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What is This?

Business and logistics hub integration to facilitate global supply chain linkage

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Abstract: With the development and integration of the global supply chain, manufacturing industries are rapidly adjusting their modes of operation within and between enterprises. Existing manufacturing processes are being improved to meet the requirements of lean and agile manufacturing, and suppliers are given additional responsibilities to provide parts and services dynamically. An enterprise must strategically re-engineer its operations model to face the rapid changes of the global market place. This paper identifies prevailing challenges and highlights a future vision of the global logistics management framework for the automotive industry. An integrated business and logistics hub (IBLH) model integrating information flows (via the business hub) and material flows (via the logistics hub) is presented. This research uses the case of a Taiwan automobile parts and assembly manufacturer to analyse the processes of the IBLH. The goals of the case are to shorten supply chain processes, reduce inventory costs, and ensure information transparency during material flow and product distribution. Finally, this research provides suggestions to depict the case company's current limitations and deficiencies, and presents a future plan for e-logistics services.

Keywords: global logistics management, automotive industry, e-logistics services

1 INTRODUCTION

Taiwan's manufacturing companies have earned a reputation for providing services as both original equipment manufacturer (OEM) and original design manufacturer (ODM). Clients served by these models, however, frequently request quick deliveries and door-to-door shipping. In response, Taiwan's manufacturing companies are forming alliances with international brand companies, joining global logistics activities, and becoming an integrated link in the demand chain. Owing to rising production costs, shortened product life cycles, and globalization of business operations, industries increasingly adopt global logistics and production models to remain competitive. Manufacturers hire experienced logistics service providers to outsource logistics operations and form virtual enterprise collaboration networks to meet the needs of clients. These global networks require members to share information and integrate systems.

Taiwan's logistics service providers, however, are mostly small- and medium-sized enterprises with limited capability to improve service quality and efficiency owing to a poor information and communications technology infrastructure that decreases real-time connections between channel members. Research shows that the integration and synchronization of material and information flows between supply-chain sites are increasingly required by modern industrial organizations [1]. The automotive industry was among the first to introduce supply-chain changes in manufacturing systems to guarantee optimal trade-off between customer satisfaction and production costs [2]. However, implementing these changes often exceeded expectations in terms of costs and the ability to gain cooperation among members [3].

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The present paper presents the strategies and architecture of an integrated business and logistics hub (IBLH) to facilitate and enhance global supply-chain linkage. The logistics hub is a physical facility that is constructed by the logistics service providers. The hub manages multi-client warehousing, transportation management, and customs compliance, and controls the information flows for establishing, executing, and adjusting the logistics operations. The goal of an integrated hub for the automotive industry is to establish a higher quality and cooperative operations environment that enhances the outsourced logistics services. The functional goals of the IBLH include meeting real-time material needs, merging information flows, shortening the supply-chain process flows, reducing total inventory costs, ensuring information transparency during distribution, and increasing total profit. This research surveys an automobile manufacturer in Taiwan, (called Y-Motor Company to remain anonymous) and documents the current ('as-is') logistics models. The material in-flows include materials, parts, and components entering the warehouse and the assembly plants. The material out-flows include the components for dealers, maintenance shops, and other inventory facilities located domestically and overseas. The existing (as-is) models and the improved ('to-be') models are analysed and compared as the first step towards improving logistics efficiency, enhancing international collaboration, and expanding market opportunities for products and services.

The current paper is organized in eight sections. In section 2, research in the areas of supply-chain management, global logistics management, business-to-business integration (B2Bi), B2B exchange hubs (e-hubs), and supply-chain performance evaluation are reviewed. Section 3 to 4 describe the current (as-is) logistics operation of a global automotive supply chain and investigates the physical and information flows among the members. Sections 5 to 7 provide the to-be integrated hub model and the proposed processes for the Taiwan automotive supply chain. Finally, conclusions are drawn in section 8.

2 LITERATURE REVIEW

The literature review is divided into three parts covering supply-chain management and performance evaluation, global logistics management, and B2B exchange hubs. The supply chain refers to the network that supplies raw materials to manufacturers, the manufacturers that make the intermediate or finished goods, and the logistic centres that deliver the goods to final customers. The network includes material suppliers, production facilities, warehouses, distribution services, and customers that are linked together via a feedforward flow of materials and feedback flow of information [4–6]. The purpose of supply chain management is to optimize the process flows among the elements of the supply network [7, 8]. Businesses must work together to form an integrated supply chain that increases the flow of material, cash, resources, and information [9]. It is difficult, however, to implement supply-chain management in practice, since the chains often resemble complex network systems [10]. Different facilities in the supply chain often have conflicting objectives [11]. Further, there are numerous uncertainties in the supply chain including the forecast of inventory levels and back orders.

Distribution and logistics management consists of a series of activities including warehouse management, order management, goods picking and dispatching, transportation, and inventory control [12]. Since a vast amount of information is generated and shared between logistic participants, the efficiency and quality of logistic services are difficult to monitor and control. The emergence of the extended manufacturing enterprises, a globally dispersed collection of strategically aligned organizations, has focused research on how organizations coordinate the flow of information and materials across their supply chains [13, 14]. With the growing trend towards the use of international supply chains and e-commerce, logistic service providers are placing greater emphasis on information technology to increase global competitiveness [15, 16].

Worldwide manufacturing networks require new models that include complete lifecycle material and information flows. Logistics is often viewed as the integrating element for global production, especially for virtual factories. Further, improving the supply chain requires that logistics organizations improve the flow of internal and external information. The increased information requirements necessitate the integration of logistics information systems and supply-chain information systems [17]. These systems are essential for coordinating the physical flow of goods along the supply chain. Systems integration leads to greater inventory visibility that, in turn, leads to reduced costs and improved customer service by decreasing shipping and receiving cycle times, increasing shipment and inventory accuracy, and decreasing lead-time variability [18].

Researchers have proposed that information-sharing strategies can help coordinate supply-chain members and reduce the impact of supply-chain dynamics [19, 20]. However, effective management and integration of information between business partners remains a significant challenge [21]. Electronic commerce and associated business-to-business transaction capabilities have changed the way in which supply chains operate. Software developers and enterprises are actively pursuing the next phase

of business-to-business integration (B2Bi), namely customized XML-based web applications that enable enterprise integration [**22**, **23**]. The B2B exchange hub hosts the enterprise integration architecture and provides the functions required to execute transactions as well as manage the document exchanges in the network. Berryman and Heck [**24**] point out that the B2B exchange hub (e-hub) should provide knowledge sharing for all supply-chain participants in order to lower handling and processing times. The e-hub should also automate data exchanges and execute optimized business transactions with minimum interaction. Ho *et al.* [**25**] extended this definition of the e-hub by including customized functionality for members while integrating different enterprise applications (enterprise resource planning (ERP) systems) in the supply-chain network.

In recent years, supply-chain collaboration has become increasingly prevalent and important. In order to achieve competitive advantages, an organization must optimize its own processes and, in addition, work in collaboration with other organizations to achieve large-scale optimization across the chain [**26**]. Hence, the performance measures used to determine the efficiency and effectiveness of supply-chain collaboration are critical to successful implementation. There are many decision factors and criteria relating to supply-chain performance and a decision maker should consider multiple factors before making decisions [**27**]. Many models, sophisticated mathematical algorithms, and computer tools have been developed to evaluate supply chain performance at both the strategic and operations levels. Lau *et al.* [**28**] proposed a framework using fuzzy logic and neural networks to automate the selection of suppliers and adjust the order quantity according to the suppliers' performance. Chan *et al.* [**29**] derived a heuristic that combines the analytic hierarchy process (AHP) with genetic algorithms (GAs) for order distribution in a demand-driven supply-chain network. Simulation is also an effective method to evaluate the supply-chain performance and alternative supply-chain models. Many academics and practitioners have developed supply-chain simulation tools to assist supply-chain design and management [**30**]. Reiner and Trcka [**31**] provide an improvement model that helps enhance the performance of a product-specific supply chain in the food industry. Using a simulation approach, the authors measure and analyse the performance effects (work in progress and lead time) of the supply-chain configuration alternatives. Chan *et al.* [**32**] presented a method for studying order-release mechanisms using simulation techniques and possible performance curves (PPC). The proposed new order-release mechanism (NORM) was assessed and compared with previous research approaches and shown to provide improved supply-chain performance. Some authors have applied agent technology to optimize supply chains [**33**]. Chan and Chan [**34**] developed a coordination mechanism for inventory management that uses flexible quantities to reduce the impact of supply-chain dynamics. The authors modelled the supply chain as a distributed-constraint satisfaction problem and demonstrated that the approach was effective in reducing costs. Labarthe *et al.* [**35**] used an agent-based approach to simulate a customer-centric supply chain and illustrated the application with a case from the golf club industry.

3 AS-IS MODEL ANALYSIS

This research surveys the Y-Motor Company and derives the current (as-is) logistics operation model. In addition, the difficulties with the current logistics practice are analysed and modified to construct improved (to-be) logistics processes. After Taiwan entered the World Trade Organization (WTO), the Taiwan automotive industry faced increased international competition and an oversupply in the domestic market. Taiwan's automobile manufacturers are much larger than the automotive component companies, which are mostly small- and medium-sized enterprises with fewer than 100 employees per company. Six leading prime automotive enterprises (i.e. General Motors, Daimler-Chrysler, Ford, Toyota, Volkswagen, and Renault-Nissan) presently hold 70 per cent of the world market [**36**]. Taiwan's automotive companies often obtain key manufacturing technology by forming joint ventures with leading automotive enterprises or by paying licence fees. Global automotive enterprises promote the view that the most effective way of developing the market is to outsource production using low-cost OEM/ODM. By outsourcing, the prime enterprises are better enabled to market products, develop key technologies, and provide new products. Facing intense global competition and capital requirements, Taiwan's automotive companies shifted hopes from becoming global prime enterprises to becoming OEM/ODM assembling vehicles for the leading prime automotive enterprises. Prime companies represented in Taiwan include General Motors, Ford, Toyota, Daimler-Chrysler, and Renault-Nissan.

Y-Motor Company, the case focus of this paper, holds as its core business model automotive manufacturing services and OEM/ODM activities. Y-Motor Company operates several well-established parts and component manufacturing centres in Taiwan, China, and the Philippines. The material and information flows between Taiwan and China are independently managed. Automotive parts production is divided into OEM for clients and aftermarket parts production for Y-Motor Company's licenced

dealers. Taiwan's OEM automotive parts supply the local market, but some parts are exported to China or other Southeast Asian countries for assembly operations. The Philippine facility of Y-Motor Company is considered a downstream plant since all production and maintenance parts are supplied from Taiwan. All three Y-Motor Company locations (China, Taiwan, and the Philippines) seek to expand economic cooperation through a brand-to-brand complementation programme. As a member of the Association of Southeast Asian Nations (ASEAN), this programme allows for the mutual exchange of parts and components across national boundaries.

The automotive supply chain of Y-Motor Company consists of domestic or overseas suppliers, central car assembly plants, regional dealers, independent distributor sites, maintenance shops, and consumers as shown in Fig. 1. At present, the production part sources for Y-Motor Company are divided into international purchases and domestic purchases. The imported parts, called knock down parts, account for 30 per cent of the inventory and are supplied from Japan. Most of the automobile components (70 per cent) are supplied by 142 domestic suppliers and include electronic components, engine components, sheet metal and steel, auto frames, rubber components, and interior and exterior plastic components. The suppliers hold long-term contracts and maintain strong business relationships with the central assembly plants. Y-Motor Company contracts 15 local dealers to sell vehicles and aftermarket parts to consumers in Taiwan. The logistic operations are divided into the OEM parts for production supply and aftermarket parts for maintenance and repair.

For OEM parts supply, Y-Motor Company adopts three logistics operation models, which are just-in-time (JIT) sequenced delivery, traditional order shipment, and vendor-managed inventory (VMI).

3.1 Just-in-time sequenced delivery

Just-in-time is a common production part supply model used to provide the right quantity of quality parts to the assembly line at the right time and in the exact sequence required. Y-Motor Company connects with its suppliers via an internal supply-chain information system and uses JIT to minimize inventory required for assembly. The companies, operational model works best for higher value parts provided by suppliers capable of real-time delivery. JIT works best for parts that are larger sized (frees more warehouse space), have an economic delivery quantity (suppliers deliver a production-run quantity per shipment), and are supplied by close partners (satellite companies) located near the assembly plant.

3.2 Traditional order shipment

Traditional order shipment is used by the suppliers of small-quantity common parts. This delivery approach depends on the order cycle (per day, week, or month) to determine the quantity, time, and frequency of the delivery.

3.3 Vendor managed inventory

Suppliers set up a VMI warehouse at the assembly plant site to provide a stable supply with a safety
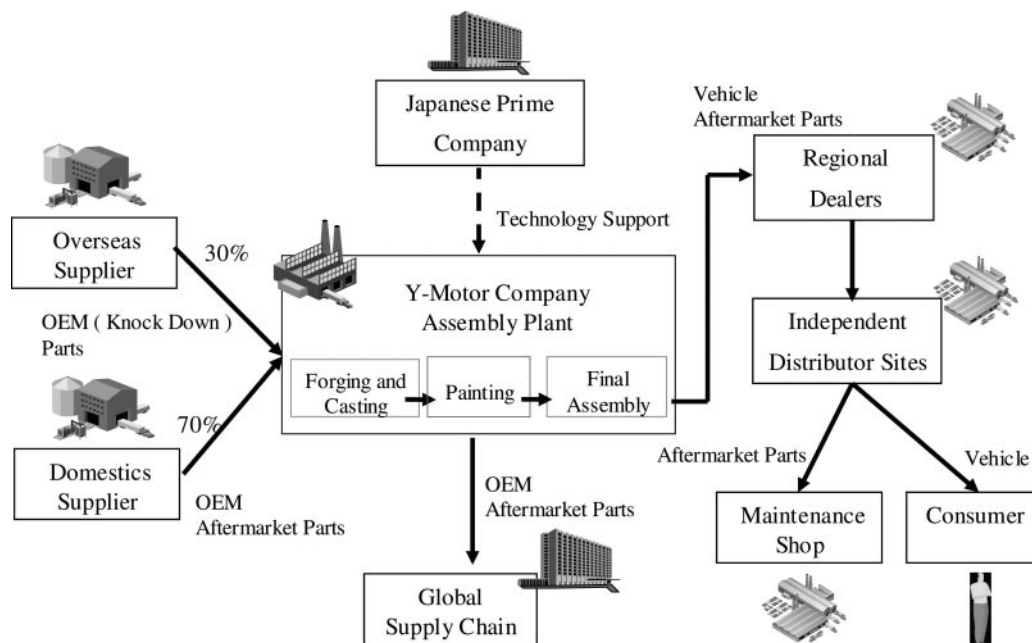

Fig. 1 Y-Motor Company supply chain architecture

stock. The ownership of VMI parts belongs to the suppliers until the parts are checked out of inventory and used for assembly. Under VMI, suppliers are responsible for inventory replenishment and logistics management.

The above-mentioned logistics approaches are implemented by the suppliers themselves. Some suppliers also monitor the supply and demand levels, and coordinate the pick-up and transfer of parts by logistics service providers. When raw materials or components are required from overseas suppliers, suppliers outsource the work to overseas forwarders. The logistics service providers dispatch vehicles to the loading site, acquire customs approvals for shipping, and transport goods to the final destination.

Y-Motor Company maintains an inventory of aftermarket parts since demand is difficult to forecast. After the manufacturer orders aftermarket parts via the supply-chain system, the suppliers deliver the parts to the Y-Motor Company's aftermarket parts warehouse. If the supplier is also an OEM parts provider, the aftermarket parts can be combined with the delivery of OEM parts. Part orders are received by Y-Motor Company using the aftermarket parts order purchase system. Y-Motor Company provides daily delivery of aftermarket parts to the 15 local automobile dealers' component centres. The dealers' component centres use twice-daily delivery of the aftermarket parts to their independent distributor sites. When exporting aftermarket parts to overseas dealers or assembly plants' components centres, manufacturers hire freight forwarders for global logistics. The as-is logistics operation model of OEM and aftermarket parts is shown as Fig. 2.

4 CURRENT LOGISTIC PROBLEMS

The problems of the as-is model relate to the manufacturer and the logistics service providers. The OEM manufacturers' post-delivery parts inspection and storage operations are carried out by the warehouse operator, which causes higher costs and lower efficiency. On the other hand, aftermarket parts require higher inventory levels with a large variety for new and old car models. Lacking information about inventory and shipping, the manufacturers and regional dealers incur high inventory and logistic costs. Further, if suppliers do not provide timely notification for changes in the production schedule, the delay in material handling and transportation leads to high logistics charges (express services) and poor customer service (delay of order fulfilment).

Since Y-Motor Company's aftermarket parts are exported to many countries for their maintenance and repair operations, the global logistics are complex and critical to profits. When aftermarket parts are exported and delivered by sea or air cargo, the shipment requires coordination between various logistic activities and participants such as the forwarders, brokers, carriers, the container yard, and the terminal warehouse. Since large amounts of information are generated by the logistic activities, Y-Motor Company has difficulty monitoring and controlling goods location and delivery. Without centralized and consolidated information, logistics is often inconsistent and disorganized. The communication between logistics service providers relies on mail, phone, and fax. The IT applications are inadequate, many documents are photocopied, and data are frequently
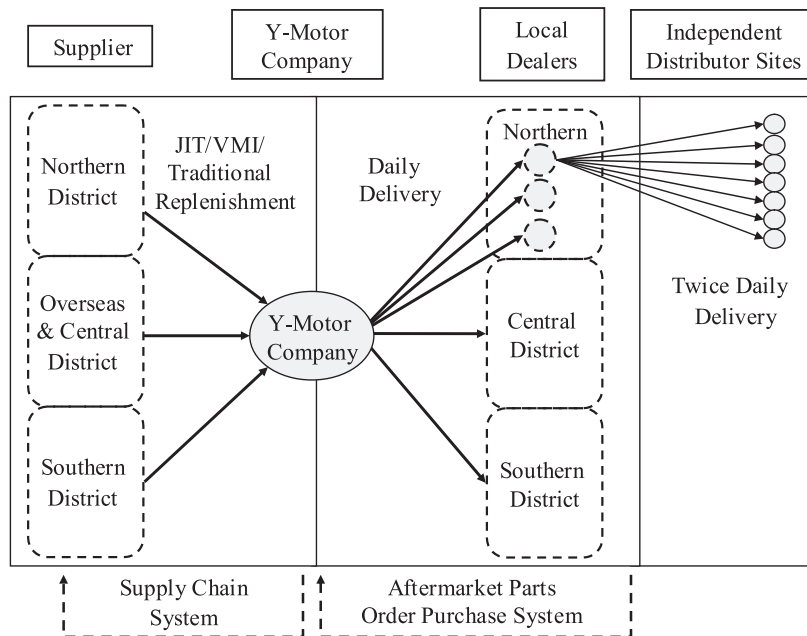

Fig. 2 As-is logistics operation model

entered into multiple systems. Loose and inefficient data exchanges lead to unexpected shipments and bottlenecks in responding to customer inquiries. Therefore, real-time interaction and coordination among logistics service providers, suppliers, manufacturers, and local dealers are required. Re-engineering of the supply chain and logistics will target integrated transportation, warehousing, loading, information processing, and customs clearance services.

5 THE PROPOSED INTEGRATED HUB MODEL

Since global logistics problems tend to be complex and cross functional, the proposed IBLH model is designed to help automobile companies analyse and improve logistics operations. In this section, the architecture of the IBLH is presented, and the to-be logistics operation models for the automobile parts and assembly industry are developed. Further, the information system function processes of the IBLH, the application of the B2B e-hub, and the benefits of adopting IBLH are described.

The automobile parts and assembly manufacturers and the logistics service providers form strategic alliances with the IBLH. The IBLH uses the business hub for information flows and the logistics hub for material flows as shown in Fig. 3. The IBLH implements a vertically integrated system that enhances information transparency and delivers e-commerce based logistic services. The scope of the logistic

services is expanded to offer a wider range of e-logistics information and strategic services. E-logistics applies internet technology and applications (XML, B2B exchange hub, radio frequency identification (RFID) to accelerate the transmittal and exchange of information. By promoting collaborative processes with trading partners (carriers, forwarders, truckers, and customs clearance services) it is possible to reduce cycle times, lower transportation expense, and provide event notification. In order to implement the IBLH, this research proposed three development steps as follows.

5.1 Business hub construction

The business hub, constructed by an application service provider, is an integrated e-logistics collaborative platform. The business hub contains a B2B e-hub module that focuses on data tracking, exchange, query, and data sharing among upstream and downstream partners. The objective of this step is to implement the system platform and build robust information connections between channel members.

The business hub manages the procurement, storage, transportation, customs clearance services, order processing, and other activities at the request of manufactures, suppliers, local dealers, and maintenance shops. The hub also manages the information-sharing functions of the logistics hub; that is, information about raw material and component orders, inventory levels, and forecasted demand are coordinated with
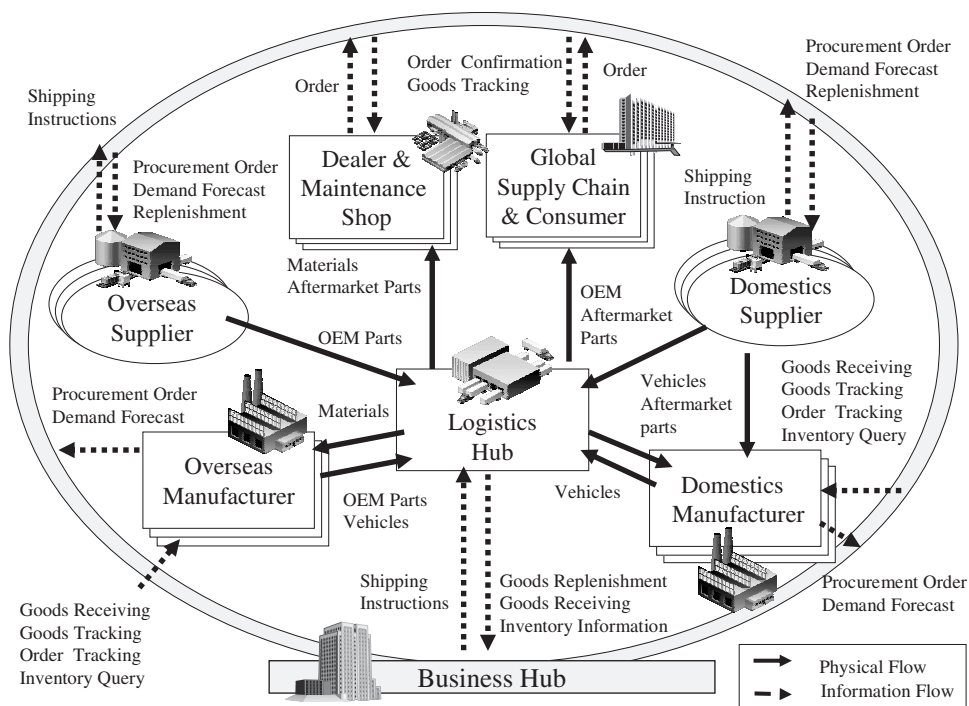

Fig. 3 IBLH architecture

Table 1 IBLH construction steps and directions

Development steps	Fundamental action	Further development
Step 1. Business hub construction	Design and construction of fundamental system functions.	Customize design and implementation.
	Achieve hardware and software stability and provide information security.	Insure completeness and compatibility of system functions.
Step 2. Logistics hub construction	Select proper sites.	Build library of import and export regulations.
	Design storage facility and functions.	Develop industry strategic alliances.
Step 3. Improving the IBLH's versatility	Establish IBLH regulations.	Provide sufficient marketing information and achieve economies of scale.
	Provide information access, real time operations and accurate forecasting.	

the production plan. In addition, the business hub provides reports to related organizations (e.g. customs offices) and requests approvals. The business hub also provides fulfilment management and transportation planning for raw materials, components, and end-products. Finally, the supply-chain members receive messages about warehouse shipments, inventory status, transportation schedules, allocation of vehicles, and the transportation status.

5.2 Logistics hub construction

The logistics hub focuses on management, integration, and synchronization of physical goods flow, and includes transportation, warehousing, and customs clearance between manufacturing sites. The hub also supports shipment consolidation from multiple suppliers and stable material supply. The objective of this step is to utilize logistic service outsourcing and automate the logistics operations with integrated information flows. The transportation operations include the various modes of transportation for supplying production materials, components, end products, and maintenance parts. When orders are received from manufactures, suppliers, and maintenance shops, they are divided into overseas and domestic shipments. Overseas shipments cover transportation between Taiwan, China, Japan, and the Philippines, whereas domestic shipments cover the local automobile dealers in Taiwan. The warehousing operations coordinate storage for related companies. The warehouses store raw materials, components, and end products; operational tasks include receiving and inspecting goods, managing inventory, and classifying and packaging parts. Finally, the customs operation coordinates goods clearance and inspection for shipments between China, the Philippines, and other countries.

5.3 Improving the versatility of IBLH

Different members have different business processes that require a stable and secure system. The construction and architectural details are provided in Table 1.

6 TO-BE LOGISTICS OPERATION MODELS FOR THE Y-MOTOR COMPANY

Since 73 per cent of the suppliers, 43 per cent of the dealers, and 50 per cent of the transactions are concentrated in the North of Taiwan, Y-Motor Company built the logistics hub in the Northern district and implemented a new inventory and logistics policy. The Central district and Southern district will retain the previous logistics operation models until the next round of strategic changes are implemented. The upstream suppliers in the North, which previously used traditional order and shipment processes, have adopted a milk-run logistics approach. The milk-run logistics approach facilitates the receipt of parts from a geographically distributed area.

The aftermarket parts' shipments from downstream regional dealers and independent distributor sites in the North use cross docking. When aftermarket parts' suppliers deliver parts to the logistics hub, parts are re-packed and transferred to the local dealers within 10 h. In order to accelerate the delivery of aftermarket parts, twice-daily deliveries are made to the component centres of dealers in the North. Y-Motor Company plans to reduce warehouse manpower costs by outsourcing inspections and storage operations. The to-be logistics operation model for OEM and aftermarket parts is shown in Fig. 4.

7 SYSTEM MODULES AND PROCESSES

The information system architecture for the IBLH merges multiple systems (i.e. the supply-chain system, the aftermarket parts order–purchase system, and the warehouse management system) to centralize control of all logistics affairs. The IBLH is designed to meet the operational goals of participants and to enhance their business competitiveness.

1. Product suppliers (manufacturer, overseas suppliers, and domestic suppliers) – receive orders from global customers and efficiently ship the orders by cooperating with logistics service providers.
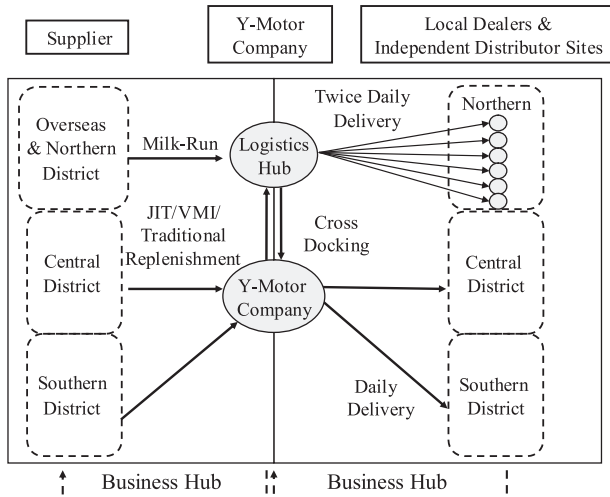
Fig. 4 To-be logistics operation model

2. Customers (global end-users, enterprise, dealers, and maintenance shops) – forecast requests for products or services from manufacturers and logistics service providers to improve scheduling and delivery.

3. Logistics service providers (forwarder, broker, trucker, warehouse and storage, carrier, cargo terminal, third-party logistics companies, and customs clearance services) – provide logistic services with comprehensive information support.

The information system platform consists of the fundamental module, the inventory and safety stock management module, the order tracking and query module, and the goods tracking and query module. The main functions of these modules are provided in Table 2. This research assumes that the Y-Motor Company owns the IBLH information system (the business hub platform) and delivers information to trading partners via the fundamental module as shown in Fig. 5. The system uses XML as the standard for internal and external data transformation and exchange with a homogeneous data format.

As shown in Fig. 6, the business hub requests all suppliers to input product data, safety stock levels, and company information before beginning business transactions. If suppliers already have XML product content, they can upload the files directly to the hub. The inventory and safety stock management module controls the physical goods status in the logistics hub. The shipping status in the logistics hub is generated from the order tracking and query module data. The manufacturer's ERP system establishes a production plan according to the market demand and transmits purchase orders to the suppliers via the business hub. After order confirmation, the suppliers request that the logistics service providers deliver the goods to the logistics hub. When

Table 2 Business hub functionality

Main function module	Sub function module
Fundamental module	B2B exchange hub (e-hub): data tracking, exchange, query, and information sharing among partners
	Company management: provide the supply-chain members information and authority control
	Production management: provide production data importing, mapping, and maintenance
	Automatic alarm and notification: provide detailed status reports with time alerts
Inventory and safety stock management module	Goods-receipt notice, storage-capacity information, RFID shipping, inventory query, demand forecasting, replenishment notice and shipping notice.
Order tracking and query module	Order upload, query, confirmation, receipt, order termination, invoice, and packing list management.
Goods tracking and query module	Logistics document delivery, import and export shipment management, goods tracking with RFID electronic product codes, delivery fee accounting.

materials are needed, the manufacturer sends shipping instructions to the supplier and the logistics hub. The supplier examines material supply and demand and prepares for delivery. The logistics hub arranges transportation, allocates goods to the designated locations, and transports the goods to the destination. If the goods are out of stock, the logistics hub replenishes the goods from the suppliers. The detailed process and modules of order fulfilment are shown in Fig. 7.

All the upstream and downstream participants use the real-time goods tracking and query module that also monitors the shipping status, as shown in Figs 8 and 9. Upon receipt of an import arrival notice from overseas suppliers, the business hub transmits messages to forwarders and brokers to book space and begin customs clearance processes. When the logistics hub receives the goods from the port warehouse, it coordinates shipment to Y-Motor Company. Y-Motor Company uses electronic product codes based on RFID to enhance the quality of logistics management throughout the supply chain. The goal of using these codes is to tag every item in the supply chain with a unique RFID number. By combining the electronic seals of RFID technologies with the features of the IBLH, the logistics processes yield more precise tracking information. Tracking information such as whether the goods are at the docks or in the control of the overseas forwarder are provided in real time. The time needed for tracking a specific shipment can be reduced from a half day (using phone calls) to 15 min (using the internet). All bills
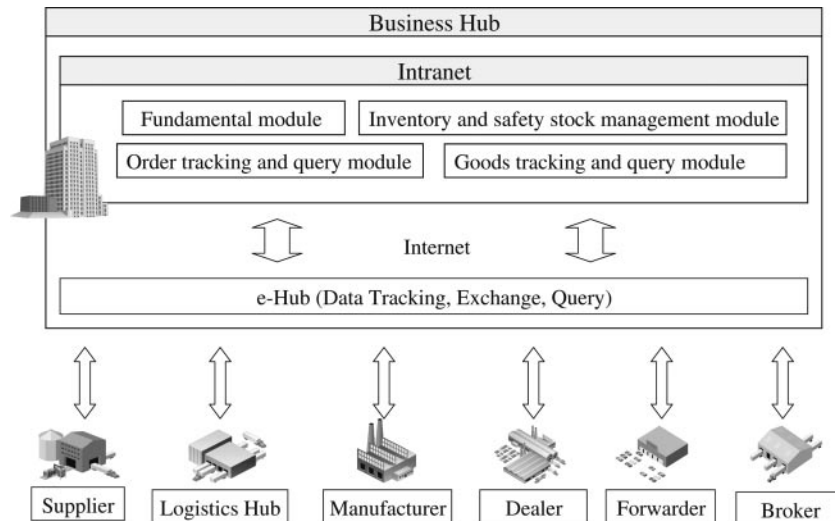
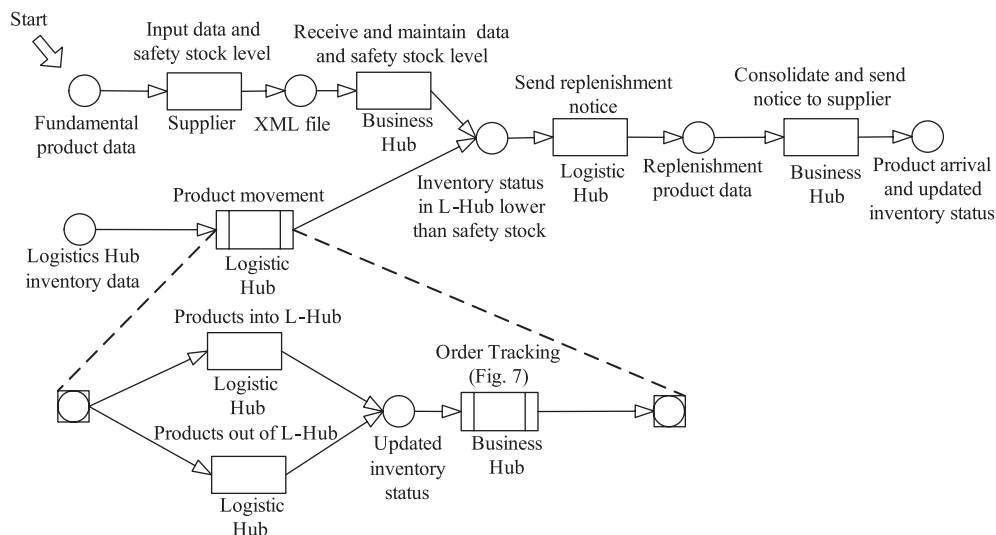**Fig. 5** E-hub architecture proposed by application service provider

Fig. 6 Inventory and safety stock management processes

of lading and information associated with the container can be retrieved online. Within a factory or warehouse, the system can generate a real-time report at several levels of detail.

The main purpose of building the IBLH is to satisfy the demand of the manufacturer's production model, maintain stable inventories, and provide real-time supply. Given better communications between manufacturers, domestic and overseas suppliers, forwarders, and local distributors, Y-Motor Company can maintain and improve service relationships. In addition, the logistics cost of the individual suppliers and dealers decreases when the hub takes responsibility for delivery of goods. The benefits of adopting IBLH are shown in Tables 3 and 4.

There were two challenges encountered when implementing the IBLH project. First was the suppliers'

resistance to accept a new logistics policy and second was the selection of experienced logistics service providers. After constructing the logistics hub, the outsourced logistics service providers applied a milkrun approach to consolidate goods shipments from multiple suppliers. The delivery fees are shared by Y-Motor Company and the suppliers. Given new cost, some suppliers disputed the new logistics policy during the initial promotion of the IBLH. Fortunately, through explanation and negotiation of fair accounting of delivery fees, almost all suppliers agreed with the policy.

Another difficulty encountered was the limited number of professional logistics service providers. Automobile parts place many demands on the logistics providers since the parts can be very irregular in shape and weight and require specialized container,
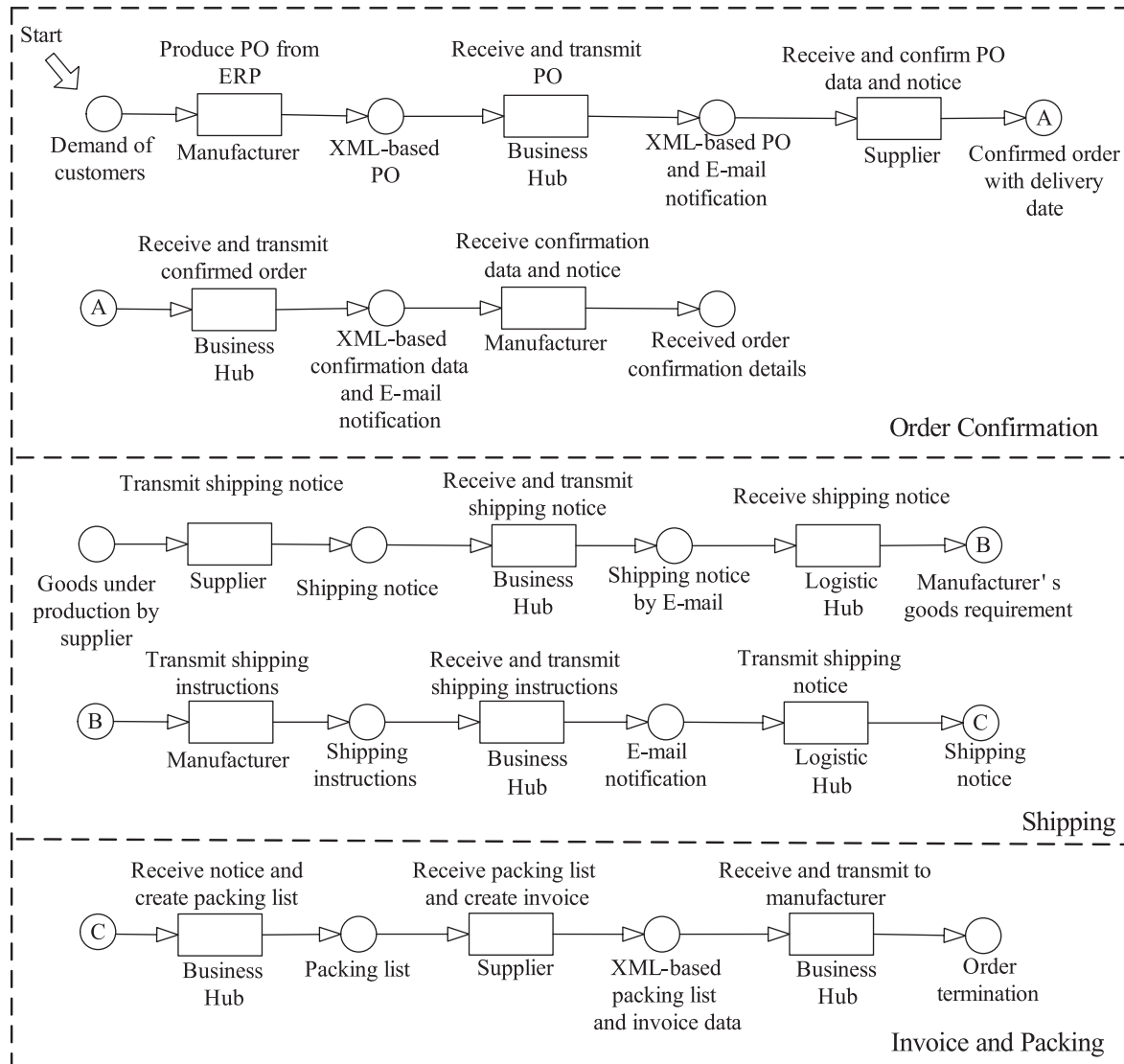
Fig. 7 The IBLH enables real-time order tracking and status query

pallet, and rubber cushion. Some service providers were not willing to cooperate to change their delivery practices.

8 CONCLUSIONS

In order to provide complex supply-chain and logistics service providers with efficient logistics operations environment and high-quality customer service, the current paper proposes an IBLH architecture for creating improved e-logistics automotive supply-chain services. The IBLH is a centralized and cross-functional platform for Y-Motor Company that replaces multiple and dispersed information systems. The integrated platform, which uses XML technology for messaging and data exchange, controls the transportation, storage, customs clearance, and other administrative affairs associated with

supplying manufacturing processes and end-customer demands. It allows manufacturers, suppliers, clients, and the other supply-chain members to access information about orders, shipments, and inventory moving through their facilities.

At the current stage of development, the IBLH is far from perfect. The system requires further upgrades for full implementation. For instance, when Y-Motor Company broadens its production scope in the future, it will need to ensure the functionality of the system, evaluate the suitability of the system modules, and weigh the feasibility of applying new information technology. The logistics operations among the upstream and downstream logistics network are outsourced to logistics service providers to improve operating efficiency, lower logistics cost, and shorten delivery lead time. The collaboration between Y-Motor Company and Taiwan's local logistics service providers has strengthened competitiveness and has
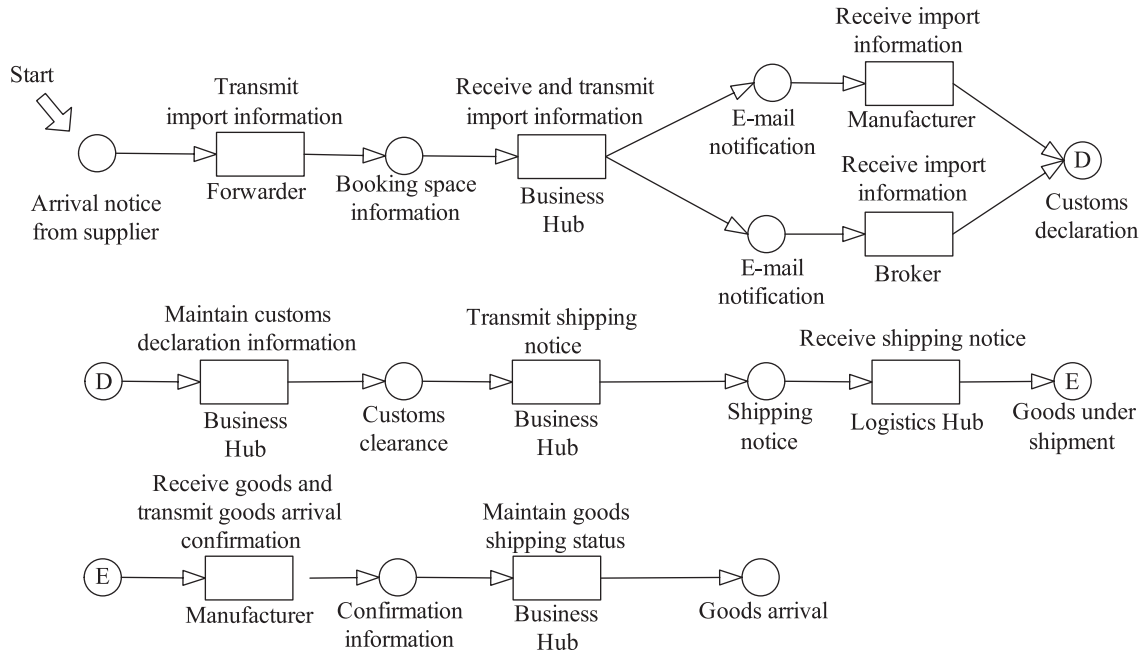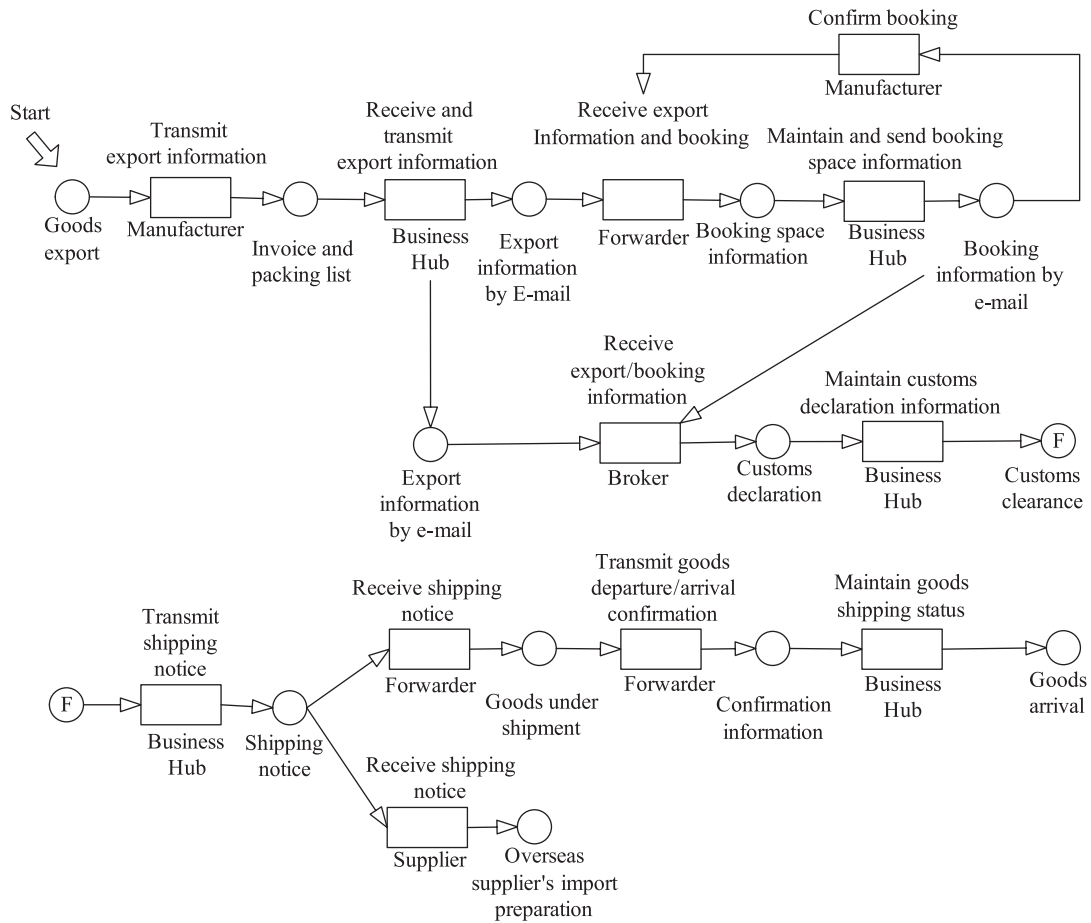
Fig. 8 The IBLH import processes

Fig. 9 The IBLH export processes

Table 3 IBLH qualitative benefits

Participant	Limitations	Benefits
Y-Motor Company	Lacks a centralized and consolidated information source	Upgrades and automates information systems
	Difficult to integrate numerous supply-chain systems	Spends less time tracking shipments
	Large inventories and redundant labour	Higher customer satisfaction
		Lower logistical costs and total inventory
		Reduces labour and handling expenses
Supply chain members	Insufficient IT applications to communicate and coordinate logistics operations	Easy to collect, store, forward, and track data
	Too many documents confounded with repeated data entry from manual operations	E-documents replace fax and reduce telecommunication costs
	Loosely controlled shipments and limited capacity to improve processes	Provides detailed shipment status and timely automatic announcements
		Enhances supply-chain members' IT ability
		The RFID solution makes it possible to track the carriers and location of merchandise throughout the supply chain

Table 4 IBLH quantitative benefits

Participant	Key performance indicators	Results (per month)	Explanation
Y-Motor Company	OEM parts' logistics cost reduction ratio	2.5% cost reduction	Pre-implementation of OEM parts' logistics costs divided by post implementation costs
	JIT delivery rate	2% improvement in JIT delivery	JIT shipment value divided by total shipment value
	Aftermarket parts' logistics cost reduction ratio	5% cost reduction	Pre-implementation of aftermarket parts' logistics costs divided by post implementation costs
	Inventory accuracy ratio	2% improvement in accuracy	Correct items divided by total inventory items
Supply-chain members	Dealers average inventory ratio	15% reduction in inventory at dealer sites	Ending inventory value divided by average selling cost in the past half year
	Lead time	2 h lead time reduction	The lead time from ordering to shipping
	Suppliers delivery fulfillment	3% improvement in delivery fulfilment	Total delivery items divided by total order items
	Suppliers inventory value	NTD $150 million reduction in suppliers inventory	Ending inventory value at the supplier sites

created new international business opportunities. Future research will analyse and evaluate the performance of the proposed IBLH model using analytical techniques, e.g. simulation and supply chain operation reference (SCOP) models.

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