



An integrated approach for the electronic contract manufacturer selection problem [☆]



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ABSTRACT

In the global competitive environment, lead companies have to outsource their manufacturing to electronic contract manufacturers (ECM) in order to reduce operational cost and capture higher profit. Thus, the process of selecting contract manufacturers to be strategic partners is important for these companies. For this reason, this paper proposes an integrated approach for the electronic contract manufacturer selection problem, combining the voting method and the goal programming (GP) model to take into account quantitative factors involved in the selection process, which is applied to a real-world ECM selection problem encountered by a leading provider of complete broadband access solutions. Results of the case study indicate that the voting method can acquire the rating information quickly from manufacturing managers based on suitable evaluating criteria. The rating information simultaneously incorporates ECMs' performance scores as a weight for each ECM. A production planner can easily employ the GP model and ECMs' weight information to effectively assign demand quantities to ECMs. Therefore, the integrated approach is a practical and useful tool for solving the contract manufacturer selection problem.

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1. Introduction

In the global competitive environment, more and more customers are demanding low total systems cost, high product quality, and good delivery performance to achieve their competitive advantage. Many manufacturing firms have responded to this trend by outsourcing non-critical activities to supply chain partners. Outsourcing is an effective method that may provide manufacturing firms access to external sources of competencies and expertise that are of world-class quality [1,2]. In the past, outsourcing was primarily relegated to the procurement of non-core components and services. Today, the outsourcing trend has expanded to include virtually every activity of a firm, including core and non-core components, business processes, information technology processes, manufacturing and distribution activities, and customer support activities [3–5].

In the electronics industry, a new manufacturing outsourcing model, electronics contract manufacturing (ECM), has emerged as a centerpiece of globalized production networks. Major ECM firms can be regarded as being a part of a transnational mass production

system that serves different markets based on highly flexible work arrangements. They conduct printed circuit board (PCB) assembly and systems assembly for a growing number of information technologies so that the outsourcing firms can focus their financial and managerial resources on product development and marketing. In such a production network, strong coordination between the outsourcers and their ECMs is essential, because poor coordination results in excessive delays, low-quality products, and ultimately leads to poor customer services [6]. When companies outsource a significant part of their production and become more dependent on their contract manufacturers, the consequences of poor coordination become even more severe. It is therefore very important for an outsourcer to carefully evaluate and select its contract manufacturers. As a result, the evaluation and selection of contract manufacturers has become a strategic and important component of companies' supply chain strategy.

When an electronics manufacturing company adopts an outsourcing policy, attempts to outsource its PCB assembly to ECMs for better operational performance may encounter some problems, including ECMs' quality, how to select ECMs, the quantity to outsource, etc. Those problems may cause some production handicaps to the company. This paper assembles references from the literature to serve as criteria for evaluating ECMs, including four strategic dimensions - satisfaction, quality, delivery, and cost - and 16 criteria. It also provides an integrated approach for weighting and

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selecting ECMs to overcome these handicaps for a company and its production.

The objective of the ECM selection process is to identify ECMs with the highest potential for meeting a manufacturer's needs consistently at an acceptable overall performance level. Selecting ECMs from a large number of possible alternatives with various levels of capabilities is a difficult task and inherently a multiple criteria decision-making (MCDM) problem since various criteria must be considered in the decision-making process. Once the ECMs are rated and selected, the appropriate order quantities for these ECMs need to be determined to meet the outsourcing companies' multiple goals. The integrated approach, which combines the voting method and goal programming technique, is proposed to consider both tangible and intangible factors involved in rating the ECMs and in determining the optimum outsourcing quantities for the ECMs. The voting method determines the appropriate weights of these dimensions and criteria. These weights are then used in conjunction with ECMs' performance scores to obtain ratings of the ECMs. The resulting ECM ratings are then used by GP models to determine the optimal order quantities for the ECMs.

The remainder of this paper is organized as follows. Section 2 reviews relevant literature on electronic contract manufacturers. Various commonly adopted techniques in supplier selection are discussed and supplier selection criteria are identified. Section 3 presents the gap analysis and research motivation. Section 4 describes the background of the proposed approach. A case study is presented in Section 5, in which the proposed approach is applied to a leading provider of complete broadband access solutions in Taiwan. Section 6 analyzes the research results and discussions. Section 7 discusses the research implications and limitations. Finally, conclusions and future work are drawn in Section 8.

2. ECMs and selection issues

Section 2.1 briefly discusses electronic contract manufacturers and the types of outsourcing arrangements. Section 2.2 describes the techniques and criteria for the selection of electronic contract manufacturers.

2.1. ECMs

Electronics companies have increasingly focused on their core competencies and outsourced part or all of their manufacturing operations to third-party manufacturers called "subcontractors".

Subcontractor firms have branded themselves as "electronic contract manufacturers" or "electronic manufacturing service" firms, implying a form of organization and service, such as Solectron, Celestica, Flextronics, and Sanmina-SCI for the assembly of modules and subsystems. An ECM is regarded as a supply chain arrangement by which a manufacturing firm outsources some of its manufacturing processes to an outside supplier through a contractual agreement [7–11].

There are two different types of electronic contract manufacturing arrangements: components consignment and turnkey arrangement. Under components consignment, the electronics companies buy components from the component suppliers and ship components to the ECMs so that they can assemble the components to make finished units. The finished goods made by ECMs will eventually be shipped back to the electronics company [8,12]. The second type, turnkey arrangement, allows the ECMs to order parts directly from component suppliers that have been pre-approved by the electronics companies. Under this type of arrangement, ECMs have to integrate their operation with the electronics companies to increase their competitiveness. ECMs have vertically integrated themselves within their specialty by increasing the range of services they offer. Aside from PCB assembly, most ECMs provide a range of back-end and front-end services, such as design for manufacturability, circuit-board layout, product process development and documentation, product testing, test routine development, fixture design and final product assembly, final packaging, software programming, and shipping finished products directly to distributors. Table 1 shows the types of services typically offered by turnkey ECMs. Traditionally, manufacturing companies only delegate the fabrication of components and sub-assemblies to other manufacturers. However, when an electronics company like Sony or Nokia outsources to an ECM, it delegates the entire manufacturing/assembly process to that ECM. In this case, the ECM no longer limits itself to contract manufacturing. Most ECMs also offer turnkey contract services.

2.2. Selection issues

2.2.1. Selection techniques

Techniques for selecting suppliers can be classified into two main categories. Those techniques in the first category select the best single supplier that can meet all the requirements of customers, while the approaches in the second category select an appropriate combination of suppliers when no single supplier can satisfy all the requirements. In the latter, management must split order quantities among the available suppliers taking into account a variety of factors. There is a handful of literature devoted to the

Table 1
Services typically offered by turnkey ECM [60].

Backward integration:	Core service:	Forward integration:
<ul style="list-style-type: none"> • Design services <ul style="list-style-type: none"> – Component design – Circuit board design – Test fixture design – Test routine design • Layout services <ul style="list-style-type: none"> – Circuit board layout – Through-hole to SMT conversion – Redesign for manufacture ability • Turn-key purchasing <ul style="list-style-type: none"> – Component selection – Component purchasing – Incoming component inspection – Materials management • Logistics 	<ul style="list-style-type: none"> • Circuit board assembly <ul style="list-style-type: none"> – Screen printing – Component placement – Soldering – Cleaning 	<ul style="list-style-type: none"> • Testing services <ul style="list-style-type: none"> – In-circuit test – Functional test – Environmental test • Final product assembly • Document reproduction • Software reproduction • Final packaging • Shipping to distribution • Repair <ul style="list-style-type: none"> – Circuit board level – Final product level

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