

Role of Design and Manufacturing Services in the New Product Development Process in Taiwan

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The development of the manufacturing process for innovative products has always been a challenge for startup businesses. In recent years, different types of manufacturers have emerged in Taiwan, known for its rich manufacturing resources and industry chains. In light of this, the study seeks to identify the roles played by different types of suppliers as well as the services they provide in the bootstrapping stage, seed stage, and creation stage of the startup process by conducting interviews with design consultants, design matching organizations, design manufacturing service providers, and an IoT startup. Research has found that designers can provide project management, matching, and manufacturing services as well as help startup companies visualize their concepts and evaluate the marketability of their products or services. They can also provide assistance with any communication related to prototype development and mass production, division of labor within the organization, outsourcing, and overall time management so as to make sure that the product can hit the market as scheduled. Since confirming the engineering requirements of the components of a product in the design concept paper early in the process so as to confirm the technical and manufacturing feasibility is an issue often overlooked by startup companies, we suggest startup companies seek assistance from manufacturers during the concept development stage.

Keywords: *startup; innovative tech products; design prototype; product manufacturing process; Startup PLC*

1. Introduction

Recent years have witnessed an entrepreneurship boom around the world. The importance of startup businesses to the domestic economy is drawing increasing attention. The Maverick Research by Gartner found that although startup companies are good at making use of low-cost products and creating IoT devices using open source hardware, they still face a number of risks including delayed or missed production date, added capital expense costs, extended project timeline, additional operating expense with no production, and risks from environmental, health and safety (<https://www.mavtechglobal.com>). Based on the research conducted by Shikhar Ghosh from Harvard University, 75% of the startup teams end up failing (Blank, 2013), especially when it is related to technological innovation as the highly dynamic market and technological uncertainties often lead to research and

development failures (Wang, Lin, & Hunag, 2010). Other factors include the lack of knowledge on business models and delayed technologies (Gómez, 2007). This study aims to identify ways to make use of the abundant OEM (Original Equipment Manufacturer) and manufacturing resources in Taiwan in order to provide startup teams with the assistance they need at the early stage of the new product development process, thus reducing failure rates.

2. Literature review

2.1 High tech network and policy in Taiwan

In the late 1970s, as home electronics and consumer electronics companies in the United States and Japan began to look for OEMs in Taiwan, many electronics manufacturing companies emerged in Taiwan. Subsequently, in the late 1990s, Taiwan became the world's third largest producer of IT hardware products. Some research studies believed that the success of the PC and IC industries in Taiwan should be attributed to the Industrial Technology Research Institute of Taiwan established by the government and the affiliated Electronics Research and Service Organization (Amsden & Chu, 2003). In addition to transferring the technological knowhow to local manufacturers, this phenomenon also provided the capital necessary for the diversified development of the manufacturing industry. Thanks to the government's support, many large companies met the requirements for mass production, and as a result, many local manufacturers were able to make use of new manufacturing technologies to manufacture different kinds of new products at a low cost (Saxenian, 2007).

2.2 The lifecycle of startup companies

The structure of startup companies is not only diverse but also highly complex. It was not until recent years that the explanation of the startup lifecycle came into existence. According to Salamzadeh & Kawamorita (2015), it is important that the bootstrapping stage and the seed stage be taken into consideration even before a startup company is formally established (see figure 1).

The bootstrapping stage is the earliest stage of the startup process. At this stage, a startup team is required to rely on its available resources so as to achieve its goals instead of obtaining resources from the outside. Yet, the key at this stage is for the team to determine the feasibility of the product, financial management, team structure and management as well as the strategy of the startup based on customer acceptance of the product (De Bruin, Bush, & Welter, 2006). The seed stage, in contrast, focuses on teamwork, prototype development, market entry, evaluating joint ventures, and seeking outside assistance, such as accelerators and incubators. Nonetheless, this stage is the most unstable period of time for most startup teams as many teams fail to find an appropriate support mechanism and therefore partner with companies with relatively low profit margins, further increasing their failure rate. A team begins to stabilize as it enters the creation stage, which is when the product has already hit the market and the team has begun to hire more staff, meaning that the company is formally being established.

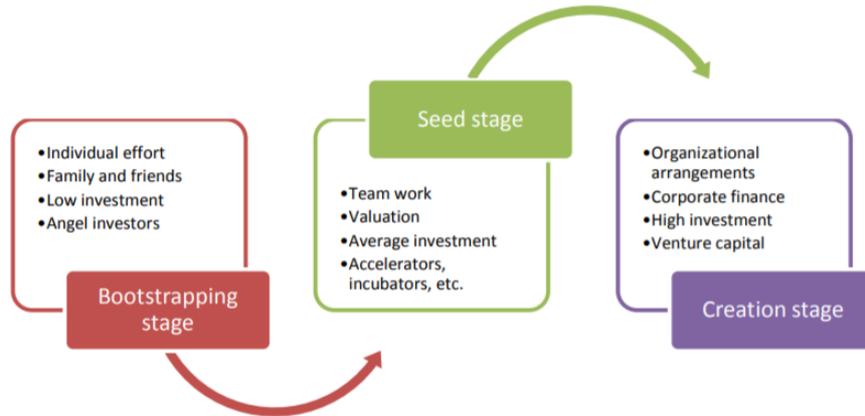


Figure 1. Lifecycle of startups (Salamzadeh & Kawamorita, 2015)

2.3 The product lifecycle of the electronics manufacturing industry

Observing the flow chart of the electronics manufacturing service, we note that whether or not the product can be delivered on time is a primary concern. The development process is usually separated into five stages. 1. Concept Prototype 2. Engineering Validation Test (EVT) 3. Design Validation Test (DVT) 4. Production Validation Test (PVT) 5. Mass Production (Folgo, 2008). This process is a widely used and studied concept in the development of electronic products and is the common way of referring to the product development process in the engineering and manufacturing industry (see Figure 2).

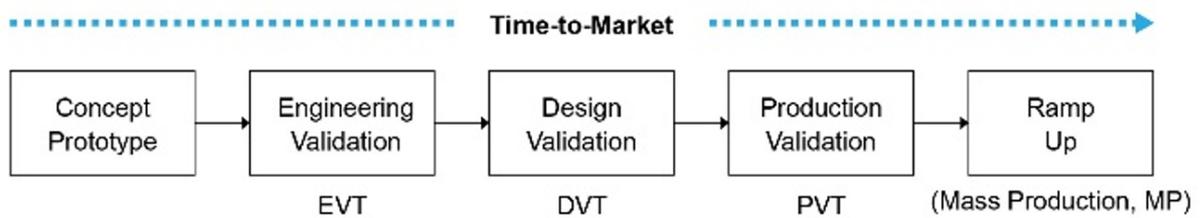


Figure 2. The product lifecycle of the electronics manufacturing industry (Folgo, 2008)

3. Research methods and subjects

This study adopted a case study method and attempted to understand the development path of each company by conducting case analysis (Yin, 2009). Prior to the interviews, the researcher first gathered online news articles of the companies being interviewed from various news outlets before designing an interview guide. Through interviewing non-profit organizations, corporate teams, and consultants that provide design and manufacturing matching services in Taiwan, the study sought to understand the challenges faced by design, technical development, hardware manufacturing, mass production, and so on in developing IoT products. In addition, the researcher conducted an in-depth interview with one of the startup companies that produce IoT products in order to understand the way the company looked for manufacturing resources. The researcher then compared the result with the research findings. The respondents are listed in Table 1. They either have experiences in developing new IoT products or have provided consulting services in this field and are

therefore very familiar with the development and manufacturing process. Of all the respondents, three of them have a design background.

Table 1 Basic information of respondents

Company Name	Taiwan Rapid Innovation Prototyping League for Entrepreneurs	Metro Products Inc.	BLOCKS (modular watch)	Director Li
Founding Year	2015	2004	2013	2016
Job Title of the Respondent	Manager	General Manager	Co-founder	Design Director
Capital	N. A.	5 million	20 million	N. A.
Location	Taipei	Taipei	United Kingdom	Taipei
Product/Service Type	Manufacturing matching /non-profit matching organization	Small-scale manufacturing company	Modular smartwatches	Product design consultant

Source: this study

4. Research findings

4.1 New product development stages vs matching services

The research findings are summarized in Table 2. The major finding reveals that three different types of service matching respondents can assist startup companies in developing and manufacturing their IoT products by playing the important roles of “project manager,” “service matcher,” and “design manufacturing service provider,” respectively. In the bootstrapping stage, for instance, a “design consultant” can help the company define problems, visualize the initial concept to facilitate internal and external communication as well as evaluate the marketability of the product (by participating in international design competitions to test the value of the concept) based on their professional design experience. In addition to identifying the human and financial resources required for the product development process and assisting with the division of labor, this individual can also attract investor eyeballs and promote the marketing concept using aesthetically appealing and succinct presentations. This study found that many designers who used to work in the technology plants have now transitioned to working as design consultants in medical technology or software startup companies. On the one hand, due to lack of resources and projects at the beginning, many startups find it difficult to afford a full-time design manager to develop their product. On the other hand, since startup companies have a relatively good understanding of the value of design, they recognize that design consultants are ideal project managers in the development process of user-friendly products as they can lead both the research and development team and help a company reach its goals in an efficient manner through visual communication. As far as designers are concerned, being the consultant of multiple companies not only allows them to focus on the key design concept of a product at an early stage but also affords them the opportunity to develop a variety of products at the same time. This type of experience is highly sought after among big brand names and large-scale manufacturing companies. Therefore, companies tend to be eager to pursue collaborations of this type.

Second, this study believed that the seed stage is the specialty for the Taiwan Rapid Innovation Prototyping League for Entrepreneurs. Taking advantage of the large amount of manufacturing information in the database of this non-profit organization will allow a

company to simultaneously identify multiple manufacturers that can offer engineering solutions as well as engineering teams. This encourages companies to focus on collaboration and to control the cost of prototype development. During the matching process, the staff from the organization will also participate in team meetings as well as meetings with manufacturers, acting as the bridge between the team and the manufacturers. The objective of the Taiwan Rapid Innovation Prototyping League for Entrepreneurs is only to facilitate the matching process and this League is not responsible for the manufacturing process and mass production. Its major asset, i.e., manufacturing resources, is not used for modifying design concepts. In light of this, this study believed that companies benefit the most from working with outside companies or teams to fulfill their needs during the bootstrapping stage and the creation stage while relying on the Taiwan Rapid Innovation Prototyping League for Entrepreneurs during the seed stage.

We believe that during the creation stage, startup companies should partner with “small-scale manufacturing companies” that have experience in mass production. The reason is that these service providers tend to be more willing to accommodate the production needs of small-scale startup businesses. Since the production scale of a startup company is especially small, it generally does not meet the minimum quantity requirements of large-scale manufacturing service providers. Furthermore, large-scale manufacturing service providers lack the incentive to confirm or modify the production process due to a product’s uncertain prospects in the market and a limited budget. Small-scale manufacturing companies, however, not only possess mass production experience in the supply chain but are also more willing to provide flexibility and co-develop the production process with startup companies, ultimately delivering the products within the agreed timeframe. Since the respondent, the person-in-charge of the small-scale manufacturing service provider, is also a designer, he/she believed that these small-scale service providers can also fulfill some of the needs of startup businesses in the bootstrapping or seed stage. That being said, this study believed that the advantage of providing manufacturing services while modifying designs is what sets these small-scale companies apart as they are more likely to be able to meet the production schedule of startup companies during the creation stage.

Table 2 Comparison Chart between New Product Development Stages and Respective Services

	Bootstrapping Stage	Seed Stage	Creation Stage
Design Consultant (Project manager managing the design)	<ul style="list-style-type: none"> Identify weaknesses of the new product or service Plan the product development path, division of labor, and communication Visualize the concept and conduct market testing Convert the vision into a business solution that appeals to the audience 	<ul style="list-style-type: none"> Assist with time management during prototype development Look for prototype manufacturers based on personal experience Conduct cross-discipline evaluation of a prototype to test its feasibility 	<ul style="list-style-type: none"> Determine the quality of the mass production manufacturer Assist with time management during the manufacturing process
Taiwan Rapid Innovation Prototyping League for Entrepreneurs (service)	<ul style="list-style-type: none"> Arrange experts to conduct tutoring courses Suggest start-up companies apply for different start-up 	<ul style="list-style-type: none"> Make use of the large amount of data on manufacturers held by Industrial Technology Research Institute of Taiwan 	<ul style="list-style-type: none"> Provide a contract for hiring manufacturers and offer partnership suggestions

matching organization managing the design)	subsidies	<ul style="list-style-type: none"> • Recommend experts for free consultations • Arrange and participate in meetings with the team and different manufacturers 	
Metro Products Inc. (manufacturer managing the design)	<ul style="list-style-type: none"> • Identify weaknesses of the new product or service • Plan the product development path, division of labor, and communication • Visualize the concept and conduct market testing 	<ul style="list-style-type: none"> • Look for prototype manufacturers based on personal experience • Assist with the manufacturing of prototypes 	<ul style="list-style-type: none"> • Undertake trial production or mass production projects and entrust the subcontractors to manufacture the product • Deliver the mass produced products to the client as scheduled • Assist the management of inventory and shipment
The primary task in each stage	<ul style="list-style-type: none"> • Right idea 	<ul style="list-style-type: none"> • Workable to prototype 	<ul style="list-style-type: none"> • Time to market
The corresponding stage in electronics manufacturing services	<ul style="list-style-type: none"> • POC-EVT 	<ul style="list-style-type: none"> • EVT-DVT 	<ul style="list-style-type: none"> • DVT-MP

Source: this study

4.1.1 Bootstrapping stage: Identifying the weaknesses of the product concept, planning product development and division of labor, and attracting investment

All three respondents considered the development direction of a concept at the early stage to be crucial. Despite possessing specialized technologies, professional guidance on product design and sufficient planning to achieve the objectives of a design are absolutely necessary for a concept to develop into a consumer product that appeals to investors. A designer with manufacturing experience can assist in developing a project plan and identifying the weaknesses of a product concept by conducting test marketing, thus preventing resources from being wasted. This concept is consistent with the view of Fritz Frenkler (2018) from Technische Universität Münche who believed that the value that designers can offer startup companies far exceeds what they can offer medium-sized to large enterprises since the latter already have a product roadmap. Startup companies, in contrast, are relatively immature and the market for their products does not yet exist. Visual communication of their abstract and technical concepts is therefore necessary for making these companies realize the importance of design. For this reason, the study believed that design consultants can generate more value working with startup companies in the early stage of a product development project. For instance, a respondent, who is a design consultant, mentioned,

“... when observing user needs, it is important to understand that there are different types of users. Teams tend to get stuck in a rut and it’s the responsibility of industrial design experts like us to put our foot down and bring the team back to reality. We have experience working with electronic products

and therefore have a good idea of the kinds of expertise and fields that are needed, the lead time, whether a concept is mature enough for product development, production issues, and mold fees.”

The respondent from Metro Products Inc. also believed that without the help of a designer at the early stage of product development, innovative technology products, such as IoT devices, are likely to suffer from technological blind spots. A designer who gets involved at the early stage of a product development process can bridge the gap between technological application and user needs as well as accurately identify the weaknesses of the product design,

“... most people who develop IoT products have a background in technology. They tend to look at things from a technical perspective but not a human perspective. This is not ideal as you are not approaching things based on the basic needs of humans.”

The startup team of BLOCKS, the modular smartwatch, is a case in point and can attest to the design needs that arise in the early stage of concept development including the need to detect the weaknesses of the concept, to create the prototypes needed for market testing, and the immediate need to conduct market testing. The company later drew the attention of the users through crowdfunding and grew increasingly popular among investors, which allowed them to formally establish a company. As such, the respondent said,

“... you come up with an idea. And then you need to think about demand. But how do you know what you have in mind is actually in demand? You don't know. That's why the first thing we did was to verify the demand.”

The Design In Tech report published by John Maeda (<https://www.slideshare.net/johnmaeda/design-in-tech-report-2017>) echoed the aforementioned viewpoint. Between 2013 and 2016, there was a total of 32 mergers and acquisitions involving companies like Facebook, Google, Deloitte, Accenture, IBM, Capgemini, Wipro, and Ernst & Young. The designers at these companies did not simply contemplate and work closely with the corporate leaders or engineers to develop new products, perhaps more importantly, they listened to the needs of the stakeholders in the early stages of product development and converted visions into appealing business solutions, which helped secure funding from investors and further develop the business, ultimately fulfilling clients' and companies' development objectives.

4.2 Seed stage: Converting design concepts into engineering specifications to produce prototypes

4.2.1 Confirming the specifications and limitations of components

According to the three respondents who provide manufacturing services, the key during the product prototype stage is to lay out the concept functions in terms of “engineering specifications.” Before converting an idea into engineering terms, it is vital to learn about the language used by manufacturers so as to avoid delays resulting from misunderstandings during the communication process. The respondent from Taiwan Rapid Innovation Prototyping League for Entrepreneurs stated the following.

“... you have to convert your product into simple specifications and brief them on your specifications. This is the language of manufacturing and design. Once it is done, the manufacturing company and the design company will conduct a first-stage evaluation based on that language.”

The respondent from the startup company BLOCKS also mentioned that the company ran into certain issues. Due to the lack of real-life manufacturing experience, the team had to

adjust the prototype multiple times until the product was ready for production. The respondent said,

“... for this type of electronic products that are relatively complex, customizing the components would cost 20 to 30 million US dollars, which is utterly impractical. You have to know the specifications well and then look for the materials that can meet the requirements of these specifications.”

4.2.2 The use of neutral industrial espionage to understand the quality of prototype manufacturers

Startup teams believed that the difficulties in producing prototypes involve not only software and hardware but also firmware, which is why it is necessary to work with multiple manufacturers. The lack of knowledge on the industry chain of prototype manufacturing and the degree to which potential partners can fulfill your needs can make it difficult for the partnership to work due to a lack of resources. For this reason, the key of this stage is to find a suitable supplier and evaluate the risks in subsequent mass production in advance. For instance, the components used in the prototype should be identical to the ones used in mass production. Moreover, it is important to purchase the best-performing components in the procurement market and avoid using non-standard specifications (even if the price is low) as those components may no longer be produced in the future, causing delays in production. Worse still, the company may have to re-modify the design. A small-scale manufacturing service provider said,

“... when it comes to hardware manufacturing, startup companies need the supply chain the help them design and manufacture their product before they can come work with us. This type of supply chains is plentiful on the streets of Xinzhuang and New Taipei City. We can deliver the products these startup companies need.”

Taiwan Rapid Innovation Prototyping League for Entrepreneurs, an affiliated organization of Industrial Technology Research Institute of Taiwan, has information of many manufacturers in Taiwan. The respondent said,

“... regarding manufacturing and design, if a team feels that there's still lots of research and development work they can do themselves, I can introduce a few manufacturers to you and you can hear what they have to say. If they can help with planning and design, they will be able to tell you early on what changes you will have to make.”

4.3 Creation stage: The seamless relationship between the design team and the manufacturer.

In reality, the last step of mass production depends on the correctness of the decisions made in the previous two stages. During this stage, the primary concern is the manufacturing quality in mass production and the ability to introduce the products to the market as scheduled. The respondent also mentioned that working with large-scale manufacturers might not be the ideal option for startup companies, due to the minimum quantity requirements, limited flexibility of the partnership, and the general unwillingness to fulfill the needs of a startup company. The respondent from the small-scale manufacturer mentioned,

“... our industry is about: design and one stop shop manufacturing, from planning, designing, and manufacturing a product. Clients generally hire a company to handle the entire process for them. In contrast, Foxconn, for example, will not take an order of 500, 50, or 100 units for a startup team. That's because their clients are all big corporations.”

5. Research conclusion and suggestions

This research uses the “lifecycle of startups” and the “lifecycle of electronics manufacturing industry” as the framework and explores the combination of different partners that startup companies can consider when developing IoT products. This includes the following steps: 1. bootstrapping stage where startup companies can seek assistance from design consultants in order to confirm the marketability of the development concept. 2. During the seed stage, startups businesses can make use of the information of manufacturers that service matching centers are able to provide so as to increase their options for business partners. 3. During the creation stage, startup companies can look for design manufacturing service companies that are willing to take on small orders so that the products can be delivered as scheduled. In addition, we believes that the key to success that is often overlooked by startup companies is to confirm the engineering specifications of the components in the design as early as possible and to confirm the technical and manufacturing feasibility of the product. The earlier a company is able to understand the specifications and limitations of the components, the more likely that a concept will be ready for mass production and be introduced to the market on time.

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