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Innovative Services of Financial Warehousing – Influence of Power within Supply Chain and Multi-product Portfolio for Pledge Financial Performance

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Abstract — This study examines multi-item product inventories as a pledge subject, and proposes a quantitative model to manage multi-item product values and cash flows; thus, enabling enterprises to obtain optimal profits, and maximizing financial loans from financial institutions. It is also possible to use the proposed model to create an optimal financing solution for a small business firm from the company's inventory database. This study shows that a company's supply chain determines the optimal financing situation. When a company is small, its power of inference within supply chain is small; this could delay accounts payable and accounts receivable. These delays cause short-term funding shortages in small and medium enterprises (SMEs), which directly affect operations. Power of inference within supply chain allows companies to apply small inventory changes and high-value multi-product inventories to optimize profits and maximize loans when performing financial warehousing. Therefore, this study proposes a multi-item product financial-warehousing quantitative model for financial institutions, SMEs, and third-party logistics enterprises. The model accounts for three aspects of service innovation, and is essential for profitability.

Keywords— Financial warehousing, third-party logistics, inventory pledge, power of influence

1. INTRODUCTION

Most of Taiwanese companies are small and medium enterprises (SMEs). SMEs are important for Taiwanese economic development. However, liquidity shortages disrupt SME operations. Therefore, SMEs must borrow money from financial institutions. Lau *et al*., (2002) introduced financial warehousing as a method of borrowing money from financial institutions. Financial warehousing is a newly developed concept that combines conventional inventory management and accounting principles. A third-party logistics company can affect the fairness of the financial warehousing process. It synthesizes a logistics service platform and develops public warehousing for inventory pledges, distribution, and accessing inventory values using (Radio Frequency Identification (RFID) technology, warehousing information systems, and inventory flow monitoring for financial institutions to promote financial warehousing. Previously, financial institutions provided several financing channels to SMEs. However, because SMEs are small and lack capital, they cannot provide sufficient collateral (such as, real estate or equipment) to financial institutions. SMEs also have commodity-circulation purchasing accounting because of several products in their inventories, resulting in large payable accounts. In addition, insufficient sales channels result in slow inventory sales and delayed payments. If the accounts payable period occurs after purchasing and storage row material and is shorter than the accounts receivable period after sale product inventory, then the financing gap occurs (Fig. 1). This means that SMEs cannot access short-term funds, and have operational difficulties.

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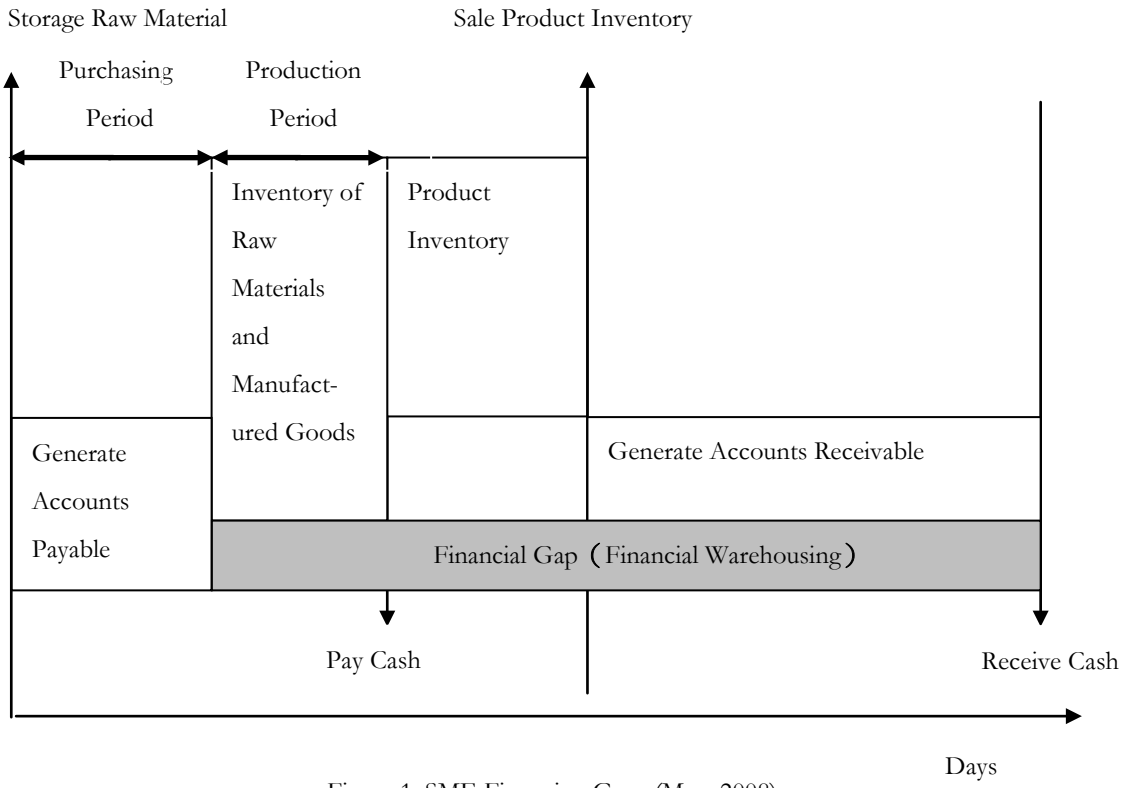

Figure 1. SME Financing Gaps (Mao, 2008)

Financial warehousing can resolve capital shortage problems (Lee, 2007). Before proceeding to financial warehousing, financial institutions must establish inventory valuation mechanisms, including fair valuation of inventories, price volatility, and inventory risk. Financial institutions aim to decrease financial risk and SME cash flow problems, which increase bad debts. Financial institutions, however, are unfamiliar with SME inventories and business structures. Thus, third-party logistics enterprises assist financial institutions in valuing inventories. Therefore, the selection of third-party logistics enterprises is important to financial institutions.

Figure 2 shows financial warehousing relationships between SMEs, financial institutions, and third-party logistics enterprises. By using inventory as collateral, SMEs apply for loans from financial institutions, and store their products in third-party logistics enterprise warehouses. Third-party logistics enterprises provide SME inventory valuations and risk assessment certificates to financial institutions for loan applications. Therefore, this study explores these relationships, and assumes that SMEs are willing to participate in financial warehousing, and store their inventories in third-party logistics enterprise warehouses. To accept appropriate risks, financial institutions review various risk assessment certificates provided by third-party logistics enterprises.

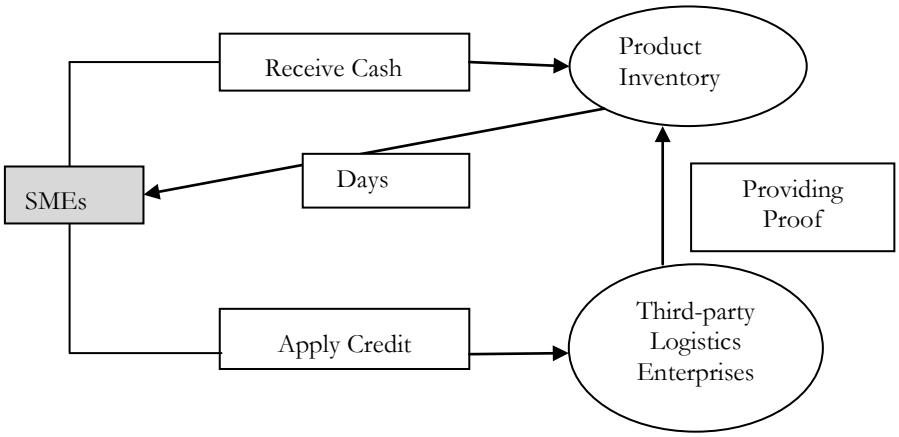

Figure 2. Financial warehousing relationships (Wang, 2007)

Logistics financing refers to the combination of goods circulation and constrained cash flow. Third-party logistics enterprises are important for logistics financing. Logistics financing means that third-party logistics enterprises provide ogistics service. They offer SMEs logistics, insurance, guarantees, asset-based financing, risk assessments, inventory

financing, inventory control, consulting services, and other services. Therefore, logistics services reflect financial innovation. Logistics financing refers to SMEs that use third-party logistics services to stock products and finance receivable accounts (Mao, 2008).

Logistics is the foundation for protecting funds. Cash flow determines the status of logistics activities and the locative efficiency of social resources and economic activities. The globalization of logistics also requires financial services innovation (Zhun, 2007). Logistics financing research has focused on asset-based financing and inventory financing. Buzacott and Zhang (2004) analyzed inventory management under asset-based financing and integrated asset-based financing into production decision-making. CFA (2001) held a seminar on inventory financing for the Commercial Finance Association (CFA), and produced a report on inventory financing. It identified the types of inventory financing that CFA members used most often and strategies and ideas for promoting inventory financing. Holdren and Hollingshead (1999) analyzed the integration of inventory control problems, financial management, and commercial lending, and proposed that the type of inventory management affects company operational costs. Loan officers from financial institutions can confirm the risks and benefits of inventory financing based on different inventory types. Carpenter *et al*., (1998) examined financing constraints to explain the importance of cyclical inventory investments.

Financial warehousing integrates financing, material flow, and logistics warehousing to manage and coordinate these variables. Financial warehousing logistics services represent banks to supervise assets, and provide financing and other bundling services for enterprises (Lau *et al*., 2002). Financial warehousing is a funds circulation service formed by third-party logistics enterprises that receive financing from financial institutions through pledging (Chang, 2007). Financial warehousing includes logistics, financial, brokerage, and risk management services; therefore, financial warehousing services typically target SMEs. Third-party logistics is based on moving stored products, and provides an integrated platform for credit, reengineering, distribution, electronic commerce, and traditional business models for SMEs.

Financial institutions offer SMEs many types of financing in Taiwan. SMEs consider their short- or long-term financing requirements to select portfolios to maintain operations. However, few studies have examined domestic logistics financing. The most common logistics financing approaches are asset-based financing, inventory financing, and warehouse financing. In Taiwan, asset-based financing is primarily used by financial institutions; inventory and warehouse financing services are rarely used. Studies have shown that asset-based financing benefits banks and enterprises. Enterprise decisions are affected when financing institutions set financing limits (Buzacott and Zhang, 2004). When an asset is used to measure an enterprise's asset-value, financial institutions set the most appropriate multipliers for reducing loan risks (Cossin and Hricko, 2003).

Most loans in Taiwan are collateral-based but most SMEs have few fixed assets to use as loan collateral. Therefore, for these SMEs, unfixed assets, such as inventory, warehouse receipts, accounts payable, and accounts receivable, often account for a large proportion of their total assets. Therefore, financial warehousing provides services for small business loans. The actual financing requirements of SMEs can introduce a financial innovation service model. Financial institutions support up and downstream supply chains to establish corporate financial transaction models. For SME up and downstream supply chains, accounts receivable and prepaid accounts pay for product mortgage financing to cover funding gaps and credit shortages. In China, financial institutions have designed accounts receivable and inventory-confirming warehouse models (Wang, 2007). Studies have found that when enterprises face insufficient funds, it affects the performance of the enterprise and of other enterprises in the supply chain, including logistics, cash flow, and information-flow performance (Yun, 2008).

Studies have also explored financial warehousing models. When dealers face financial constraints, they use financial warehousing services and trade credit models. This could benefit dealers and upstream manufacturers, reduce the impact of financial constraints on firm performance, and improve earnings (Yun, 2008). Leora (2006) studied inventory financing research based on SME financial warehousing models in the supply chain. Gonzalo *et al*., (2006) examined short-term supply chain management production and the finance plans of enterprises. They proposed that reasonable supply chain management affects business operations and financial intermediation, and thereby, increases overall revenue.

Inter-firm power often plays a critical role in the supply chain. Maloni and Benton's (1999) research seeks to expose the detrimental and beneficial effects of power on the ability to build integrated, high performance buyer-supplier relationships. This research highlights the need for power awareness and promotes the benefit of effective power management. Supply chain integration efforts have tended to be driven more by issues of power and control rather than mutual, win-win intentions. Industry-wide cost-cutting efforts have instigated manufacturer consolidation, further elevating the degree of power asymmetry in the industry and thus, placing more pressure on suppliers to yield to influence of power. This research's findings may be summarized with four key theses:

(1) Power plays a significant role in the supply chain, and the different sources of power have contrasting effects upon inter-firm relationships in the chain. Thus, both the power source and the power target must be able to recognize the presence of power, and reconcile supply chain strategy for power influences.
(2) A stronger buyer-supplier relationship will enhance performance throughout the chain. This offers validation for the pursuit of supply chain integration as a key driver of corporate strategy and promotes the need for a better understanding of the integration process.

(3) Exploitation of the supply chain by the power partner may lead to dissention and under performance, thus hurting the power holder. Likewise, a judicious use of power may serve to benefit the power holder.
(4) Influences of power on the buyer-supplier relationship and subsequent effects of this relationship upon supply chain performance expose the potential of power as a tool to promote integration of the chain and empower higher levels of performance. This performance benefit incites the power holders to take a second look at their positioning of power within supply chain strategy and urges a more conscious, considerate use of power.

2. FINANCIAL MODEL FOR FINANCIAL WAREHOUSING OF LOGISTICS

Based on inventory value, this study develops a quantitative model that accounts for cash flow constraints. This study refers to relevant literature and considers that SMEs may store different products simultaneously to maximize financial benefits. Thus, this study modifies a single-item warehouse model by Mao (2008) to a multi-item warehouse model and establishes a multi-item inventory model and cash flow model for SMEs. The models were coded in Delphi, linked to ActiveX Data Objects (ADO), and accessed inventory management databases. The models were used to maximize financing by optimizing inventory product combinations and enhancing SME profits.

2.1 Summarized Balance Sheet

To simplify SME financing methods, a summarized balance sheet was used instead of an account sheet (Buzacott and Zhang, 2004). This is shown in Table 1.

2.2 Objective Function

The objective function is defined as:

$$\text{Max} \sum_{k=1}^{N} \left(\frac{\sum_{t=0}^{T} \pi_{kt}}{T_k} \right), \tag{1}$$

where $t : t = 0, 1, ..., T$, with the initial condition $t = 0$,
$k : k = 1, 2, ..., N$, item k for third-party logistics,
T : length of the planned period,
k : number of SME items during the planned period,
T_k : The k-item of third party logistics in the length of planned period of T,
π_{kt} : SME profit for item k during period t,

Table 1. Summarized balance sheet (Buzacott and Zhang, 2004)

Accounts	Variables
Assets	Cash flow (X_{total})
	Accounts receivable (Y_{total})
	Inventories ($I_{total,t}^{Fg}$)
Liabilities	Net finance (W_{total})
	Accounts Payable (Z_{total})
Owners'equity	Profits (π_{total})

Note:
$X_{total,\,t}$: summarized SME cash flow during period t,
$Y_{total,\,t}$: summarized SME accounts receivable during period t,
$I_{total,t}^{Fg}$: summarized SME inventory value during period t,
W_{total} : summarized SME net finance during period t,
Z_{total} : summarized SME accounts payable during period t, and
π_{total} : summarized SME profits during period t.

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2.3 Inventory Value Model

Define the parameters of inventory value model and balance conditions (or constraints) for objective function as follows:

u_{ktj} : item *k* bought during period *t*, and used in period *j*, $t \leq j$

v_{kti} : item *k* bought during period *i*, and used in period *t*, $i \leq t$

Q_{kt} : amount of *k* purchased during period *t*,

D_{kt} : demand for item *k* during period *t*,

O_{kt} : shortage of item *k* during period *t*,

I_{kt} : inventory value of item *k* during period *t*,

c_{kt} : unit cost of item *k* during period *t*, and

$p_{k(t-1)}$: average sales price of item *k* during period *t*-1.

(a) The basic inventory model

Based on variable u_{ktj} definitions, represents item *k* bought during period *t*, and is used in period *j* ($t \leq j$.). Variable v_{kit} represents item *k* bought during period *i* and used in period *t* ($i \leq t$). Because the two indexed periods are equal (Fig. 3), Equation (2) remains true. The inventory treatment was adapted to the first-in first-out method.

$$u_{ktj} = v_{kit}, \tag{2}$$

$$Q_{k3} = u_{k33} + u_{k34} + u_{k35} + \ldots\ldots\ldots + u_{k3(T-1)} + u_{k3T}$$

$$D_{k3} = v_{k13} + v_{k23} + v_{k33} + O_{k3}$$

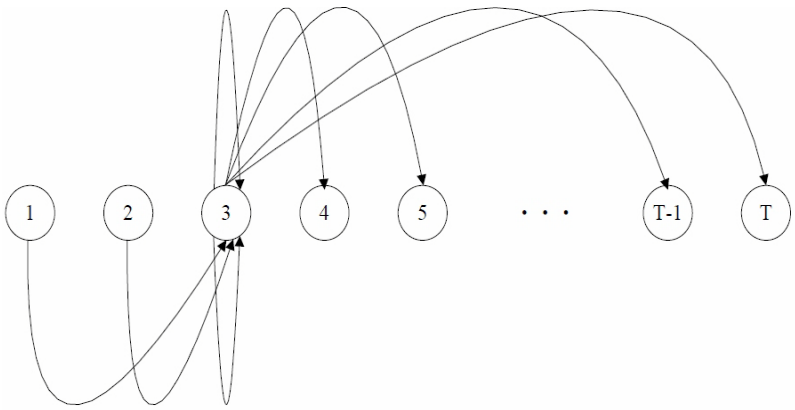

Figure 3. The Basic Inventory Single-item Model (Mao, 2008)

(b) Order Quantity

Furthermore, based on the total order amount for all products equals to the summation of individual product *t* buying in the period *t*, and will use for period *t*, *t* +1, …, T , $t \leq j$, and formed by Equation (3).

$$Q_{total,\ t} = \sum_{k=1}^{N} Q_{kt} = \sum_{k=1}^{N} \sum_{j=t}^{T} u_{ktj}\ , \tag{3}$$

(c) Demand

In addition, the demand for all products equals to the summation of individual product *t* buying in the period *t*, *t* +1, …, T , $t \leq j$, and will use for period *t*, plus the amount of individual product *k* in the period *t* cannot meet the shortage, where period 0 is the initial inventory $i \leq t$ and formed by Equation (4).

$$D_{total,\ t} = \sum_{k=1}^{N} D_{kt} = \sum_{k=1}^{N} \sum_{i=0}^{t} v_{kit} + \sum_{k=1}^{N} O_{kt}\ , \tag{4}$$

(d) Inventory value

In the inventory model, third-party logistics companies and financial institutions measure the collateral value of SMEs. In this study, the inventory value of N products equals the sum of the inventory values of individual product k. This also equals the sum of the inventory values of product k during period t -1 and the purchasing price multiplied by the ordered quantity of product k during period t, minus the sum of the purchasing price multiplied by the ordered quantity of product k bought during period i = 1, 2, ..., t - 1 and used in period t. This produces Equation (5).

$$I_{total,\ t}^{FG} = \sum_{k=1}^{N} I_{kt} = \sum_{k=1}^{N} I_{k(t-1)} + \sum_{k=1}^{N} \sum_{j=t}^{T} (c_{kt} \times u_{ktj}) - \sum_{k=1}^{N} \sum_{i=0}^{t} (c_{ki} \times v_{kit}) \tag{5}$$

2.4 Cash Flow Model

The parameters and variables of cost flow model are defined as follows:

m : period that SMEs deferred supplier loans,

n: period that retailers deferred SME loans,

$h_{(t-i)}$: inventory cost multiplier (%) of holding (or carrying) costs for period t - i

α : financial institution loan interest rates

α' : financial institution deposit interest rates

γ_1 : financial institution accounts receivable financing multiplier,

γ_2 : financial institution product inventory financing multiplier,

$b_{total,\ t}$: the total loans of SME during period t,

b_{kt} : the loans of SME for item k during period t,

l_{kt} : SME repayments for item k during period t,

W_{kt} : SME net financing for item k during period t,

$A_{total,\ t}$: SME loan interest expenses during period t,

$A'_{total,t}$: SME interest income from all cash deposits during period t,

Y_{kt} : SME accounts receivable financing loan for item k during period t, and

Z_{kt} : SME accounts payable for item k during period t.

(a) Cash flow

Financial warehousing exists to remedy cash flow gaps caused by delays between accounts received and accounts paid. If a party defers its loans or repayments, this also causes cash flow gaps. Therefore, this study applies different cash flow models resulting from loan or repayment delays. All capital equals the summed value of individual product k in period t. Financial warehousing cash flow results in different supply chain effects in relevant industries based on firm size. This study focuses on different periods between accounts receivable, n and accounts payable, m. Three types of cash flow models $n < m$, $n = m$ and $n > m$ were designed based on different firm sizes, producing Equations (6) to (12).

- If $n < m$.

$$X_{total,\ t} = \sum_{k=1}^{N} X_{k(t-1)} + \sum_{k=1}^{N} (b_{kt} - l_{kt}) - \sum_{k=1}^{N} \sum_{i=0}^{t} (h_{k(t-i)} \times c_{ki} \times v_{kit}) + (A'_{total,\ t} - A_{total,\ t}) \tag{6}$$

where t =1, 2, …, n and k = 1, 2, …, N. Or

$$X_{total,\ t} = \sum_{k=1}^{N} X_{k(t-1)} + \sum_{k=1}^{N} (b_{kt} - l_{kt}) + \sum_{k=1}^{N} \sum_{i=0}^{t-n} (p_{k(t-n)} \times v_{ki(t-n)}) - \sum_{k=1}^{N} \sum_{i=0}^{t} (h_{k(t-i)} \times c_{ki} \times v_{kit}) + (A'_{total,\ t} - A_{total,\ t}) \tag{7}$$

where t = n + 1, n +2, …, m ; k = 1, 2, …, N. Or

$$X_{total,\ t} = \sum_{k=1}^{N} X_{k(t-1)} + \sum_{k=1}^{N}(b_{kt} - l_{kt}) + \sum_{k=1}^{N}\sum_{i=0}^{t-n}(p_{k(t-n)} \times v_{ki(t-n)}) - \sum_{k=1}^{N}\sum_{j=t-m}^{T}(c_{k(t-m)} \times u_{k(t-m)j})$$
$$-\sum_{k=1}^{N}\sum_{i=0}^{t}(h_{k(t-i)} \times c_{ki} \times v_{kit}) + (A'_{total,\ t} - A_{total,\ t}) \quad (8)$$

where $t = m + 1, m + 2, \ldots, T$ ； $k = 1, 2, \ldots, N$.

- If $n = m$:

$$X_{total,\ t} = \sum_{k=1}^{N} X_{k(t-1)} + \sum_{k=1}^{N}(b_{kt} - l_{kt}) - \sum_{k=1}^{N}\sum_{i=0}^{t}(h_{k(t-i)} \times c_{ki} \times v_{kit}) + (A'_{total,\ t} - A_{total,\ t}) \quad (9)$$

$$X_{total,\ t} = \sum_{k=1}^{N} X_{k(t-1)} + \sum_{k=1}^{N}(b_{kt} - l_{kt}) + \sum_{k=1}^{N}\sum_{i=0}^{t-n}(p_{k(t-n)} \times v_{ki(t-n)}) - \sum_{k=1}^{N}\sum_{j=t-m}^{T}(c_{k(t-m)} \times u_{k(t-m)j})$$
$$-\sum_{k=1}^{N}\sum_{i=0}^{t}(h_{k(t-i)} \times c_{ki} \times v_{kit}) + (A'_{total,\ t} - A_{total,\ t}) \quad (10)$$

where $t = n + 1, n + 2, \ldots, T$； $k = 1, 2, \ldots, N$.

- If $n > m$:

$$X_{total,\ t} = \sum_{k=1}^{N} X_{k(t-1)} + \sum_{k=1}^{N}(b_{kt} - l_{kt}) - \sum_{k=1}^{N}\sum_{i=0}^{t}(h_{k(t-i)} \times c_{ki} \times v_{kit}) + (A'_{total,\ t} - A_{total,\ t}), \quad (11)$$

where $t = 1, 2, \ldots, m$； $k = 1, 2, \ldots, N$.

$$X_{total,\ t} = \sum_{k=1}^{N} X_{k(t-1)} + \sum_{k=1}^{N}(b_{kt} - l_{kt}) - \sum_{k=1}^{N}\sum_{j=t-m}^{T}(c_{k(t-m)} \times u_{k(t-m)j}) - \sum_{k=1}^{N}\sum_{i=0}^{t}(h_{k(t-i)} \times c_{ki} \times v_{kit})$$
$$+(A'_{total,\ t} - A_{total,\ t}), \quad (12)$$

where $t = m + 1, m + 2, \ldots, n$ and $k = 1, 2, \ldots, N$.

$$X_{total,\ t} = \sum_{k=1}^{N} X_{k(t-1)} + \sum_{k=1}^{N}(b_{kt} - l_{kt}) + \sum_{k=1}^{N}\sum_{i=0}^{t-n}(p_{k(t-n)} \times v_{ki(t-n)}) - \sum_{k=1}^{N}\sum_{j=t-m}^{T}(c_{k(t-m)} \times u_{k(t-m)j})$$
$$-\sum_{k=1}^{N}\sum_{i=0}^{t}(h_{k(t-i)} \times c_{ki} \times v_{kit}) + (A'_{total,\ t} - A_{total,\ t}), \quad (13)$$

where $t = n + 1, n + 2, \ldots, T$ and $k = 1, 2, \ldots, n$.

(b) Accounts receivable

SMEs may also defer selling gains for n periods; thus, the accounts receivable in period t equals the accounts receivable of individual product k in each period. The same result may be obtained by summing the accounts receivable of individual product k and costs in period t - 1, then subtracting the income of product k in period t - n. This produces Equations (14) and (15).

$$Y_{total,\ t} = \sum_{k=1}^{N} Y_{kt} = \sum_{k=1}^{N} Y_{k(t-1)} + \sum_{k=1}^{N}\sum_{i=0}^{t}(p_{kt} \times v_{kit}), \quad (14)$$

where $t = 1, 2, \ldots, n$ and $k = 1, 2, \ldots, N$

$$Y_{total,t} = \sum_{k=1}^{N} Y_{kt} = \sum_{k=1}^{N} Y_{k(t-1)} + \sum_{k=1}^{N}\sum_{i=0}^{t}(p_{kt} \times v_{kit}) - \sum_{k=1}^{N}\sum_{i=0}^{t-n}(p_{k(t-n)} \times v_{ki(t-n)}), \quad (15)$$

where $t = n + 1, n + 2, \ldots, T$ and $k = 1, 2, \ldots, N$.

(c) Accounts payable

SMEs may also defer purchasing loans for m periods. Therefore, the sum of accounts payable, m, equals the sum of accounts payable of individual product k in each period. The same results may be obtained by summing the accounts payable and costs of individual product k in period t - 1, then subtracting the income of product k in period t - m, and producing Equations (16) and (17).

$$Z_{total,\ t} = \sum_{k=1}^{N} Z_{kt} = \sum_{k=1}^{N} Z_{k(t-1)} + \sum_{k=1}^{N}\sum_{j=t}^{T}(c_{kt} \times u_{ktj}), \quad (16)$$

where $t = 1, 2, \ldots, m$ and $k = 1, 2, \ldots, N$. Or

$$Z_{total,\ t} = \sum_{k=1}^{N} Z_{kt} = \sum_{k=1}^{N} Z_{k(t-1)} + \sum_{k=1}^{N}\sum_{j=t}^{T}(c_{kt} \times u_{ktj}) - \sum_{k=1}^{N}\sum_{j=t-m}^{T}(c_{k(t-m)} \times u_{k(t-m)j}), \quad (17)$$

where $t = m + 1, m + 2, \ldots, T$ and $k = 1, 2, \ldots, N$.

(d) Loan interest expense

If the interest expenses of SME loans equal the product of the lending interest rate and product k in period t - 1, this creates the following equation:

$$A_{total,\ t} = \alpha \times \sum_{k=1}^{N} W_{k(t-1)}\ , \tag{18}$$

where t = 1, 2, …, T and k = 1, 2, …, N.

(e) Interest income from cash

The deposit interest rate of a product multiplied by individual product k in period t - 1 equals the SME interest income, producing the following equation:

$$A'_{total,\ t} = \alpha' \times \sum_{k=1}^{N} X_{k(t-1)}\ , \tag{19}$$

where t = 1, 2, …, T and k = 1, 2, …, N.

(f) Financing

When financial institutions use their products as pledge financing, the sum of net financing equals the sum of individual net financing of product k, producing the following equation:

$$W_{total,\ t} = \sum_{k=1}^{N} W_{kt} = \sum_{k=1}^{N} W_{k(t-1)} + \sum_{k=1}^{N} (b_{kt} - \ l_{kt}), \tag{20}$$

where t = 1, 2, …, T and k = 1, 2, …, N.

In addition, all the loan amount of the individual products of SME equals to all the repayment amount of the individual products, and producing the Equation (21).

$$\sum_{k=1}^{N}\sum_{i=1}^{T} b_{ki} = \sum_{k=1}^{N}\sum_{j=0}^{T} l_{kj}, \tag{21}$$

where k = 1, 2, …, N.

(g) Profits

This study aims to increase SME profits by optimizing financing amounts. Profits equal the sum of profits of individual product k in period t, producing the following equation:

$$\pi_{total,\ t} = \sum_{k=1}^{N} \pi_{kt} = \sum_{k=1}^{N} \pi_{k(t-1)} + \sum_{k=1}^{N} (p_{kt} \times D_{kt}) - \sum_{k=1}^{N}\sum_{i=0}^{t} (c_{ki} \times v_{kit}) - \sum_{k=1}^{N}\sum_{i=0}^{t} (h_{k(t-i)} \times c_{ki} \times v_{kit}) - A_{total,\ t}\ , \tag{22}$$

where t = 1, 2, …, T.

(h) the borrowing ceiling

In the SME's inventory financing, the total SME loan ceiling in period t equals to aggregate the SME accounts receivable financing loan of individual product k in period t - 1 and multiply the financial institution accounts receivable financing multiplier, γ_1, plus the aggregated inventory value of individual product k in period t - 1 and multiply the financial institution product inventory financing multiplier, γ_2, and producing the Equation (23).

$$b_{total,\ t} \le \gamma_1 \times \sum_{k=1}^{N} Y_{k(t-1)} + \gamma_2 \times \sum_{k=1}^{N} I_{k(t-1)}^{FG}, \tag{23}$$

where t = 1, 2, …, T.

(i) Accounts balancing equation

Assets equal liabilities and owner equity as follows:

$$\left(X_{total}\right) + \left(Y_{total}\right) + \left(I_{total}^{FG}\right) = \left(W_{total}\right) + \left(Z_{total}\right) + \left(\pi_{total}\right). \tag{24}$$

(j) Non-negative Constraints

In order to facilitate the above mathematical formula for solving this set of decision variables, it is positive and is not limited to an integer.

$$Q_{total,\ t}\ ,\ Q_{kt}\ ,\ I_{total,\ t}\ ,\ I_{kt}\ ,\ A_{total,\ t}\ ,\ W_{total,\ t}\ ,\ W_{kt}\ ,\ A'_{total}\ X_{total,\ t}\ ,\ X_{kt\ ,}\ ,\ Y_{total,\ t}\ ,\ Y_{kt}\ ,$$

$$Z_{total,\ t}\ ,\ Z_{k}\ ,\ \pi_{total,\ t}\ ,\ \pi_{kt}\ ,\ u_{ktj}\ ,\ v_{kit}\ ,\ b_{kt}\ ,\ l_{kt} \ge 0; \quad \forall t\ ,\ \forall k \quad t \leqq j, i \leqq t.$$

In addition, X_0, Y_0, I_0^{FG}, W_o, Z_0, π_0 are given initial values.

According to the objective function in Section 2.2, inventory value model in Section 2.3 and cash flow model capital model in Section 2.4. This study used the database engine ADO linking the programming language of Delphi to code the system of financial warehousing and inventory management database using ACCESS (or some ERP system) software package. Under the power of influence within SME's supply chain as well as using a pledge of portfolio multi-item products, this study will illustrate to optimize profits and maximize loans for SME. In this study, inventory information and database of a real case, U company, with its initial-value sets are used to solve the ultimate outcomes this case company. Follow-up studies is able to elaborate the results and analysis.

3. EMPIRICAL STUDY

This section uses Company U, an SME in the pharmaceutical industry, as a case study. Its drug inventory data in 2011 and certain assumptions were used to estimate the initial accounting values. Actual financing data from financial institutions were also used. The influence power of Company U on its supply chain is discussed based on the logistics financing and quantitative model (assuming that Company U stores its inventories in a third-party warehouse). Optimal profits and maximal loans obtained by Company U are also explored, assuming that multiple products are collateralized in financial warehousing. This section presents an empirical analysis and discussion of these topics.

3.1 Model Parameters

3.1.1 Settings and description of initial accounting value on Company U's simple balance sheet

This analysis is based on a simple balance sheet (Section 2.1) and monthly purchasing and shipping data from Company U in 2011. Company U supplies hundreds of products, which are described in a confidential document. Therefore, three types of products were randomly selected for this empirical study. The initial inventory value $I_{total,0}^{Fg}$ is the inventory value from 2010. The initial inventory value was established based on the inventory model equation in Section 2.3. The initial working capital of Company U, which is confidential, was replaced by a simulated value. Table 2 shows Company U's simple balance sheet.

Table 2. Summarized balance sheet of company U

Accounts	Variables	Total Initial Value	Product			Description
			1	2	3	
Assets	$X_{total,0}$	\$492,000	\$125,000	\$200,000	\$167,000	The summation of SMEs initial cash flow.
	$Y_{total,0}$	0	0	0	0	The summation of SMEs initial accounts receivable.
	$I_{total,0}^{Fg}$	\$343,236	\$89,056	\$90,528	\$163,652	The summation of SMEs initial inventory values.
Liabilities	$W_{total,0}$	0	0	0	0	The summation of SMEs initial net finance.
	$Z_{total,0}$	0	0	0	0	The summation of SMEs initial accounts payable.
Owners' equity	$\pi_{total,0}$	\$835,236	0	0	0	The summation of SMEs initial profits.

3.1.2 Settings and description of initial values for other parameters

Other initial values were established based on critical variables in the cash flow model (Table 3). These parameters are related to financial institutions, and include loan multiplier, γ_2, loan interest rate, α, accounts receivable multiplier, γ_1, and deposit rate, α'. These were all based on actual values listed by financial institutions. However, because the values listed by financial institutions differ, this study sets conservative initial values. Inventory value was simulated. To evaluate the influence of Company U on its supply chain, its status as an intermediate agent in the supply chain was considered.

Approximately 80% of Company U's products are imported from well-known pharmaceutical manufacturers. Hence, upstream manufacturers affect Company U, resulting in a short accounts payable period. In contrast, downstream distributors (such as, hospitals, clinics, and drug stores) have little effect on Company U, resulting in a long accounts payable period. Table 3 shows particular parameters and their descriptions.

Table 3. Some parameters and their descriptions

Parameters	Assumed Value	Description
$h_{k(1-i)}$	$h_{k1} = 1\%$, $h_{k2} = 2\%$, $h_{k3} = 3\%$.	Product inventory cost multiplier; assuming that the costs of product inventory were the same multipliers, and the following phases by each 1% increment to the maximum of 8%.
γ_2	0.6	Different product inventory financing bank loans multiplier.
m	0 - 2	Set the corporate delaying 0 - 2 disbursements to vendors in the given model.
n	1 - 4	Set the corporate delaying 1 - 4 periods receivable loans from the downstream retailers or customer in given the model.
α	5%	The financial institution lending interest rate; based on corporate financing, corporate capital under 300 million (included) and considering the type of industry, business operating risks, repayment capacity, and channel relationship, thus, will be given by 5% - 14% of loans with different interest rates. The U company is based on the common industry style.
γ_1	0.7	Accounts receivable financing of domestic financial institutions will provide a loan of 0.7 - 0.9 different multipliers.
α'	1 %	Corporate cash deposit rate of domestic financial institutions; the model assumes that is 1%.

3.2 Optimizing Profits and Maximizing Loans for Multi-Product Portfolios to Optimize Supply Chain Influence

The application of financial warehousing relies on the size of the SME. Enterprise size is reflected by tangible (lands, capitals, and equipment) and intangible (human resources and skills) assets. Thus, this study explores the effects of company size on financial warehousing by using company capital. Because Company U's influence on upstream manufacturers is small, the accounts payable period is short. Company U's greater influence on downstream distributors results in a longer accounts receivable period. This study presents 9 of 108 types of influence when m = 0, 1, 2; n = 1, 2, 3, 4; and $m < n$, and explores the effects of optimizing profits and maximizing loans on multi-product portfolios serving as collateral. Table 4 presents two multi-product portfolios to show the difference between optimal profits and maximal loans with different company sizes and supply chain influences.

Table 4. Experimental design

Corporate Scale	Influence Power of Supply Chain	Multi-product Portfolio
Small size：$ 125,000 Large size：$ 200,000	Case 1 of Influence: (m = 0, n = 1) Case 2 of Influence: (m = 0, n = 2) Case 3 of Influence: (m = 0, n = 3) Case 4 of Influence: (m = 0, n = 4) Case 5 of Influence: (m = 1, n = 2) Case 6 of Influence: (m = 1, n = 3) Case 7 of Influence: (m = 1, n = 4) Case 8 of Influence: (m = 2, n = 3) Case 9 of Influence: (m = 2, n = 4)	Case 1 of product portfolio: (Products 1and 2 Mixed) Case 2 of product portfolio: (Products 2and 3 Mixed) Case 3 of product portfolio: (Products 1and 3 Mixed) Case 4 of product portfolio: (Product 1, 2and 3 Mixed)

(a) Optimal profits and maximal loans for small enterprises (small capital reserves)

This study found that when Company U is small, the delayed accounts payable period is 0, and the delayed accounts receivable period is 4. Products 2 and 3, as financial warehousing collateral, can help Company U optimize profits $\overline{\pi}_{total}$ = $750,258.1 (Table 5), and maximize financial institution loans $\overline{W}_{total}$ = $275,786.9 (Table 6).

Table 5. The Five Most Profitable Situations if Company U is Small

Situation	*m*	*n*	Product Portfolios	$\overline{I}_{total}^{Fg}$	$\overline{\pi}_{total}$	$\overline{W}_{total}$
The 49th of Situations	0	4	2 and 3	$325,605.0	$750,258.1	$275,786.9
The 48th of Situations	0	3	2 and 3	$325,605.0	$737,885.2	$178,227.7
The 55th of Situations	0	1	1 and 3	$208,968.0	$730,190.0	0
The 59th of Situations	1	2	1 and 3	$208,968.0	$729,266.8	0
The 62th of Situations	2	3	1 and 3	$208,968.0	$728,730.1	0

Table 6. The five best loan situations if company U is small

Situation	*m*	*n*	Product Portfolios	$\overline{I}_{total}^{Fg}$	$\overline{\pi}_{total}$	$\overline{W}_{total}$
The 49th of Situations	0	4	2 and 3	$325,605.0	$750,258.1	$275,786.9
The 52th of Situations	1	4	2 and 3	$325,605.0	$644,800.9	$251,546.0
The 40th of Situations	0	4	1 and 2	$251,947.0	$722,590.1	$217,692.3
The 48th of Situation	0	3	2 and 3	$325,605.0	$737,885.2	$178,227.7

(b) Optimal profits and maximal loans for large enterprises (large capital reserves)

If Company U is large and has sufficient capital, it could face capital shortages caused by the supply chain because products with high inventory values are selected as collateral. Therefore, when Company U is large, the delayed accounts payable period is 0, and the delayed accounts receivable period is 1. Products 1 and 3, which have high inventory values, are used as collateral for capital shortages. This produces optimal profit $\overline{\pi}_{total}$ = $888,065 without financial warehousing (Table 7). However, when Company U is small, the delayed accounts payable period is 0, and the delayed accounts receivable period is 4. This suggests that the company has sufficient capital; however, when Products 2 and 3, which have low inventory values, are used as collateral, Company U must apply for a maximal loan $\overline{W}_{total}$ = $219,546.5 (Table 8) from financial institutions. This can reduce profit losses.

Table 7. The five most profitable situations if company U is large

Situation	*m*	*n*	Product Portfolios	$\overline{I}_{total}^{Fg}$	$\overline{\pi}_{total}$	$\overline{W}_{total}$
The 82th of Situations	0	1	1 and 3	$208,968.0	$888,065.0	0
The 86th of Situations	1	2	1 and 3	$208,968.0	$887,141.7	0
The 89th of Situations	2	3	1 and 3	$208,968.0	$886,605.0	0
The 90th of Situations	2	4	1 and 3	$208,968.0	$882,842.7	0
The 87th of Situations	1	3	1and 3	$208,968.0	$882,356.5	0

Table 8. The five best loan situations if company U is large

Situation	m	n	Product Portfolios	$\overline{I}_{total}^{Fg}$	$\overline{\pi}_{total}$	$\overline{W}_{total}$
The 76th of Situations	0	4	2 and 3	$325,605.0	$836,534.1	$219,546.5
The 67th of Situations	0	4	1 and 2	$251,947.0	$821,647.4	$161,013.9
The 79th of Situations	1	4	2 and 3	$325,605.0	$823,098.4	$133,503.1
The 66th of Situations	0	3	1 and 2	$251,947.0	$841,582.9	$69,420.5
The 70th of Situations	1	4	1and 2	$251,947.0	$847,748.3	$69,171.3

3.3 Summary

This study investigates Company U, and verifies the significant effects of company size and influence on the supply chain and multi-product portfolio pledges to optimize profits, and maximize loans during financial warehousing. Table 9 shows the empirical results.

The main effects are as follows:

(a) Influence on the supply chain

This study investigates Company U, which used three of its products as pledges in 9 of the 108 situations that influence the supply chain. If the difference between the accounts payable delay (m) and accounts receivable delay (n) is small, the company can avoid excessive loan interest, and thereby, produce greater profits because of more flexible capital flows. In contrast, if the difference between the accounts payable delay (m) and accounts receivable delay (n) is large, the company could lose profits because of less flexible capital flows. Therefore, the company may approach financial institutes for product financing. Although financing may result in less profits, it can maintain corporate operations.

(b) Multi-product portfolio pledges and supply chain influence

Table 9 Empirical results

Corporate Scale	Influence Power of Supply Chain $m < n$	Product Portfolio	Situation of Financing Warehouse	Suitability
-	Difference of Issue Small ($n - m$)	1, 2 and 3	Averaging Optimal Profit	Fit
-	Difference of Issue Large ($n - m$)	1, 2 and 3	Averaging Maximum Loan	Fit
-	Difference of Issue Large ($n - m$)	2 and 3	Averaging Optimal Profit and Averaging Maximum Loan	Very fit
Small	Difference of Issue Small ($n - m$)	1, 2 and 3	Averaging Optimal Profit	Fit
Small	Difference of Issue Large ($n - m$)	1, 2 and 3	Averaging Maximum Loan	Fit
Large	Difference of Issue Small ($n - m$)	1, 2 and 3	Averaging Optimal Profit	Fit
Large	Difference of Issue Large ($n - m$)	1, 2 and 3	Averaging Maximum Loan	Fit
Small	Difference of Issue Large ($n - m$)	2 and 3	Averaging Optimal Profit and Averaging Maximum Loan	Very fit
Large	Difference of Issue Small ($n - m$)	1 and 3	Averaging Optimal Profit	Fit
Large	Difference of Issue Large ($n - m$)	2 and 3	Averaging Maximum Loan	Fit

Note 1：Product sale price: Product 3 ＞ Product 2 = Product 1

Note 2：Product purchase price: Product 3 ＞ Product 2 ＞ Product 1

Note 3：The amount of product sales: Product 2 ＞ Product 3 ＞ Product 1

This study investigates the effects of Company U using three portfolios (Products 1 and 2, Products 2 and 3, and Products 3 and 1) of three products in nine supply chain influence situations. Without considering a single-product pledge, three portfolios and nine supply chain influence situations were investigated. The results show that a direct link exists between profit and stock values of product portfolios and supply chain influences, and that purchasing prices, order quantity, and demand variations influence stock value. It is best for companies to perform financial warehousing of multi-product portfolio pledges when public goods are under government control or at stable prices, and when prices and demand for products are driven high in a short period. Thus, the company can earn more profits by selecting the optimal product portfolio as pledges before performing financial warehousing, and acquire maximal finance loans from financial institutes.

(c) Company size and multi-product portfolio pledges

This study verifies if when Company U is large, financial warehousing relies on the inventory value of its products. The company can survive a capital shortage with sufficient capital when the inventory value is relatively high, and optimize profits and maximize loans with financial warehousing when the inventory value is relatively low. Company U requires a maximal loan when it is small and large. Thus, this study verifies that an enterprise can operate most efficiently using financial warehousing when it is small.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

This study builds a mathematical model for financial warehousing for SMEs. The model was constructed based on the inventory value and capital flow models. A multi-product portfolio was used to optimize pledge financing for SMEs to facilitate scenario analysis. Thus, the database engine ADO was used to link the financial warehousing model with Delphi, and was used to access the inventory management database to acquire optimal profits and maximal loans for different supply chain influence situations and multi-product pledges. Conclusions drawn from this research include the following:

(a) SMEs require financial warehousing because of capital flow shortages. When SMEs have a smaller effect on their supply chain, they also require financial warehousing because they experience capital flow shortages. When the difference between the delayed accounts payable period (m) and the delayed accounts receivable period (n) is small, the company can avoid excessive loan interest, thus producing greater profits because of more flexible capital flow.

(b) When SMEs perform financial warehousing, they select the product inventory as pledges because their value can influence the effectiveness of financial warehousing. An enterprise can optimize profit. and maximize loans from financial institutes with high value product pledges.

(c) When Company U is large, the decision to perform financial warehousing relies on the value of products owned by the company. With a high-value inventory, the company has sufficient capital flow to survive capital shortages without financial warehousing. When the stock is of a lower value, the company must perform financial warehousing to obtain capital to optimize profit and maximize loans.

4.2 Constraints

Because most relevant literature has used qualitative research, this research is based on few studies. The single product models were developed in 2010. Financial warehousing involves three aspects: SMEs, third-party logistics enterprises, and financial institutes. Research constraints include the following:

(a) This study analyses SMEs and third-party logistics enterprises. Hence, we do not account for financial institute risk analyses.
(b) Because financial warehousing is new in Taiwan, relevant laws concerning financing products with pledges and risk analyses are not legislated.
(c) Although actual data were used for the case, the empirical results may not apply to companies from all industries because the company used in the case study is from the medical industry.
(d) Because the data used are confidential, this study could only investigate three products. This results in less robust empirical results.
(e) The data used only included 1 year of inventory flow; thus, the results do not reflect long-term purchasing and sales prices. Therefore, price fluctuations are not discussed.
(f) Parameter settings in this study were set conservatively.
(g) Data from Company U was used to simulate the model; however, because some company data were confidential, they were excluded.

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