The dynamic of technological accumulation at the microeconomic level: lessons from Indonesia -- a case study

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This is a paper on technological capability building at the microeconomic level -- the firm as the unit of analysis. The research strategies selected to conduct the study were a case study combined with a retrospective study. The case study was PT Texmaco Perkasa Engineering (TPE) of the Texmaco Group Indonesia. It is shown in the paper that technological accumulation at TPE is incremental and dynamic. It tends to move along trajectories in which past learning contributes to particular directions of technical change and experience reinforces the existing stock of knowledge and expertise. The accumulation of technological capability at TPE did not come merely from experience, though experience is important. It came from conscious efforts - to monitor what was being done, to try new things, to keep track of developments throughout the world, to accumulate added skills, and to increase the ability to respond to new pressures and opportunities.

Keywords: Firm, Technological capability, Technological Accumulation, Learning, Production Capacity

1. Introduction

The study of the accumulation of technological capability at the microeconomic level -- the firm as the unit of analysis -- is useful for policy makers and development planners in developing countries. It is much understood nowadays that the stock of useful knowledge and the extension of its application are the essence of modern economic growth. Unfortunately, there is still little recognition among the policy makers and the development planners that the augmentation of the stock of useful knowledge as well as the extension of its application takes place primarily by business firms.

The policy makers and the development planners in developing countries have given relatively short shrift to the firm as the agent of economic development. While firms are by no means neglected, the weight of the policy

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focuses on the role of macro-economic variables and the public sector in the development process. Capital availability, exchange rates, savings, and taxation issues are well recognised and comprehensively studied. It is not exaggerating then to say that the poor policies that have been pursued so far by the policy makers and also by the development planners are possibly due to the relative neglect of the study of firms and institutions that support firms [62]. This paper hopefully will fill this gap.

Since the process of acquiring, assimilating, developing and maintaining the technological capabilities at the firm level is very dynamic, it is therefore very interesting if this process can be investigated and explained. This study is devoted to this matter and will try to investigate and elaborate the process of technological accumulation at the firm level in Indonesia. The research strategies selected to conduct the study were a case study combined with a retrospective study. The case study was PT Texmaco Perkasa Engineering (TPE) of the Texmaco Group Indonesia.

The paper will be divided into the following sections. Section 2 gives the theoretical background of technological capability building. Section 3 concerns with the process of technological learning at TPE. Section 4 is concerned with the lessons that can be learnt from the experience of TPE in accumulating its production capacities and technological capabilities. Section 5 is concerned with policy recommendations. Section 6 will suggest agenda for further research. And finally section 7 will give conclusion of the paper.

2. Definition and Concept of Technology

2.1. What is Technology?

Although mastering technology is important, technology is not an easy term to define. In fact, there is no universally accepted definition of the term that might serve as a natural point of departure. Definition is not made any easier by the fact that the semantics of the term technology differs in German and English – the former emphasising the science of technology, the other the application of technical knowledge [74]. Summing up the widely accepted definition, it is possible to delimit two variants – a narrow definition and the broad one.

In a very narrow sense, technology is only technical information contained in patents or technical knowledge communicable in written form [31]. Very often, technology refers to a class of knowledge about specific
product or production technique and sometimes includes the technical skills necessary to use a product or a production technique [16,68]. Technology thus is largely identified with the hardware of production or technical artifacts.

Frances Stewart [101] provided probably the broadest definition of technology by including all skills, knowledge and procedures required for making, using and doing useful things. Technology in her definition therefore includes the software of production - managerial and marketing skills, and extended to services - administration, health, education and finance. Smillie [95] describes this broader definition of technology as "the science and art of getting things done through the application of skills and knowledge".

If we look at all the above definition, no matter how technology is defined, most experts recognise that the concept implies a subtle mix of know-how, techniques and tools. Technology in this sense is vested in people - their knowledge, skills and routines - just as much as in the machine they use. Machines and tools are only the physical manifestation of a particular technology or technologies. Indeed, mere access to the physical elements of technology - even if accompanied by instructions for their use, and time to build up experience in using them - does not automatically lead to 'mastery' of that technology [2].

For mastering technology as stated by Clark [18], should not consist just of the establishment of new production facilities along with ancillary manuals, charts, schedules, diagrams and people - embodied know-how. It requires also the knowledge and expertise for implementing technical change. This in turn involves both the underlying 'know-why' of the technological system itself as well as the various technomanagerial capabilities needed to evaluate and transform existing plant to meet new and innovative operating conditions. Thus, technological mastery here implies the capability to use knowledge about physical processes underlying that technology in order to assimilate, adapt and/or create novel elements, in response to changing needs [22,70,83].

2.2. Technology in Economic Literature

In the economic literature, the importance of technology has been known since the beginning of the discipline. Economists writing about economic growth for example have recognised technological advance as its key driving force [72,93,96]. In the 1950s and 1960s many studies tried to
measure the contribution of technological change to economic growth in countries operating at the frontiers of technology [26,100]. The conclusion was that productivity growth depends very heavily on the introduction and efficient diffusion of new and improved processes and products in the economic system.

Although the contribution of technology is well recognised in the economic literature, for long it was treated as a ‘black box’ [86]. As a result, it is still common to find technology being equated simply with machines and devices, in isolation from the human resources and social contexts of their use, which give these tools their technological value. In this light, technology is defined in a static way. Technology is a product, a package, that is produced by one set of firms or other institutions and consumed or used by another[2].

The conceptual framework underlying the static view was predominantly neo-classical. As firms all operate on a given production function, their technological task is merely to choose whichever technology is most appropriate to their local factor endowments and relative prices. It is assumed by the neo-classical framework that all firms can shift their position on the production function effortlessly in response to change in factor endowments or relative prices, since they all have equal access to a global technology shelf, and are able to immediately operate the technology chosen with optimal efficiency [87].

The implication of the neo-classical framework, technical change in industry has then conventionally been seen as involving two main activities. First, the development and initial commercialisation of significant innovations. Second, the progressively wider application of these innovations in a process that economists and others have described as ‘diffusion’. The first of these activities is assumed to be heavily concentrated in the developed countries, becoming significant in developing economies only as they approach the international technology frontier - a pattern which is becoming evident in the recent data on international patenting by firms in the more industrialised developing countries such as Korea and Taiwan. Before this stage, developing countries are assumed to be involved in the international diffusion of technology, and since this is seen simply as involving the choice and adoption / acquisition of established technologies, creative innovation is assumed to be irrelevant. From this perspective, “technological accumulation” in industrialising countries is seen as involving technology that is embodied in the stock of capital goods, together with the associated operating
know-how and product specifications required to produce given products with given techniques at the relevant production efficiency frontier[9].

In the real world however, the evidence shows that the technology market does not function like a product market, and its 'goods' could not be transferred like physical products. The reality indicates that most developing countries are rather inept in using industrial technologies. They are in other words, technically inefficient in using the imported technologies. As a result, many industrial technologies are used at lower levels of productivity in developing than in developed countries.

According to Lall [66,67] the technical inefficiency in developing countries can take several forms:

- The inability to find, choose and negotiate for the best imported technologies at the best prices, even when where market prices are undistorted, leading to high capital costs and low productive efficiency.
- The inability to master properly, in a static sense, the technologies that have been imported, i.e. technologies may be used below 'best practice' level of efficiency, needing too many inputs to produce a given level of output or producing output of inferior quality.
- Wide variations in efficiency levels among enterprises in the same industry. This implies that resources are being wasted by the enterprises that fall below the technological levels of the best firms (which may themselves be below world 'best practice' levels).
- Lack of technological dynamism, of the ability to adapt or upgrade technologies to cope with changing circumstances at home or technological progress outside. Developing countries’ enterprises may stay at the low value added end of the industrial spectrum, falling behind world technological frontiers as others forge ahead or as factor conditions change.

Thus, because of this technical inefficiency, developing countries then may stay at the low value added end of the industrial spectrum, falling behind world technological frontiers as others forge ahead[67].

The neo-classical approach to technological development was challenged on both theoretical and empirical ground by a number of 'alternative' more dynamic approaches that began to emerge in the second half of the 1970s. The new approach, which is much broader than its original perception that prevailed during the 1960s and 1970s, has been rapidly
developing, particularly since the early 1980s.\(^1\)

Bell and Pavitt, for example, give a more realistic view of the nature of technology. According to them, understanding of technological change requires the distinction between innovators and adopters to be rejected[8,9]. The successful adoption of technology involves more than merely the purchase of machinery and the learning of operating procedures [22]. In part, this is because of the tacit nature of much technological knowledge: making it difficult or very costly to effectively communicate the full range of skills and knowledge required in executing complex tasks. This means that firms can not shift effortlessly along the production function [66], nor operate any particular technique immediately at optimal efficiency. For firms in developing countries therefore, while technology 'transfer' may be necessary, it is not sufficient. The effective adoption and mastery of technology requires the acquisition of knowledge about a set of procedures, understanding of why procedures work and skill in putting them to use [2]. According to Bell and Pavitt[9] it also involves firm-level processes in which:

- The basic features of a technology are adapted to meet the idiosyncratic needs of a specific situation, and
- A stream of further incremental modifications improve the technology and / or adapt it to changes in the inputs or products demanded by a competitive market.

Evidence from studies of large-scale industrial plants in many countries, indicates both phases of adaptation require complex and creative activities, and have the potential to generate significant improvements in production and economic gains [23,48]. This suggests that innovation should be understood not as a distinct precursor to technical change in production, but rather as part of an integral process which takes place within the environment of the innovating firm. It is among other things, the process which involves matching technological possibilities to market opportunities[37]. Furthermore, the incremental innovations - adaptations,

\(^1\) The contributors of the approach include Teitel (1984), Dahlman, et al (1987), Enos and Park (1988), Forsyth and Solomon (1994), Lall (1987, 1992), Nelson (1987), Freeman (1982), Enos (1991) and Bell and Pavitt (1997). The approach is variously referred to as institutionalist, structuralist or evolutionary. Although the authors use different terms such as technological mastery, technological capacity, technological capability, technological promotion, technological development, technological accumulation, technological acquisition, etc, there is a consensus to the meaning of the concept, that the acquisition of technological capability is a dynamic process.
modifications and enhancements to products and processes - which occur within firms may be just as economically important as major investments in new machines or changes in products that originate outside the firm [2,12].

2.3. The Technological Effort of Learning

The kind of improvements in industrial performance mentioned above, are often interpreted in most economic analysis as a natural consequence of doing production; the result of an automatic learning by doing process[5]. This doing – based learning according to Bell[10] has three remarkable properties;

- It arises quite passively. Little or no explicit action is required to capture the increased knowledge / skill and whatever benefits flow from that acquisition.
- The learning process is virtually automatic. Given a period of ‘doing’ some quantum of learning will take place.
- It is costless. Learning is acquired simply as a free by – product from carrying on with production. No expenditure beyond that needed for production is required to generate the increased knowledge and skill.

This ‘something for nothing’ model of the learning process leads inevitably towards certain kinds of policy prescription. Increased ‘learning’ requires increased ‘doing’, and hence various forms of protection for doing are seen as appropriate means for enhancing learning – the benefits of the learning gained will offset the inevitable cost of protection. Beyond that, the role of policy intervention is limited. Since experience accumulation is simply a function of time or of cumulated total output, questions about policy intervention designed to raise the rate of learning derived from a given stream of production activity are largely irrelevant[10].

However, studies of infant industries in developing countries[7] demonstrate that learning does not occur spontaneously, and that performance can easily stagnate or decline over the long-run.

Firms which do manage to master technology and initiate a process of incremental innovation, do so as a result of learning which is neither automatic nor effortless. Even minor innovation requires a spectrum of skills, knowledge and capacities for searching, selecting, assimilating and adapting techniques. Developing and maintaining these capabilities requires both a conscious effort by firms and the investment of significant resources [2]. Thus, we can say that the acquisition of technological capability does not
come merely from experience, though experience is important. It comes from conscious efforts - to monitor what is being done, to try new things, to keep track of developments through out the world, to accumulate added skills, and to increase the ability to respond to new pressures and opportunities [24].

The need for such effort has been emphasised in virtually every article on the subject of capability building. The term has a certain intuitive appeal because it affirms that capability building is not a trivial activity; however, effort is a very broad term and does not tell us a great deal about what the learning process involves concretely [85].

An attempt to overcome this problem was made by Bell, who designed a useful classification of learning mechanisms based on the existing empirical evidence [10]. In addition to identifying experience - based learning by operating, he distinguished five mechanisms as shown in figure 1 that are predominantly 'effort based'.

According to Bell as shown in figure 1, the process of learning consists of the following elements:

(1) Learning by Doing / Operating

Bell points out that the most elementary form of learning is learning by operating, a variant of learning by doing (doing-based learning arises passively, is virtually automatic as ‘doing’ occurs, and it is a costless, free, by product from carrying out production) and by using. On the whole, the enhancements to operating capacities which result from learning process are rather small.

(2) Learning by Changing

Bell refers to learning by changing as the improvement upon equipment and techniques subsequent to gaining experience with them. When the ‘black box’ of technology is opened by investment in successive project, technical change can be quite major as principles are acquired and confidence in manipulating technology is gained. In this kind of learning there is introduction of innovative technical changes (attempts to adapt, diversify, improve quality, and bring out new products or variants of production processes).

(3) Learning by Evaluating (Learning from Performance Feedback)

This kind of learning involves monitoring and recording the perform-
ance of a technology. This can generate understanding about why certain things work and others do not. We can say then that this kind of learning is generated from feedback of regular monitoring of changes and performances in production.

Source: Bell, R.M. (1994)' Learning and the Accumulation of Industrial Technological Capacity in Developing Countries', in M. Fransman & King (eds), Technological Capability in the third World.

Figure 1 Different Learning Mechanisms
(4) Learning through Training

Transmission of skills and further improvement during periods explicitly set aside for those purposes

(5) Learning by Hiring

Technological capability can also be improved by hiring consulting services and taking specialist advice, outside the firm.

(6) Learning by Searching

In this kind of learning, it is assumed that an organisation has the capability to investigate various sources of information, to absorb ‘disembodied’ knowledge and information about several types of technology, and to choose the most suitable one. This requires an explicit allocation of resources for non-production tasks, usually R&D.

Although it is shown in the diagram, the flow of knowledge that is generated by R&D activities is excluded in Bell’s discussion. With the concept of learning defined broadly to encompass all forms of knowledge acquisition, this is somewhat arbitrary. If one defines R&D in the conventional manner, it does not produce technical change as such. It produces the knowledge upon which technical change can be based. In principle, then, R&D, and the flow of knowledge it generates, might be considered a ‘learning’ mechanism that is equivalent to all the others.

2.4 Technological Capability

Technological capability was defined in the early 1980s as ‘the ability to make effective use of technological knowledge... It inheres not in the knowledge that is possessed but in the use of that knowledge and in the proficiency of its use in production, investment and innovation’ (Westphal, Kim and Dahlman, 1985:171). This concept was interchangeable with other concepts that referred to the same idea, such as technological effort [22,65] or technological capacity [10,59]. Later on the concept of technological capabilities became more widely used.

Although technological capability is a key issue for the firms in developing countries, interpreting and comparing studies of capability acquisition is not easy, in part because the resources firms accumulate are diverse and difficult to categorise. They comprise both human capabilities: skills, experience and knowledge vested in people, along with institutional resources: the
internal procedures, routines and organisational structures of the firm, and the external linkages cemented with other firms and institutions. An easy trap to fall into, is to associate 'technology' only with production activities, for example product design, manufacturing processes and the organisation of production. However, this ignores the importance of capital goods; in raw materials supply, and in distribution of products[2,66]. One common approach is to distinguish three general types of capabilities: production capabilities, investment capabilities and innovative capabilities [2,66,85].

**Production capabilities** involve those skills, knowledge and resources needed to use existing plant and processes efficiently to make established products. These capabilities enable firms to monitor raw materials inputs, schedule production, control output quality, maintain and replace machinery, and generally deal with day to day problems.

**Investment capabilities** involve those skills, knowledge and resources which enable firms to expand workshop facilities, procure and install standard equipment; as well as to search for, evaluate and select technology and its sources for new production projects.

Finally and crucially, **Innovative and Adaptive capabilities** consist of the skills, knowledge and resources which enable firms to assimilate, change and create technology via such activities as capital stretching, adapting processes and modifying products[2].

However, to give these three categories equal status is to miss an important distinguishing dimension. Lall for example points out that the process of developing capabilities occurs gradually and cumulatively. In general, it leads from simple routine activities in which learning is based on experience, through more complex adaptive and duplicative activities requiring searching functions, to the most innovative activities based on more formalised research [66].

Bell and Pavitt [9] introduce a general distinction between basic production capacities and dynamic technological capabilities. This distinction applies across the full range of firm activities and adds a new dimension to the taxonomy of capabilities.

**Production capacities** are static attributes. Knowing a firm's production capacities gives a 'snapshot' of the firm's ability to use existing production facilities, make standard investment decisions, expand established processes.


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<tr>
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<th>Production Capacities</th>
<th>Technological Capabilities</th>
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<tr>
<td><strong>Ability to do</strong></td>
<td><strong>production activities</strong></td>
<td><strong>such as :</strong></td>
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<tr>
<td><strong>Investment Activities</strong></td>
<td>-Construct workshop facilities.</td>
<td>Search for, evaluate and select technology and its sources for new production projects.</td>
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<td></td>
<td>-Procure standard equipment</td>
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<tr>
<td><strong>Process &amp; Production Organisation</strong></td>
<td>-Do routine operation and maintenance.</td>
<td>-Improve layout of workshop</td>
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<td></td>
<td>-Improve efficiency of existing tasks.</td>
<td>-Improve maintenance procedures</td>
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<td></td>
<td></td>
<td>-Adapt and improve production process.</td>
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<td>-Design organisational change</td>
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<tr>
<td><strong>Product Centred Activities</strong></td>
<td>-Replicate fixed specifications and designs</td>
<td>-Adapt products to changing market needs.</td>
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<td>-Do routine quality control</td>
<td>-Improve product quality</td>
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<td>-Design new products</td>
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<tr>
<td><strong>Supply of Capital Goods</strong></td>
<td>-Replicate unchanging equipment and machinery</td>
<td><strong>Ability to do supporting activities such as :</strong></td>
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<td></td>
<td>-Replace original parts(capital stretching)</td>
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<tr>
<td><strong>Inputs Supply</strong></td>
<td>Procure available inputs from existing suppliers</td>
<td>Copy new types of tools or machinery</td>
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<tr>
<td>(Backward Linkages)</td>
<td></td>
<td>-Adapt existing designs and specifications.</td>
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<td></td>
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<td>-Design original tools and machinery</td>
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<tr>
<td><strong>Customer Orientation</strong></td>
<td>Sell 'given' products to existing and new customers</td>
<td><strong>Source:</strong> Albu, M. (1997) 'Technological Learning and Innovation in Industrial Clusters in the South,” SPRU Electronic Working Paper No.7, University of Sussex, Brighton.</td>
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<td>(Forward Linkages)</td>
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The resources needed to generate and manage technological capabilities are dynamic resources, which encompass the skills, knowledge and routines involved in generating and managing technical change, whether they concern production activities, investment activities or relations with other firms. Table 1 below illustrates the differences between the respective types of capabilities by showing the kinds of activities associated with each.

Bell and Pavitt call the learning process involved in building the underlying dynamic resources as 'technological accumulation' or 'technological learn-
The relationship between these different terms and concepts is represented schematically below in figure 2:

By using Bell and Pavitt conceptual model, it is easy to see how a firm with a fixed set of technological capabilities might generate a stream of improvements in production capacity over time. Such improvements may be important in enabling the firm to modify or scale-up production. A firm with no technological capabilities at all, would be rigidly unable to adapt to any changes in its environment, and would not survive long. However, the fact that a firm has a limited set of technological capabilities, and uses these to gradually improve production capacity, may not always be adequate either. In the long run, such a firm may not be able to change radically enough to bridge the discontinuities that occasionally arise in technical change, and may be out-competed by those that can. If this conceptual model reflects reality, then a most important task facing firms in the long run is technological learning: the acquisition and strengthening of their technological capabilities [2].

3. Technological Accumulation at Microeconomic Level: A Case Study of PT TPE Indonesia.

3.1. Background and History of TPE

PT. Texmaco Perkasa Engineering (hereinafter TPE) is a member of Texmaco Group. TPE commenced its operation initially as a machine shop to manufacture spare parts and service textile mills operated by Texmaco. TPE has today become a vertically integrated engineering company which is involved in a wide spectrum of engineering activities including manufacturing of castings, machine tools, textile machinery, capital goods, steel, automotive and automotive components. TPE now is one of Indonesia’s leading industrial equipment and machinery manufacturers.

The owner of Texmaco group, Mr Marimitu Sinivasan, started as a textile importer and trader in the 1950s. Because his business was running well, he then established his first traditional weaving mill, called Firma Djaya Perkasa, in Pekalongan, Central Java in 1961. The factory was equipped with around 300 traditional and simple hand looms for its operation. The traditional looms were bought from carpenters around Pekalongan. And it was not strange, since Pekalongan has been well known as a Batik city in Indonesia. Moreover, weaving by using traditional and simple hand looms has been known there for hundred years [108]
After successfully managing the mill to supply textiles for domestic consumption, the company in 1967 expanded the business with the opening up of a new textile mill in Pemalang, around 35 km from Pekalongan. The new factory was also equipped with the traditional hand looms for its operation.

The business expansion to Pemalang was made possible due to the conducive environment created by the Indonesian government. At the beginning of the so-called new order period under President Soeharto after period of stabilisation, the government adopted an import substitution strategy as its Industrialisation strategy. And in this new industrialisation strategy dramatic changes were introduced in the trade and investment regime, particularly in the basic necessity industries such as food and beverages and textiles. The textile industry, for example, was offered various incentives, such as duty free imports of capital equipment and tax holidays. Other than these policies, the business was more attractive due to the rapid growth of the economy which was also followed by the increasing of per capita income and the purchasing power of most of the Indonesian people. All of these factors contributed to an ever growing domestic demand for textiles.

In November 1970, the name of the company was changed from Firma Djaya Perkasa to TEXMACO JAYA (hereinafter TJ). Texmaco was chosen as an abbreviation for Textile Manufacturing Company.

As a response to rapidly rising demand in domestic market and also encouraged by the favourable incentives offered by the government such as duty free imports of capital equipment and tax holidays, TJ in 1970 imported second hand shuttle looms from Korea (Wang Pong) and India (Sun Rise and Cooper) for its factories in Pemalang and Pekalongan. Despite the price was reasonable, this decision to import the second hand shuttle loom was mainly affected by the government policy from 1971-1974 in allowing the textile industrialist like Mr. Sinivasan to import used spinning and weaving machinery under the condition that these machines were 10 years old or less.

The Indian companies and the Korean were chosen because the owners of these companies were friends of Mr. Sinivasan. It was not strange, since Mr Sinivasan had been in the textile business for almost 20 years, which enabled him to have a lot of friends and accumulate enough knowledge and information concerning textiles and also the capital equipment for his textile factories.

As stated in the previous section, when TJ in 1970 imported shuttle looms from India and Korea, TJ had two textile factories which were located in Pemalang and Pekalongan.

Lacking experience in textile machinery, TJ formed two small teams, one for its factory in Pemalang and one for its factory in Pekalongan. The teams were responsible for operating and maintaining the machines in each location. The Indian and the Korean companies at that time transferred ‘packages’ technology to TJ with a set of explicit knowledge such as technical specifications of the machines and also production manuals. They designed the plant layout and also constructed them. There was also agreement between TJ and the machines’ suppliers that the TJ team members would be taught on how to operate the machines by technicians from the machine suppliers.

The ‘on the job’ training given by the Indian and Korean technicians helped the members of TJ’s team in translating the transferred explicit knowledge into the teams’ tacit knowledge. The training really gave TJ’s team members valuable migratory knowledge with which to create and upgrade their tacit and explicit knowledge related to textile machinery. Moreover, the technicians of the Korean and Indian companies were still at TJ for almost one month to help TJ staff in running the factories and they also helped the TJ technicians if there were problems regarding the machines.

When the foreign technicians left, if something happened to the machines such as damaged to spare parts, the machines going down etc, with limited experience and simple equipment the teams then tried to fix and repair them by using the machines’ manual and more often by trial and error. The teams during the process gained and accumulated some tacit knowledge and skills about the spare parts and also the whole machines. And in order to increase their knowledge base the teams also recruited several new team members who had a background in general machinery (not specific to textile machinery) from local motor garages around the factories’ location. The new recruited team members brought in migratory knowledge that raised the level of tacit knowledge related to operating, maintaining and fixing the textile machinery.

As time went by, the machines used by TJ were getting obsolete. The teams realised that the machines’ spare parts were becoming more difficult
to repair, and therefore they needed to be replaced by new ones. But since the spare parts had to be imported, TJ was in ‘crisis’. TJ could not afford to delay or postpone its operation because of the high demand for textiles from the domestic market. But besides the fact that it was expensive, importing the spare parts from overseas would create a time lag from ordering them until they arrived at TJ's factories.

To overcome the problems, in 1979, the two teams who were initially responsible for maintaining and repairing the textile machinery in Pemalang and Pekalongan were merged by TJ’s management into a single unit. And using the unit as the backbone, TJ then established a small machine shop as a separate entity from TJ in Kaliungu. The responsibility of the new entity was not only for maintaining and repairing the TJ machines but also for manufacturing their spare parts. So at that time, TJ on the one hand concentrated on running the textiles factories and the machine shop (the unit) on the other hand was responsible for maintaining and fixing the textile machinery and also for manufacturing the machines’ spare parts.

Manufacturing the spare parts was not a totally new job for the unit, since the unit had gained some knowledge and skills about the machines from their previous experience of maintaining and repairing them. On some occasions they had even done it accidentally. Instead of using any specific patterns in manufacturing the spare parts, the team members did it manually and only by using their feeling. So when the unit started to manufacture the spare parts, the unit already had ability in procuring simple and traditional equipment for the small machine shop. The unit also had the ability to procure available input from existing suppliers around the factories and in doing routine operations and maintenance.

3.3. Development of Texmaco's First Loom (1979-1985)

In the late 1970s, both the external and internal environments were favourable and challenging for Texmaco group. The oil booms in the 1970s for example, allowed the Indonesian economy to continue to enjoy rapid growth which made the per capita income and purchasing power of the Indonesian people continue to increase as well. All of these factors contributed to a growing domestic demand for textiles. Moreover, various incentives, such as duty free imports of capital equipment and tax holidays, were continuously offered by the government.

The internal environment of Texmaco was encouraging as well. In 1975, for example, a new garment factory, PT Ungaran Sari Garment
(USG) was established by Texmaco Jaya in Ungaran (Central Java) and another division in Texmaco Jaya was able to develop yarn from polyester in 1977. The division then incorporated in Kaliungu as a new firm called PT Texmaco Taman Syntetics (TTS). All of these factors then stimulated and forced Texmaco Jaya to increase its production volume.

Because of the conducive external environment and the ability of TTS in developing yarn from polyester, the business prospects for Texmaco group were promising. And Texmaco group responded to the conditions by opening up a new textile mill in Kaliungu in 1980, in exactly the same location where the machine shop was established.

As a result of discussions between TJ as user of the textile machinery and the people from the machine shop as technicians, the TJ management realised that in order to increase the production volume and at the same time improve the quality, TJ needed better textile machinery for the new factory. The existing machines were already old-fashioned and could not cope with the volume and quality expected by USG (Texmaco’s garment company) and other consumers. Moreover, at that time the domestic market for textiles had become saturated and reoriented by the government to the export market. And since export markets required better quality textiles, TJ then had to improve the quality of its products.

The government regulation which exempted export industries, including textiles, from all import duties and taxes for spare parts, intermediate goods, and raw materials really influenced and triggered TJ as one of the largest textile company in Indonesia in investing in better textile machinery. It also should be worth noted that the regulation allowing the imported of used textile machinery was also abrogated at that time.

Therefore, for the new factory in Kaliungu, Texmaco Jaya then imported Picanol, rapier looms from Belgium. The rapier loom was better in terms of speed and capacity compared to the shuttle looms that were used by TJ.

In the process of designing the plant layout and constructing the plant, a team from Picanol was working closely with the team from Texmaco’s machine shop. The Texmaco technicians were actively involved in discussions with the team from Picanol on the exact designs and technical specifications of the capital equipment. The discussions were very intensive since the Texmaco technicians had already accumulated tacit knowledge about textile machinery from their experience in maintaining, repairing and manufacturing spare parts of shuttle looms in their factories.
When the technicians of Picanol left, the machine shop then was not only responsible for maintaining, repairing and manufacturing spare parts of shuttle looms for Texmaco’s factories in Pemalang and Pekalongan, but also for maintaining and repairing spare parts of the rapier looms in the new factory in Kaliungu. Because of the more broad responsibility in maintaining all Texmaco’s textile machinery, the unit realised that its equipment should be upgraded. Therefore, in 1982, the equipment of the unit was improved and modernised by introducing more appropriate equipment and tools. The unit at that time was also incorporated into a new separate firm from Texmaco Jaya, called PT. Texmaco Perkasa Engineering (TPE).

In the new firm, two expatriates from India who had expertise in spare part pattern design were hired and more experienced employees who had backgrounds in textile machinery were recruited. The total employees of TPE at that time were around 60. The new recruited members brought in migratory knowledge that raised the level of tacit knowledge related to operating, maintaining and manufacturing the spare parts of the textile machinery.

As a result of introducing more appropriate equipment and tools for manufacturing the spare parts, the firm strengthened its production capacities. In terms of investment activities, for example, the firm was able not only to procure standard equipment, but it was also able to construct its own workshop facilities. In terms of process and production organisation, the firm was not only doing routine operation and maintenance but was also able to improve efficiency of its existing tasks. The firm was even able to manufacture the machines’ spare parts by using a more appropriate pattern, design etc. Because of this improvement in production capacities and also from knowledge and skills gained from the experience of manufacturing by using the new equipment, the firm then managed to have incremental adaptation and improvement in its operations. And as a result, TPE then was able to produce more reliable and better quality spare parts for Texmaco Jaya.

TPE gained some knowledge and skills from the investment project, such as improving the equipment above, and also obtained some insight from the incremental adaptation and improvement of its performance. All of this feedback enabled the firm then to acquire some technological capabilities. In terms of investment activities, for example, the firm was able to evaluate and select the technology and its sources for the new production
process. In terms of process and production organisation, the firm was not only able to do routine operations and maintenance, but was also able to improve the layout of workshops, improve the maintenance procedure, adapt and improve the production process etc. The firm had acquired the technological capabilities in terms of investment activities, process and production organisation, and product centred activities, backward and also in forward linkage. The acquisition of the technological capabilities or technological learning process enabled the firm then to improve its performance, which again strengthened its production capacities, and its flourishing new technological capabilities.

Based on the knowledge feedback from the technical change and also from the technological learning process, the firm realised that indigenous availability of casting was a pre-requisite for providing impetus to its growth. Therefore, although equipped with very simple techniques and facilities, TPE diversified its activities into foundry in 1983.

The existence of the foundry division enabled TPE to control the quality of the spare parts input. More and more reliable and better quality spare parts were able to be produced by TPE for Texmaco Jaya. In 1985, almost all spare parts of the shuttle loom were able to be produced by TPE. And at that time people at TPE already thought that they were actually able to produce the whole shuttle loom machine.

It may have been blessing in disguise when in 1985, there was a big flood in Pemalang where one of Texmaco’s factories had commenced its operation. All the machines there were damaged and could not be used to run the factory’s operations. It was a ‘crisis’ for TJ. TPE was then responsible for handling the problem. And since TPE had acquired and accumulated adequate production capacities and also technological capabilities, instead of ordering or buying new machines, the machines then were broken in by TPE’s employees. One by one the machines’ components were repaired and fixed by TPE’s own employees. And after that they even managed to re-assemble them into complete machines!

This momentum boosted the confidence of TPE’s employees. And since all the spare parts had been able to be manufactured indigenously, the firm then developed its own looms in 1985! All the old machines imported from India in 1970 (Cooper and Sun Rise) were then melted in TPE’s foundry as raw materials for the new Texmaco machines. The new ‘home made’ machines then replaced all the Indian machines in Texmaco’s factory in Pemalang and Pekalongan.
By developing the first ‘home made’ loom, new knowledge and skills were gained by TPE from the experience of production and also from the feedback of TJ as the machine’s user. All of these factors strengthened TPE’s technological capabilities and also its production capacities.

The ability of TPE in developing the textile machinery also had an impact on TPE’s growth as an organisation. TPE then divided its organisation into two IBUs or divisions, namely; foundry and the ‘old’ TPE which was involved in machining, assembling, pattern, and training. Mr. Sinivasan, the owner of Texmaco group became the president director of TPE.

Since most of the training at TPE was done ‘on the job’, the involvement of TPE in the training activities was quite unique. But actually it was a response to a government campaign called Gugus Kendali Mutu (Quality Control Programme) which forced Indonesian companies to give more attention to training of their employees. As a result, production manuals, machines’ technical specification etc were then translated and printed into explicit knowledge such as pamphlets, booklets etc for TPE’s employees. The availability of the explicit knowledge then accelerated the internal diffusion of knowledge within TPE.

3.4. Producing Looms and ‘Creative’ Imitation (1985-1990)

Since 1979, as stated earlier, TPE was not only responsible for maintaining, repairing and manufacturing shuttle loom spare parts but also for maintaining and repairing rapier looms’ spare parts and the whole machines (Picanol). TPE during this time had accumulated tacit knowledge regarding the rapier looms. The technicians of TPE, for example, were able to recognise the difference between components of shuttle looms and rapier looms. They were also able to recognise factors making the rapier looms more powerful than the shuttle looms.

In the process of maintaining and repairing the rapier looms, the TPE technicians realised that by using the tools and equipment which were available at TPE, some components of the rapier loom could be produced by TPE. But to manufacture the whole rapier looms like Picanol was still impossible. They understood the limitation of their equipment. But since TPE had been able to manufacture shuttle looms, they thought why not try to modify Texmaco’s shuttle loom with some spare parts of the rapier looms which were already able to be produced by TPE? Therefore, in 1986, some spare parts of the rapier looms were put in to Texmaco’s shuttle loom. As a result TPE then was able to produce looms which were better than shuttle
looms but not as good as rapier looms. The experiment boosted the confidence of TPE which then continued to try and modify the ‘new model’ looms. During the process Picanol was used as the benchmark. And when TJ opened up a new Textile Mill in Cakung (Jakarta) in 1987, around fifty of the ‘new modification machines’ were installed in the new location. It should also worth noted here that the textile mill in Cakung at that time was opened by President Soeharto.

The year 1987 was very challenging for TJ and TPE. The dramatic fall in the price of oil and other commodities during the 1982-1986 period forced the government to shift its industrialisation strategy from import substitution to export orientation. And since textiles had been the mainstay of Indonesia’s non oil export since the 1980s, the government then actively encouraged the textile industry to grow at a steady pace to achieve the export targets set by the government. A crucial element in achieving the set target would be the replacement of obsolete low-productive textile machines with modern high-productive textile machinery to enhance product competitiveness in export markets.

The internal environment was challenging as well, because in 1987, TTS, the chemical firm, was able to develop polymer chips, a raw material for yarn. So, Texmaco Jaya did not need to import the raw material for its yarn anymore. The breakthrough stimulated and forced other parts of Texmaco group, including TPE, to respond.

As part of an effort to respond to the external and internal environment, in late 1987, Mr Sinivasan and a team from TPE attended the textile machinery exhibition in Hannover (Germany). At that expo the team noticed ‘naked’ rapier loom produced by Pignon (Italy). The machine was quite simple compared to Picanol. Mr Sinivasan asked and challenged the TPE team whether they could produce that kind of rapier loom. After examining the machine in detail, the team thought that using the current equipment and tools, they could produce the rapier loom. So, TPE then contacted Pignon and stated that TPE was interested in its rapier loom. The team from Pignon explained everything about their machine in detail and invited TPE to come to Italy to see how the machine was produced at Pignon’s factory.

In the beginning of 1988, TPE then sent 3 top technicians to Pignon’s factory in Italy. They were shown how to produce the rapier loom, its components, etc. After reporting the development, TPE then decided that for the first stage TPE would buy three machines from Pignon for the sake of
training at TPE. And if TPE felt happy with the machines TPE then would contact Pignon. After the deal, for almost two weeks the TPE team spent their time in Italy and asked, investigated and explored everything about the rapier loom. After two weeks training and intensive discussion between Pignon’s and TPE’s technicians and also among the TPE technicians in their hotel, the TPE technicians thought that TPE actually could produce most of the rapier looms’ components by using its facilities in Indonesia.

Three rapier looms from Pignon were then brought to Kaliungu (Central Java). At TPE all the three machines were broken down in detail. All the components were explored and assessed. And as they had thought, with the facilities and tools available at TPE, most of them could be manufactured at TPE except the gear and some small components. The gear then was imported from India, and the small components were imported from Pignon’s factory².

The process of imitating the pignon’s rapier loom by TPE - from blueprint, pattern, casting, etc until running the machines - took about eight months to finish. During the process the TPE team - 10 core members- had very intensive discussions. The 10 members were recruited from foundry, machining, assembling, pattern and also from Texmaco Jaya as the user. The involvement of the user from Texmaco Jaya was useful and significant since they had experience in using the machines. During the discussions, members from Texmaco Jaya gave the team a lot of feedback based on their experience as users.

One member of the team, Mr. Rippon Dwí – now one of the general managers at TPE- said the working atmosphere at TPE’s team at that time was just like in formula 1 motor racing. The people from foundry, machining, assembling and pattern were just like the mechanic at the pit stop who design, develop, repair and are responsible for the reliability of the car racing, and the people from Texmaco Jaya as users were just like the driver of the car. The driver gave the feedback to the mechanics about what he needed in the track, how he felt about the performance so far, etc. So, the team was working shoulder by shoulder in developing the machines.

During the eight months period, the TPE team worked in ‘crisis’ and

² Since TPE only provides its machines only for Texmaco Jaya and not for customers outside the group, there were no objection from Pignon about the imitation. According to Mr Rippon Dwí – one of the technician- Pignon at that time underestimated the ability of TPE’s technicians in developing modern looms such as rapier looms. Moreover, loom is not standardised, so they could modify the machines into completely new form of machines.
demanding environment. It was due to the clear message given by Mr Sinivasan that the rapier looms developed by TPE should be finished on time for the sake of the Indonesian Product Fair II which would be opened by President Soeharto. Moreover, the machines should also different from the one belonging to Pignon. Mr Sinivasan emphasised that the markets of Indonesia and Italy were not the same. The taste, purchasing ability, demand, etc were different. Therefore, if the machine from Pignon could only be used for one type of fabric, the TPE rapier loom should be able to manufacture many types of fabrics. The message was stimulated by the establishment of three new garment factories by Texmaco Jaya in Bogor (West Java), which intended to fulfill different market segments. The better quality fabrics and garments would be produced for the export market and the lower quality would be produced for the domestic market. So, TPE should and had to be able to produce the machine for different purposes.

The TPE team then developed three prototypes of machines for different kinds of fabrics. And after eight months trial and error, modification, etc, in 1988, they finally managed to assemble and create its rapier looms made in and by TPE. The rapier loom was branded Perkasa.


In the late 1980s, the Indonesian economy continued to run on a high-growth track. The economy had been growing very rapidly, averaging 9.0 per cent (1993 prices) annually during the period 1988-1991 (Thee, 1996). In this period Texmaco as a group had succeeded in applying internal integration as its business strategy. Most of the raw material for its fabrics such as polymer chips, yarn from polyester, fibre and PTA (purified terephthalic acid) had been able to be produced by TTS (the chemical company). As a result, various factories under TJ have been able to manufacture various kinds of yarn including 100% cotton, polyester/cotton and polyester/rayon, woven fabrics, dyed fabrics, and other high quality finished fabrics from denim to synthetic fabric. The yarn and fabrics are used internally as well as exported. TJ’s exports have also grown steadily and comprise about 50% of their output on average.

The development of TJ could not be separated from the development of TPE and vice versa. Therefore, when TJ was ready to be a global player, TPE as provider for the textile machinery also had to move and respond to the challenge. TPE’s management then decided that the firm should transform itself to be a domestic, quality manufacturer of high technology textile
To transform itself to be a quality manufacturer of high technology textile machinery at competitive prices in Indonesia was not an illusion for TPE, since it had accumulated enough production capacities and technological capabilities. Moreover, the market for TPE’s products was quite captive since TI continued to transform itself as the largest producer of yarn and fabrics in Indonesia. But in doing so, TPE had to modernise its equipment and facilities. It was true that TPE had been able to produce shuttle and rapier looms, but TPE still could not provide all the textile machinery needed by all the whole factories of the Texmaco group. Despite the limitation of facilities and tools available, TPE was still producing the textile machinery manually.$^3$

TPE’s management realised that to move ahead in developing capital goods machinery and precision components depends to a great extent upon the availability of quality Machine Tools known as "Mother Machines". Therefore, if TPE would like to develop further, it needed machine tools. To realise the dream, in 1990 the firm then diversified its activities into machine tools by importing 23 CNC (computerised numerically controlled) machine tools from Mazak (Japan). Mazak was chosen because Mazak was able to provide credit to enable TPE to purchase the CNC machines. And as a package of the agreement, TPE’s technicians were then trained by Mazak in Japan and Singapore for operating and maintaining the machines.

Following the dealing with Mazak, TPE then made a strategic decision in 1990 by moving and expanding the machine tools division to Karawang (West Java) where strategic investment was made by building a 40,000 sq meter machine tools facility there.

The diversification to machine tools division was strategic and needed for further development of TPE. And the decision to invest in the new capital equipment was possible for TPE due to a government policy introduced in the late 1980s which exempted companies from paying import duties on new capital equipment if the new investment was intended for restructuring of the textile industry.

The new location and the investment in new capital equipment also had implications for TPE’s activities as shown in figure 3.

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$^3$ Manually means here that at that time TPE was not using machine tools for manufacturing its machines’ components.
TPE’s main activities can be divided into main divisions (IBUs); textile Machinery and foundry. The machine shop at the textile machinery division which was still located in Kaliungu (Central Java) was responsible for manufacturing the spare parts of the weaving machinery, such as shuttle and rapier looms which were then assembled by the assembling department. Machine processing department was responsible for developing other parts of textile machinery such as preparatory machine and finishing machine. Foundry division was responsible for manufacturing castings. The training activities was integrated into PPSDM (Texmaco’s Centre for Human Resource Development), a training institution for all the members of Texmaco Group.

It is worth noting that a whole package of complete textile machinery usually consists of three types of machines; preparatory, weaving and processing/finishing machines. A preparatory machine is needed for preparing yarn for weaving. A weaving machine then will weave the yarn for various kinds of fabrics, and processing machines will finish the fabrics into many categories such as silk, denim etc.

Before the machine tools were available, TPE could only produce weaving machinery such as shuttle and rapier looms. The preparatory and processing machines were still imported from Japan, German and Italy. The availability of machine tools which was supported by accumulated product-
ion capacities and technological capabilities enabled TPE then to manufacture all three types of machines.

Backed by continuous learning from the experience of production, by hiring a Japanese machine designer in 1993, and also by strategic technical alliances with world renowned manufacturers like ICBT Diedrichs (France), Thies GmbH (Germany), Mario Croasta and MS Machinery (Italy), the firm in 1994 produced world class textile machines like Water Jet and Air Jet Weaving Machines. By limited licensing and unpackage technology transfer from Murata and Tsudokoma (Japan), Beninger (Switzerland) and Barmag (Germany) the firm was able to produce High speed Twisting Machines, state-of-the-art Stenters, Dyeing and Rotary Printing machines in 1994. The company was also engaged in the production of Two-for-One Twisters, Pirn Winders, Texturising machines, and Ring Spinning Frames in 1995.

During the process of manufacturing the spare parts of textile machinery, the firm was also able to manufacture spare parts of the machine tools. And since the outlook for prospect of TPE’s business was promising, TPE would need more machine tools for its operation. The decision was made then that TPE should produce its own machine tools. Buying the new machine tools was too expensive, and TPE actually had accumulated enough knowledge base for producing its own machine tools which was a result of its experience in maintaining and manufacturing the component of machine tools.

Although TPE had accumulated production capacities and technological capabilities regarding the machine tools, TPE found that Mazak was too sophisticated to be imitated. There was still a technology gap between TPE and other machine tools producers such as Mazak. Moreover, because the market was the same, TPE could not get technical licensing from Mazak for producing the machine tools. However, when Mr Sinivasan and a team from TPE went to the machinery exhibition in Hannover (Germany) in 1995 to find out more information regarding the machines, they found simpler machine tools, made by Casanov (France), in the exhibition. They then bought two Casanov Machine tools and then broke them down at TPE. Most of the machines’ components could be produced at TPE, except the control system. Fortunately, in late 1995 TPE succeeded in acquiring the know-how and technical rights from ACIERA. Since then the firm diversified its activities into machine tools division and started to manufacture the well-known Aciera Machine Tools of Switzerland.

3.6. Becoming Indonesia’s Leading Industrial Equipment and Machinery
Manufacturers (1995-Present)

The ability of TPE in providing machine tools for its own operations has transformed itself into the largest manufacturer of textile machinery in Indonesia. The range of textile machinery produced by the firm, as depicted in table 2, includes spinning, preparatory, weaving and processing machinery to produce yarn, weave and convert it into finished fabrics.

<table>
<thead>
<tr>
<th>DIVISION</th>
<th>PRODUCTS</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textile Preparatory</td>
<td>-Warping Machines</td>
<td>Preparatory machines for the preparation of yarn for weaving</td>
</tr>
<tr>
<td>Machinery</td>
<td>-Sizing Machines</td>
<td></td>
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<tr>
<td></td>
<td>-Twisting Machines</td>
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<tr>
<td></td>
<td>-Beaming Machines</td>
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<tr>
<td></td>
<td>-Texturising Machines</td>
<td></td>
</tr>
<tr>
<td>Textile Weaving</td>
<td>-Shuttle Looms</td>
<td>High tech looms for weaving various kind of fabrics, smoother than silk and heavier than denim</td>
</tr>
<tr>
<td>Machinery</td>
<td>-Flexible Rapier</td>
<td></td>
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<tr>
<td></td>
<td>-Double-Width Rapier</td>
<td></td>
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<tr>
<td></td>
<td>-Telescopic Rapier</td>
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<tr>
<td></td>
<td>-Air Jet</td>
<td></td>
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<tr>
<td></td>
<td>-Water Jet</td>
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</tr>
<tr>
<td>Textile Processing</td>
<td>-Stenters</td>
<td>Processing machines for finishing various kinds of fabrics from silk to denim</td>
</tr>
<tr>
<td>Machinery</td>
<td>-Printing Machines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Jet Dyeing Machines</td>
<td></td>
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<tr>
<td></td>
<td>-Comfit Machines</td>
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<tr>
<td></td>
<td>-Washing Range</td>
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</tbody>
</table>

Source: From The Company

Because its foundry facilities were quite good and also because of the availability of machine tools, some automotive assemblers and manufacturers in Indonesia, such as Opel, GMBI, Izusu and Yanmart in 1996 subcontracted some of the automotive components to the machine shop division of TPE. So at that time, the machine shop and the foundry division were not only responsible for manufacturing the textile machinery parts but also automotive components.

Since the job was getting more complex, more sophisticated machine tools were then needed. Therefore, a joint venture was formed in Indonesia, between Bridgeport Machines Inc of USA and the firm to produce Bridgeport series 1, the E-Z Trak Universal Milling Machines and the Torq-Cut Machining Centers. With the collaboration with Aciera and Bridgeport, the firm now is able to produce a variety of machine tools as shown in table 3 such as Conventional and CNC (Computerized Numerically Controlled) Lathes, Milling Machines, Drilling and Boring Machines, CNC Machining.
Centers, and Special Purpose Machines of various sizes for large volume production requirements, particularly for the automotive industry.

Based on the experience of production of components of textile machinery, automotive and machine tools and also technical change from the new collaboration with Aciera, Bridgeport, etc, the firm realised that some facilities should be modernised. Therefore, in the first half of 1997 the firm then modernised its casting facilities in the foundry division, which now rank as one of the most modern and largest in the country. The foundry has state-of-the art machinery for castings and molding with a capacity of 50,000 tons per annum of Grey and SG iron castings. The castings produced in this facility meet the stringent quality standards for critical housing frames for machines and automotive components to precision parts in CNC Machine Tools.

Table 3: TPE’s Machine Tools Products

<table>
<thead>
<tr>
<th>DIVISION</th>
<th>PRODUCTS</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Tools</td>
<td>- CNC Lathes</td>
<td>Machine tools for the production of machines and machine components</td>
</tr>
<tr>
<td></td>
<td>- Conventional Lathes</td>
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<tr>
<td></td>
<td>- Drilling Machines</td>
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<td></td>
<td>- Boring Machines</td>
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<td></td>
<td>- Special Purpose Machines</td>
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<tr>
<td></td>
<td>- CNC Machining Centre</td>
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</tbody>
</table>

Source: From The Company

Table 4: Automotive Components

<table>
<thead>
<tr>
<th>DIVISION</th>
<th>PRODUCTS</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive Components</td>
<td>- Flywheels</td>
<td>Motor vehicle engines and components</td>
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<tr>
<td></td>
<td>- Clutch Housing</td>
<td></td>
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<td></td>
<td>- Retainers</td>
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<tr>
<td></td>
<td>- Exhaust Manifolds</td>
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<tr>
<td></td>
<td>- Disc Brakes</td>
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<tr>
<td></td>
<td>- Steering Knuckles</td>
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<tr>
<td></td>
<td>- Engines</td>
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<td></td>
<td>- Axles</td>
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<td></td>
<td>- Gears</td>
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<td></td>
<td>- Manual Transmissions</td>
<td></td>
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<tr>
<td></td>
<td>- Starter Motors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Alternators</td>
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</tbody>
</table>

Source: From The Company

As a result of improvements in the foundry and machine shops division, TPE then was able to manufacture more automotive component as shown in table 4.
With the second foundry established in Kaliwungu, Central Java, the firm has additional capacity for sourcing outside job orders for castings. Further, with the foundry being upgraded to handle castings from 2 kgs to 25,000 kgs (single piece), the company is able to execute orders for heavy castings required by heavy industries. All the foundries are backed by state-of-the-art testing labs, CAD/CAM centers, well-equipped Pattern Shop and other support facilities. The establishment of modern casting facilities enabled the firm to extend its activities into heavy engineering in 1998. The involvement of TPE in heavy engineering was actually stimulated and forced by the further development of TTS (the chemical company) of Texmaco Group into PT Polysindo Eka Perkasa (PEP). In late 1996, because of the development of TJ as a textile manufacturer (fabrics and garment), Texmaco Group needed to establish more sophisticated chemical factories in Karawang. The establishment needed heavy fabrication services and engineering. Supervised by people from Eastment Chemical Company from the USA and also John Brown Engineering (Germany), the processing division of TPE then was in charge of the project. Based on the experience of production in textile machinery, automotive and machine tools components and also input and feedback from Eastment Chemical Company and John Brown, the mission was accomplished in late 1997.

Through the ability of TPE in the heavy engineering sector and also by introducing more modern facilities, the firm’s production capacities and technological capabilities were then strengthened. As a result the firm then was very active in searching for new markets, and identifying ways into them. By attending trade fairs overseas, for example, many world renowned manufacturers such as General Electric started to subcontract some of their products to the firm.

From knowledge and skills gained from manufacturing, insight gained from improvements and modifications, from internal training in operating skills, and also from hiring skilled labor from India, the firm now is able to be involved in various activities in heavy engineering. The activities of the firm in heavy engineering include fabrication, machining and assembly of large and heavy components to meet the requirements for the Construction, Petro-Chemical, Fertilizer, Power and Mining industries. The firm is also able to manufacture specialty vessels for Process plants including Heat Exchangers, Reactors, Process Columns and other Specialty Vessels. Besides, the firm also manufactures custom tailored plant equipment for a variety of other industries like Mining, Pulp & Paper, Oil & Gas, Cement and Sugar. To strengthen its production capacities and technological
capabilities in the heavy engineering sector, the firm has modernised its facilities which now covers a production area of 86,000 sq mtrs with capabilities for fabrication using metals like titanium, stainless steel, alloy steels and carbon steel. The firm also has the largest titanium welding shop and clean room facility, the only one of its kind in South East Asia. The plant is designed to handle heavy fabrication and machining requirements of weights up to 250 tons and size up to 8 mtrs diameter and 25 mtrs long, with an annual capacity of 18,000 tons. Extensive fabrication facilities such as CNC Flame Cutting with nesting programs, Shearing, Bending and Rolling equipment with modern welding equipment enable fabrication of plates from 20 mm to 240 mm in carbon steel, stainless steel and titanium. With its modern facilities, the firm is also capable of manufacturing Kilns, Raw Mill, Hammer Mill, Cyclone Pre-heater, Air Separator and other equipment for the Cement industry; while Digesters, Evaporators, Blow Down Tanks and other heavy equipment are manufactured for the Paper and Pulp industry. The firm can also produce Boilers, Super Heaters, Water Walls, Box Columns, Heavy Duty Compressors, Reduction Units and Economizers for Power Plants. In short, the firm has been able to build and strengthen its production capacities and also its technological capabilities, which enable it to manufacture a variety of products, as shown in table 5, in the heavy engineering sector.

Table 5: Heavy Engineering and Fabrication

<table>
<thead>
<tr>
<th>DIVISION</th>
<th>PRODUCTS</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Engineering and Fabrication</td>
<td>-Pressure Vessels</td>
<td>Heavy engineering equipment and fabricated structures for use in various industries, including chemical, sugar, cement, paper &amp; pulp, rubber, power, oil &amp; gas and fertilizers</td>
</tr>
<tr>
<td></td>
<td>-Reactors</td>
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<td>-Tank and Storage Vessels</td>
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<td>-Shell and Tube heat Exchangers</td>
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<td>-Process Columns</td>
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<tr>
<td></td>
<td>-Digestors</td>
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<td></td>
<td>-Kilns</td>
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<tr>
<td></td>
<td>-Boilers</td>
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<td></td>
<td>-Super Heaters</td>
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</tr>
<tr>
<td></td>
<td>-Box Columns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Heavy Duty Compressors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Reduction Units</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Economizers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Raw Mill</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Cyclone Pre-Heaters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Air Separators</td>
<td></td>
</tr>
</tbody>
</table>

Source: From The Company
Because the firm has acquired a very high level of technological capabilities in heavy engineering, all of its products and fabrications can be made to customer specifications following international codes and standards. Its ability has been awarded the “Certification of Authorization” by the American Society of Mechanical Engineers (ASME) for heavy fabrication. Backed by strategic alliances with Murray and Roberts of South Africa, PLN (Perusahaan Listrik Negara, Indonesia) and PT Rekayasa Industry, Indonesia, the firm is well equipped to execute large projects on a turnkey basis in Indonesia and elsewhere in the world, as shown in table 6. Currently the firm is executing two turnkey projects for Botswana and South Africa.

Table 6: The Company’s External Customers

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>ITEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bethlehem Corporation, USA</td>
<td>-Incenerator System (Heavy Fabrication)</td>
</tr>
<tr>
<td>Door Oliver, Australia</td>
<td>-Incenerator System (Heavy Fabrication)</td>
</tr>
<tr>
<td>Kaverner Chemetic, Canada</td>
<td>-Titanium Fabrication</td>
</tr>
<tr>
<td>Nigatta Engineering, Japan</td>
<td>-Vessels &amp; Tanks (Heavy Fabrications)</td>
</tr>
<tr>
<td>General Motors (Worldwide Purchasing)</td>
<td>-Auto Components</td>
</tr>
<tr>
<td>Pacific Textiles, Tunisia</td>
<td>-Stenters (Textile Machinery)</td>
</tr>
<tr>
<td>Coastal Group, South Africa</td>
<td>-Range of Textile Machinery</td>
</tr>
<tr>
<td>ABB</td>
<td>-Titanium Welding</td>
</tr>
<tr>
<td>Textil, USA</td>
<td>-Looms (Textile Machinary)</td>
</tr>
<tr>
<td>Metal Consult Industrienlagen, Germany</td>
<td>-Machine Tools</td>
</tr>
<tr>
<td>Clausing Industrial, Inc. USA</td>
<td>-Machine Tools</td>
</tr>
<tr>
<td>Hitachi Zosen Co., Japan</td>
<td>-Heat Exchanger, Tanks &amp; Vessels</td>
</tr>
<tr>
<td>Krupp, Germany</td>
<td>-Heat Exchanger &amp; Pressure Vessels</td>
</tr>
<tr>
<td>General Electric, USA</td>
<td>-Gas Turbine Components</td>
</tr>
<tr>
<td>Noell Cranes, Germany</td>
<td>-Crane Components</td>
</tr>
<tr>
<td>Leyland, UK</td>
<td>-Cabs (for Trucks)</td>
</tr>
<tr>
<td>Nooter Corporation, USA</td>
<td>-Chemical Process Equipment</td>
</tr>
<tr>
<td>Mohawk Steel Co., USA</td>
<td>-Heat Recovery Steam Generators</td>
</tr>
<tr>
<td>Tulsa Fin Tube, USA</td>
<td>-Finned Tubes</td>
</tr>
<tr>
<td>Coastal Group, South Africa</td>
<td>-Textile Machinery</td>
</tr>
</tbody>
</table>

Source: From The Company

All the development of TPE also had implications for its organisational structure, which then divided into 5 divisions as shown in figure 4, foundry, machine tools, textile machinery, automotive and heavy fabrication.

In the automotive area, the firm has managed to produce most of the automotive components. And as a result TPE has accumulated a significant knowledge base in this area. To strengthen its production capacities and technological capabilities in the automotive division, the firm had been
successful in obtaining technology from world-renowned leaders like Cummins (USA) for engines, ZF (Germany) for gears and transmissions, Steyr (Austria) for engines and axles and Eaton (USA) for axles. The company has signed a license agreement with Fiori (Italy), to produce a range of construction equipment.

Figure 4. New Structure of TPE

Because of the knowledge and skills gained from manufacturing automotive components, and also technical alliances with world renowned automotive manufacturers such as Leyland (UK), Terex (USA), and Matra (France), in 1999 the firm launched its 17 ton truck with the firm’s brand on it. The truck has more than 80% local content and most of them are manufactured in the firm’s automotive division. Based on Kubota’s model, by using the same competence and facilities, the firm also launched its hand tractor in 1999.

4. Lessons from TPE

There are many lessons that can be learnt from the process of technological learning at TPE;

a. The usual simplifying assumptions in the neoclassical economist perspective, that there are not learning costs in using industrial technologies, and that efficient production can be launched merely in response to ‘right’ prices, do not do justice to the complex process of technological learning at TPE.

b. Conventionally, technical change in industry has been seen as a two step process: first, the development and initial commercialisation of significant innovations, and second the wider application - or diffusion - of those innovations. The former activity is heavily concentrated in the industrial countries and is significant in developing economies only as they approach the international technology frontier. Before that stage,
since developing countries are seen as involved primarily in the diffusion of technology or in the choice and adoption of existing technologies, creative innovation and technical change seem irrelevant. From this perspective, the accumulation of technology in industrialising countries is seen as technology that is embodied in production capacity: in other words, in the stock of capital goods and operating know how required to produce existing goods at the relevant production efficiency frontier. From the study of technological accumulation at TPE, however, this paper shows that diffusion involves more than just the acquisition of machinery or product designs and related know how. It also involves continuing, often incremental technical change to fit specific situations and to attain higher performance standards.

c. Technological accumulation at TPE is incremental and dynamic. It tends to move along trajectories in which past learning contributes to particular directions of technical change and experience reinforces the existing stock of knowledge and expertise. Easy capabilities at TPE in every stages were acquired by brief training combined with learning by doing (i.e, repetition without technical search, investment or experiment- ation). More difficult capabilities necessarily required more complex learning mechanisms and technological effort to master, with concomit- ant risk and uncertainty.

d. The paper has also shown that the acquisition of technological capability at TPE did not come merely from experience, though experience is important. It came also from conscious efforts - to monitor what was being done, to try new things, to keep track of developments throughout the world, to ac- cumulate added skills, and to increase the ability to respond to new pressures and opportunities.

e. From the experience of TPE in accumulating its technological capabilities, it is apparent that successful technological accumulation depends on:
The acquisition of foreign technology
Economic incentives for innovation
Continuous growth of demand
Institutions and policies designed to encourage firms to accumulate technology

5. Policy Recommendations

There are some recommendations that can be suggested to the policy makers in Indonesia from the experience of TPE in accumulating its tech-
nological capabilities.

a. The Need for Focus at the Firm and Industry Level

Current economic and technology policies in Indonesia have tended to focus primarily on the actions and initiatives that need to be taken by public technological institutions that have sometimes been referred to as the technology ‘supply side’ (e.g. universities, training and R&D institutes).

However, many studies in industrialised and newly industrialised countries indicate that most industrial technology development takes place as a result of technological activities and human resource development undertaken in industrial firms (Kim, 2000). The findings in this paper also support this idea. Thus, not only is the ‘demand side’ of industrial technology development generated by industry, most of the ‘supply side’ as well is located inside industrial firms, not outside.

Therefore, economic and technology policy should no longer concentrate exclusively on universities and other public sector institutions as the central actors in industrial technological development. Instead, industrial enterprises must be set at the centre of the Indonesian technology system. By concentrating on other institutions, technology policy might be misplaced. In other words, we can say that a major reorientation of emphasis in industrial technology policy in Indonesia is needed to ensure that firms’ capabilities to supply technology are strengthened, while also shifting and stimulating their demand for technology and strengthening infrastructural institutions outside industry.

b. Policies Should Encourage the Firms to Build not only Their Production Capacities, but also Their Technological Capabilities

By building technological capability, TPE has achieved considerable success in expanding its business activities from only a small informal team for maintaining the textile mills into a vertically integrated engineering company from foundry, to machine tools to machinery building to heavy fabrication and also to automotives.

Policies then should encourage other firms in Indonesia to build not only their production capacities (static resources) but also their technological capabilities (dynamic resources).

c. The Need for More Support on Other Learning Mechanisms, not only R&D.
From the experience of technological learning at TPE, it is apparent that a very large part of the technology that the firm needs in order to introduce new products and processes and to change and improve its existing products and processes, did not draw on the state system R&D. It involved the implementation of technical change and technological learning by:

[i] The acquisition, assimilation and improvement of existing know how, equipment, designs and materials and

[ii] The original design and engineering adaptation of unique and incrementally novel processes or products on the basis of existing underlying technology. In all the processes of technical change and technological learning are involved various learning mechanisms such as learning by operating, changing, training, hiring, searching, etc.

Therefore, economic and technology policy should not only focus on developing public sector infrastructural institutions that are primarily concerned with undertaking R&D but also on other institutes involved in training activities, etc. In other words, we can say that higher priority should be given to expanding technology training institutes, targeting the short to medium skill needs of industry that are mainly concerned with the supply of such skills as technicians of all kinds: mechanical, chemical, electrical and metalurgical engineers, process-product designers, etc.

d. Technology Policy Cannot be Generalised in All Industries

This paper is concerned with the technological learning in a firm in the manufacturing sector. But it should be borne in mind that different types of industry face different kinds of challenge and learning mechanisms[6,9] . These challenges are fundamentally rooted in the sectoral nature of technologies and markets.

Technology policy therefore must be differentiated accordingly since a generalised technology policy alone may fail to meet sector-specific needs. In particular, an emphasis largely on ‘generic’ technologies cannot deal effectively with the specifics of technology development in particular kinds of industry [6].

6. Further Research

Not many studies have been carried out in Indonesia in the area of technological learning at the microeconomic level, that is, with the firm as the unit of analysis. This paper suggests a new research agenda which
explores the accumulation of technological capability for the whole Texmaco as a group or for other sectors in Indonesia. And since linking the process of technological learning and its impact on corporate development is not well explored in this paper, it is going to be a challenging agenda for future research.

7. Conclusion

The paper has shown that technological accumulation at the microeconomic level is incremental and dynamic. It is not the result of an automatic learning by doing process. The technological learning tends to move along trajectories in which past learning contributes to particular directions of technical change and experience reinforces the existing stock of knowledge and expertise. It is also shown that the accumulation of technological capability at the firm did not come merely from experience, though experience is important. It came from conscious efforts - to monitor what was being done, to try new things, to keep track of developments throughout the world, to accumulate added skills, and to increase the ability to respond to new pressures and opportunities.

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