

TECHNOLOGY TRANSFER IN THE MALAYSIAN IRON AND STEEL INDUSTRY : SOME INSIGHTS

Cheah Kooi Guan and Tan Siew Ee

Artikel ini memberikan satu gambaran yang mendalam mengenai pelbagai aspek pemindahan teknologi di dalam industri besiwaja di Malaysia. Berasaskan temuramah dengan para pemimpin industri tersebut, kajian yang dijalankan memperolehi penerangan yang amat menarik mengenai jenis-jenis teknologi yang sedang digunakan di dalam sektor ini serta saluran dan cara pemindahannya. Di samping ini satu gambaran didapati mengenai kepayahan pemindahan teknologi yang dihadapi oleh industri tersebut. Sebagai kesimpulan tinjauan, kedua pengarang menyarankan beberapa dasar agar pemindahan teknologi di dalam industri besiwaja dapat dimajukan lagi.

This article offers an inside look into the many facets of technology transfer in the steel industry of Malaysia. Based mainly on interviews with industry leaders, the survey yielded very interesting information regarding the kinds of technology currently being used in this sector, their channels and modes of transfer as well as the difficulties involved with transferring technology. The authors conclude with some policy recommendations to enhance the transfer of technology within this industry.

I. INTRODUCTION

Rapid economic development in developing countries necessitated the construction of economic infrastructure and growth of various industries. In this context iron and steel products are essential both in infrastructural construction such as roads, railways and buildings, as well as in most industries in the form of machinery and other inputs. Furthermore the development of the iron and steel industry itself will generate substantial demand for local inputs and provide an opportunity for the transfer and diffusion of technology to other industries. Compounded by the problems of reliance on imported iron and steel products, their fluctuation in prices and strains on balance of payments, many developing countries see a need to develop their own iron and steel industries.

In view of the importance of this industry, an attempt is made here to assess the extent and success of technology transfer (henceforth denoted by TT) in the Malaysian iron and steel industry. Data for the study was collected through mailed questionnaires to all major mills, followed by personal interviews.

In this paper, after a cursory overview of theoretical issues, the firms' perception of technological level and mastery of technology are examined. The paper then looks at the channels through which foreign technology is acquired as well as modifications of the imported technology, after which an assessment is made regarding the extent of diffusion of the acquired technology into other areas of the economy. In the final part of the paper, the success of TT in the Malaysian iron and steel industry is reviewed, and some recommendations are offered, based on the views gathered from the interviews.

One of the primary issues raised in TT is that the technology imported from developed countries is too capital intensive and hence not appropriate to developing countries' factor endowments. This argument also implies that technology is needed primarily for employment generation. But TT has in fact enormous capacity and effectiveness. It could be used, for example to attain growth or skill generation objectives (O'Herlidy, 1972). More importantly, TT can help improve the technological infrastructure of the recipient economy and pave the way for industrialization.

Secondly, as argued by Caves (1971), an economy does not benefit directly from a foreign firm's efficiency or technology *per se*. It is only when the foreign firm cannot capture all the quasi-rents due to its productive activities that the economy gains from the spillovers of its productivity. The most notable spillover effects are the forward and backward linkages generated by the recipient firm (Hirschman, 1958). However, a large part of the foreign investments take the form of "enclave" industries that mainly draw upon the cheap and unskilled local labour and which do not generate significant linkages with other parts of the recipient economy. Moreover, most diffusion of technology via the movement of workers tends to occur among foreign firms so that the skills acquired seldom diffuse into the domestic industrial sector (Cohen, 1975).

To date, few studies have been carried out on TT in Malaysia, and even fewer have been published. From the limited evidence, it is found that TT in Malaysia is still not substantial. K.C. Cheong and C.K. Lim's (1981) study on the electronic industry found "extremely limited" TT, while P.L. Chee (1981) felt that the quality of TT and extent of technical absorption were unsatisfactory among European Community investments in Malaysia. Md. Ariff, et. al (1981) concluded that TT in the Malaysia iron and steel industry was limited as new mills still had to be set up entirely by foreigners. K.G. Cheah (1984) found a heavy reliance on FDI and expatriates for the TT in the Malaysian textile industry and that its linkages were fairly restricted. In their study on Japanese investment in Malaysia, C.L. Chee and P.P. Lee (1979) also discovered that the investment was mainly concentrated in the relatively low technology industries and thus had not resulted in the transfer of any sophisticated technology to Malaysia.

II. THE IRON AND STEEL INDUSTRY IN MALAYSIA

The iron and steel industry is relatively new in Malaysia. It was a decade after independence that the first iron and steel mill commenced operations. However, production since then has expanded significantly and so has the number of steel mills. Presently there are a large number of iron, steel and rolling mills in the country. The more important ones are:

- . Malayawata Steel Bhd.
- . Amalgamated Steel Mills Sdn. Bhd.
- . Antara Steel Mills Sdn. Bhd.
- . United Malaysian Steel Mills Bhd.
- . Dah Yung Steel Manufacturing Sdn. Bhd.
- . Malaysia Steel Works
- . Southern Iron and Steel Works Sdn. Bhd.
- . Perwaja Trengganu Sdn. Bhd.

Of the eight mills listed, the last one started production only very recently (1985). Its production, however, with a capacity of 560,000 tons per annum had not been stabilised as there remained some technical problems to be solved. Excluding the last mill, the first three, i.e. Malayawata, Amalgamated and Antara accounted for nearly 85% of total capacity in the industry. Southern Iron and Steel had recently increased its rolling capacity to a quarter million tons per annum, while the other three were mini mills with individual capacity ranging from 18,000 to 30,000 tons per annum. Crude steel output capacity for the industry as a whole increased rapidly since 1980, rising from 230,000 tons in that year to 680,000 in 1981 and reaching 2,000,000 in 1985.

In terms of production, the basic iron and steel industry in Malaysia ranged from iron making to steel making in its upstream operation and the rolling of billets into various steel product (e.g. rods, bars) in the downstream operation. Basically two processes are relied upon by the Malaysian industry for making iron. First there is the blast furnace process where iron ore is converted into pig iron in a blast furnace. Second, the iron ore may be reduced directly into hot briquetted iron (HBI) in a shaft furnace. The first process requires a large quantity of solid fuel (such as coal or coke) and is more suitable for large scale production. The Malaysian blast furnace is reputed to be among the smallest in the world and differs from most other blast furnaces (except those of Brazil) in that it uses as fuel charcoal converted from used-rubber trees. The second process is more suitable for small scale operation and is used mainly in countries that have cheap and abundant natural gases.

In the next stage, two other processes are used in Malaysia to convert iron into steel. The electric arc furnace is commonly used by most firms to melt scrap iron or HBI to produce liquid steel which is then moulded into billets.

On the other hand, one Malaysian firm has in addition a Linz-Donawitz (LD) Converter that converts molten pig iron (from the blast furnace) into steel.

Finally a common process is used to produce steel products from billets. Billets are usually reheated so that it becomes plastic. They are then passed through a series of paired heavy rolls, which are so grooved and spaced out that each succeeding pass is smaller and more resembling the required final shape.

The eight mills listed above can be divided into four categories.

1. *Fully Integrated From Iron-Making to Rolling.*

This category covers iron-making using charcoal fuelled blast furnace and steel-making using two processes - LD Converter using molten pig iron and electric arc furnace using scraps. In addition to rolling mills which produce mainly steel rods and bars, there is also a hot coil reprocessing mill that makes flat bars, fence posts and lip channels.

2. *Upstream Operations From Iron Making to Steel Making.*

This category uses direct reduction process to produce hot briquetted iron. The major inputs are local natural gas and imported pellets and lump ores. Electric arc furnaces are then used to refine the HBI into steel billets.

3. *Midstream to Downstream Operations From Steel Making to Rolling.*

Electric arc furnaces are used to melt steel scraps and or HBI into steel billets. These billets as well as additional billets purchased are reheated and rolled into rods and bars.

4. *Downstream Operations of Rolling.*

Firms in this category have rolling mills only, and do not produce their own iron or steel. Reheating furnaces are used to heat up steel fillets into red hot plastic metal, which are then rolled into required shapes and sizes of bars and rods.

III. PERCEPTIONS OF TECHNOLOGY

In our study, the Malaysian iron and steel mills were found to be very confident of their own state of technology as well as their mastery of that technology. Table 1 shows that all five firms interviewed believed that the level of technology in the Malaysian industry was comparable to that of other countries. Three firms placed the Malaysian level at medium, while the other

two considered it sophisticated. On the other hand, most firms were fairly confident of their own firms' level of technology as compared with other local firms. Two of the firms felt that their level was justifiably more sophisticated than that of others.

Such subjective perceptions however, have to be qualified as the nature of their production processes is not strictly comparable. Moreover, it is thought provoking to hear from one director that sophisticated technology was not necessarily more advantageous. He felt appropriate technology should be preferred. A technology may not be the latest or most sophisticated, but above all it has to suit the local factor endowment, price ratio and market size. The presence of such thinking indicates that there are local entrepreneurs who are rational and critical in their selection of technology and who are not overly preoccupied with high sophistication of technology.

TABLE 1
PERCEPTIONS OF LEVEL OF TECHNOLOGY

Level of Iron and Steel Technology	Very Sophisticated	Sophisticated	Medium	Unsophisticated	Total no. of firms
Malaysian level compared with other countries	-	2	3	-	5
Own firms' level compared with that of other local firms	2	2	1	-	5

Source : Own Survey

Another indication of technology transfer is shown by the degree of TT the firms themselves perceived to have mastered. Most firms felt that they had partly mastered their main process technology (Table 2). They were also positive of being able to fully master the technology in the future. As there were very few expatriates working in these firms, this could be taken as an indication of the confidence of these firms. In fact one firm did not have any expatriates now and believed that it had completely mastered its main process technology. It could operate on its own and effectively carry out maintenance and repairs without outside help. More significantly, it felt confident enough to offer consultancy services to other mills, and even complained that its services should have been availed when the latest iron and steel mill was set up recently. On the other hand, Table 2 indicates that one

firm had not yet mastered its main process technology. Having just recently started operations, its personnel certainly would need time to master the technology.

TABLE 2
PERCEPTION OF MASTERY OF TECHNOLOGY

Degree of TT achieved on main process		
completely mastered	partly mastered	not yet mastered
1	3	1

Source: Own Survey

IV CHANNELS OF TECHNOLOGY TRANSFER

Foreign technology can be transferred through numerous channels. The choice of the channels depends on several criteria including the complexity of the production techniques, the absorptive capacity of the recipient firms and the transfer environment of both the donor and recipient firms. The relative importance of various channels as perceived by the firms in our study are summarised below:

TABLE 3
CHANNELS OF TECHNOLOGY TRANSFER

Types of Channels	Importance of various TT channels
1. Overseas Training	4
2. Joint Venture Partners	3
3. Equipment Suppliers' Aid	3
4. Employment of Expatriates	2
5. Public Knowledge	2
6. Technical Agreements	2

Source: Own survey

(a) Overseas Training

From the interviews, we found that overseas training was the most commonly used channel for obtaining foreign technology. Out of the five firms covered, four regarded it as an important source. One established firm for example, reported sending nearly a dozen workers for overseas

training every year since it started production. This finding is consistent with that of Mohamed Ariff et al (1981), which concluded that training is "the main vehicle of technology transfer in the iron and steel industry" (p. 112).

From our conversations with the managers of the firms, it was discovered that joint venture partnership facilitates overseas training, as the local firms had better access to training facilities that usually were available in their joint venture partners' firms. However, we must bear in mind that the scale of operation in the Malaysian iron and steel industry is very much smaller than that of these foreign partners in developed countries. Moreover, the Japanese steel firms that designed the charcoal-fuelled blast furnace and direct reduction shaft furnace did not have similar facilities in their own mills. Hence, as pointed out by one mill supervisor, there was not much of exact job nature that these trainees could learn and apply directly when they came home. Nevertheless, the exposure and whatever new technology acquired had been beneficial to the firms concerned. Such trips could also be one way to encourage stability of the workforce as the trainees generally had to sign contracts requiring them to continue serving the same firm after their return.

To the extent that experienced workers with overseas training had moved to other local firms (whether within or outside the iron and steel industry), there would have been some diffusion of technology. From our study, it was discovered that over 50 experienced workers (many having long overseas training) from the oldest mill had in fact left and joined other iron and steel mills. This was corroborated by the management of other mills, which admitted having recruited experienced workers from the oldest mill. This occurred especially during the initial operation stage of new mills, when some experienced workers were badly needed to guide other inexperienced ones. Thus we can conclude that overseas training had in fact helped the iron and steel industry in Malaysia, especially in the diffusion of technology.

(b) *Joint Venture Partners*

Traditionally, the flow of technology to developing countries is an integral part of foreign direct investment which is made up of a package of finance, technology, product specification, management and marketing. However, in a relatively resource rich country like Malaysia with a favourable balance of payments, foreign investment may be "sought and welcomed not so much for the capital itself as for the modern technology it injects into the economy" (Hughes & You, 1969). Joint venture partners thus represent an important channel for TT.

All five firms that we interviewed had some (minority) foreign equity participation. But the degree of joint venture participation in operation and technical assistance varied directly with the age of the firm (and thus partnership). Generally, all firms had very active foreign participation (especially technology-wise) in their early stages of operation. For example, the oldest mill was designed and set up almost entirely by the Japanese partner. By now, foreign equity had substantially diminished, and the firm could be operated entirely by Malaysians, without a single expatriate on the payroll. While all firms acknowledged receiving great technical assistance from joint venture partners in the initial operation stages, most established firms no longer regard such assistance as a major TT channel. However, as shown in Table 3 over half of the firms (and all of them being newer ones) still relied on this channel for foreign technology.

(c) *Equipment Suppliers Aid*

All the major machinery and equipment used in the Malaysian iron and steel industry are imported. Most of them come from Italy, Japan, Germany and Switzerland. The purchase of equipment is normally one channel for acquiring foreign technology and this is indicated by the responses of firms in our study. It is in fact one of the more important channels as three out of five firms surveyed regarded it as important.

The equipment or machinery itself invariably incorporates a given state of art or a certain level of technology. Normally newer models of equipment would embody more up-to-date technology. This is what perhaps prompted a mill supervisor to remark that constant purchases of new machinery would raise the technological level of a local firm. However, what is more important from the point of TT is the assistance given by the equipment supplier, which extends all the way from installation and training to major repairs. To ensure efficient utilisation of their machinery, suppliers normally continue to provide advice on operational technology after the installation and test run.

There are two ways in which the suppliers provide training. Most suppliers would train the buyers' employees at the latter's factories during the installation period of the equipment. At the time when this study was carried out, over 40 Japanese trainers were found in a mill, to train the local workers to handle the new machinery that were just installed. Where longer and higher level of training is required, trainees from the buyer's firm could be sent abroad to the suppliers' mills.

Between the two types of training, on-the-spot training was found to be actually more effective. As each mill might face particular constraints different from other mills, on-the-spot training will thus be more appropriate to the local needs of the buyer.

Nevertheless, equipment suppliers' aid, though useful as a channel of TT, has a severe limitation. The level of technology acquired is limited by that which is embodied in the machinery. The operational techniques, repairs and servicing, which are human embodied, are related and confined to handling that particular machinery. Moreover, the human embodied technology of handling the equipment may never be fully mastered. What is actually desired is the technical ability to not only handle the equipment, but to modify, adapt and further develop the technology to suit local conditions.

(d) *Employment of Expatriates*

Employment of expatriates as a channel of TT could take several forms - as part of FDI or joint venture agreements, under technical or other agreements and freelance specialists where the technology is not incorporated in specific firms. All these forms of TT were found in our sample. One firm was set up with much help from a free-lance expatriate. His vast experience, skill and personal contacts were crucial to the initial operation of the firm.

We found that as a channel of TT, employment of expatriates, just as joint venture partnership, declines in importance as a firm grows older. This is an indication of the success of TT in this industry⁸ as it implies that the local workers have gradually acquired the technology from the expatriates. The two firms claiming this to be an important channel were the youngest in the industry.

(e) *Public Knowledge*

Foreign technical information can also be obtained through technical books, journals and trade or machinery exhibitions. However, technology that could be thus acquired usually belongs to the more open and non-proprietary types. Furthermore, it is more for information purposes rather than for immediate application in the local mills. It is nevertheless important to firms without much foreign connections, or where joint venture partners are not active in sharing knowledge of new technology.

In our survey, this channel is especially important to the older firms, where the foreign partners no longer actively assist in technology transfer. Hence these firms were left to their devices and had to rely on more

open channels to acquire technology. The newer firms still had fairly active and supportive participation from their foreign partners and thus had less need for this channel.

(f) *Technical Agreements*

Technical agreements here refer to agreements relating to communication of technical knowhow on agreed commercial terms, but exclude joint venture and training agreements, which have been discussed earlier. The acquisition of technology through technical agreements without foreign equity participation has been considered an ideal transfer channel. It is an indication that local entrepreneurs are capable of unbundling the "foreign package", and thus enabling capital, management, technology and marketing to be acquired from different sources. However, such agreements could be costly and straining on the balance of payments of the recipient country (Santikarn, 1981). Moreover, many such agreements are restrictive and inhibit the export growth potential of the recipient country (UNIDO, 1973).

As revealed in Table 3, this channel is not important for the Malaysian iron and steel industry. This finding is also borne out by that of P.L. Chee (1982), where only 27 agreements (6.9% of total agreements signed) had been signed for iron and steel basic industries up till 1980. However, one firm in our survey claimed extensive use of this channel.

V. MODIFICATION OF TECHNOLOGY

Foreign technology is developed to suit the technical knowhow, management practices and other factor endowments within the social cultural environment of developed countries. Such technologies may not be appropriate to developing countries as qualitatively and quantitatively all the factors concerned could be very different.

Hence modification of technology is necessary to enable the technology transferred to work to the best advantage of the recipient firm and country. In the case of the iron and steel industry, one million tons per annum output is regarded as a minimum for a blast furnace, but the blast furnaces in Malaysia have a capacity of approximately 180,000 tons per year, making them among the smallest in the world. The other mills too, are mini-mills by world standard. On the other hand, the foreign partners to these local mills are not other similar mini-mills, but are among the largest in the world, e.g. Nippon Steel Corporation of Japan, and Kloeckner Industrie Anlagen GMBH of Germany. The designing and setting up of Malaysian iron and steel mills were invariably done by these highly developed firms, which of course had to modify their technology. P.L. Chee & P.P. Lee (1979) reported that

considerable technical innovations were made by Yamata Steel Corporation (later become Nippon Steel Corporation, or NSC) in designing and installing the blast furnace of Malayawata Steel Bhd. The use of charcoal-fuel for the blast furnace and the small size of the furnace were matters new to the Japanese partners too.

The Perwaja direct reduction plant in Trengganu was the first that NSC built outside Japan, and in fact the only one it had in Japan was more of an experimental one. Certain technical problems (e.g. the shaft furnace) were still in the process of being overcome and modifications to the original design were already being made right in the first year of operation. However, these modifications were less significant in enhancing the technical absorptive capacity of the local economy because they were carried out by expatriates. They were made in the early operational stage and were not continuous.

However, continuous modifications to the machinery are necessary from time to time to adjust the machinery to changing needs or improve it for higher efficiency and profitability. But the degree of such on-going modifications depends on the technical ability of the firms and especially the level of technology mastered. In our survey, all firms were found to have made modifications to their production systems. But these were mainly minor modifications to the machinery or production system, and not to the basic production process.

Apart from making adjustments to enable production to operate as scheduled, there were also modifications to improve the system. For example, a firm reported changing the calibration to increase its capacity. There were also reports of improving the finished goods conveyor system. A far more significant one was that a mill modified and consequently increased the capacity of its reheating furnace from 16 tons to 36 tons. In all of these modifications, local workers were actively involved, as the extent of modification (fairly minor) did not warrant importing expensive expatriates. In general, we conclude that these modifications of technology are fairly minor. Nonetheless, to the extent that local workers could manage the necessary modifications and improvements without foreign help, a clear case of sufficient TT has been established. The local workforce has acquired sufficient foreign technology to maintain production and improve it. Viewed from a more demanding level, however, we could also argue that TT has not been satisfactory as we could still not carry out comprehensive adaptation of technology to suit local environment (especially producing most economically in a small market).

VI. DIFFUSION OF TECHNOLOGY

Since a great part of technology is embodied in the skills and experiences of workers, the movement of these workers represents an important channel through which foreign technology acquired by a few could be spread to other units of the local economy (D. Germidis, 1977). The extent of diffusion again, depends on several factors, chief of which is the presence of other units requiring similar specific skills.

In this aspect the technology for iron making and steel making is very specific and there are not many similar mills in Malaysia. Thus diffusion of specific iron and steel technology is limited to a handful of mills and a small number of large foundries. On the other hand, other technical skills like factory management, marketing and corporate finance have wider markets and thus are more easily diffused. In fact, Pavitt (1971) remarked that the "most critical contribution by foreign firms in less developed countries is likely to be through the transfer of 'soft-ware' technologies, i.e skills related to management, accounting, supervision and quality control".

The first integrated iron and steel mill started production in 1967 and it represented a milestone in the industrialization programme of the country, considering that the industrial base and technological infrastructure of Malaysia were then hardly developed, and the iron and steel mill was a heavy industry and a fully integrated one.

Considering the fact that the interval between the commencement of the first two iron and steel mills was 10 years, workers of the oldest mill would have accumulated much skill and experience by the time subsequent mills were built. The diffusion of technology from this established firm was thus significant and beneficial at the intra-industry level. A senior official of the firm estimated that more than 50 experienced and skilled engineers and supervisors had resigned and joined other iron and steel mills. In fact other mills admitted to recruiting experienced workers from this firm, especially during their initial setting up and operation. One firm revealed that it recruited 10 executives, 11 supervisors and 16 graded staff from other iron and steel mills. An even larger number of experienced workers left to join other iron and steel related, as well as unrelated enterprises. As there were not many very large and foreign managed firms in the 1960's, skills like factory management, marketing, distribution and corporate finance which these workers learnt in this firm would have been very useful to other firms. Substantial though such diffusion may be, it is very difficult to quantify.

Such diffusion process was much slowed down at the time this study was conducted. Prolonged recession slowed down economic activity and deterred firms from expansion and recruitment of new workers. Tight job

market and growing unemployment discouraged resignation and movement of workers to other firms. This has resulted in less diffusion of technology.

Hirschman (1958) explains that any industrial production will provide a need for local industrial inputs which would be supplied by other firms (backward linkage) and its output may generate other industries using it as an input (forward linkage). In fact, the first iron and steel mill in Malaysia was established to create backward as well as forward linkages "in view of the increased demand for imported construction steel bars, the availability of local iron ore and the possibility of processing waste rubber wood into charcoal. Thus we could say that the linkages were the major factors that gave birth to the iron and steel industry in Malaysia. In its first decade of operation, Malayawata relied mainly on a high grade haematite iron ore, limestone and charcoal (from rubber wood) all obtained from the northern states of Malaya.

TABLE 4
LOCAL CONTENT OF INPUTS

Types of Input	No. of firms	Percentage of Local Content
1. ores*	2	0 - 88
2. fuel	5	85 - 100
3. scraps*	2	30 - 100
4. machinery	5	0 - 25
5. parts	5	0 - 60
6. billets	4	20 - 100

* only 2 firms smelt iron from ores.

** only 3 firms used scraps to make steel.

Source: Own survey

While backward linkage was very substantial more than a decade ago, it was no longer so when this study was made, as evident from Table 4 above. Local ore supplies were depleting and quality ore had deteriorated. Charcoal too began to be imported as rubber wood has several more valuable alternative uses (e.g. furniture). Other major fuels of electricity and gas were 100% local and the direct reduction mill was in fact set up to utilize the local natural gas. The local content of scraps varied from firm to firm. Surprisingly, the newest firm used more of foreign scraps, which another firm alleged to be more expensive than local scraps. Nevertheless, it has to be admitted that local scraps cannot meet the combined demands of all three firms. In the long run however, the consumption and import of scrap will decrease as local firms would have to buy local HBI (which will replace large quantity of scraps) and local billets (from another Government owned mill).

As shown in the same table, the local content of machinery is inevitably low as the local market is too small to support the iron and steel machinery industry and the technical capacity to produce such machinery is not sufficient. There was only one local firm, built without much foreign assistance, that tried to use as much local machinery and equipment as possible. Its director estimated that about a quarter of the machinery requirement was procured locally, with much cost savings.

The local content for parts and components are not high either, as shown in Table 4. Most of the specialised parts are not produced locally. However, wherever local parts of comparable quality are available, most firms would use them as they represent a cost saving.

Until a year or two ago, all billets were imported except for two firms that produced part of their own requirements. But one mill was set up recently to reduce this foreign dependency. It is envisaged that soon demands for billets could be satisfied with by production.

Backward linkage with local iron foundries is not prevalent and is unorganised. This situation is different from that of Japan where sub-contracting by iron foundries is common. This is perhaps due to the lack of scale economies. The Malaysian iron and steel industry is not large enough to support specialised sub-contracting. Since such jobs are not common, the technical capability of sub-contractors could not be raised, and thus remains low. The low technical level in turn discourages the iron and steel mills from utilising the sub-contractors' services. The two therefore work in a vicious cycle. Much assistance and attention from the mills were required to overcome this problem. A technical director related an experience with a local iron foundry, which was given the job of constructing 400 kg furnace doors. It was with much help from the mill that the doors were finally delivered.

As not much of the outputs are exported, the iron and steel industry actually generates a lot of forward linkage, i.e. its outputs are used by other industries (especially construction industry) as inputs. Steel rods and bars, the major output, are extensively used in the construction of buildings, roads, bridges and ports. Other outputs are further processed by smaller mills into wire mesh, nails, fencing and other products for industrial uses. The establishment of these iron and steel mills has substituted the importation of such goods and hence help to save on foreign exchange. But in terms of technological assistance and diffusion of technology through such linkages, the effects are found to be negligible. There does not seem to be much direct contact between these users and the mills. Most outputs are sold in bulk to wholesalers like hardware firms or construction materials firms. Without direct contacts, the users do not normally approach these mills to solve their technical problems in using the outputs, or to improve the use

of the outputs. Big construction firms on the other hand have their own engineering consultants.

The iron and steel industry which is meant to spearhead industrialization in Malaysia, to substitute imports and to utilise local inputs, should actually have significant linkages with the other units of the local economy. It is hard to deny that it has produced much intermediate goods necessary for industrialization, especially infrastructural facilities, and it is a major consumer of local energy and metallic materials (iron ores and scraps). Its role to diffuse technology, which is another role expected from it, has not been widespread.

VII. CONCLUSION

The iron and steel industry was among the first heavy industries to be set up in Malaysia soon after its independence. Considering its long history and the nation's industrial infrastructure when it first started, it cannot be denied that the industry has not only grown steadily but had also assisted in the industrial development of the country.

Our study has explored the channels of TT in the industry and found that it relied mainly on overseas training for workers to obtain foreign technology. This channel is even more useful as the labour mobility rate was fairly high among iron and steel workers. Hence the benefits of overseas training has been diffused into other firms. The presence of ex-workers of the oldest mill in all other mills is a clear evidence of such diffusion.

As all the firms in our study had foreign equity, foreign partners also represented another important source of TT. Not all partners however, were active in TT. Thus firms (older ones) without active foreign partners had to seek other channels of transfer such as public information. For most firms, assistance from equipment suppliers was an important channel too. The human elements in handling sophisticated machinery are themselves major effects of TT. This is perhaps why some firms regarded investment in new equipment and mills as one way to upgrade their technology.

As the industry experiences constant technical innovation, and the Malaysian market remains too small to support in-depth indigenous research and development, it will continue to rely on foreign technology. Nevertheless, the local mills were satisfied with the level of technology they had achieved, and confident of mastering their main process technology in time to come. One firm in fact believed that it had achieved complete TT and could offer consultancy services to others. However, what it could offer probably could hardly be above the level which is being currently practised in its own mill.

Furthermore, even though the industry has fairly widespread backward and forward linkages, its role in diffusing technology to other economic units in the economy is not significant.

As a source of industrial growth, the Malaysian iron and steel industry has contributed in no small measure to the economy. But as a dynamic source of diffusion of technology, it has not lived up to expectations.

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