Supply Chain Causal Linkage-based Strategic Map Design

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***Abstract*—Supply chain management (SCM) practices and performance are managed through a strategic map. They are bridged by the attention to a few measures including both financial and non-financial perspectives. Such the measures are embedded into the balanced scorecard (BSC). The BSC is however criticized as limitations because of unidirectional causality and internal focus. These could be overcome by a supply chain causal linkage-based strategic map design. Its conceptual framework is proposed in this paper purposing to causally link SCM practices to performance. The causal linkages contribute to identify their root causes leveraging the organizational vision and mission. This contribution is useful for decision makers to set SMART (specific, measurable, attainable, relevant, and timeline) objectives.**

***Index Terms*—supply chain management, causal linkage, strategic map**

I. Introduction

The attention to supply chain management (SCM) has been increasingly paid. Its aim is to create more values for customers and stakeholders [1]. Previously, most studies focused on only one or few supply chain activities i.e. inbound logistics [2], operations [3], or outbound logistics [4]. Their performance was measured with single indicator (or objective), especially by financial measurement [5]. On the other hand, a few studies simultaneously considered activities along the supply chain with several SCM performance [6]. For example, Boonsothonsatit et al. [7] developed a generic decision support system for designing the cheapest and the greenest supply chain networks in the shortest lead time. Yu et al. [8] investigated the effects of supply chain integration on customer satisfaction and financial performance.

SCM practices are often dispersed from their performance, which spreads from the organizational vision and mission [6]. They are managed through a strategic map using balanced scorecard (BSC). It purposes to turn the organizational vision into actions (ViA). The ViA divides key performance indicators (KPIs) into four perspectives including learning and growth, internal process, customer, and financial [9]. Their relationships can be direct and indirect [5][10] which are considered as causal (or interdependent) in upward directions [11][12][13].

The KPIs found in learning and growth enable to improve the internal process-based KPIs. They in turn support obtaining the desired results in customer and financial perspectives. These KPIs drive to initiate their related practices enabling to the organizational vision and mission as shown in Fig. 1.

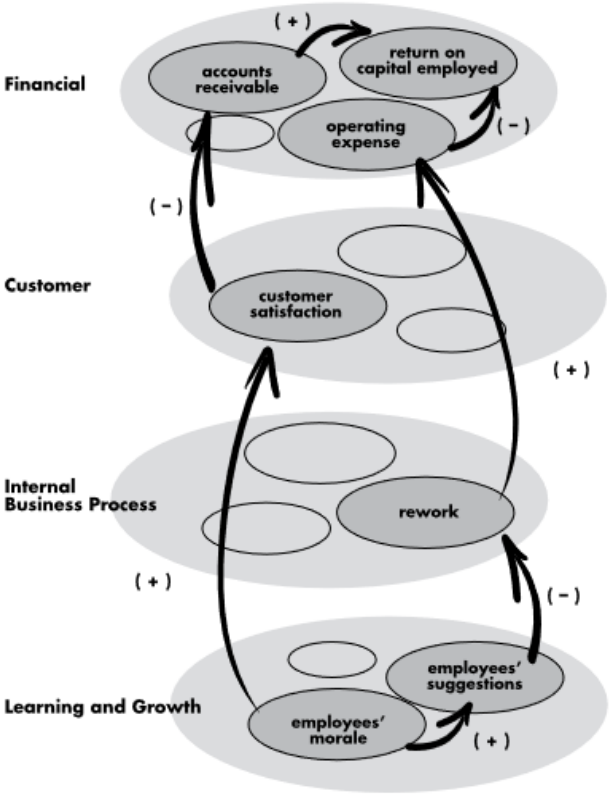

Figure 1. BSC example [9]

Noticeably, the traditional BSC-based KPIs are chained as unidirectional and uncovered as a whole of supply chain activities. The unidirectional chains are overcome by applying causal linkages (in general, nonlinearly) [5][10], whereas supply chain activities are regarded. Consequently, this paper develops a conceptual framework for effectively designing a causal linkage-based strategic map. It contributes decision makers to set SMART objectives interrelated systematically along the supply chain.

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II. Conceptual Framework

In order to effectively design a causal linkage-based strategic map, the conceptual framework is developed as shown in Fig. 2. It is driven from the organizational vision and mission as the basis of core values. These drivers support generating strategy themes and then their related objectives. They are interrelated systematically along the supply chain activities including inbound logistics, operation, outbound logistics, service, marketing and sales.

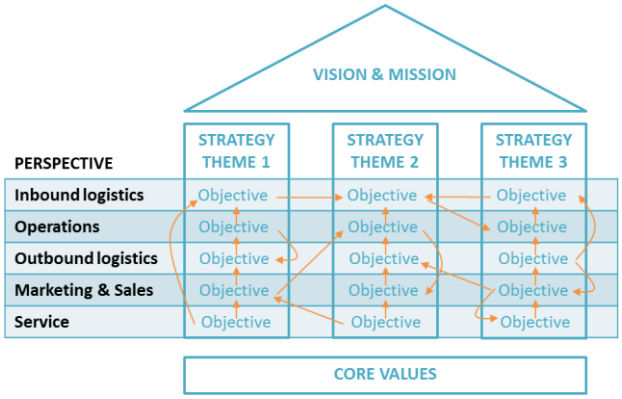

Figure 2. Conceptual framework.

III. Four-step Methodology

Such the conceptual framework is successfully validated by undergoing four steps as follows (Fig. 3). Firstly, the organizational vision and mission are clarified. The strengths, weaknesses, opportunities, and threats (SWOT) are secondly brainstormed and applied to synthesize strategy themes. Thirdly, they are interrelated systematically along the supply chain into a unified causal loop diagrams (CLD). The unified CLD contributes to identify the root cause-based objectives leveraging the clarified vision and mission. This contribution is useful for decision makers to set SMART objectives as the fourth step.

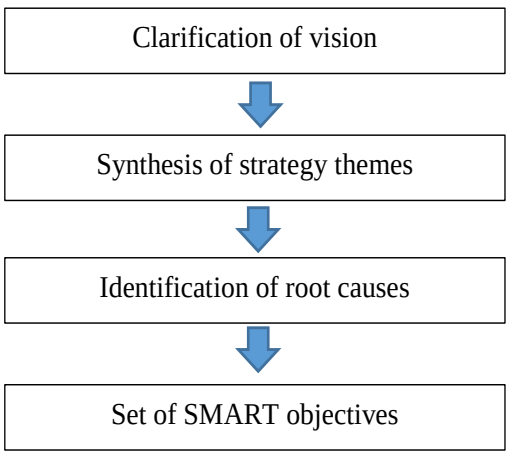

Figure 3. Four-step methodology

IV. Results and Discussions

The proposed framework is verified and validated in a multinational large-sized company in Thailand. The verification and validation are achieved by team participation in brainstorming. The results and discussions are presented by following on the four-step methodology.

A. Clarification of Vision and Mission

The company's vision and mission emphasize excellence in customer service by focusing on delivered in-full, on-time (DIFOT) (1) which targets at 100%. In addition, profit margin (2) and cash-to-cash cycle (CCC) (3) are valued at 23% and 49 days respectively. They are different from actual values by 4% of DIFOT, 1% of profit margin, and 8 days of CCC.

$$\text{DIFOT} = \frac{\text{Number of orders delivered in-full on-time}}{\text{Total number of orders delivered}} \quad (1)$$

$$\text{Profit margin} = \text{Production value} - \text{Material cost} - \text{Labor cost} - \text{Overhead cost} - \text{Scrap cost} \quad (2)$$

$$\text{CCC} = \text{Accounts receivables} + \text{Inventory days} - \text{Accounts payable} \quad (3)$$

B. Synthesis of Strategy Themes

According to the clarified vision and mission, the company pays attentions to three strategic themes as follows. Firstly, production base are expanded to overseas for taking competitive advantages e.g. lower labor and material costs, and larger-size market. Secondly, flexibility is enhanced by procuring materials from local vendors, reducing company size, and enlarging product variety. Thirdly, innovative products are developed and launched at the right time.

C. Identification of Root Causes

According to the synthesized strategy themes highlighted in yellow, their causes and effects (elements) are interconnected systematically along the supply chain activities as shown in Fig. 4. Its primary activities include inbound logistics, operations, outbound logistics, marketing and sales, and service. An interconnections is symbolized by an arrow, and directed by either positive (+) or negative (-) sign. A positive sign is depicted when a cause reinforces its effect(s); otherwise, that sign is negative. The individual interconnections are linked until closing cycles. A closed cycle is defined as either reinforcing (R) or balancing (B) loop as shown in Figs. 5 to 7. A reinforcing loop is incurred when an element supports itself in the same direction; otherwise, that loop is balancing. There are four reinforcing and eight balancing loops emerged from the expansion of production base to overseas as a strategy theme. Consequently, it has effects on the other two strategic themes which eventually influence DIFOT, profit margin, and CCC as depicted in red font.

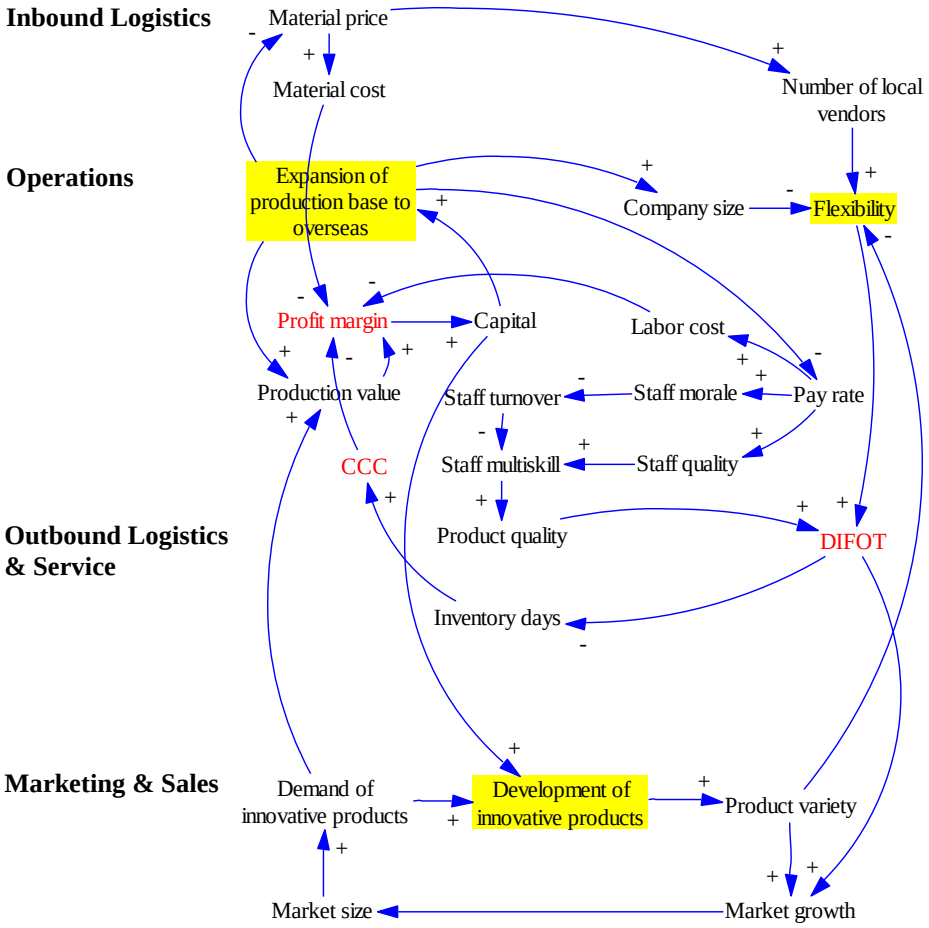

Figure 4. CLD overview

The four reinforcing loops (i.e. R1 to R4) are illustrated in Fig. 5. R1 to R3. They are caused by the strategic theme to expanding a production base to overseas. It aims to acquire higher production value (+), lower oversea material price (-), and cheaper pay rate (-). These three causes support higher profit margin (+) and capital (+) which result in more expansion of production base to overseas (+). The higher capital is also spent for products innovation and variety. These result in higher-growth and larger-size market aiming to reinforce profit margin and capital (R4).

However, the strategy theme expanding a production base to overseas eventually reduces those profit margin and capital (B1 and B2) as shown in Fig. 6. This is because of poorer-rate pay (-) which yields lower staff morale (+) and quality (+). The lower staff morale (B1) drives to more turnovers (+) and lesser multi-skill (+). The lesser multi-skill is also reinforced by the lower staff quality (B2), whereas generating lower product quality (+) and DIFOT (+), respectively. As a result, they have effects on higher inventory days (-) and then longer CCC (+). These requirements lead to such the reduced profit margin and capital.

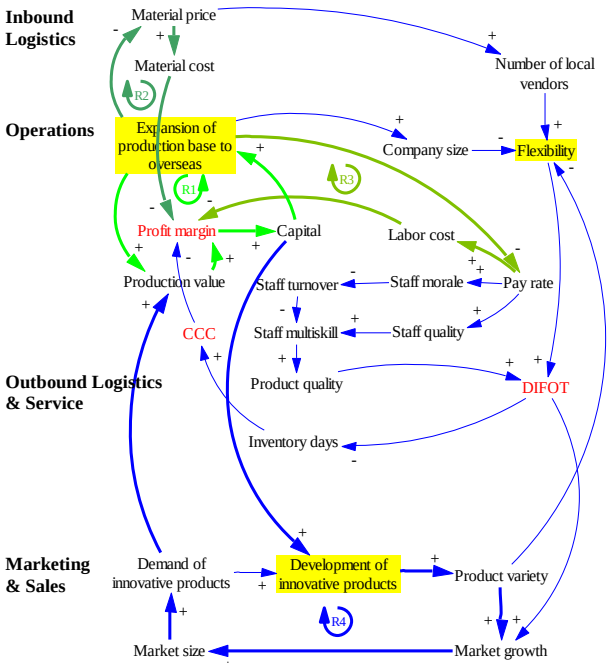

Figure 5. CLD reinforcement

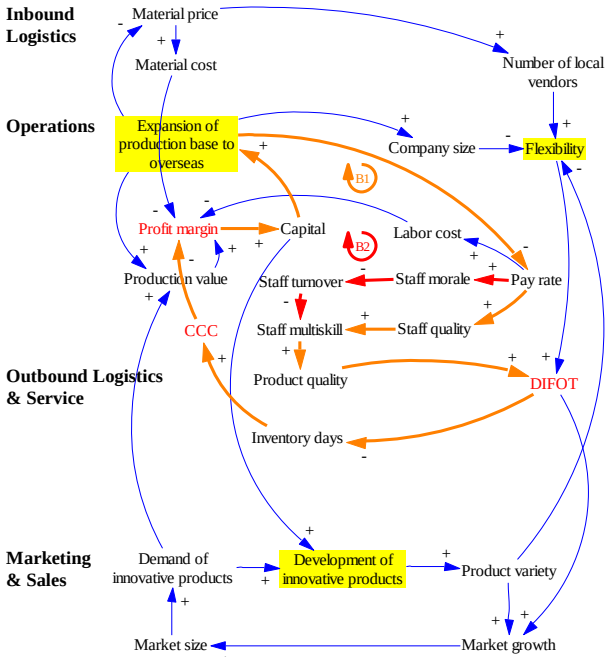

Figure 6. CLD balancing 1

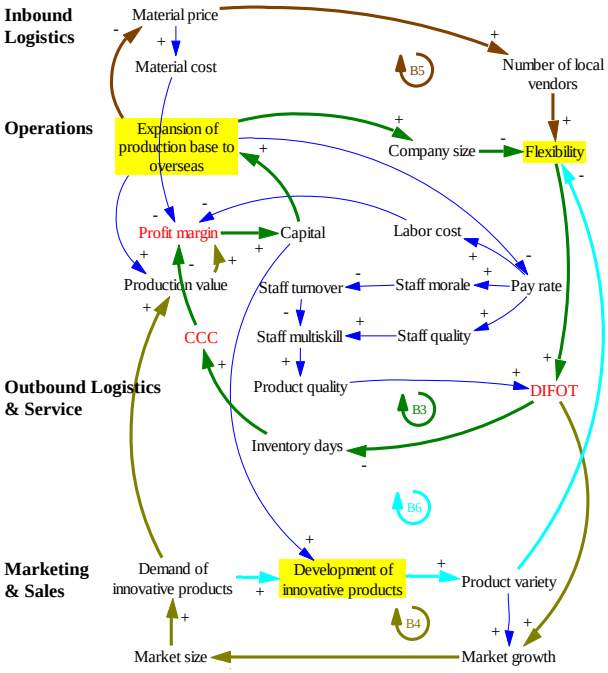

Figure 7. CLD balancing 2

In addition, the profit margin and capital are decreased when flexibility is lesser (B3 to B6) as shown in Fig. 7. The lesser flexibility causes lower DIFOT (+). This causal linkage is influenced by enlarging company size (B3 and B4), lessening number of local vendors (B5), and increasing levels of product variety (B6). The lower DIFOT has effects on higher inventory days (-), whereas causing slower-growth market (+). The greater the inventory days, the longer the CCC lead to lower profit margin, and lower capital consecutively. The slower-growth market returns smaller market size (+) and lesser innovative product demand (+). The fewer demand of innovative products generates lower-value production (+) leading to such the more reduced profit margin and capital.

According to the three strategy themes (i.e. expansion of production base to overseas, development of innovative products, and flexibility), Figs. 4 to 7 are capable of identifying two root causes including pay rate and flexibility. Their optimization is required as follows. Firstly, the optimal pay rate is incurred by trade-offs between lower labor cost and higher products quality. Secondly, the smaller-size company, more number of local vendors, and lower levels of product variety are traded-off in order to obtain the optimal flexibility.

D. Set of SMART Objectives

The identified two root causes (i.e. pay rate and flexibility) leverage the achievement of three objectives as follows. Firstly, the profit margin is increased by 1%, namely 1.15 million United States Dollars (USD). It is achieved by increasing 5 million USD (i.e. 4.35%) of production value but worsening 2% of material cost and 1% of labor cost.

To generate more 4.35% of production value, new products need to be introduced. The new product introduction however lose flexibility. It is offset by using more local content but pricing more expensive than overseas material consumption. This flexibility offset spends 2% of material cost more. Apart from increasing 4.35% of production value, the more local content supports shortening 120 days (i.e. 66.67%) of lead time and reducing 8 days (i.e. 88.89%) of inventory. The last one contributes to the second objective. Its aim is to eliminate 8 days of CCC more.

Thirdly, DIFOT is increased to 100% by upgrading product quality to 100%, and shortening lead time to 60 days. These achievements requires higher-rate pay and more local content respectively. These requirements cause 1% of labor cost and 2% of material cost more as aforementioned.

TABLE I. SMART OBJECTIVES

Objective	Measure	Actual	Target	Initiative
Profit margin maximization	Production value (Million USD)	115	120	Introduce new products
	Material cost (%)	65	67	Consume more local contents
	Labor cost (%)	4	5	Offer more pay rate
CCC minimization	Inventory (days)	9	1	Consume more local content
DIFOT minimization	Product quality (%)	99	100	Offer higher pay rate
	Lead time (days)	180	60	Consume more local content

V. CONCLUSION

This paper proposes a conceptual framework of causal linkage-based strategic map design. It is superior to the traditional BSC in terms of systematic interrelations among SMART objectives along the supply chain. In addition, the proposed framework is capable of clarifying

the organizational vision and mission, synthesizing the strategy themes, and identifying the root cause-based objectives. These eventually leverage the clarified vision and mission.

However, the proposed framework is considered as qualitative. It only informs how the organizational vision and mission, strategy themes, and objectives are interrelated. These interrelations cannot be otherwise expressed as quantitative. This concern could be extended by applying a technique of system dynamics as a future work.Acknowledgment

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