An exploratory study on manufacturing strategy formulation in start-up companies

Sirirat Sae Lim1, Ken Platts2, Tim Minshall3
Institute for Manufacturing, Engineering, University of Cambridge
Mill Lane, CB1 2RX, Cambridge, UK
1 sls33@cam.ac.uk, 2kwp10@cam.ac.uk, 3thwm1000@cam.ac.uk

Abstract
In the UK, as more traditional manufacturing is outsourced to lower-cost countries, the development of new high-tech manufacturing firms is increasingly perceived as important for sustaining a competitive UK manufacturing base. Early in their lifecycle, start-ups are vulnerable and prone to failure. Mistakes made in critical decisions regarding entry into manufacturing can significantly impact the survival of the firm. Developing the most appropriate strategy is probably more critical in start-up companies than in established organizations, yet little research has addressed this area. This paper reports research into the development of manufacturing strategy in start-up companies. The paper first reviews the literature and then presents findings from nine case studies of start-up companies, showing the nature and timing of the key strategic decisions that were taken, and examining the issues and problems encountered. Using the results from the cases, and the concepts of development tasks and strategic decision areas taken from the literature, a conceptual framework for strategy formulation in such companies is developed. The paper concludes by discussing the use of the framework, and suggesting how it might be operationalised to provide assistance to operational managers in start-up companies.

Keywords: Manufacturing Strategy, Start-up Companies

Introduction
The role of high-tech manufacturing start-ups as a major source of innovation and as an engine of economic growth is increasingly recognized by Western economies. In the UK, as more traditional manufacturing is outsourced to lower-cost countries, the development of new manufacturing firms based on science and engineering is increasingly perceived as important for sustaining a competitive UK manufacturing base.

Start-ups are new businesses with limited operational histories and few established practices. Early in their lifecycle, start-up companies are vulnerable and prone to failure. Usually small and with limited resources, they have yet to build up the strength and resources to sustain them through both internal and external challenges [1]. Operating in such an environment, mistakes made in critical decisions regarding entry into manufacturing can significantly impact the survival of the firm. Only a minority of start-ups survive ([1], [2] and [3]). Most fail to move beyond building a feasible prototype into creating significant market value.

Despite the increasingly important role high-tech start-ups play in the economy, research relating to the manufacturing strategy development process of start-ups is surprisingly scarce. Most literature on manufacturing strategy assumes the existence of established activities and industry structure (see, for example, [4], [5], [6], [7], [8] and [9]). In established manufacturing firms, target markets, products and manufacturing strategy have already been defined to a certain extent. It is unclear whether or not findings about manufacturing strategy development and implementation processes in established firms are relevant to start-up companies that have far fewer resources and face markets and products that are still evolving. Studies of new firms, on the other hand, have concentrated on
entrepreneurial personality and activities in the process of discovery and exploitation of business opportunities (see, for example, [10] and [11]). There is little collective knowledge about the practical methodologies and tools which can help start-ups design, formulate and manage their manufacturing strategies.

**Understanding Start-ups**

Start-ups are fundamentally different from established firms and require decisions and solutions to problems that are unique to them. A review of the literature about start-ups shows that they have different organization structure, management style and management focus from established firms ([12], [13] and [14]). The challenges facing start-ups are also unique to themselves [14]. In early stages of existence, the organizational structures in start-ups are informal [12] or even non-existent, as observed by Kazanjian and Drazin ([14] and [15]). The main business objective is simply to exist and to survive ([14]). Usually technically or entrepreneurially oriented, the founder(s) play a central role in decision making and often supervise directly the overall operations of the firm [14]. Due to the skeleton structure, the management is often able to respond swiftly to customer and market feedback [13]. Business activities that take place during the early stages of operation include: a search for matching opportunities and resources, selection of entrepreneurial projects, securing resources and setting up production [10].

Flamholtz [16] observes that after a company is formed, it focuses on identifying and defining the markets, as well as on developing products and services (depicted in pyramid (a) in Figure 2). As the young firm grows, the development foci are shifted to another set of key development task: acquiring resources and developing operational systems (pyramid (b) in Figure 2). Flamholtz’s observations are consistent with those of Churchill and Lewis [13] and Kazanjian and Drazin [14] who suggest that obtaining customers and developing products are the two management foci at these early stages. Greiner [12] affirms that as a young firm grows, the need for knowledge about the efficiency of manufacturing becomes apparent.

**Figure : Development emphases in various stages of growth**

Source: adopted from [17] and [18]
<table>
<thead>
<tr>
<th>Area</th>
<th>Types of problem</th>
<th>Details of the problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product development and technology</td>
<td>• Technical problems</td>
<td>• unforeseen product design difficulties</td>
</tr>
<tr>
<td></td>
<td>• Market credibility</td>
<td>• customers are uncertain about the new company</td>
</tr>
<tr>
<td></td>
<td>• Lack of focus because of desperation for sale volume</td>
<td>• underestimate marketing costs</td>
</tr>
<tr>
<td></td>
<td>• Manufacturing equipment does not work to specification</td>
<td>• underestimate time to get established</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• overestimate sales revenues</td>
</tr>
<tr>
<td>Marketing</td>
<td>• Managing suppliers</td>
<td>• untried and untested, so may be unreliable</td>
</tr>
<tr>
<td></td>
<td>• Difficulty in scaling up production from pilot operation</td>
<td>• suppliers unwilling to sign contracts</td>
</tr>
<tr>
<td></td>
<td>• Delays</td>
<td>• new company lack creditworthiness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• delays</td>
</tr>
<tr>
<td>Suppliers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>• Cost overruns</td>
<td>• poor estimations in original business plan</td>
</tr>
<tr>
<td></td>
<td>• Overtrading</td>
<td>• cost of moving along the learning curve not taken into account</td>
</tr>
<tr>
<td></td>
<td>• Financial leverage too high</td>
<td>• grow faster than cash resources permit</td>
</tr>
<tr>
<td></td>
<td>• Accounting and control systems relegated to bottom of priority list</td>
<td>• delays in arrival of funding</td>
</tr>
<tr>
<td>Finance</td>
<td>• Finding the right people</td>
<td>• do not know where to find staff</td>
</tr>
<tr>
<td></td>
<td>• Retaining people</td>
<td>• poor at judging them</td>
</tr>
<tr>
<td></td>
<td>• Lack of experience managing people</td>
<td>• cannot pay enough to recruit top-quality people</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• may have little or no experience in this area</td>
</tr>
<tr>
<td>Human resource</td>
<td>• Entrepreneur’s own attitudes</td>
<td>• lack of real commitment to the business</td>
</tr>
<tr>
<td></td>
<td>• Lack of business skills and management experience</td>
<td>• lack of urgency when no cash flow problems exist</td>
</tr>
<tr>
<td></td>
<td>• Informal entrepreneurship leadership</td>
<td>• poor leadership ability when the inevitable crises arise</td>
</tr>
<tr>
<td></td>
<td>• Time pressure on entrepreneur</td>
<td>• partnership problems or boardroom conflicts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• everything takes longer than planned because entrepreneurs consistently underestimate the time necessary to implement even simple actions, speed of market acceptance, the cost of moving along the learning curve, etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• too much to do, stress and its effect on health and family</td>
</tr>
</tbody>
</table>

Source: Adopted from [18]; [19 Table 3]; [20 Table 2.2, pp. 62] and [21]

*Table 1: Typical problems encountered by start-ups*
Table 1 presents a list of typical challenges facing start-ups. These challenges include: exhaustion of early resource endowments, the absence of a strong and experienced management team, informal entrepreneurial leadership (that cannot cope as the firm grows more complex) and communication problems ([18] and [19]). Other challenges are: product development and technology problems, cash flow problems, scaling up production from pilot lines, marketing, enlisting suppliers, managing supply chains and the lack of management experience ([20] and [21]). Slatter [20] emphasizes that these challenges often are interrelated with one another, causing cash flow problems. Specifically, Ford [21] finds that while they are highly skilled in a specific technical area, many founders of start-ups recognize that they lack the business skills to turn the venture into a profitable business. Founders also often face difficulties in recruiting and retaining sufficiently skilled individuals [21].

Manufacturing Strategy
This paper defines manufacturing strategy as ‘a pattern of decisions, both structural and infrastructural, which determine the capability of a manufacturing system and specify how it will operate to meet a set of manufacturing objectives which are consistent with overall business objectives’ [22, pp. 7]. Despite the differences between start-ups and established firms, current research findings about manufacturing objectives, strategic decision areas and strategy process provide a useful basis for research into manufacturing strategy for start-ups. Manufacturing objectives address the issue of competitive priorities, which according to Skinner [4] include cost, quality, deliverability and flexibility. Table 2 summarizes these objectives and their scopes.

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Scopes of the objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>refers to cost related factors in the production and delivery of products, i.e. internal costs (e.g. material, labour, facilities, technology, equipments and overhead costs)</td>
</tr>
<tr>
<td>Quality</td>
<td>refers to achieving the company defect rate targets, i.e. manufacturing of products with high quality and performance standards</td>
</tr>
<tr>
<td>Delivery dependability</td>
<td>refers to achieving delivery targets, i.e. meeting delivery schedules</td>
</tr>
<tr>
<td>Delivery speed</td>
<td>refers to achieving delivery targets, i.e. reacting quickly to customer orders to deliver fast</td>
</tr>
<tr>
<td>Flexibility</td>
<td>refers to the ability to cope with change or uncertainty and variety, i.e. reacting to changes in product, changes in product mix, modifications to design, fluctuations in materials, changes in sequence and volume</td>
</tr>
<tr>
<td>Others</td>
<td>refers to after-sale service, advertising, broad distributions and broad product line</td>
</tr>
</tbody>
</table>

Source: Adopted from [23, pp. 758] and [24, pp. 113 – 115]

*Table 2: Manufacturing objectives and their scopes*
Strategic decision areas, often categorized in two groups: structural and infrastructural, are the critical areas that make up a manufacturing strategy. Wheelwright [25] asserts that the collective pattern of decisions in these areas determines not just the structure but also the capabilities of a manufacturing company. Effective choices in the structural and infrastructural decisions often lead to manufacturing excellence [26]. Table 3 summarizes the strategic decision areas suggested in the literature.

<table>
<thead>
<tr>
<th>Category</th>
<th>Decision Areas</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structural Decisions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td>Total capacity, capacity flexibility, shift patterns, temporary subcontracting policies</td>
<td></td>
</tr>
<tr>
<td>Facilities</td>
<td>Location, number and size of sites, focus of manufacturing resources, allocation of tasks to sites</td>
<td></td>
</tr>
<tr>
<td>Process technology / Production equipment</td>
<td>Equipment, automation, connectedness, integration, technology choice, configuration of equipment into lines, cells, etc., maintenance policies and the potential for developing new processes in-house, implementation, subcontracted development</td>
<td></td>
</tr>
<tr>
<td>Vertical Integration</td>
<td>Strategic make vs. buy decisions, supplier policies, supplier relationship, supplier development, extent of dependence on suppliers, network behaviour</td>
<td></td>
</tr>
<tr>
<td><strong>Infrastructural Decisions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human resources</td>
<td>recruitment, training and development, culture and management style</td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td>quality assurance and control policies and practice, defect prevention, monitoring, intervention</td>
<td></td>
</tr>
<tr>
<td>Production planning and materials control</td>
<td>computerization, centralization, decision rules, production and order, material control systems</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td>structure, reporting levels, support groups, accountability and responsibility</td>
<td></td>
</tr>
<tr>
<td>Performance measurement</td>
<td>Financial and non-financial performance measurements and links to recognition and reward systems</td>
<td></td>
</tr>
<tr>
<td>New product introduction</td>
<td>design for manufacturing guidelines, introduction stages, organizational aspects e.g. manufacturing role in concurrent engineering</td>
<td></td>
</tr>
</tbody>
</table>

Source: adopted from [8]; [27] and [28]

Table 3: Strategic Decision Areas comprising a Manufacturing Strategy

It is apparent from the above review that most literature on manufacturing strategy, be it the study of manufacturing strategy content or manufacturing strategy processes (such as the processes proposed by [4], [5], [6], [7], [8] and [9]), assumes the existence of established activities and industry structure. This review also demonstrates that a start-up company is distinctive from an established firm in various aspects, ranging from organization structure to business objectives and to management focus. It is unclear whether findings about manufacturing strategy development and implementation processes in established firms are relevant to start-up companies that have far fewer resources and face markets and products that are still evolving. These observations lead to the following questions:

- To what extent are the findings about the manufacturing strategies of established firms relevant to start-ups?
• Do strategic decision areas play an equally important role in a start-up’s manufacturing strategy? Could there be some decision areas that are more prominent than others in the early stages of a firm’s operation? Which particular decisions are made earlier than the others?
• How do start-ups formulate and implement their manufacturing strategies?

The review also reveals that although the challenges facing start-ups have been identified by the research community, there is little research into how these challenges are dealt with. An in-depth case study is likely to be effective in studying these issues.

Exploratory Research
In order to address the issues highlighted above, we conducted an exploratory case study that asked the following questions:
1. How does a start-up develop manufacturing strategy?
2. What manufacturing decisions does a start-up make?
3. What are the issues and problems a manufacturing start-up encounters and how are these issues dealt with?

This research builds on the existing work on entrepreneurship, organization-growth models and manufacturing strategy. In particular, it focuses on start-ups that are set up to design, manufacture and market physical products that are assemblies of individual components. The context is set in the early stages of the start-ups’ operations (as illustrated in Figure 2). The literature on organization-growth models shows divergent views about firms’ growth patterns. Nevertheless, there are similar findings about firms’ early phase development (see, for example, [13], [18] and [29]).

Figure 2: The growth stages studied in this research

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Figure 2: The growth stages studied in this research

The study investigated strategy formulation in a total of nine UK manufacturing start-ups, all of them with less than ten years of manufacturing experience and which still have their founders managing the firms. The companies come from diverse industries ranging from bio-medical devices to renewable energy, to software developers, to security, to printing. Primary data was collected through semi-structured in-depth interviews with the company’s
founding teams. A total of twenty interviews involving fifteen informants were conducted. The informants were interviewed either together or separately in a single session or over the course of multiple sessions. On average, each interview lasted approximately 90 minutes. Past decisions that lead to and/or were linked to the development of manufacturing strategy in these companies were probed. In order to better understand the contexts of the decisions, information regarding the events that took place alongside the decisions, as well as the sequence by which the decisions and events took place was collected using Strategy Charts (developed by Mill et. al, [31] and [32]). Triangulation techniques [33] were applied to eliminate recall or hindsight bias ([34] and [35]. Contemporaneous documentation and archival records were gathered as secondary data [33] and [36]. Both the primary and secondary data were then synthesized and analyzed to illuminate the strategy content and formulation process in these companies.

Findings and Discussion
Starting a business
All the companies went into business with a technology that the founders believed would create commercial value. In some cases, businesses were sparked by a technology or a solution that was not, or not initially, developed for commercial use. When one of the founders in Company C came across a three-dimensional X-ray technology developed by an academic in a UK university, he saw a business opportunity in the security market. Subsequently, he set up a business to commercialize it. However, as the technology was not initially developed for commercial use, it took Company C three years to develop the product concept before they could turn it into a product prototype. On the other hand, in company G, from an early stage the founder developed the technology (biological scaffolds that support tissue regeneration, the founder’s PhD research) with an intention for later commercialization. Hence market requirements were taken into consideration early on. Nevertheless, not all the companies followed this technology driven route. Company I for example, was not prompted by a new technology, but rather by a market opportunity. Before starting the business, the founders conducted a thorough market analysis. Only after a business opportunity was identified did they start to develop a product that would exploit it.

Development tasks/value creating activities
Preliminary findings from the study suggested that there were seven major value creating tasks the start-ups undertook in their early stages of operations, viz. (1) acquiring financial resources; (2) developing products; (3) developing a market and acquiring customers; (4) acquiring human and production resources; (5) delivering products; (6) developing production systems and (7) developing other systems. This finding is consistent with that of Flamholtz [16], Churchill and Lewis [13], and Kazanjian and Drazin [14].

(1) acquiring financial resources
Acquiring financial resources involved activities such as identifying sources of funding, planning for rounds of funding, negotiating with investors and managing the funds received. Financial decisions dominated not just this task but also the other six tasks. Cash was the most critical resource for the survival of all the start-up companies. It had a strong impact on most strategic decisions the firms made. Founders of all the case companies found themselves constantly having to raise funds to sustain their company.
(2) developing products
Major activities involved in developing products were the proof of product concept and product technology through working prototypes, the proof of production viability through pilot lines, and managing issues associated with intellectual property and regulations. Key decisions made while this task was performed covered the areas of process technology, make vs. buy, new product introduction, capacity and facility.

(3) developing a market and acquiring customers
This task included activities such as understanding and identifying potential markets, creating a market/niche, developing a competitive strategy, acquiring the first customer and expanding from one key customer to a broader sales base. The majority of the companies acquired their first customers in tradeshows where they demonstrated their working prototypes. These companies were also quick to engage their new customers in the development of their prototypes into products. For Company A, this not only helped the young company understand the market but also raised its profile and expanded its customer base. Most decisions relevant to this task were marketing related. The dominant strategic decision areas were connected to the introduction of new products.

(4) acquiring human and production resources
Acquiring human and production resources involved activities associated with capital investment, production technology, scaling up of production, recruitment, new product development, and so on. Closely linked with this task was the development of production systems.

(5) delivering products
Delivering products included activities related to inventory management, product delivery, distribution channels and after-sales service. Most decisions were related to vertical integration.

(6) developing production systems
Developing production systems involved establishing systems for production planning and material control, quality, performance measurement, and so on. Key decisions were made in the areas of process technology, make vs. buy, supplier relations, vertical integration, human resources and facilities.

(7) developing other systems
Finally, developing other operational systems such as human resource systems, knowledge management systems and information systems meant decisions in the strategic areas of organisation and human resources were made.

Business and manufacturing objectives
Most of the case companies did not explicitly state business or manufacturing objectives, and none had formal processes for setting objectives and formulating plans for achieving them. Rather than setting production standards concerning quality and performance, they concentrated on activities related to survival. In order to survive, the start-ups strove to maximize their funding and minimize their running costs. In start-ups B and C for example, the founders reduced prototype development costs by making use of the production labs in the organizations they were associated with. The founder of Company B explained,
“Construction and testing are obviously important parts of the prototyping process, but increasingly modern devices require very high capital cost equipment to construct and test…. The only solution is to partner early on with someone with the facilities to manufacture and possibly also test the design for you.”

Approach to strategy
In the early stages when there was no clear division of responsibilities between the founders, most key decisions were made collectively by the members of the founding team rather than by just one person. The entrepreneurial mode of decision-making highlighted by Mintzberg [37] was not apparent in these case companies.

The study also found that most strategies in start-ups were emergent rather than deliberate. In other words, strategy emerged as strategic learning took place in the companies [38]. Most strategies emerged as a result of trial and error as unpredictable developments continually dominated the business landscape. Few strategies were deliberately planned in advance or developed consciously and purposefully. Additionally, most start-ups approached strategy development in an unstructured way. In most companies, no formal strategy processes were developed. It seems that a feasible way of understanding strategy formulation in start-ups is to identify at which point in the business cycle key decisions were made.

A majority of the founders, especially those without business or industrial experience were unsure of the events or challenges that were lying ahead of them. As a result, most of them failed to plan in advance and the management teams often had to make unplanned decisions. A decision roadmap that shows at which point key decisions are made is likely to be useful. A founder gave a clear description of this issue:

“It’s a reactive company rather than (a proactive one), we tend to react to situations. We have never had the luxury to sit back and plan... and that hits the personnel because it’s high pressure for people, it hits our bottom line because reactive is always more expensive than planning for it, it can eliminate some of our customers because we can’t respond the way they wanted us to...”

Resource constraints
A lack of financial resources was one of the biggest challenges facing start-up companies throughout their operations. Comments by a founder expressed this point clearly:

“Cash is king. Cash pays the wages, bills, suppliers, development, advertising, etc. This is particularly the case for start-up companies. Until neutral cash generation is achieved the start-up is regarded as a ‘cash-burn’ company. If you run out of cash at any point you fail. You raise more cash when you have cash not when you have run out of cash.”

Financial constraints called for flexible solutions to all challenges, ranging from product development problems to production problems. Most companies attempted to delay investment in expensive equipment at the early stages. To test their prototypes, Companies B, C and G made use of equipment in the laboratories of universities where the founders worked. Company B recruited part-time technicians to work on its production line. To obtain the funding to scale up production and to extend their markets, some companies
floated on the stock market. In 1996, when Company D decided to change its business model from licensing its technologies to selling physical products, it went public to fund the implementation of the decision.

**Pressure to bring product to market**
A common feature found across the companies was pressure to reduce *time to market*. Time to market refers to the length of time a product takes from its conceptualization until its being available for sale. Owing to shortages in vital financial resources, especially in the early stages, a short *time to market* is crucial for a start-up’s survival. This pressure had significant effects on the decisions the case companies made. For instance, as it was both time-consuming and uneconomical for the small start-ups to make the components of their products, almost all of them bought the components from suppliers. In addition, to shorten *time to market*, most firms outsourced standard and common manufacturing processes in order to achieve maximum parallelism in their product development. Company A achieved a short *time-to-market* through outsourcing almost the entire production process of its first product to a contract manufacturer. Only critical processes such as loading of software and product testing were kept in-house.

In some of the case companies, high pressure to bring the first product to market quickly resulted in the launching of premature products with compromised quality. Defects in product designs and manufacturing processes then became the triggers for setting manufacturing objectives (such as quality). For example, company A only realized that it had problems in its product design after receiving complaints from customers about bugs in their software and their products. This company responded by making quality its primary objective and introducing quality assurance processes into its production mechanism.

**Lack of marketing, recruitment and management skills**
Developing a market was a major task the companies undertook early on. For founders who lacked marketing experience, to understand and to identify potential markets, as well as to compete in them were challenging tasks. To tackle the problem, the founders of Company F engaged the services of an external marketing consultant who conducted a market assessment. This lead the team to identify four potential markets, viz. trade exhibitions, visitor attractions, advertising and mobile entertainment. Company F was then able to narrow down the scope to visitor attractions and advertising, and develop competitive strategies to enter these markets. Similarly, Company G employed external experts to help its founding team formulate a regulatory compliance roadmap that came with clear and explicit targets and milestones. Company B adopted another approach; instead of finding external help, the founders conducted a market survey themselves, followed by a product trial involving 100 participants to help them understand their potential customers.

**Developing products, make vs. buy decisions and supplier relations**
Whilst developing prototypes, a major challenge encountered by those founders without prior industrial experience was the sourcing of components. Off-the-shelf components found in catalogues were often used. As a result, the designs of their prototypes were dictated more by the available materials than by the most desirable designs. As catalogue suppliers usually hold a limited range of products (“typically the most common and most multi-purpose ones” as commented by a founder), start-ups had to alter their product designs to fit in. Off-the-shelf components were also often products of older technology
making the prototypes “inefficient” as commented by a founder of Company B. He explained,

“If there is a new development in an area, it can take literally years for it to filter into the catalogues, because insufficiently large numbers of catalogue chip purchasers are leading edge developers, so you also end up only with old technology in the catalogues. That means your design is inherently inefficient because you are unnecessarily compromising your design simply because of what you can get hold of.”

Additionally, as a start-up lacks a track record and creditworthiness, initiating business with suppliers and contract manufacturers was not easy, especially for inexperienced founders. This is consistent with the findings of Slatter [21] concerning challenges facing small high-tech firms. For instance, most companies found that payments for components had to be made up front, increasing the financial pressure on the already cash-tight company. Equally challenging was managing effective relationships with the suppliers and contract manufacturers.

Challenges related to scaling up

When the need to produce more products arose, two major problems were experienced: limitations in resource availability (often due to cash constraints), and uncertainty in sales. As a result, most companies only expanded their production capacity gradually. Shortages in vital resources called for flexible solutions to production problems. For example, companies rented third parties’ facilities or collaborated with suppliers or contract manufacturers, as discussed in the earlier sections. Uncertainty in sales also made forecasting a challenge. Mistakes made in forecasting when scaling up production, such as over or under ordering components and recruiting, could be very costly for a young company. Recruiting professional production personnel early on was seen by many founders to be the solution to many production-related challenges. With hindsight, most companies commented that they would have recruited their professional production personnel sooner than they did. A founder’s comment explains this issue clearly:

“Getting someone thoroughly professional in manufacturing early on is the key, the earlier you can get it the better. What would have solved a lot of problems for us would have been to get this guy (an Operations Manager) in 1997 (when the company started to manufacture its first product from prototypes).”


The findings and key learning points lead to the construction of a conceptual framework that illustrates the development of manufacturing decisions in start-ups. The framework, as illustrated in Figure 3, may provide a manufacturing decision roadmap for operations managers in start-ups.

The conceptual framework incorporates four elements: business/manufacturing objectives, value creating/development tasks undertaken by start-ups, decisions made in strategic decision areas of a manufacturing strategy, and the dimension of time.
The first component of the framework is the setting of business/manufacturing objectives. Findings from the research demonstrated that in the early stages of operations, the main aim of start-ups is to survive. In order to do so, they strive to secure maximum funding, to minimize their production and operational costs, and to bring the first product to the market quickly. Manufacturing objectives are only developed as start-up companies begin to build manufacturing capacities and deliver products to customers.

The second part of the conceptual framework shows the major development tasks start-ups undertake: (1) acquiring financial resources; (2) developing products; (3) developing markets and acquiring customers; (4) acquiring human and production resources; (5) delivering products and (6) developing production systems and (7) Developing other systems. In the conceptual framework, these tasks are plotted against a timeline to show the sequence in which they occur. Some tasks are presented in columns which are overlap with one another to show that they take place together.

The third element of the conceptual framework illustrates the financial, structural and infrastructural decisions start-ups make in order to accomplish their development tasks as well as to achieve their business objectives. These decisions, in the form of a list of questions, are also plotted along a timeline to show the sequence in which they are made. The framework also illustrates the links between the decision areas and the development tasks, as well as showing the interrelations with value creation activities. Showing the interrelations between these decisions and value creation activities illustrates the dynamics among them. In addition, the study also identified the sequence in which these development tasks were performed and strategic decisions were made.

**Conclusion**

This paper has identified from both the literature and from industry a knowledge gap in the study of manufacturing strategy of start-up companies. An exploratory case study inquiry involving nine manufacturing companies was conducted to help identify the key manufacturing strategy development decisions and issues in a start-up. Findings from both the literature and the exploratory case studies gave rise to a conceptual framework of manufacturing strategy development in start-ups. The framework captures key manufacturing decisions start-ups make as they develop their manufacturing strategies and elucidates how strategies are formulated. Further development of the framework in the forms of testing and refining it will be undertaken by means of multiple in-depth historical case studies, and longitudinal cases of companies that are currently in the start-up phase.
### Figure 3: Conceptual Framework of Strategy Formulation in Start-up Companies

<table>
<thead>
<tr>
<th>Development Tasks</th>
<th>Financial, Structural and Infrastructural Decisions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Acquiring financial resources</td>
<td><strong>Financial:</strong> How much money should we raise? From where can we raise the money? How do we raise the money? How do we manage the money when we get it? When should we raise funding again? Should we sell the business and exit? Should we go public?</td>
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<tr>
<td>(2) Developing products</td>
<td><strong>New Product Introduction:</strong> What are the product standards or regulations associated with the product/technology? Should we patent our technologies/products? Could we produce the prototypes by ourselves? Where can we get the necessary equipment to produce the prototypes/products? What is the ownership of the equipment? Who will manage the equipments? How do we test the prototypes/products? Should we enter into manufacturing our products? <strong>Make vs. Buy/Supplier Relations:</strong> What components of the prototypes should we be making in-house? Why? Which production processes should we keep in house and which should we outsource? Why? <strong>Vertical Integration:</strong> Where can we find suppliers of components and contract manufacturers for assembly? How do we choose among the suppliers/contract manufacturers?</td>
</tr>
<tr>
<td>(3) Developing a market and acquiring customers</td>
<td><strong>New Product Introduction:</strong> How can we speed up time-to-market? What are the order winning criteria in the chosen markets? Are the prototypes/products meeting customers’ needs? How flexible are the product designs to changes? Are there any relevant product/technology competitions we can take part in to raise the profile of the product/technology? <strong>Capacity:</strong> Do we have the production resources to meet market/customers’ requirements/needs? <strong>Vertical Integration:</strong> What are the channels to acquire customers?</td>
</tr>
<tr>
<td>(4) Acquiring production resources</td>
<td><strong>Human Resources:</strong> What set of skills does the company require in order to grow? Should we recruit professional staff or technical ones? Should we contract professional services? Where could we find staff? How do we attract the right people to join us? How do we keep them? Are people in the team compatible? <strong>Facilities:</strong> Should we build a pilot line? Should we expand the size of our site? Where should the site be located? <strong>Process Technology:</strong> What production equipment should we get? <strong>Financial:</strong> How do we finance the building of the pilot line/scale up production? Can we afford to recruit new staff and to invest in production equipments? How do we finance the decisions? <strong>Make vs. Buy/Supplier Relations:</strong> What have we learned about suppliers while building prototypes to scale up production? Should we stay with the same suppliers? Why and why not? How do we ensure the quality of components we buy? <strong>Vertical Integration:</strong> Which production processes should we keep in house and which should we outsource? <strong>New Product Introduction:</strong> What is our new product development strategy? When developing new products/evolving existing ones – can we afford to support the new product and the old one?</td>
</tr>
<tr>
<td>(5) Delivering products</td>
<td><strong>Vertical Integration:</strong> How do we best deliver the products to customers? How do we build a distribution network? What after-sales services should the company provide?</td>
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<tr>
<td>(6) Developing a production system</td>
<td><strong>Process Technology:</strong> What are the process technology policies on maintenance, automation, connectedness, technology choices, configuration of equipment into line, and so on? <strong>Production Planning and Material Control:</strong> What systems (i.e. computerisation, decision rules, production and order, material control) should the company adopt? <strong>Facilities:</strong> Should we focus all production on a single site? <strong>Financial:</strong> How can the company finance our expansion? <strong>Human Resources:</strong> What set of skills does the company require in order to develop our production systems? <strong>Vertical Integration:</strong> How do we evaluate the performance of our suppliers and contract manufacturers?</td>
</tr>
<tr>
<td>(7) Developing other systems</td>
<td><strong>Organization:</strong> What organization structure should we adopt? <strong>Human Resources:</strong> How do we develop a HR system? How can the company prevent knowledge drain when staff leave?</td>
</tr>
</tbody>
</table>
Reference


