based on the importance of the product to the customers. This relationship is formulated as:

$$
CS_{delivery}(tn + 1) =
\begin{cases}
1 & T'(tn + 1) = TT'(tn + 1) \\
\frac{a''(tn + 1) + b''(tn + 1)e^{\frac{TT'(tn + 1)}{TT'(tn + 1)}}}{TT'(tn + 1) - T(tn + 1)} & \lambda = a_1 \\
\frac{T'(tn + 1) - T(tn + 1)}{TT'(tn + 1) - T(tn + 1)} & \lambda = a_2 \\
a'''(tn + 1) + b'''(tn + 1)\log\left(\frac{TT'(tn + 1)}{T'(tn + 1)}\right) & \lambda = a_3 \\
0 & TT'(tn + 1) > T(tn + 1)
\end{cases}
$$

where $CS_{delivery}(tn + 1)$ represents customer satisfaction at period $tn + 1$ based on the delivery time, while $a''(tn + 1), b''(tn + 1)$ and $a'''(tn + 1), b'''(tn + 1)$ are real numbers, known as scaling factors or scaling coefficients, to put the satisfaction level in the proper area. $\lambda$ represents different ranges for product importance, $T'(tn + 1)$ is the promised time of delivering products to the customers at period $tn + 1$, $TT'(tn + 1)$ denotes the actual time of delivering and $T(tn + 1)$ represents the end date of period $tn + 1$.

### 5.1.1 Model Formulation

**Objective Function**

The stated goal of this thesis is to maximise the cash flow of a firm in a supply chain in each time period by optimising the payment strategy and prioritising the cash outflow. This is expressed in the objective function as:

$$
\text{Maximize } CF(tn + 1) \quad (91)
$$
\[
CF(tn+1) = [1 - (\alpha(tn+1) \ast x(tn+1))] \ast (C(tn) \ast AVGIn(tn+1) + \theta(tn+1)) + CF(tn) \\
- \text{OUT}(tn+1) \\
- \left( \sum_{i \in I} [n(tn+1,j) \ast ST(tn+1)] \right) \\
+ \sum_{i \in I} [(m(tn+1) \ast ST''(tn+1)) + (m'(tn+1,i) \ast ST'(tn+1))] \right)
\]

The first statement on the right hand side of Eq. (91), \([1 - (\alpha(tn+1) \ast x(tn+1))] \ast (C(tn) \ast AVGIn(tn+1) + \theta(tn+1))\) shows the firm’s cash inflow received from customers in period \(tn+1\) by considering the effect of customer satisfaction and customer discounts. However, \([1 - (\alpha(tn+1) \ast x(tn+1))]\) is the effect of customer discounts on the firm’s cash inflow where \(x(tn+1)\) is a discount rate applied by the firm to compensate for the cost of dissatisfaction due to late delivery; and \(\alpha(tn+1)\) is a binary variable to show whether the discount rate is applied or not; while \((C(tn) \ast AVGIn(tn+1) + \theta(tn+1))\) shows the amount of cash received from both satisfied and new customers respectively. In Eq. (91), \(C(tn)\) denotes the number of satisfied customers in period \(tn\), and \(\theta(tn+1)\) represents the amounts expected to be received from new customers in period \(tn+1\). In addition, \(AVGIn(tn+1)\) represents the average amount of cash that the firm is expected to receive from customers who order at the beginning of the time horizon, if they continue to purchase from the firm in period \(tn+1\), and from new customers who started buying from the firm in previous periods as formulated in Eq. (92).

\[
AVGIn(tn+1) = \frac{\sum_{i=1}^{N+C_{new}(tn)} PV(tn+1,i)}{(N + C_{new}(tn))} \tag{92}
\]

where \(PV(tn+1,i)\) is the present value of cash that customer with invoice \(i\) is supposed to pay in period \(tn+1\), \(N\) is the number of customers at the beginning of the time horizon and \(C_{new}(tn)\) is the number of new customers who enter to the firm at period \(tn\). The present value of cash that a customer with invoice \(i\) is supposed to pay in period \(tn\) is:
\[ PV(tn + 1, i) = \sum_{d(tn+1,i)=s(tn+1,i)}^{du(tn+1,i)-1} \left( u(tn + 1, i) \frac{F(tn + 1, i)(1 - v(tn + 1))}{(1 + r)^{d(tn+1,i)}} \right) \]

\[ + \sum_{d(tn+1,i)=du(tn+1,i)}^{T(tn+1)} \left( u(tn + 1, i) \frac{F(tn + 1, i)}{(1 + r)^{d(tn+1,i)}} \right) \]

\[ + \sum_{d(tn+1,i)=du(tn+1,i)+1}^{T(tn+1)} \left( u(tn + 1, i) \frac{F(tn + 1, i)(1 + p(tn + 1))}{(1 + r)^{d(tn+1,i)}} \right) \] (93)

The first statement on the right hand side of Eq. (93), \( \frac{F(tn + 1, i)(1 - v(tn + 1))}{(1 + r)^{d(tn+1,i)}} \), shows the present value of invoice \( i \) at period \( tn + 1 \) received from customers before the due date on the discount value, the second statement, \( \frac{F(tn + 1, i)}{(1 + r)^{d(tn+1,i)}} \), represents the present value of the invoice \( i \) at period \( tn + 1 \) received from customers on the due date on the normal value, while the third statement, \( \frac{F(tn + 1, i)(1 + p(tn + 1))}{(1 + r)^{d(tn+1,i)}} \), shows the present value of the invoice \( i \) at period \( tn + 1 \) received from customers after the due date with a delay on the penalty value. The parameters of the model are introduced in Table 4. The constraints of cash inflow are explained in the section headlined Constraints.

\( OUT(tn + 1) \), the aggregate firm’s cash outflow, in Eq. (91), representing the total amount that the firm pays to upstream partners in period \( tn + 1 \) as presented in the cascade diagram (Figure 26), can be formulated as the summation of the present value of cash paid to the supplier with invoice \( j \) in period \( tn + 1 \):

\[ OUT(tn + 1) = \sum_{\forall j \in J} PV'(tn + 1, j) \] (94)

However, the present value of cash outflow invoice can take three values: i) discount value, ii) normal value and iii) penalty value.
\[
PV'(tn + 1, j) = \sum_{d'(tn+1,j) = s'(tn+1,j)}^{du'(tn+1,j)-1} \left( u'(tn + 1, j) \left( 1 - v'(tn + 1) \right) \frac{du'(tn+1,j)-d'(tn+1,j)}{(1 + r)^{d'(tn+1,j)}} \right) \\
+ 1, j \right) F'(tn + 1, j) \left( 1 - v'(tn + 1) \right) \frac{F'(tn + 1, j)}{(1 + r)^{d'(tn+1,j)}} \\
+ \sum_{d'(tn+1,j) = du'(tn+1,j)}^{T(tn+1)} \left( u'(tn + 1, j) \frac{F'(tn + 1, j)}{(1 + r)^{d'(tn+1,j)}} \right) \\
+ 1, j \right) F'(tn + 1, j) \left( 1 + p'(tn + 1) \right) \frac{d'(tn+1,j)-du'(tn+1,j)}{(1 + r)^{d'(tn+1,j)}} \right) \\
} \tag{95}
\]

The statement, \( F'(tn+1,j)(1-v'(tn+1)) \frac{du'(tn+1,j)-d'(tn+1,j)}{(1+r)^{d'(tn+1,j)}} \), on Eq. (95) shows the present value of invoice \( j \) at period \( tn + 1 \) paid to the suppliers before the due date at the discount value; \( F'(tn+1,j) \frac{F'(tn + 1, j)}{(1 + r)^{d'(tn+1,j)}} \) shows the present value of invoice \( j \) at period \( tn + 1 \) when it is paid on the due date and the statement, \( F'(tn+1,j)(1+p'(tn+1)) \frac{d'(tn+1,j)-du'(tn+1,j)}{(1+r)^{d'(tn+1,j)}} \), shows the present value of the invoice \( j \) at period \( tn + 1 \) when it is paid after the due date with a penalty. The constraints of cash outflow are explained in the sub-section Cash Outflow and Penalty Rate in the Constraints section.

On the other hand, \( \sum_{\forall j \in J} [n(tn + 1, j) \ast ST(tn + 1)] + \sum_{\forall i \in I} [m(tn + 1) \ast ST''(tn + 1) + (m'(tn + 1, i) \ast ST'(tn + 1))] \) in Eq. (91) represents the effect of storage costs as a result of overestimating customer demand, as well as early delivery on the firm’s cash flow. \( ST(tn + 1) \) represents the present value of the storage cost in period \( tn + 1 \) because of inequality between the suppliers’ delivery times as explained in Eq. (33). \( ST''(tn + 1) \) represents the present value of the storage cost applied in the period \( tn + 1 \) for demand variation as formulated in Eq. (30) and \( ST''(tn + 1) \) is the present value of storage cost applied for early preparation of products in period \( tn + 1 \) as introduced in Eq. (33). In addition, \( n(tn + 1, j), m(tn + 1) \) and \( m'(tn + 1, i) \) are the binary variables to show whether the storage costs should be added to the cash flow model or not.
In order to manage the cash outflow and schedule the payment, the firm needs to have enough cash in hand at the time of paying each invoice. The amount of available cash at the time of paying invoice \( j \) at period \( tn + 1 \), denoted by \( \text{cash}(tn + 1, j) \), previously formulated as:

\[
\forall j \in J \quad \text{cash}(tn + 1, j) = \sum_{i \in I} (w(tn + 1, j, i) * PV(tn + 1, i)) + CF(tn) - \sum_{j' \in J} \lambda(tn, j, j') * PV'(tn, j') \\
- \left( \sum_{j' \in J} [n(tn + 1, j) * ST(tn + 1)] \\
+ \sum_{i \in I} [(m(tn + 1) * ST''(tn + 1)) + (m'(tn + 1, i) * ST'(tn + 1))] \right) \quad (96)
\]

In the above equation, \( PV'(tn + 1, j') \) represents the present value of invoice \( j' \) during period \( tn + 1 \), while \( j' \) is indexed to all the payable invoices except invoice \( j \). The variable \( w(tn + 1, j, i) \) is defined to distinguish whether, at the time of paying invoice \( j \) at period \( tn + 1 \), invoice \( i \) has been received or not. The variable \( \lambda(tn + 1, j, j') \) is used to show whether, at the time of paying invoice \( j \) at period \( tn + 1 \), invoice \( j' \) has been paid.

The model is programmed using the GAMS software tool allowing it to be tested and analysed. GAMS has different solver for solving an optimisation model; however, based on the model developed in Eq. (91), the solver, “COUENNE” has been chosen for this analysis in the software.

Based on the model defined as an objective function, three variables need to be optimised in order to maximise the cash flow in each period. They are:

i) the time of paying each cash outflow, \( d'(tn, j) \), which needs to be optimised and scheduled

ii) the penalty rate, \( p(tn) \), applied to the customer for late receipt of invoices, and

iii) the discount rate, \( x(tn) \), which needs to be optimised to maximise the number of satisfied customers and consequently maximise the cash flow of a firm.

However, to define an optimisation model the constraints need to be defined.
**Constraints**

The constraints are defined to express the requirement on variables and also to limit the possible values for the decision variables. Based on the defined decision variable, the constraints of this model can be divided into Cash Inflow, Cash in Hand, Cash Outflow, Penalty Rate, Customer Discount and Customer Satisfaction.

- **Cash Inflow**

  In order to schedule the payment, a time frame is defined during which cash outflows are expected to take place. The amount of cash inflow expected to be received from every customer in each defined time period can be categorised under three values: discount rate, normal rate and penalty rate as shown in Eq. (92). In order to determine whether invoice \( i \) is received under the discount value, normal value or penalty value, the binary variable \( u(tn + 1, i) \) is defined. Therefore, Eq. (97) is used to show that invoice \( i \) is received once during the period \( tn + 1 \).

\[
\sum_{d(tn+1,i)=s(tn+1,i)}^{T(tn+1)} u(tn + 1, i) = 1 \quad \forall i \in I \quad (97)
\]

Moreover, to schedule payment in a specified period, cash inflow needs to happen once from the time the invoice is issued, \( s(tn + 1, i) \), until the end of time period \( T(tn + 1) \) as presented in Eq. (98) and (99).

\[
d(tn + 1, i) \leq T(tn + 1) \quad (98)
\]

\[
d(tn + 1, i) \geq s(tn + 1, i) \quad (99)
\]

- **Cash in Hand**

  However, the amount of cash in hand at the time of paying invoice \( j \) during period \( tn + 1 \) should be greater than the value of invoice \( j \) which is supposed to be paid in period \( tn + 1 \). The firm needs to have enough cash in hand in order to pay the cash outflows. Eq. (100) is used to express this constraint.

\[
cash(tn + 1, j) \geq PV'(tn + 1, j) \quad (100)
\]
Moreover, the binary variable \( w(tn + 1, j, i) \), \( \lambda(tn + 1, j, j') \), \( n(tn + 1, j), m(tn + 1) \) and \( m'(tn + 1, i) \) used on Eq. (96) defined to find the amount of available cash on the firm in period \( tn + 1 \) are formulated as:

\[
w(tn + 1, j, i) = \begin{cases} 
1 & d'(tn + 1, j) \geq d(tn + 1, i) \\
0 & \text{Otherwise}
\end{cases} 
\tag{101}
\]

\[
\lambda(tn + 1, j, j') = \begin{cases} 
1 & d'(tn + 1, j') < d'(tn + 1, j) \\
0 & \text{otherwise} 
\end{cases} 
\tag{102}
\]

\[
\begin{align*}
    n(tn + 1, j) &= \begin{cases} 
    1 & Rd_{sm}(tn + 1) \neq Rd_s(tn + 1, j) \\
    0 & \text{Otherwise}
    \end{cases} \\
    m(tn + 1) &= \begin{cases} 
    1 & T'(tn + 1) < T'T'(tn + 1) \\
    0 & T'(tn + 1) \geq T'T'(tn + 1)
    \end{cases} \\
    m'(tn + 1, i) &= \begin{cases} 
    0 & ED(tn + 1, i) + q'(tn + 1 - 1) \leq RD(tn + 1, i) \\
    1 & \text{Otherwise}
    \end{cases}
\end{align*} 
\tag{103}
\]

**Cash Outflow**

Regarding the cash outflow, the firm has three options to pay the invoices: pay earlier than the due date under the category “discount value”, pay on the due date under “normal value” or pay after the due date with the penalty value as represented in Eq. (95). The decision variable \( u'(tn + 1, j) \) is used to determine whether invoice \( j \) is paid at the discount value, normal value or penalty value. Eq. (104) is used to show that invoice \( j \) must be paid once between \( s'(tn + 1, j) \), when the invoice is issued, and \( T'(tn + 1) \), the end of the time period.

\[
\sum_{d'(tn + 1, j) = s'(tn + 1, j)} T(tn + 1) u'(tn + 1, j) = 1 
\tag{104}
\]

\[
u'(tn + 1, j) = \{0, 1\}
\]

All cash outflow invoices must be paid in a specific period. Eqs. (105) and (106) show that \( d'(tn + 1, j) \), as a decision variable of the optimisation model, needs to be paid between \( s'(tn + 1, j) \) and \( T'(tn + 1) \).

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\[ d'(tn + 1, j) \leq T(tn + 1) \quad (105) \]

\[ d'(tn + 1, j) \geq s'(tn + 1, j) \quad (106) \]

- **Penalty Rate**

The penalty rate in each period as a decision variable of the model has to be set lower than the competitor’s penalty rate in order to avoid customer dissatisfaction and any decision by customers to switch to the competitor. Moreover, the penalty rate in each period is being considered as higher than the interest rate, \( r \), in order to encourage customers to pay the invoices as soon as possible.

\[ r \leq p(tn + 1) < p'(tn + 1) \quad (107) \]

- **Customer Discount**

Customer discount as a decision variable of the model ranges from 0 to 1, while the optimum value for such a discount can be calculated taking into account the number of days late a product is delivered.

\[ 0 \leq x(tn + 1) \leq 1 \quad (108) \]

The effect of customer discounts on the firm’s cash inflow is represented in Eq. (83). The binary variable \( a(tn + 1) \) is defined to show whether the products are delivered to the customers on time or late during period \( tn + 1 \).

\[ a(tn + 1) = \begin{cases} 
1 & TT'(tn + 1) > T'(tn + 1) \\
0 & TT'(tn + 1) \leq T'(tn + 1)
\end{cases} \quad (109) \]

In Eq. (109), \( T'(tn + 1) \) and \( TT'(tn + 1) \) are the promised time and actual time of delivering products to the customers in period \( tn + 1 \) respectively. Based on Eq. (109), whenever \( TT'(tn + 1) \) becomes greater than \( T'(tn + 1) \), products are delivered late to the customers, the customer discount needs to be applied, as: \( a(tn + 1) = 1 \).

- **Customer Satisfaction**

The number of satisfied customers in each time period is:

\[ C(tn + 1) = C(tn) * CS(tn + 1) + C_{new}(tn + 1) \quad (110) \]
where $C(tn + 1)$ and $C(tn)$ represent the number of satisfied customers at period $tn + 1$ and $tn$ respectively, $CS(tn + 1)$ represents customer satisfaction at period $tn + 1$, while $C_{new}(tn + 1)$ representing the number of new customers entering the firm. Customer satisfaction in each period ranges from 0 to 1 for fully dissatisfied and fully satisfied respectively.

$$0 \leq CS(tn + 1) \leq 1 \quad (111)$$

Based on Eqs. (45) and (47), the mathematical formula between penalty rate and customer satisfaction, the scaling factors or scaling coefficients $a, b, a', b'$ are the real numbers used to scale the level of satisfaction properly in the border of areas based for the different penalty rates.

$$\left\{ \begin{array}{ll}
a + be^{\frac{p(tn+1)}{p(tn)}} & = 1 \quad \text{if} \ p(tn + 1) = p(tn) \\
a + be^{\frac{p(tn+1)}{p(tn)}} & = 0 \quad \text{if} \ p(tn + 1) = p'(tn + 1)
\end{array} \right. \quad (112)$$

$$\left\{ \begin{array}{ll}
a' + b' \log \left( \frac{p(tn + 1)}{p(tn)} \right) & = 1 \quad \text{if} \ p(tn + 1) = p(tn) \\
a' + b' \log \left( \frac{p(tn + 1)}{p(tn)} \right) & = 0 \quad \text{if} \ p(tn + 1) = p'(tn + 1)
\end{array} \right. \quad (113)$$

On the Eq. (112) and (113), $p(tn)$ and $p(tn + 1)$ are the penalty rate of the firm in period $tn$ and $tn + 1$ respectively, while $p'(tn + 1)$ represents the competitor penalty rate in period $tn + 1$.

Moreover, the scaling factors or scaling coefficients $a''(tn), b''(tn), a'''(tn) \text{ and } b'''(tn)$ used in Eq.(50), which express the mathematical formula linking delivery time and customer satisfaction, are the real numbers to reflect the satisfaction levels in the proper area in each period, based on the ratio between the promised time and actual time of delivering products to the customers. Thus:

$$\left\{ \begin{array}{ll}
a''(tn) + b''(tn)e^{\frac{TT'(tn)}{T'(tn)}} & = 1 \quad \text{if} \ TT'(tn) = T'(tn) \\
a''(tn) + b''(tn)e^{\frac{TT'(tn)}{T'(tn)}} & = 0 \quad \text{if} \ TT'(tn) = T(tn)
\end{array} \right. \quad (114)$$

$$\left\{ \begin{array}{ll}
a'''(tn) + b'''(tn) \log \frac{TT'(tn)}{T'(tn)} & = 1 \quad \text{if} \ TT'(tn) = T'(tn) \\
a'''(tn) + b'''(tn) \log \frac{TT'(tn)}{T'(tn)} & = 0 \quad \text{if} \ TT'(tn) = T(tn)
\end{array} \right.$$
5.2. Conclusion

The aim of this chapter is to develop an optimisation mathematical model to maximise the cash flow of a firm over a particular time period by optimising the payment strategy attributes, such as penalty rate and customer discount, and also by scheduling the payment of invoices as a firm’s cash outflow. In order to develop a proper cash flow model, the effect of supply chain operation including delivery time, demand variation and customer satisfaction is added to the cash flow model.

To evaluate the effect of customer satisfaction on cash flow of the firm within different periods, a new cascade diagram is developed using a combination of the cash flow cascade diagram and the customer movement cascade diagram. Finally, the objective function and constraints of the model are explained.
Chapter Six
Numerical Results, Analysis and Approach Justification

In this chapter, the cash flow model of a manufacturer whose work is in a supply chain producing smartphones is tested by developing the numerical example. First of all, the chain for the production of the smartphones consists of two suppliers, one manufacturer and two customers. The cash flow model is tested from the manufacturer’s perspective. Then, the effect of the supply chain operation, including customers’ demand variations, delivery time and customer satisfaction, on the manufacturer’s cash flow is presented numerically. Finally, the effect of merging the manufacturer with Supplier 1 and with a competitor in a different supply chain on the manufacturer’s cash flow is tested.

6.0. Introduction

In this section, the cash flow model for a firm working as a manufacturer in a supply chain producing smartphones is analysed using numerical data. A supply chain producing smartphones consisting of two main suppliers, which provide the complementary material and two customers of a manufacturer which has the main share of the manufacturer’s market, is considered (Figure 27). This example has been developed just to test the cash flow model and to illustrate the effects of the supply chain operation on cash flow. The model for the cash flow management and optimisation is developed from the manufacturer’s point of view.

![Figure 27 Supply Chain of Producing Smartphone](image)

To test the model, first of all, a cascade diagram to represent the manufacturer’s cash flow is developed; then, the effect of demand variation and delivery time as cause of logistic bullwhip on the manufacturer’s cash flow is investigated through the corresponding numerical example. Finally, the financial performance of the manufacturer before and after merger is assessed by merging the manufacturer with suppliers as vertical integration and then with another manufacturer in the form of horizontal integration.
After devising a mathematical model for the manufacturer’s cash flow in each time period, the model is solved using a GAMS® modelling tool. For this case, it is desired to maximise the cash flow of the manufacturer through optimising the penalty rate, discount rate and determining the time and amount of payments for each invoice in each time period.

In above supply chain, each supplier provides different parts of the manufacturer’s requirements, while the customers buy the same quantities of the products from the manufacturer; thus, each customer occupies fifty percent of the manufacturer’s market. The manufacturer in the aforementioned supply chain receives two invoices from the customer for the purchased smartphones in each time period and has to pay two invoices to the suppliers for delivering the complementary materials in each time period.

6.1. Modelling the Manufacturer’s Cash Flow

A five-month time horizon is defined to cover the manufacturer’s cash flow and then the objective function is to maximise the cash flow in each time period. To develop a model for the manufacturer’s cash flow, the required parameters such as annual penalty rate $p(tn)$, annual competitor’s penalty rate $p'(tn)$, annual interest rate $r$, daily overhead costs $h$, and cost of storage for each unit of product $dd$ for the five different time periods are illustrated in Table 6.

<table>
<thead>
<tr>
<th>Time period</th>
<th>$p(tn)$ annually</th>
<th>$p'(tn)$ annually</th>
<th>$r$ annually</th>
<th>$h$ ($\frac{$}{\text{Day}}$)</th>
<th>$dd$ ($\frac{$}{\text{product}}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>0.05</td>
<td>0.09</td>
<td></td>
<td>0.03</td>
<td>200</td>
</tr>
<tr>
<td>February</td>
<td>0.05</td>
<td>0.09</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>March</td>
<td>0.05</td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>0.05</td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>0.05</td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A cascade diagram for the manufacturer’s cash flow in each period including the amount of cash supposed to be received from the two customers, the amount of cash supposed to be paid to the two suppliers at a particular time and the amount of cash available in the firm from the previous period is developed (Figure 28). The left-hand side of the cascade diagram represents the face value of cash inflow signified by $FV$, and $b$ signifies the due date of each receivable invoice, while the right-hand side shows the face value of cash outflow signified by $FV'$ and the due date of each payable invoice, $b'$. $IN$, $OUT$ and $CF$ represent the overall cash inflow, cash outflow and cash flow of the manufacturer within each time period respectively. It is assumed that the initial amount of cash in January, the amount of cash remaining from the previous period, is zero.
The due date for each invoice is the time the invoices are expected to be received/paid at the normal value, while the actual time of receiving/paying the receivable or payable invoices could be different from the due time. Clearly, the value paid for each invoice can vary based on the actual time of paying the invoice.

![Cascade Diagram for the Manufacturer's Cash Flow](image)

Figure 28 Cascade Diagram for the Manufacturer’s Cash Flow

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Regarding the manufacturer’s cash inflow, the manufacturer requires to know the time and amount of cash received from the customers; thus, based on the explanation presented in Chapter 3 two different scenarios as best and worst scenario for the manufacturer’s cash inflow are developed. Based on the due date of invoice issued for each customer and payment records of each customer, two scenarios – worst and best – for customers within five time periods are developed. Table 7 shows the two scenarios developed for the cash inflow of the manufacturer in five different time periods for two customers.

![Table 7 Two Scenarios for the Manufacturer’s Cash Inflow](image)

As shown in Table 7, Customer 1 probably pays the invoice on 4th and 15th January as best and worst scenario respectively, while Customer 2 probably pays the invoices on the 6th January as best scenario and 30th January as worst scenario. With the use of Eq. (19) and Table 7, the manufacturer calculates the amount of cash available to the firm on each day within a time period in order to schedule the payments and find the best time to pay the bills as an optimisation variable.

Figure 29 shows the amount of cash available to the manufacturer on each day within the January period based on the two developed scenarios; therefore, the manufacturer can schedule its payments. In fact, based on the amount of cash available in each day of January the manufacturer can optimise the payment. The vertical axis in Figure 29 represents the amount of cash, while the horizontal axis shows the days in January. As can be seen from Figure 29, the manufacturer can see that the firm would have no cash to pay any invoices before 3rd January, while after 15th January $2,000 would be available. Therefore, in the best scenario, the optimum dates for the manufacturer to pay invoices from Suppliers 1 and 2 would be on the 5th and 8th respectively; while in the worst scenario, it would be wise to make the payments a little later on the 15th and 30th respectively.
The aim of the optimisation model is to find out the best time to pay the bills. The same graph could be drawn for other time periods within a time horizon. It also helps manufacturers to distinguish the days in each period on which a firm might face a financial crisis if cash outflow becomes necessary but no funds are available.

Moreover, if the manufacturer has customers with a bad history of paying the invoices, the gap between the best and worst scenarios increases, while the gap decreases as the manufacturer has customers with a better history of paying the invoices. Figure 30 shows the amount of available cash within the days in January period, where the customers have worse history of paying the invoices. As can be seen from Figure 30, a manufacturer should notice there would be cash in the firm to pay invoices on 1st January, while the invoices of Customer 2 may not even be received within January, thus; the payments to the upstream partners could be postponed due to lack of liquidity.
Figure 30 Time and Amount of Available Cash within January for the Customers with Worse Payment History

Comparing Figures 29 and 30 illustrates that the gap between the best and worst scenarios has become wider since the firm has customers with worse payment history, while customers with bad payment history may even mean that a manufacturer fails to receive payment for invoices within the required period. Therefore, the existing gap between the best case and worst case scenarios in the cash inflow is sensitive to the customer’s payment history.

Regarding the manufacturer’s cash flow and with the use of Eq. (81), the maximum amount of manufacturer’s cash flow and the optimum time for paying invoices in every time period under three different scenarios for the cash inflow; best scenario where the cash inflow received earlier than due date, worst scenario where the cash inflow received later than due date and normal scenario where the cash inflow received on due date, are represented in Tables 8, 9 and 10 respectively.

In Tables 8, 9 and 10, $CF$ represents the amount of manufacturer’s cash flow within the different periods while $d'(1)$ and $d'(2)$ represent the optimum time of paying invoices to Suppliers 1 and 2 respectively. In fact, $d'(1)$ and $d'(2)$ are the optimum time of paying the payables to the suppliers within different periods based on the amount of available cash in the firm and time of receiving receivable from the customers in order to have a maximum cash flow in each period.
As can be seen from the above tables, the optimum time of payment in the last two periods, April and May, for all three scenarios is day 1, which means the manufacturer has enough cash in hand from the previous period to pay suppliers’ invoices earlier than the due date in order to get the discounted rate. On the other hand, the results in Tables 8, 9 and 10 illustrate that the optimum time of payment is a relative function of the manufacturer’s cash inflow time, as well as cash in hand and the amount of the penalty added to each invoice.

In order to understand and to compare the manufacturer’s maximum cash flow in different periods under different scenarios, Figure 31 was developed. The vertical axis in Figure 31 illustrates the manufacturer’s cash flow in US dollars, while the horizontal axis represents the time periods. As can be seen from Figure 31, there is little difference between the amounts of cash flow for each time period in the worst, best and normal scenarios.

As can be seen from Figure 31, the amount of the manufacturer’s cash flow in the worst-case scenarios becomes greater than the amount of the manufacturer’s cash flow in the best-case scenario in previous periods, as the firm has enough cash in hand to pay the invoices to its suppliers earlier than the due date, thereby avoiding penalty payments to the suppliers. In addition, it is not always better for a firm to receive
cash from its downstream partners earlier than the due date, although it is better for a firm to receive its own cash inflow with any additional penalties.

![Figure 31 The Maximum Amount of the Manufacturer’s Cash Flow for Different Periods](image)

### 6.2. Effect of Supply Chain Operation on the Manufacturer’s Cash Flow

Regarding the penalty rate as a factor of payment strategy, penalty rate, usually set by the manufacturer at the beginning of each time period, affects the satisfaction of customers, and consequently cash inflow of the manufacturer. However, customers of the manufacturer usually compare the penalty rate in each time period with the penalty rate of the previous period and the penalty rate of competitors. As Table 6 shows, the manufacturer sets the penalty rate to five percent annually throughout all the periods, while the manufacturer can manipulate the penalty rate on each period.

As explained earlier in Section 4.2.1 two scenarios, logarithmic and exponential, are defined to mathematically link customer satisfaction and penalty rate in each time period (Eq. (41) and (42)). To understand and quantify the effect of increasing the penalty rate on the satisfaction level and on the movement of customers, a cascade diagram is developed (Figure 32). Based on the scenarios defined between penalty rate and customer satisfaction, two cascade diagrams are developed in Figure 32: i) the cascade diagram labelled A shows the effects of the penalty rate on customer satisfaction when they’re linked logarithmically, and ii) the cascade diagram labelled B shows the effects of the penalty rate on customer satisfaction when they’re linked exponentially. However, it is assumed that 1 new customer
enters to the firm at each period of time horizon. The logarithmic and exponential relationship as defined in Chapter Four is used to represent how customer satisfaction changes within a period if the penalty rate increases, with the use of Eq. (45) and (47).

Figure 32 Effects of Increasing Penalty Rate on the Level of Satisfaction and Movement of Customers within Five Periods. Cascade Diagram A (Logarithmic) Cascade Diagram B (Exponential)

As can be seen from Figure 32, the satisfaction is 100 percent in the first period, January; thus, all customers are satisfy and move to the next period, while satisfaction decreases through the periods and
drops to zero in May where the penalty rate becomes equal to the competitor’s penalty rate. As satisfaction decreases within the periods, the number of satisfied customers in each period decreases as well. Comparing diagrams A and B in Figure 32 illustrates how customer satisfaction changes and how customers move from one time period to the next due to increasing penalty rates in each period in comparison with the previous period; thus, the manufacturer can quantify the effect of customer satisfaction on cash flow. Whenever the level of customer satisfaction drops to zero, customers prefer to switch to the competitors and do not repeat their purchase from the firm in the next period. However, the level of customer satisfaction does not have any effects on the decision of new customers.

As explained earlier and seen from Figure 32, the exponential relationship between satisfaction and penalty rates shows that increasing the penalty rate is not significant for customers as it doesn’t have a marked effect on their cash flow. Thus, satisfaction does not drop significantly. Conversely, the logarithmic relationship between satisfaction and penalty rates shows that increasing the penalty rate is significant for customer because it has an important effect on their cash flow. Thus, the level of customer satisfaction drops significantly over periods as the penalty rate increases. Moreover, the exponential relationship shows that a small increase in the penalty rate does not change the level of satisfaction considerably; however, significant changes take place in the logarithmic relationship, and this is what the firm needs to have in mind when deciding to increase its penalty rate.

As the level of customer satisfaction is dropped, the amount that customers are going to pay decreases and subsequently the manufacturer’s cash inflow decreases. Tables 11 and 12 represent the effect of different penalty rates on customer satisfaction and consequently on the manufacturer’s cash inflow in different time periods based on the two defined scenarios for the relationship between the penalty rate and customer satisfaction logarithmically and exponentially respectively.

It is assumed that the penalty rate at the beginning of the time horizon, January, is set at 5%, while it is increased in each period by 1% and rises to 9%, equalling the competitor’s penalty rate, in the final period. As explained earlier in Chapter 4, cash inflow in each period is related to customer satisfaction during the previous period. As can be seen from the tables below, the cash inflow in February is equal because of customer satisfaction in January. The cash inflow of the manufacturer at the beginning of the next time horizon, a period after May, is the cash received just from new customers as there are no satisfied customers from the previous period.
Table 11 Customer Satisfaction and Penalty Rate (Logarithmic)

<table>
<thead>
<tr>
<th></th>
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<th>February</th>
<th>March</th>
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<td>$p = 7%$</td>
<td>$p = 8%$</td>
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<td></td>
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<td>$CS = 69%$</td>
<td>$CS = 73%$</td>
<td>$CS = 77%$</td>
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<td></td>
</tr>
<tr>
<td>cash inflow = 5324</td>
<td>cash inflow = 6347</td>
<td>cash inflow = 5539</td>
<td>cash inflow = 2134</td>
<td>cash inflow = 1052</td>
<td></td>
</tr>
</tbody>
</table>

Table 12 Customer Satisfaction and Penalty Rate (Exponential)

<table>
<thead>
<tr>
<th></th>
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<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
</tr>
</thead>
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<td>$p = 5%$</td>
<td>$p = 6%$</td>
<td>$p = 7%$</td>
<td>$p = 8%$</td>
<td>$p = 9%$</td>
<td></td>
</tr>
<tr>
<td>$CS = 100%$</td>
<td>$CS = 82%$</td>
<td>$CS = 85%$</td>
<td>$CS = 87%$</td>
<td>$CS = 0%$</td>
<td></td>
</tr>
<tr>
<td>cash inflow = 5324</td>
<td>cash inflow = 6347</td>
<td>cash inflow = 6555</td>
<td>cash inflow = 2906</td>
<td>cash inflow = 1616</td>
<td></td>
</tr>
</tbody>
</table>

Furthermore, Figure 33 compares the effects of different penalty rates in different time periods on the manufacturer’s cash inflow based on the data represented in Tables 11 and 12 with the scenario where the penalty rate is not changed during the time periods and remains constant within time horizon. The horizontal axis in Figure 33 shows the different penalty rates in different time periods, whereas the vertical axis represents the manufacturer’s cash inflow.

The bar chart in Figure 33 indicates how increasing the penalty rate may decrease the manufacturer’s cash inflow within periods, while, the green line in Figure 33 represents the ‘not changed’ scenario where the penalty rate is fixed during the periods within a time horizon. The “no change” scenario represents the manufacturer’s cash flow when the penalty rate does not change and all customers are satisfied; thus, the manufacturer receives cash inflow as expected. It seems from Figure 33 that keeping the penalty rate constant within the periods improves the firm’s cash inflow, whereas a constant penalty rate across the different periods may encourage customers to pay invoices later and consequently the manufacturer cannot pay cash outflow invoices when due. Thus, the manufacturer’s cash flow is affected.
The penalty is applicable whenever the amount of invoices is received or paid after their due date. It is assumed that all customers pay the amount of invoices after the due date; thus, the optimum penalty rate is found by solving the model in GAMS tools. If customers pay their invoices on the latest possible date in February, the optimum penalty rate is 5% for that time, while the optimum penalty rate when invoices are paid on the latest possible date in March is 9%.

However, in order to find out the level of the optimum penalty rate, it is assumed that customers pay their invoices as late as possible during all of the time periods. The GAMS results show that the optimum penalty rate for January, February, March, April and May is 6%, 7%, 8%, 8% and 9% respectively. In order to understand the effect of the optimum penalty rate on a manufacturer’s cash flow, the manufacturing company’s cash flow when the optimum penalty rate is applied is compared with its cash flow when the penalty rate is constant within periods. Figure 34 represents the manufacturer’s cash inflow with a constant penalty rate and with an optimum penalty rate when the receivables from customers arrive on the latest date possible.

The vertical axis in Figure 34 represents the cash inflow of the manufacturer, whereas the horizontal axis shows the different time periods. Figure 34 shows how applying the optimum penalty rate improves a manufacturer’s cash inflow. The optimum penalty rate in each period is a relative function of the time and number of invoices due from each customer in that period and the amount of cash expected to be received from them in the near future.
Regarding the demand variation and order fulfilment, the relationship between demand variation and customer satisfaction as explained earlier in Eq. (49) is linear. As the customers’ demand in each period increases and this increase is not met by the manufacturer, the level of customer satisfaction changes. Figure 35 represents the effect of increasing customers’ demand on customer satisfaction within five different time periods.

The vertical axis in Figure 35 shows the level of customer satisfaction ranging from 0 to 1, while the horizontal axis represents the rate of increased customer demand which is not fulfilled by the manufacturer. As can be seen from Figure 35, customer satisfaction changes significantly in those periods with higher expected cash inflow. When customer demand increased by 70%, the level of customer satisfaction dropped to 0.74 in March when the firm was supposed to have the most cash inflow. However, the level of customer satisfaction drops to 0.93 in May, when the firm is supposed to have the least cash inflow. Therefore, accurate customer demand forecasting is important especially at times when firms expect to have higher cash inflow.
In order to investigate the effect of increasing customers’ demand on the manufacturer cash inflow within five different time periods with the use of Eq. (42) two different scenarios: i) the forecasted demand and the actual demand are equal and ii) the actual demand is greater than the forecasted demand are defined. Figure 36 compares the manufacturer’s cash inflow within five different periods where 30% increasing actual demand is not met by the manufacturer. The vertical axis as labelled represents the manufacturer’s cash inflow, while the horizontal axis shows five time periods. The bar chart in Figure 36 represents the manufacturer’s cash inflow when the actual demand, \( RD \), is balanced with the forecasted demand, \( ED \), while the blue line shows the manufacturer’s cash inflow when the actual demand increases 30%. As can be seen from Figure 36, whenever the \( RD \) and \( ED \) are in equilibrium, the manufacturer will receive the full amount of inflow from its own customers in each period; however, as soon as customers’ demand increases in each period and this increase leads satisfaction to decrease, the manufacturer’s cash inflow decreases in the next period.

Figure 35 Effect of Increasing Customers’ Demand on Customer Satisfaction
On the other hand, variations in demand affect not only a manufacturing company’s cash inflow but also its cash outflow through storage costs as explained in Section 4.1.1. Figure 37 shows the effect of demand variation on the manufacturer’s cash flow by comparing the expected customer demand and actual customer demand in different periods when it may either increase or decrease by 10%.

Figure 37 shows how overestimation or underestimation of customer demand decreases a manufacturer’s cash flow within different periods. As can be seen from Figure 37, which illustrates an overestimation of customer demand, the expected demand becomes greater than actual demand, and decreases the manufacturer’s cash flow significantly through the imposition of storage costs in comparison with the impact of underestimating customer demand on the manufacturer’s cash flow.

The effect of customer demand on the manufacturer’s cash flow is calculated using Eq. (30) and (49) respectively. As can be seen from Figure 37, the effect of overestimation and underestimation of customer demand on the manufacturer’s cash flow increases significantly period by period when the variation moves toward the end of the time horizon. Moreover, the overestimation of customer demand affects the manufacturer’s cash flow significantly in comparison with the effect of an underestimation of customer demand.
Regarding manufacturers’ delivery times, whenever a manufacturing company prepares its products earlier than expected in each time period, the products have to be stored; thus, the cash flow decreases. Figure 38 represents the effect of early preparation of a product on the manufacturer’s cash flow within five different time periods by adding the effects of storage costs using Eq. (34).

The vertical axis in Figure 38 represents the manufacturer’s cash flow, while the horizontal axis represents the number of days the products are prepared earlier than expected. Regardless of the relationship between the delivery time and customer satisfaction, early preparation of the product affects the manufacturer’s cash flow because of the storage costs. As can be seen from Figure 38, the amount of cash applied because of storage cost is related to the amount of cash income expected in each period.
Apart from the manufacturer delivery time, supplier delivery time also affects the manufacturer’s cash flow as explained earlier in Section 4.1.2. As explained in Figure 27 the manufacturer has two suppliers, therefore; whenever one supplier delivers the materials with a delay, the other materials have to be stored until all materials are received. The storage cost created by the supplier delivery time is formulated in Eq. (33). Table 13 represents the amount of storage cost that has to be applied by the manufacturer for the materials delivered with a delay from Supplier 1 and 2. The first column, green column, in the Table 13 shows the number of days Supplier 1 delivers the materials with delay, while Supplier 2 delivers on time, whereas the blue rows show the number of days Supplier 2 delivers the materials with delay, while Supplier 1 delivers on time.

Table 13 Storage Cost Created by the Supplier Delivery Time

<table>
<thead>
<tr>
<th>Supplier 1</th>
<th>Supplier 2 Delay on Delivery (day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Delay on Delivery (day)</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>297.2</td>
</tr>
<tr>
<td>3</td>
<td>668.7</td>
</tr>
<tr>
<td>5</td>
<td>1040.2</td>
</tr>
</tbody>
</table>
As can be seen from Table 13, storage costs increase as inequality between suppliers’ delivery times increases. When both suppliers deliver the materials with five days’ delay, no storage cost is applied by the manufacturer, but when one supplier delivers the material on time and the other one has a five-day delay, a storage cost of $1,040.20 has to be applied.

The relationship between customer satisfaction and product delivery time could be linear, exponential or logarithmic depending on the product importance for the customers, as explained earlier in Eq. (50). However, late delivery of a product to customers affects the level of customer satisfaction and consequently the manufacturer’s cash flow. In order to investigate the effect of late delivery on a manufacturer’s cash flow, it is assumed that all products are delivered to the customers late and that this delay happens in every period. The effect on a manufacturer’s cash inflow of delivering products five days late within different time periods based on the different relationships defined between satisfaction and delivery time is represented in Figure 39. Figure 39 compares the effect of delivering on time with the impact of delivering products five days late when the relationship between customer satisfaction and delivery time is linear, exponential and logarithmic. The vertical axis in Figure 39 represents the manufacturer’s cash inflow, while the horizontal axis shows the periods of time. Comparing the line graph with the bar charts in Figure 39 illustrates how late delivery decreases the manufacturer’s cash inflow in different scenarios.

Figure 39 Effect of 5 Days Late Delivery on the Manufacturer’s Cash Inflow within Different Time Periods

![Figure 39 Effect of 5 Days Late Delivery on the Manufacturer’s Cash Inflow within Different Time Periods](image-url)
As can be seen from Figure 39, the rate of decrease of the manufacturer’s cash inflow in each period for late delivery depends on the level of customer satisfaction in the previous period, the average amount expected from each customer in each period and the importance of the product to the customers. Moreover, the rate of decrease of the manufacturer’s cash inflow increases period by period, which means the manufacturer’s cash inflow drops significantly in the final period of the time horizon. Based on the data represented in Figure 39, the manufacturing company needs to try to deliver products which are very important to customers on time as this has a significant effect on the manufacturer’s cash inflow.

As explained in Figure 17, the time taken to deliver products to customers consists of the suppliers’ delivery time, as well as time taken for production, and the manufacturer’s delivery time. The manufacturer’s delivery time can weaken or strengthen the effect of suppliers’ delivery time on the manufacturer’s cash flow with early or late preparation of products. Therefore, the manufacturer can set its own delivery time in order to have a better cash flow. Figure 40 shows the effect of the manufacturer’s and Supplier 1’s delivery time on the manufacturer's cash flow in the January period. The vertical axis in Figure 40 represents the manufacturer’s cash flow in January, while the horizontal axis shows the deviation of the manufacturer's delivery time from the due date.

Figure 40 Effects of the Manufacturer’s and the Suppliers’ Delivery Time on the Manufacturer’s Cash flow in January
As can be seen from Figure 40, whenever the manufacturer receives the products from Supplier 1 with three days’ delay and the manufacturer can prepare the products three days earlier than expected, which means shortening the production process, the manufacturer achieves a better cash flow. On the other hand, when Supplier 1’s delivery time is -3, the manufacturer’s delivery time should be 0 to have a better cash flow. In fact, this graph helps the manufacturer to choose the best strategy for its delivery time based on Supplier 1’s delivery time in order to increase cash flow. As can be seen from Figure 40, when the manufacturer receives the products from Supplier 1 earlier than expected, creating a negative delivery time, it would be better for the manufacturer to prepare the product on time to achieve a better cash flow.

However, to improve the level of customer satisfaction dropped because of late delivery and increase the number of satisfied customers, the manufacturer can apply a customer discount. As explained earlier in Section 4.2.3, Eq. (52-57), customer discounts not only improve the level of customer satisfaction but also affect the cash flow of the firm, Eq. (58). Customer discounts as a mechanism to improve cash flow should be optimised based on the number of days the products are delivered late in each time period.

Table 14 represents the customer discount rate applied by the manufacturer within periods to improve customer satisfaction levels which have fallen because of late delivery of products to the customers. As can be seen, the customer discount rate has been applied based on the number of days the products are delivered late and this rate does not relate to the relationship between customer satisfaction and delivery time. When the products are delivered 10 days late, regardless of the relationship formulated between delay and customer satisfaction, a 2.4% customer discount should be applied to improve the level of cash inflow.

<table>
<thead>
<tr>
<th>Number of Days Delay</th>
<th>Customer Discount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.24%</td>
</tr>
<tr>
<td>5</td>
<td>1.2%</td>
</tr>
<tr>
<td>10</td>
<td>2.4%</td>
</tr>
<tr>
<td>15</td>
<td>3.6%</td>
</tr>
</tbody>
</table>

Figure 41 compares the manufacturer’s cash inflow with or without applying the customer discount within all time periods when the products are delivered 10 days late to the customer, when the relationship between satisfaction and delivery time is exponential. The vertical axis in Figure 41
represents the manufacturer’s cash inflow, while the horizontal axis represents the time periods. Figure 41 shows how a customer discount improves the amount of manufacturer’s cash inflow when delivery is 10 days late in all periods and how the firm’s overall cash inflow improved after applying a customer discount, at times when customer satisfaction is exponentially related to the delivery time.

![Figure 41 Manufacturer’s Cash Inflow With/Without Applying Customer Discount](image)

**6.2.1. Merger and Acquisition**

In the following section, the financial performance of the manufacturer in the mentioned supply chain before and after vertical and horizontal merger is evaluated. To study merger and acquisition, two supply chains working in the same industry are defined. The first supply chain is as explained earlier, while the second one includes Supplier 2, Manufacturer 2 and Customer 2. Figure 42 represents the two supply chains and the ways they are merged together to form a vertical and horizontal merger. The section named A shows the vertical merger, whereas the section signified by B represents the horizontal merger. Figure 42 represents the two supply chains and the ways they are merged together to form a vertical and horizontal merger. The section named A shows the vertical merger, whereas the section signified by B represents the horizontal merger.
To evaluate the financial performance of the manufacturer after a vertical and horizontal merger, financial metrics such as Gross Profit Margin (GPM), Current Ratio (CR) and Cash flow are used. Moreover, the effect of demand variation and delivery time, as cause of logistic bullwhip, and finally customer satisfaction on the manufacturer’s cash flow is studied, while the values before and after merger are compared. To evaluate the effect of merger and acquisition on the manufacturer 1’s cash flow just external cash flow, the cash flows between supply chain partners, is considered and the internal cash flow, the flow of cash between manufacturer 1 and supplier 1 after merging vertically, is not considered. In order to evaluate the merger and acquisition especially horizontal merger, a cascade diagram represents the aggregated cash flow of Manufacturer 2 in supply chain 2 within different time period is developed (Figure 43).

Figure 43 Aggregated Cash Flow of Manufacturer 2 in Supply Chain 2
As can be seen from Figure 43, Manufacturer 2 receives a payment for an invoice from a customer and has to pay the amount of one invoice to a supplier. In fact, Figure 43 graphically represents the face value and the expected time of receiving and paying the value of each invoice for Manufacturer 2 within five time periods. The production capacity of Manufacturer 2 to produce smartphones is set to 100 units annually.

To assess the performance of the merger, from Manufacturer 1 points of view, all financial metrics before merger are studied and compared with values after merger within five time periods. The value for the GPM and CR are calculated through Eq. (59) and (60) respectively. Table 15 represents the values of the financial metrics for Manufacturer 1 before and after merging with other firms within five months. The value of GPM, CR and cash flow for the Manufacturer 1 before merger are compared with the value of GPM, CR and cash flow for the Manufacturer 1 after vertical merger, merging with Supplier 1, and horizontal merger, merging with Manufacturer 2. The data in Table 15 illustrates the financial metrics, GPM and CR, of the manufacturer do not change significantly after horizontal merger in comparison before horizontal merger; thus, the financial performance of manufacture may not improve after horizontal merger.

Table 15 Financial Metrics before and after Merger within 5 Months

<table>
<thead>
<tr>
<th>Financial Metrics</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer’s GPM before merger</td>
<td>23.6%</td>
<td>23.6%</td>
<td>23.6%</td>
<td>23.6%</td>
<td>23.6%</td>
</tr>
<tr>
<td>Manufacturer’s GPM after horizontal merger</td>
<td>24.09%</td>
<td>23.92%</td>
<td>24.05%</td>
<td>24.16%</td>
<td>24.13%</td>
</tr>
<tr>
<td>Manufacturer’s GPM after vertical merger</td>
<td>45%</td>
<td>45%</td>
<td>45%</td>
<td>45%</td>
<td>45%</td>
</tr>
<tr>
<td>Manufacturer’s CR before merger</td>
<td>1.27</td>
<td>1.5</td>
<td>1.73</td>
<td>2.68</td>
<td>4.03</td>
</tr>
<tr>
<td>Manufacturer’s CR after horizontal merger</td>
<td>1.28</td>
<td>1.58</td>
<td>1.74</td>
<td>2.54</td>
<td>3.91</td>
</tr>
<tr>
<td>Manufacturer’s CR after vertical merger</td>
<td>1.79</td>
<td>2.46</td>
<td>3.05</td>
<td>5.7</td>
<td>9.7</td>
</tr>
<tr>
<td>Manufacturer’s Cash flow before merger</td>
<td>1154.9</td>
<td>2524</td>
<td>4468</td>
<td>5438</td>
<td>6108</td>
</tr>
<tr>
<td>Manufacturer’s Cash flow after horizontal merger</td>
<td>1771</td>
<td>3629</td>
<td>6480</td>
<td>8105</td>
<td>9192</td>
</tr>
<tr>
<td>Manufacturer’s Cash flow after vertical merger</td>
<td>1649</td>
<td>4273</td>
<td>7897</td>
<td>10349</td>
<td>11858</td>
</tr>
</tbody>
</table>

Regarding cash flow, the manufacturer’s cash flow increased after horizontal and vertical mergers. The increasing cash flow after a horizontal merger is related to a rise in the number of customers and consequently cash inflow (Eq. (75)), while increasing cash flow after a vertical merger is related to
reducing the number of suppliers and accordingly cash outflow (Eq. (69)). Unlike the horizontal merger, a huge jump can be seen from Table 15 in all metrics after a vertical merger; thus, the financial health of the business is improved allowing it to meet its financial obligations. Moreover, the financial performance of the manufacturer after a vertical merger improves period by period. A vertical merger can therefore help a manufacturer to increase financial performance.

Regarding the demand variation, whenever the customers increase their demand and the manufacturer cannot meet the excess demand, actual demand becomes greater than the expected demand, customer satisfaction drops based on the relationship defined between customer satisfaction and demand variation as explained in Eq. (50). Table 16 represents the effect of demand variation on customer satisfaction of the manufacturer in March. In fact, Table 16 compares the effect of demand variation on the level of customer satisfaction before and after horizontal and vertical merger.

<table>
<thead>
<tr>
<th>Demand Variation</th>
<th>Customer Satisfaction before merger</th>
<th>Customer Satisfaction after VM</th>
<th>Customer Satisfaction after HM</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>0.95</td>
<td>0.95</td>
<td>0.96</td>
</tr>
<tr>
<td>20%</td>
<td>0.91</td>
<td>0.91</td>
<td>0.93</td>
</tr>
<tr>
<td>30%</td>
<td>0.87</td>
<td>0.87</td>
<td>0.9</td>
</tr>
<tr>
<td>40%</td>
<td>0.82</td>
<td>0.82</td>
<td>0.87</td>
</tr>
<tr>
<td>50%</td>
<td>0.75</td>
<td>0.75</td>
<td>0.84</td>
</tr>
</tbody>
</table>

As can be seen from Table 16, a vertical merger does not necessarily affect the number of customers buying from the manufacturer; so the effect of demand variations on customer satisfaction after a vertical merger is equal to the effect of demand variations on customer satisfaction before such a merger. On the other hand, a horizontal merger increases not only the number of customers purchasing from the manufacturer, but also the production capacity of the manufacturer; thus, the effect of demand variations on customer satisfaction becomes more marked as presented by Eq. (80).

However, variations in demand affect the cash flow of the manufacturer not only through customer satisfaction but also through storage costs. Therefore, in order to understand the effect of variations in demand on the manufacturer’s cash flow, Eq. (30) and Eq. (50) are considered at the same time. Figure 44 shows the manufacturer’s cash flow and customers’ demand variation before and after merger within.
February. The vertical axis in Figure 44 represents the manufacturer’s cash flow in dollar, while the horizontal axis represents the customers' demand variation in percentage.

As can be seen from Figure 44, whenever customer demand decreased by 50%, the manufacturer’s cash flow dropped significantly due to the storage costs; therefore decreasing customer demand significantly affects the manufacturer’s cash flow, especially after a horizontal merger in which the number of customers increases. As can be seen from Figure 44, the effect of increased customer demand on the manufacturer’s cash flow improves after a horizontal merger. However, the rate of decrease of the manufacturer’s cash flow because of the increased variation in demand in a vertical merger is a bit greater than in a horizontal merger.

![Figure 44 Manufacturer’s Cash Flow and Customers’ Demand Variation Before and After Merger](image)

Regarding the delivery time, as explained in Section 4.1.2, delivery time affects the manufacturer’s cash inflow by changing customer satisfaction and cash outflow by the storage cost. Generally speaking, when the products provide earlier than expected; the manufacturer has to store the products, while late preparation and delivery leads customer dissatisfaction and consequently the manufacturer’s cash inflow decreases.

To understand the effect of delivery time on the manufacturer’s cash flow, especially comparing the effect of merger and acquisition, three scenarios are defined: i) the effect of suppliers’ delivery time on the manufacturer’s cash flow when the products are delivered to the customers on time, ii) the effect of
suppliers’ delivery time on the manufacturer’s cash flow when the products are delivered to the customers late, and iii) the effect of the manufacturer’s delivery time on the cash flow when Suppliers 1 and 2 deliver the products on time. Generally, any inequality between suppliers’ delivery time forces the manufacturer to store the materials received earlier.

In order to evaluate the effects of early delivery by a supplier on the manufacturer’s cash flow Eq. (32) and (33) are used. Table 17 shows the effect of suppliers’ delivery times on the manufacturer’s cash flow in January. The blue column in Table 17 shows the number of days Supplier 1 delivers the materials early, when Supplier 2 delivers on time, whereas the green row shows the number of days Supplier 2 delivers the materials earlier, when Supplier 1 delivers on time.

<table>
<thead>
<tr>
<th>Supplier 1 early preparation (day)</th>
<th>Supplier 2 early preparation (day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1154</td>
</tr>
<tr>
<td>-1</td>
<td>876</td>
</tr>
<tr>
<td>-3</td>
<td>504</td>
</tr>
<tr>
<td>-5</td>
<td>133</td>
</tr>
</tbody>
</table>

As can be seen from Table 17, whenever there is an inequality between suppliers’ delivery times, the manufacturer has to pay the storage cost to cover the inequality between suppliers’ delivery times as well as the storage costs for the early preparation of the final products. However, after a vertical merger putting the manufacturer together with Supplier 1, the number of suppliers providing materials decreases; therefore, the probability of inequality between suppliers’ delivery times decreases and then just the highlighted area of the graph applies in describing the manufacturer’s cash flow.

However, suppliers’ delivery time has the same effect on the manufacturer’s cash flow before and after a horizontal merger since there could be an inequality between suppliers’ delivery time. Figure 45 compares the effects of Supplier 2’s delivery time on the manufacturer’s cash flow before and after horizontal and vertical merger for the February period. The vertical axis in Figure 45 shows the manufacturer’s cash flow, whereas the horizontal axis shows the supplier’s delivery time.
Delayed delivery of products to customers because of late delivery of materials from Supplier 2 affects the manufacturer’s cash flow not only by causing customer dissatisfaction but also in additional storage costs, because of the inequality between suppliers’ delivery times before and after a horizontal merger; while after a vertical merger the manufacturer’s cash flow is affected only by customer dissatisfaction. As can be seen from Figure 45, a vertical merger significantly improves the effect of supplier delivery time on the manufacturer’s cash flow by removing problems of inequality between suppliers’ delivery times.

Apart from the suppliers’ delivery time, the effect of the manufacturer’s delivery time on cash flow before and after a vertical or horizontal merger is presented in Figure 46. The vertical axis in Figure 46 represents the manufacturer’s cash flow in February, while the horizontal axis represents the manufacturer’s delivery time. The relationship between delivery time and satisfaction is considered linear. As can be seen from Figure 46, the effect of positive manufacturer’s delivery time on the manufacturer’s cash flow significantly improves in comparison with the effect of positive Supplier 2’s delivery time presented in Figure 45 before merger and after a horizontal merger. However, a vertical merger improves the effect of supplier delivery time on the manufacturer’s cash flow, but it does not significantly affect the manufacturer’s delivery time.

Figure 45 Supplier Delivery Time and Manufacturer’s Cash Flow Before and After Merger
Comparing Figure 45 and 46 shows that a vertical merger can help the manufacturer to improve the problem of suppliers’ delivery times, while a horizontal merger does not significantly improve the delivery time of either manufacturer or suppliers and has no impact on the manufacturer’s cash flow.

When the manufacturer in the supply chain is faced with a supplier’s delivery time, whether early or late, the manufacturer can adjust its own delivery time in order to reduce the effect of delivery time on its cash flow. The time taken to deliver products to customers consists of delivery time of suppliers, time of production and delivery time of the manufacturer as explained in Figure 17. Therefore, the manufacturer can set its own delivery time based on the supplier delivery time in order to improve cash flow. Figure 47 represents the aggregate effect of manufacturer and Supplier 2’s delivery time on the cash flow of the manufacturer before and after a merger. Figure 47 helps the manufacturer to set its delivery time based on Supplier 2’s delivery time in order to achieve a better cash flow.

The vertical axis in Figure 47 represents the manufacturer’s cash flow in the February period, while the horizontal axis shows the deviation of the manufacturer’s delivery time from the due date. The bar chart in Figure 47 shows Supplier 2’s delivery time before merger, whereas the line graph represents Supplier 2’s delivery time after a vertical merger and the line graphs with dashes represent Supplier 2’s delivery time after a horizontal merger.
As can be seen from Figure 47, when Supplier 2 delivers the products five days earlier than the expected, the manufacturer can set its own delivery time to 0 (on time delivery) to have a better cash flow before and after horizontal merger. On the other hand, after a vertical merger the manufacturer can set its delivery time to five days (prepare with five days delay) to have a better cash flow.

6.3. Conclusion

In this chapter, a mathematical model developed for the firm’s cash flow within a supply chain is tested by developing a numerical example. First of all, a supply chain consisting of partners working together to produce smartphones is considered and a cash flow model is tested from the manufacturer’s point of view. Secondly, the effect of demand variation and delivery time on the manufacturer’s cash flow is tested and evaluated. Finally, the financial performance of the manufacturer when it is merged with a supplier as a vertical merger, or with a competitor as a horizontal merger, is tested.

Regarding the manufacturer’s cash flow, the optimum time of the manufacturer’s payment is related to the manufacturer’s cash inflow, cash in hand and the penalty rate applied to each invoice. On the other hand, the optimum penalty rate in each period is a relative function of time, the number of invoices due to
be received from customers in each period, and the amount of cash expected to be received from the customers in the following periods. Moreover, customer discounts as a mechanism to improve the level of customer satisfaction have to be optimised based on the number of days the products are delivered late. However, the customer discount is not related to the formulated relationship of delivery time and customer satisfaction. In fact, the optimum customer discount is calculated using the GAMS software based on the number of days the products are delivered late regardless of any exponential, logarithmic or linear relationship defined between delivery time and customer satisfaction.

The financial metrics GPM and CR, applicable to the manufacturer, do not improve significantly after a horizontal merger, while there is a huge jump in all metrics after a vertical merger in comparison with the pre-merger figures. By contrast, horizontal mergers increase the number of customers purchasing from the manufacturer as well as the production capacity of the firm; thus, the effect of demand variation on customer satisfaction is strengthened. For its part, a vertical merger enhances the effect of a supplier’s delivery time on the manufacturer’s cash flow.
Chapter Seven

Case Study

In this chapter, a case study is developed to verify the mathematical cash flow model developed for a firm in a supply chain. The cash flow model is tested with real data from the viewpoint of an Iranian manufacturer working in the home appliance industry. The effect of customer demand variation on the Pars Company’s cash flow is also tested. Regarding mergers and acquisitions, data from a competitor and a supplier of the Pars Company is used to verify the effect of horizontal and vertical mergers.

7.0. Introduction

In this chapter, an Iranian company in the home appliance industry within a supply chain is introduced. Then the effects of the supply chain operation, namely demand variation, delivery time and customer satisfaction on the financial performance of a firm are tested using real data from the company in the supply chain. Regarding the mergers and acquisitions, the effects of a horizontal merger on the financial performance of the firm are investigated, while due to the lack of information from the suppliers, just the effect of supplier delivery time on the manufacturer’s cash flow is investigated.

The company Pars was established on 1975 as a limited company cooperating with partners in the home appliance industry to produce and to deliver different home appliance products to retailers or final customers. Different types of products such as air coolers, vacuum cleaners, washing machines and refrigerators are produced by the Pars Company. The Pars Company is in relation to around 200 local suppliers who supply materials and 600 customers as distributors or retailers. However, two major suppliers provide most materials for the Pars Company and also four main retailers as the biggest customers of Pars Company are represented in Figure 48 as a supply chain of Pars Company.

Figure 48 Pars Company Supply Chain
The main office of the company is located in Tehran, while the factory of the Pars Company is founded in the industrial park in Qazvin. The retailers and suppliers are located in different areas of Iran as shown in Figure 49. As shown in Figure 49, the yellow markers mark the location of the two main suppliers, the green marker represents the main office of the company, the pink marker shows the location of the Pars Company’s factory and the red markers represent the retailers of Pars. Blue lines in Figure 49 represent the cash outflow from Pars, i.e. the amount of cash which goes to the suppliers for provided materials, while the red lines show the cash inflow to Pars, i.e. the amount of cash which comes from the retailers for delivered products.

![Figure 49 Location of Pars Partners across Iran](image)

In order to understand and evaluate the cash flow of Pars, first of all a time horizon consisting of different time periods covering all cash inflow and outflow for the firm is defined. In this case, Pars defines a year as a time horizon for the cash flow. However, the Pars Company divides the time horizon into four smaller units as time periods. Each time period is a quarter of a year consisting of three months when the products are sold and produced based on customers’ demand.

Regarding the customers’ demand, Pars has a prediction of the customers’ requirements to produce different types of product in each period. Table 18 represents the Pars’ prediction of customers’ demand in each quarter based on different products. As it is apparent from Table 18, the Pars Company predicts that it will produce a total of 200,000 units of different products in 2014, while it is predicted that most customers’ demands will occur in quarter 4. Regardless of the prediction in each period, some units of
unsold products are remaining from the previous period, thus the manufacturer has to pay a storage cost to store them. In this case, a total of 16,218 unsold products are remaining from the previous year in storage.

Table 18 Customers’ Forecasted Demand in Each Quarter

<table>
<thead>
<tr>
<th>Product</th>
<th>Quarter 1</th>
<th>Quarter 2</th>
<th>Quarter 3</th>
<th>Quarter 4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerator</td>
<td>32,560</td>
<td>35,900</td>
<td>35,810</td>
<td>35,730</td>
<td>140,000</td>
</tr>
<tr>
<td>Washing Machine</td>
<td>5,910</td>
<td>7,540</td>
<td>8,320</td>
<td>8,230</td>
<td>30,000</td>
</tr>
<tr>
<td>Vacuum Cleaner</td>
<td>3,600</td>
<td>7,200</td>
<td>9,000</td>
<td>10,200</td>
<td>30,000</td>
</tr>
<tr>
<td>Total</td>
<td>42,070</td>
<td>50,640</td>
<td>53,130</td>
<td>54,160</td>
<td>200,000</td>
</tr>
</tbody>
</table>

Clearly, the number of products sold within the four time periods is not usually same as the number of product that they forecast to produce; thus, the number of unsold and remaining products from the previous period forces the manufacturer to pay a storage cost in each period. Table 19 represents the quantity of sold and unsold products and the amount that the manufacturer has to pay for storing the unsold products within different time periods. As it is apparent from Table 19, in quarter 4 the number of sold products becomes greater than the number of products produced, which means the excess sold products have to be provided from the remaining products from the previous periods.

Table 19 Sold, Unsold Products and the Storage Cost

<table>
<thead>
<tr>
<th>Time period</th>
<th>Quantity sold</th>
<th>Number of unsold products</th>
<th>Remaining products at the end of period</th>
<th>Storage cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarter 1</td>
<td>35620</td>
<td>6450</td>
<td>22668</td>
<td>104,649</td>
</tr>
<tr>
<td>Quarter 2</td>
<td>50540</td>
<td>100</td>
<td>22768</td>
<td>105,069</td>
</tr>
<tr>
<td>Quarter 3</td>
<td>51420</td>
<td>1710</td>
<td>24478</td>
<td>112,251</td>
</tr>
<tr>
<td>Quarter 4</td>
<td>67550</td>
<td>-13390</td>
<td>11088</td>
<td>56,013</td>
</tr>
<tr>
<td>Total</td>
<td>205130</td>
<td>11088</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To understand the cash flow of the Pars Company, a cascade diagram is developed for the four time periods based on the firm’s prediction to maximize the cash flow in each period. The diagram includes the manufacturer’s cash inflow, i.e. the cash which comes from the amount of sales, and cash outflow which consist of the cost of the products and the storage cost for the unsold products within the four different time periods. Figure 50 represents a cascade diagram for the Pars Company’s cash flow which occurred within four different time periods during the time horizon. The right hand side of the cascade diagram, red arrows, shows the manufacturer’s payables or cash outflow, while the left hand side, green arrows, illustrates the manufacturer’s receivables or cash inflow. As can be seen from Figure 50, the cash outflow
consists of the cost of raw materials which has to be paid to the suppliers and the storage cost for storing the unsold products, while cash inflow is the amount of cash received from customers. Moreover, the initial amount of cash in the first quarter is the manufacturer’s profit in the previous year after tax and deductions. Based on the initial cash coming from the previous period, cash inflow and cash outflow, the amount of cash flow in each period is calculated and represented in Figure 50. The manufacturer can have a negative cash flow in some periods to have a maximum cash flow at the end of the time horizon.

![Figure 50 Pars Company’s Cash Flow within Four Different Time Periods](image)

To evaluate the financial performance of the Pars Company, the financial metric the gross profit margin and current ratio for the firm can be calculated through Eq. (59) and (60) based on the information given by Pars Company.
The effects of demand variation on the Pars Company’s cash flow within different quarters with the use of Eq. (30) and Eq. (49) are represented in Figure 51. The vertical axis in Figure 51 represents the Pars Company cash flow, while the horizontal axis shows the quarters as time periods. The bar graphs in Figure 51 show the different demand variations, whereas the line graph depicts the situation when there are no changes in customer demand. As can be seen from Figure 51, when there are no changes in customer demand, the Pars cash flow decreases as unsold products force the manufacturer to pay the price of storing them, whilst at the same time the effect of customer dissatisfaction is reduced. Increasing customer demand by 10% improves the cash flow of the Pars company as this increase is fulfilled by the unsold products left over from the previous period, while decreasing customer demand significantly affects cash flow negatively due to the storage cost.

![Figure 51 Demand Variation and Pars Cash Flow](image)

As can be seen from Figure 51, the results do not exactly match the details presented in Figure 37 because of the storage cost paid by the company to keep some products as reserve or safety stock. This storage has
a good effect on the manufacturer’s cash flow when customer demand increases, but it has a negative effect when customer demand decreases.

Regarding delivery times, the delivery time created by the suppliers affects the Pars Company cash flow by changing customer satisfaction and imposing a storage cost based on Eq. (33) and Eq. (50). Figure 52 represents the effect of suppliers’ delivery times on the Pars Company cash flow within four time periods. The vertical axis shows Pars’ cash flow, whereas the horizontal axis represents the numbers of days the materials were delivered later or earlier than their due date from the supplier. As can be seen from Figure 52, late delivery of materials from the supplier affects the Pars Company cash flow significantly as customer satisfaction decreases. However, the relationship between satisfaction and delivery time is considered linear. Early delivery of materials also affects cash flow through increased storage costs. Data in Figure 52 shows the Pars Company could have financial problems in quarters 3 and 4 as cash flow significantly drops; therefore, the firm may need funds from external sources in order to pay its bills.

![Figure 52 Manufacturer’s Cash Flow and Supplier Delivery Time](image)

Vertical merger can be evaluated by merging Pars Company with one of its suppliers, the CBAS Company. In order to study the effect of vertical merger on the financial performance of the Pars Company, the effects of supplier’s delivery time is studied. CBAS, which produces a line of specified galvanized sheets for used in the automotive and home appliance industry, is located in Dashtesefid in the province of Chaharmahal and Bakhtiari. The production capacity of this industrial unit is estimated at 400
thousand tons per year. The Pars Company occupies only 0.24% of CBAS’s market. Due to lack of information from CBAS, it is not possible to evaluate the vertical merger in more detail. Therefore, just the effect of the supplier’s delivery time on the manufacturer’s cash flow is studied. Figure 53 represents the vertical merger of the Pars Company with CBAS.

Figure 53 Vertical Merger of Pars Company

Figure 54 represents the effect of the supplier delivery time on the Pars Company’s cash flow after a vertical merger within four different periods. The vertical axis in Figure 54 represents the Pars Company cash flow after vertical merger, while horizontal axis shows the supplier delivery time.

Figure 54 Effect of Supplier Delivery Time on the Pars Cash Flow After a Vertical Merger
As can be seen from Figure 54 when compared with Figure 52, the cash flow of Pars improves after a vertical merger when the supplier provides materials either earlier or later than the expected date. When the suppliers deliver the materials earlier than the expected date in the case of a vertical merger, the amount that the manufacturer needs to pay for storage decreases; thus, the cash flow improves. On the other hand, when suppliers deliver the materials later than expected after a vertical merger, the cash flow decreases because of customer dissatisfaction; however, the manufacturer’s cash flow improves as the amount needed to pay for storage decreases. The results of Figure 54 can be compared with results shown in Chapter 6, Figure 45. In both Figures the cash flow improves after a vertical merger.

In order to consider horizontal merger, a company as a competitor of Pars Company working in the same industry needs to be considered. There is company named Pars Khazar working in the field of home appliances and producing products such as cooling products, cookers, vacuum cleaner and so on. Like Pars Company, Pars Khazar also has a prediction of customers’ demand during the year. Table 20 compares the Pars Khazar prediction of the customers’ requirements for different products in a year with sold products.

Table 20 Pars Khazar Prediction of the Customers’ Requirements

<table>
<thead>
<tr>
<th>Product</th>
<th>Year 2014 (produced)</th>
<th>Year 2014 (sold)</th>
<th>Unsold products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerators</td>
<td>330,000</td>
<td>271,814</td>
<td>58,186</td>
</tr>
<tr>
<td>Vacuum cleaners and cookers</td>
<td>490,000</td>
<td>373,939</td>
<td>116,061</td>
</tr>
<tr>
<td>Other</td>
<td>45,000</td>
<td>16,332</td>
<td>28,668</td>
</tr>
<tr>
<td>Total</td>
<td>865,000</td>
<td>662,085</td>
<td>202,915</td>
</tr>
</tbody>
</table>

The overall capacity of the firm to produce the products within a year is 890,000 products. Apart from the amount of products produced in each period, a total of 155,415 unsold products are remaining from the previous year in storage. However, based on the information provided by the Pars Khazar Company, the gross profit margin and current ratio can be calculated as below.

\[
GPM = \frac{1605039 - 1364283}{1605039} = 0.15
\]

\[
CR = \frac{2294631}{1885340} = 1.21
\]

Figure 55 represents the horizontal merger between the Pars and Pars Khazar Company. In fact, Figure 55 shows the supply chains of Pars and Pars Khazar Company with partners after forming horizontal merger.
Clearly, the new entity created due to the horizontal merger has more suppliers and customers in comparison with before the merger.

In order to evaluate the financial performance of firm after horizontal merger, financial metrics such as gross profit margin and current ratio of the manufacturer after merger is calculated using Eq. (59) and Eq.(60).

\[
GPM_{HM} = \frac{1668099 + 1861401 - 1551646 - 1406170}{1668099 + 1861401} = 0.162
\]

\[
CR_{HM} = \frac{2638378 + 2294631}{2597858 + 1885340} = 1.1
\]

Comparing the results of GPM and CR after a horizontal merger with the results beforehand illustrates that the GPM and CR do not change significantly after the horizontal merger, as explained in Chapter 6.

Merging two manufacturers, Pars and Pars Khazar, horizontally improves the effect of customer satisfaction on cash flow as the production capacity of the new entity is increased. The overall production capacity of the new firm after a horizontal merger is about 1,190,000 units within a year. However, in order to show the effect of a horizontal merger on the firm’s cash flow due to the demand variation, the effect of increased customer demand on the Pars Company’s cash flow before and after a merger is compared. Table 21 represents customer satisfaction with the Pars Company when customer demands are changed within four different time periods before a horizontal merger. However, in order to represent the effect of increasing customer demand on the firm’s cash flow after horizontal merger, Table 22 was developed.
After the horizontal merger and forming of the new entity, since the capacity of production increases, the sensitivity of customer satisfaction to the customers’ demand decreases.

Comparing the results of Tables 21 and 22 shows how satisfaction improves after a horizontal merger. This happens because of increasing the manufacturer’s capacity and also increasing the amount of remaining products stored in storage from the previous periods. These results also prove the results represented in Chapter 6.

### 7.1. Conclusion

In this chapter, a case study is proposed using the data taken from the Iranian companies in order to test and validate the cash flow model. The effect of variations in customer demand and delivery time on the cash flow of the Pars Company working in the home appliance industry is tested. Also, the effect of suppliers’ delivery times on the cash flow of Pars, during the period of a vertical merger with CBAS, is represented. Finally, the financial performance of the Pars Company, when it is merged with Pars Khazar as a horizontal merger, is tested.

Regarding cash flow, the firm has a negative cash flow in some periods, while a maximum cash flow takes place at the end of the time horizon. The financial performance indicators of the firm, GPM and CR, do not change significantly after the horizontal merger, but the effects of demand variation on customer satisfaction improve as the production capacity of the new firm increases. Although the increased cost of storing some products decreases the cash flow of the firm, this has the added effect of increasing demand variation on cash flow. Regarding the suppliers’ delivery times, when the suppliers
provide materials either earlier or later than expected, the manufacturer’s cash flow improves after a vertical merger.
Chapter Eight

Summary, Conclusion and Future work

8.0. Summary

The studies that have been reviewed in the literature, in Chapter 2, researching the cash flow of a firm in the supply chain, the “bullwhip effect” in the supply chain as a result of product flow, customer satisfaction measurement methods and techniques and mergers and acquisitions (M&A), illustrate the need for further research regarding payment strategies, supply chain operation and concomitantly the financial performance of a firm in a supply chain.

Reviewing the available literature on cash flow illustrates that there is no aggregated cash flow model for a firm in a supply chain to calculate not only cash inflow and outflow but also the effect of product flow. On the other hand, most previous research focuses on the causes of the “logistic bullwhip” effect and do not model its effects on the financial performance of a firm. There is no mathematical model to measure and quantify customer satisfaction based on the operation of a firm in a supply chain. Regarding mergers and acquisitions, the previous research mostly focuses on the effects of mergers and acquisitions on the financial performance of the firm, while the effects of “M&A” on supply chain operations, such as delivery time and demand variation, have not been studied properly. Finally, no payment strategies have been defined for a firm in the supply chain to improve its financial performance by modelling the effects of the supply chain operation.

Therefore, the main aim of this research is to propose a payment strategy to improve the financial performance of a firm in a supply chain by evaluating the effects of the supply chain operation including demand variation, delivery time, customer satisfaction and horizontal and vertical integration on the company’s financial performance. In other words, this study focuses on the cash flow management/optimisation within a firm and goes further to consider its supply chain.

In this PhD thesis, an optimisation mathematical model to maximise the firm’s cash flow within a time horizon by prioritising the payment of invoices and optimising payment strategies has been devised. Firstly, in order to propose a cash flow model and consequently to improve the financial performance of a firm in a supply chain, a diagram representing the firm’s cash flow is developed and a mathematical model for the firm’s cash inflow and outflow is formulated accordingly. The effect of the supply chain operation, demand variation and delivery time, on the cash flow of the firm in a supply chain is mathematically modelled. In addition, a new method of measuring and quantifying customer satisfaction
to improve the financial performance of the firm is proposed as part of this thesis. Finally, the effects of vertical and horizontal integration within the supply chain partners on the supply chain operation and also on the financial performance of a firm are studied.

8.1. Conclusion

A firm in a supply chain generates invoices for each customer in accordance with the different payment strategy attributes that companies can manipulate, and these can be taken as variables for the purposes of optimisation. They include:

i) Putting in place a penalty rate or discount rate to penalise and encourage customers respectively

ii) Taking steps to secure order fulfilment and the quality of deliveries (not quality of products) as well as the quantity of products that a firm can provide in each period to fulfil customers’ demand, and

iii) Ensuring the setting of a clear date for products to be delivered to the customer.

These payment strategy attributes affect the financial performance of a firm by changing the level of customer satisfaction or through the imposition of additional costs such as those necessary for extra storage. A mathematical model is developed to maximise the firm’s cash flow by optimising the attributes of the payment strategy in each period.

The accomplishments of the thesis obtained from analysis and model development are summarized as follows:

- Regarding cash inflow, the existing gap between best-case and worst-case scenarios is sensitive to the customers’ history: those with bad credit who might have difficulty paying invoices cause the gap to increase; thus, a firm might be forced to delay payments to its upstream partners and this gap will be increased through the supply chain

- A firm in a supply chain needs to schedule and prioritize its payments in order to improve cash flow, while the optimum time of payment is a relative function of the company’s weighted average cost of capital to the amount of penalty applied on each invoice.

- A penalty rate that is too low encourages customers to pay invoices at the last minute, while too high a penalty rate leaves customers dissatisfied. Therefore, the optimum penalty rate in each period is
related to the time and number of invoices received from customers in each period, the amount of
cash expected to be received in forthcoming periods and also the competitors’ penalty rates.

➢ To receive the maximum cash inflow from customers in each period, the firm should have the
maximum number of satisfied customers, since the cash inflow of a firm in each time period is
directly linked to the level of satisfaction and number of satisfied customer in the previous period.

➢ Customer satisfaction is defined as a dependent variable of three payment strategy parameters:
penalty rate, demand fulfilment and delivery time.

  o The exponential relationship between penalty rate and customer satisfaction
  shows that increasing the penalty rate does not significantly affect the firm’s
cash inflow, as cash inflow received from some customers doesn’t have a
significant effect on the firm’s overall cash inflow, whereas the logarithmic
relationship shows that increasing the penalty rate is important for the firm since
cash inflow received from some customers has a significant effect on the firm’s
overall cash inflow.

  o In order to reduce the effect of customer dissatisfaction on a firm’s cash inflow
  if the company has failed to meet its customers’ demands, some products need
to be stored, along with others kept as safety stock to guarantee the fulfilment of
customers’ demands. However, the level of safety stock needs to be optimised
for each period.

  o The relationship between customer satisfaction and delivery time in the
  “partially satisfied” area is defined as exponential for less important products,
linear for important products and logarithmic for very important products. The
level of product importance is defined from the customer’s point of view
because the products have a significant effect on a company’s cash flow and the
production process.

➢ Customer discounts as a course of action to improve the level of customer satisfaction after late
delivery of products have to be optimised in each of the time periods. The optimum level of customer
discount has been applied based on the number of days that the products are delivered late, and the
level is not related to the defined relationship between customer satisfaction and delivery time.
The effect of an upstream partner’s delivery time on the cash flow of a downstream partner can weaken or be made stronger by partners downstream adjusting their delivery time. In fact, a firm can set its own delivery time based on the upstream delivery timetable in order to have a better cash flow.

Regarding horizontal and vertical integration, gross profit margin (GPM) and current ratio (CR) do not improve significantly after a horizontal merger, while a huge jump happens in both metrics after a vertical merger in comparison with those before the merger.

The effect of an overestimation of customer demands on the financial performance of a firm increases after a horizontal merger because of the increased number of customers, while the effect of an underestimation of customer demands on their level of satisfaction and consequently on the financial performance of a firm improves after a horizontal merger as the production capacity of the new, larger firm rises.

The effect of an upstream partner’s delivery time on a firm’s cash flow diminishes after a vertical merger, while the number of suppliers decreases; however, a horizontal merger does not significantly improve a firm’s cash flow whether delivery time is set by manufacturer or suppliers.

8.2. Future work

This thesis offers various possibilities for further research. In the following section, some of these possibilities for future work are presented as below:

8.2.1. Cash Flow Expansion

Although the payment strategy is developed to improve the financial performance of a firm through considering as the flow of cash to the upstream and downstream partners; however, the cash flow of a firm can be expanded by considering the inventory cost in each period, long term loan, dividend and taxation.

Regarding the supplier delivery time, suppliers can be penalised for late delivery of products as a course of action to compensate the introduced cost to the firm due to the late delivery, while too high a penalty rate may lead the supplier to become dissatisfied; thus, it has to be optimised in each period to improve the financial performance of a firm. Also, safety stock as a mechanism to improve the effect of underestimation of customers’ demand on the financial performance of the firm has to be optimised in each time period. Moreover, a payment strategy for a firm in a worldwide supply chain with more partners and competitors with different currencies can be proposed to improve financial performance.
8.2.2. Customer Satisfaction Expansion

The effect of customer satisfaction on the financial performance of a firm was investigated when the external customers, i.e. the downstream partners, are satisfied in each time period, whilst the satisfaction of external customers is related to the satisfaction of internal customers who work for the firm; thus, to model customer satisfaction properly, the satisfaction of internal customers should be considered as well.

Moreover, the satisfaction of customers can be related to more parameters such as quality of products, services and price of the product; thus, a mathematical model has to be developed for customer satisfaction considering more parameters. In addition, the effect of customer satisfaction on the financial performance of a firm can be modelled based on the share of each customer in the firm’s market.

8.2.3. Merger and Acquisition

Regarding mergers and acquisitions within a supply chain, an optimisation mathematical model can be developed to improve the financial performance of firms after merger within different time periods and also to find out the best type of merger for a firm to expand its business and improve its financial performance. In addition, the bargaining power of suppliers and customers needs to be considered to improve the financial performance of a firm after merger and acquisition. Finally, the financial performance of the firm when it is merged with an unrelated firm in a different industry as a conglomerate merger can be studied.
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Mathematical Notations

\( t_n \) Period of time

\( i \in I \) Set of receivable invoices

\( j \in J \) Set of payable invoices

\( IN(t_n) \) Overall input of a firm in period \( t_n \)

\( OUT(t_n) \) Overall output of a firm in period \( t_n \)

\( CF(t_n) \) Cash flow of a firm in period \( t_n \)

\( a(t_n, i) \) Amount of cash received from the customer \( i \) at period \( t_n \)

\( b(t_n, j) \) Amount of cash paid to the supplier \( j \) at period \( t_n \)

\( du(t_n, i) \) Due date of invoice \( i \) at period \( t_n \)

\( p(t_n) \) Daily penalty rate for cash inflow at period \( t_n \)

\( v(t_n) \) Daily discount rate for cash inflow at period \( t_n \)

\( s(t_n, i) \) Time of generating invoice \( i \) at period \( t_n \)

\( d(t_n, i) \) Time of receiving invoice \( i \) at period \( t_n \)

\( T(t_n) \) End of period \( t_n \)

\( r \) Daily interest rate

\( PV(t_n, i) \) Present value of receivable invoice \( i \) at period \( t_n \)

\( FV(t_n, i) \) The face value of invoice \( i \) at period \( t_n \)

\( PV'(t_n, j) \) Present value of payable invoice \( j \) at period \( t_n \)

\( FV'(t_n, j) \) The face value of invoice \( j \) at period \( t_n \)

\( s'(tn, j) \) Generating time of invoice \( j \) at period \( t_n \)
\(du'(tn,j)\)  Due date of invoice \(j\) at period \(tn\)

\(p'(tn)\)  Daily penalty rate for cash outflow at period \(tn\)

\(v'(tn)\)  Daily discount rate for cash outflow at period \(tn\)

\(d'(tn,j)\)  Time of paying invoice \(j\) at period \(tn\)

\(cash(tn,j)\)  Available cash at the time of paying invoice \(j\) at period \(tn\)

\(A(tn,\beta)\)  Total amount of available cash in the firm in the time \(\beta\) at period \(tn\)

\(\beta\)  Smaller units of time in each period

\(y(tn,i)\)  Binary variable to show whether the issued invoice \(i\) is paid on or before the time \(\beta\) or not

\(u(tn,i)\)  A binary variable to show invoice \(i\) needs to be paid once during the period \(tn\)

\(u'(tn,j)\)  A binary variable to show invoice \(j\) needs to be paid once during the period \(tn\)

\(w(tn,j,i)\)  A binary variable to distinguish the invoice \(i\) has been received or not at the time of paying invoice \(j\) at period \(tn\)

\(\lambda(tn,j,j')\)  A binary variable to show that at the time of paying invoice \(j\) at period \(tn\) the invoice \(j'\) has been paid or not

\(ST'(tn)\)  Present value of the storage cost in period \(tn\) for overestimation of demand

\(T'(tn)\)  Promised time of delivering products to the customers at period \(tn\)

\(TT'(tn)\)  Actual time of delivering products to the customers at period \(tn\)

\(h\)  Overhead costs or unit cost during a period

\(dd\)  Holding cost per product

\(ED(tn,i)\)  Forecasted demand of customer \(i\) at period \(tn\)

\(RD(tn,i)\)  Real demand of customer \(i\) at period \(tn\)

\(d_{sm}(tn)\)  Expected time of delivering all materials from the suppliers at period \(tn\)
\begin{align*}
\text{\(d_m(tn)\)} & \quad \text{Expected time of production at period \(tn\)} \\
\text{\(d_{mc}(tn)\)} & \quad \text{Expected time of delivering the products to the customers at period \(tn\)} \\
\text{\(d_s(tn,j)\)} & \quad \text{Expected time of delivering raw materials from supplier \(j\) at period \(tn\)} \\
\text{\(ST(tn)\)} & \quad \text{Present value storage cost at period \(tn\) for delivery products from suppliers} \\
\text{\(qq(tn,j)\)} & \quad \text{Quantity of products received from the supplier \(j\) at period \(tn\)} \\
\text{\(q'(tn)\)} & \quad \text{The amount of unsold product which has to be stored in period \(tn\)} \\
\text{\(Rd_s(tn,j)\)} & \quad \text{Real time of delivering materials from the supplier \(j\) at period \(tn\)} \\
\text{\(Rd_{sm}(tn)\)} & \quad \text{Real time of delivering materials to the manufacturer at period \(tn\)} \\
\text{\(ST''(tn)\)} & \quad \text{Present value of the storage cost at period \(tn\) for delivery products to the customers} \\
\text{\(C_{\text{new}}(tn)\)} & \quad \text{Number of new customers entering the firm at period \(tn\)} \\
\text{\(C_{\text{dis}}(tn)\)} & \quad \text{Number of dissatisfied customers leaving the firm at period \(tn\)} \\
\text{\(C(tn)\)} & \quad \text{Number of satisfied customers at period \(tn\)} \\
\text{\(N\)} & \quad \text{Numbers of customer at the beginning of time horizon} \\
\text{\(CS(tn)\)} & \quad \text{Customer satisfaction at period \(tn\)} \\
\text{\(\theta(tn)\)} & \quad \text{Amounts received from the new customers in period \(tn\)} \\
\text{\(AVGIn(tn)\)} & \quad \text{Average amount of cash expected to be received at period \(tn\)} \\
\text{\(CS_{\text{penalty}}(tn)\)} & \quad \text{Customer satisfaction based on penalty rate at period \(tn\)} \\
\text{\(p'(tn)\)} & \quad \text{Penalty rate of the competitor at period \(tn\)} \\
\text{\(a', b', a, b\)} & \quad \text{Scaling Parameters to put the satisfaction level in the proper area} \\
\text{\(a''(tn), b''(tn), a'''(tn), b'''(tn)\)} & \quad \text{Scaling Parameters to put the satisfaction level in the proper area at period \(tn\)}
\end{align*}
$CS_{demand}(tn)$  Customer satisfaction based on demand at period $tn$

$Capacity$  Production capacity of a firm

$CS_{delivery}(tn)$  Customer satisfaction based on delivery at period $tn$

$\lambda$  Range of products

$FV(tn)$  Expected future value of products at period $tn$

$FV'(tn)$  Future value of product at period $tn$ on the actual time of delivery

$x(tn)$  Customer discount at period $tn$

$B(tn)$  The overall face value of the products sold at period $tn$

$D(tn)$  New delivery time after applying discount

$\alpha(tn)$  Binary variable to show whether the customer discount needs to be applied or not at period $tn$

$k' \in K'$  Set of all suppliers in the supply chain after a horizontal merger

$k \in K$  Set of all customers after a horizontal merger

$GPM$  Gross profit Margin

$S$  Sales of firm

$CGS$  Cost of goods sale

$CR$  Current Ratio

$CA$  Current assets

$CL$  Current liabilities