Problems in Technology Transfer *vs.* Potential for Technology Exchange: A Hong Kong Construction Perspective

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Abstract

Technology transfer has long been advocated for rapidly transferring essential core 'knowledge' and skills from one country/region/firm to another, in order to facilitate longer-term development. But the successful transfer of construction technology has been restricted by various barriers as summarized in this paper. A common problem is that different parties involved will not be equally motivated to divert resources to 'transfer technologies', if only one party is perceived to benefit from such transfers. However, a broader conceptualisation of technology, for example to include 'local knowledge' could convince other parties of mutual benefits to be derived through an'exchange' of technologies. A review of international literature was followed by interviews with a cross-section of practitioners in Hong Kong to explore the foregoing problem and proposed solution. This paper focuses on the importance of such 'technology exchange' in the construction industry, as elicited from the literature and from interviews with practitioners involved in some of the Joint Ventures that have proliferated in Hong Kong. The need is identified for facilitation of technology exchange through appropriate policies and incentives at macro (governmental), meso (organisational) and micro (project) levels. The identified scope and advantages of technology exchange for the development of construction industries and organisations in the longer term show how such strategies could lead to more rewarding outcomes for all concerned.

***Keywords**: Construction Industry Development, Construction Technology, Technology Exchange, Technology Transfer.*

INTRODUCTION

The construction industry has been considered as one of the top contributing sectors to the economy (World Bank, 1984). It consumes a major share of the public investment, contributes significantly to GDP, and provides employment to a large proportion of the labour force. The construction industry is a major economic contributor to the economic development of any country and an essential contributor to the process of development. It provides the means to convert financial investments into physical assets like roads, buildings or other infrastructure.

The construction industry's major role in economic development is illustrated in a study - The Construction Industry in Developing Countries - prepared by the Technology Adaptation Program, Massachusetts Institute of Technology and as cited by Abbot (1985). It states "The construction industry plays a major role in economic development in the less industrialised nations since it constitutes a significant portion of both gross national product and of employment. Indeed, the creation of physical facilities constitutes more than one half of the gross domestic investment of both developed and developing nations. The construction industry also plays a key role in satisfying a wide range of physical, economic and social needs and contributes significantly to the fulfilment of various major national goals. The industry's size, the nature of

its operation, and its presence in every developmental activity make it an attractive area for the transfer, adaptation, and development of technologies consistent with the developmental goals of emerging nations."

Despite the importance of construction industry and its need for development, there are many weaknesses and failures. Ofori (1994b) emphasizes the weaknesses and changes in direction of practice for construction industry development and performance improvement. The failure of efforts in construction industry development stem from weaknesses in relevant industry policies, the lack of research on these subjects as limited application of better policies and useful research results, and also the difficulties relating to and / or mistakes in, such application. Drastic changes in direction in the pursuit of construction industry development appear to be required. Research on construction industry development and the effort to implement its findings both have the broad aim of solving the problems facing the construction industries of developing countries, thus improving their performance (Ofori, 1994b).

The increasing demand for enhanced productivity, quality levels, value for money and client satisfaction are constrained by the growing complexity of large and multidisciplinary management teams, multi-dimensional projects and multiple objectives. Industry practitioners are actively seeking new ways of doing business to increase the productivity of the industry. Some common barriers that retard such growth in construction industries are the highly fragmented nature of the industry and the practitioners' reluctance to discard their trust in tried and tested organisational structures, relationships, methods and technologies.

The rapid transfer of technology and the consequentially elevated overall technology levels are two of the key factors that can catalyze a much faster (as opposed to slow or even stop-start) development of the construction industry and thus the economy. Technology, capital, labor and land are inextricably linked with national productivity and competitive growth of enterprises (Asian Development Bank, 1995). Technology, as the engine of economic growth, has been recognised as one of the major driving forces behind industrial progress, structural change, national productivity and development; enabling countries to increase their competitiveness (Asian Development Bank, 1995). Technology is critical to construction sector, which has been shown to be a significant contributor to the national economy as well as to the employment of a large section of the labour force. But the levels of technology development and deployment in different countries, societies and organisations are different partly due to differences in the degrees of economic development. Despite several efforts of developing countries to reap benefits from technologies transferred from developed countries, such endeavors have not met with desired success.

The present study is designed to analyze the problems in technology transfer vs. potential for the technology exchange in construction joint ventures from the perspective of the Hong Kong construction industry. In this connection interviews were conducted with a cross section of professionals involved with construction joint ventures in Hong Kong. Also, a questionnaire was sent to these and other professionals to request their responses through mail or fax.

The findings are analysed on the basis of responses received at interviews and to the questionnaire survey. This is followed by a discussion on the identified barriers to technology transfer. The importance of technology exchange and benefits to stakeholders in construction joint ventures in Hong Kong are focused upon. The challenges that are faced by the construction industry of Hong Kong with respect to technology transfer and the potential for technology exchange are thus examined in particular.

TECHNOLOGY TRANSFER

Transfer of technology is subject to different interpretations. Abbot (1985) defines technology transfer as "the movement of the science from one group to another, such movement involving its use". Simkoko (1989) argued that the definition was inadequate for construction projects. The definition conveyed the message that once the foreign firm made the effort of delivering the technology, the transfer process was complete. The ability of the local firm to absorb the knowledge transferred was ignored. He modified the definition as the planned conveyance and acquisition of technical knowledge and techniques. This implies that there is no true technology transfer until the technical knowledge received from the donor has been put

into effective use. It involves a two way process and can succeed only when both the donor and the recipient work together in deciding what needs to be transferred and together implement a well organized transfer of technology program to achieve the objectives of the program (Sridharan, 1994).

Construction technology may be transferred through joint ventures between foreign and local companies, which may either be project specific or of a longer-term nature (Ofori, 1994a). Technology may be transferred between persons, between parts of organisations, from a research center or educational institution to industry and between countries. As cited by Ofori (1994a): UNCTAD (in 1990) and Andrews (in 1992) suggest that effective transfer occurs when technology is requested, transmitted, received, understood, applied, diffused widely and improved. The joint venture appears the most widely preferred vehicle of construction technology transfer. The World Bank favours it, but prefers voluntary arrangements to mandatory ones specified by some countries as a condition to the award of major contracts (Cox, 1982).

The Hong Kong government has recently indicated its increased concern for construction industry development and technology transfer. The Works Bureau has defined the job responsibilities of two key officials as given below:

1. Secretary General (Construction Industry Review Committee) responsible to Head of the Construction Industry Review Committee (CIRC) Secretariat - which has been mandated to prepare far-reaching recommendations by end 2000 to develop the industry after overcoming current problems.

2. Chief Assistant Secretary (Professional Services) / Professional Services Unit responsible for Construction Advisory Board, Technology transfer, research and development of construction industry, construction industry resources, facilitating the collaboration and contact with the construction industry in other places including the Mainland.

This reflects the concern of the Works Bureau of Hong Kong for the transfer of technology and construction industry development. (http://www.wb.gov.hk/).

Technology transfer (TT) has long been advocated for transferring essential core ‘knowledge’ and skills from one country/region/firm to another, in order to facilitate longer-term development. But the process of technology transfer has its own complications and restrictions. Furthermore, it has been complicated by the fact that the transfer of technology from one country/firm to another encounters various barriers and restrictions. For example the fragmented nature of the construction industry and the unique production requirements of each new project restrict replication and extended usage of any construction technology that may have been transferred in one project.

FROM TECHNOLOGY TRANSFER TO TECHNOLOGY EXCHANGE

Despite many explicit and implicit commitments to technology transfer that may accompany foreign investments, many pitfalls are often encountered by both transferor and transferee. The instances of real and sustained transfers of technology are few in general (Kumaraswamy, 1995). Kumaraswamy (1994) has pioneered the idea of technology exchange in construction by formulating a concept of mutually beneficial technology exchange to overcome many barriers to technology transfer. A new paradigm of ‘technology exchange’ based on the complementarity of the strengths and weaknesses of organisations in terms of different components of technology was proposed by Kumaraswamy (1994). This model visualized a two-way flow, rather than elusive uni-directional transfers envisaged in the previous paradigm of technology transfer. The need for such exchanges of different components of technology is exemplified by the need for foreign partners with a technical know-how component (and possibly healthy financial resources), to have local partners with easy access to local skills, materials and markets (Kumaraswamy, 1995). He further adds that a conceptualization of technology exchange (TE) between organisations is more mutually attractive and realistic than unidirectional technology transfers, given that each organisation usually has much to gain from each other. Whilst a joint venture provides a useful framework within which to formulate such exchanges, the right choice of joint venture partners is crucial in achieving the desired synergy.

Figure 1 illustrates the broader conceptualisation of technology content, as well as the corresponding projection of the technology profile of a given organisation..

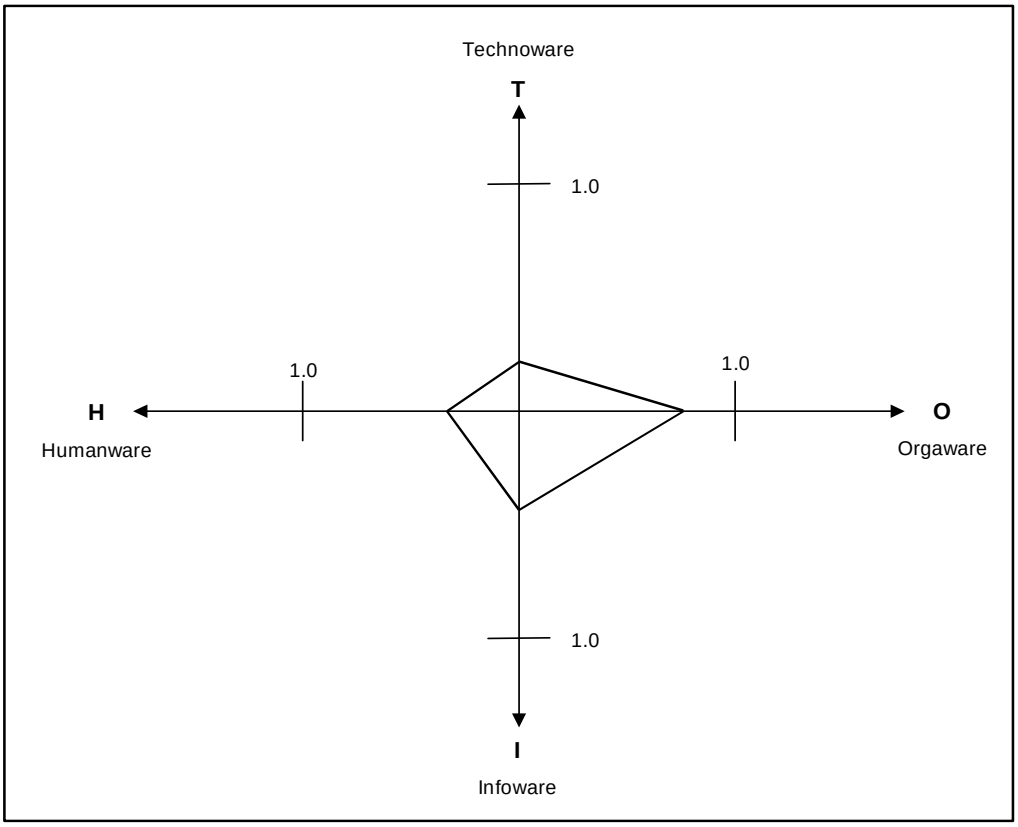

Figure 1: The APCTT model for evaluating and projecting technology profile of an organisation
(Kumaraswamy, 1995)

Figure 2 indicates an appraisal of the synergistic potential through the technology profiles of two organisations (Kumaraswamy, 1995). Figure 2 is self-explanatory in that when two organisations undertake technology exchange, the synergistic combined profile of technology capacity is not merely limited to an additive profile

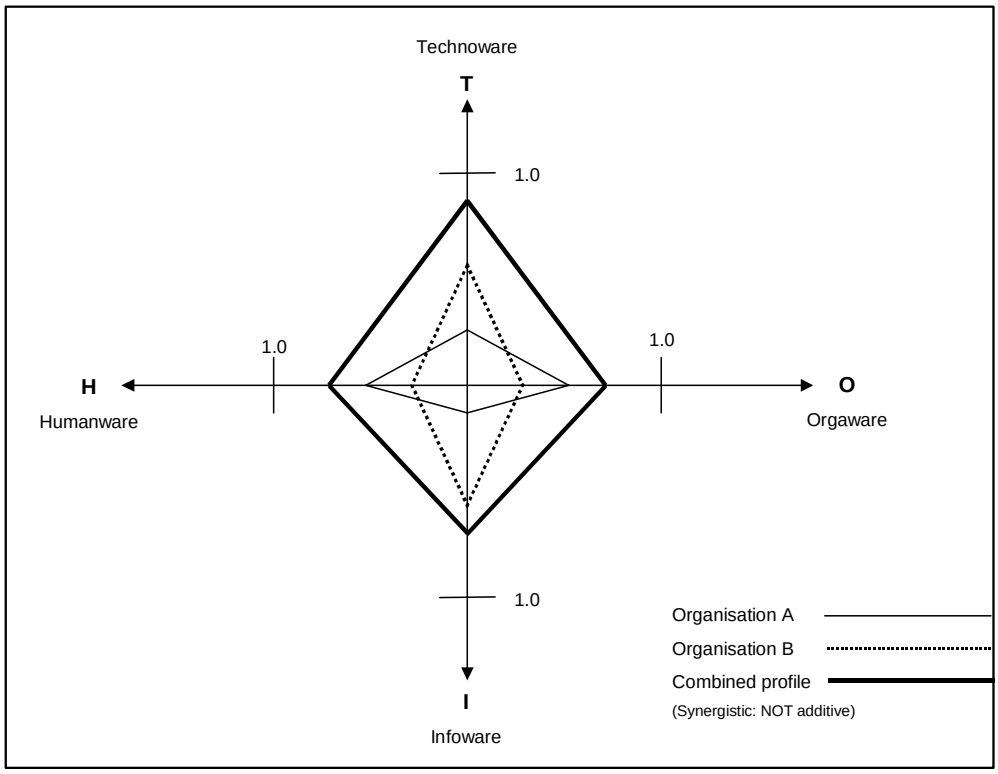

Figure 2: Appraising synergistic potential through the technology profiles of two organisations (Kumaraswamy, 1995)

An illustrative example of technology exchange and mutual benefit through dissemination can be cited from the work experience of one of the authors as below:

Nepal has been receiving assistance from the Swiss government through its development assistance wing HELVETAS, in the field of suspension bridge construction for the last 30 years or more. It has built more than 300 bridges and the programme is still ongoing. Swiss professionals brought in modern Swiss technology, whereas Nepal had made many bridges with shorter spans in the past using just the local technology and materials but with bigger and heavy anchor blocks due to the lack of cement and other modern materials. In due course efforts were made to blend Nepalese traditional technology with modern Swiss technology by using materials in different proportions. The bridge construction cost has been reduced by nearly 30-40% by using this new hybrid technology (especially with respect to the use and mix of material). Previously anchorage blocks were cast using cement, sand, gravel and reinforcement bars. Later on after blending of traditional Nepalese technology and modern Swiss technology, use of boulders was introduced. This helped to achieve a drastic reduction in the use of costly materials like cement, sand and gravel and lower requirement of labour input for the same quantity of work. After the new technique was tried, tested and used safely in Nepal for some time, the same technology was transferred back to Switzerland and then re-transferred to many other countries where HELVETAS has been involved. This example shows the benefits achievable through mutual technology transfer/exchange and dissemination to other parts of world, irrespective of whether originating from a developed or developing countries (based on experience of Shrestha in Suspension Bridge Division, Ministry of Local Development / Ministry of Works and Transport, Nepal, 1987-1992).

The transfer of technology from its place of origin to the end users takes place in various ways, which can be classified as direct use of technology, use of technology with modification, and the reverse use of technology.

The example of ‘reverse’ technology transfers and technology exchange is seen in cases where certain labour intensive technologies, which have been refined through necessity in less developed countries are sometimes found to be useful for some scenarios in developed countries. These technologies/technology

components may then be adapted and adopted, by an organisation from developed country in another scenario/country after the experience gained in a 'technology exchange' mode, for example in joint venture on one project in a developing country.

IDENTIFYING BARRIERS TO SUCCESSFUL TRANSFER OF CONSTRUCTION TECHNOLOGY

As cited by Ofori (1994a), "Construction technology transfer is widely supported by public sector clients in developing countries and leading agencies, but appears more problematic than transfer in other sectors".

Technology transfer has been advocated as a catalyst of the change or improvement required in many construction industries, however it has been restricted by various barriers to the free transfer of technology from one country or region or firm to another. In this connection a survey was conducted by issuing a questionnaire and interviewing a cross-section of professionals in the Hong Kong construction industry (a) to understand the current practices of technology transfer, (b) to identify barriers to technology transfers and (c) to examine the gaps between expected and achieved transfers. The main barriers to technology transfers for example, lack of: clear policy, clear agreements and clear procedures; language, national /ethnic and cultural differences, organisational culture barriers, lack of time, lack of funding provisions, limited capacities of individuals (e.g. training skills) and attitudes of individuals were included in the survey questionnaires and interviews.

OBJECTIVES AND DATA COLLECTION

Objectives

The major objectives of the overall study are to identify ways to improve (a) mutual benefits and (b) 'technology transfers' between companies who form joint ventures to handle construction projects, particularly in Hong Kong.

Data collection

The initial literature review revealed a background as summarized in the introduction above. Interviews and the questionnaires were used for the collection of more information aimed to meet the research objectives. The questionnaires were designed to identify the ways to improve mutual benefits and technology transfer between companies who form joint ventures particularly in Hong Kong. A sample including over 200 professionals from various construction companies were selected for the survey. Questionnaires were either mailed or faxed with requests for their return through self-addressed envelopes or by fax. A total of 36 responses were received up to the time of writing this paper. The response rate of 18% is quite reasonable compared to other surveys of Hong Kong construction companies. All the respondents are professionals from the Hong Kong construction industry with significant years of experience in construction, and management of construction companies.

Findings from the survey and data analyses

A research survey was initially conducted to identify ways to improve mutual benefits and 'technology transfers' between companies who form joint ventures to handle construction projects, particularly in Hong Kong; using a broad view of technology including technical aspects, organisational, information and associated systems and general 'know how'. Some important findings from this survey are tabulated and analysed for discussion as follows.

Subjective assessments were invited to identify the main barriers to technology transfer in joint venture construction. Due to the intangible nature of most of scenario, it is difficult to quantify such outcomes. So, a

4-point scale is adopted. The respondents were asked to rate these outcomes on the 4 point scale from 'strongly agree' = 1, to 'strongly disagree' = 4. This quantification was thus designed for convenient consolidation by assigning strongly agree to be equivalent to 1, and strongly disagree to be equivalent to 4; with 'agree' being 2 and 'disagree' being 3.

Barriers to technology transfer

Table 1 summarizes the percentage of respondents who choose each rating (i.e. strongly agree, agree, disagree, strongly disagree) as well as grouped ratings (i.e. with 'strongly agree and agree' grouped together; and 'disagree and strongly disagree' grouped separately).

Table 1: Barriers to technology transfer in joint venture construction companies in Hong Kong – Survey 2000.

Particulars	% SA/A	% D/SD	% SA	% A	% D	% SD
Organisational culture barriers	92	8	25	67	8	0
Lack of time	92	8	25	67	8	0
Capacities of individuals (e.g. Training skills)	75	25	25	50	25	0
Attitudes of individuals (e.g. Reluctance)	75	25	17	58	25	0
Lack of clear policy	67	33	25	42	33	0
National /ethnic culture differences	58	42	8	50	42	0
Lack of clear agreements	58	42	0	58	42	0
Lack of clear procedures	58	42	0	58	42	0
Lack of funding provisions	50	50	17	33	50	0
Language barriers	42	58	8	34	58	0

Notes: SA= Strongly agree, A=Agree, D= Disagree, SD= Strongly disagree, SA/A = (Strongly agree + Agree), D / SD = (Disagree + Strongly disagree)

From Table 1, it can be seen that among the stated barriers to technology transfer, organisational culture barriers (92%) and lack of time (92%) both come together as the uppermost/ highest barriers. Similarly, the relative strengths of the other barriers - capacities of individuals (75%), attitudes of individuals (75%), lack of clear policy (67%), national /ethnic culture differences (58%), lack of clear agreements (58%), lack of clear procedures (58%), lack of funding provisions (50%), and language barriers (42%) – provide an indicative profile of the series of barriers encountered.

It is seen that among the various barriers to technology transfer, the respondents agreed that organisational culture barriers, lack of time, capacities & attitudes of the individuals and lack of clear policy are the major barriers to technology transfer in joint venture construction companies. In addition the 'lack of funding' provisions drew equal responses in terms of agreements and disagreements (on its significance), which reveal that the surveyed sample of the construction industry in Hong Kong had equally divided opinions on the role of funding. This may indicate the less important role of funding in this context in Hong Kong construction companies. Similarly language was only considered as a barrier by 42% of the respondents i.e. with 58% of respondents disagreeing on its significance.

An open question on how to overcome these barriers to technology transfer was answered with various opinions like transparent partnership and frank communication, need of commitment from partners, more communications, encouragement and explanations of benefits to staff, greater commitment, more open and positive attitudes. However, approximately 33% of respondents did not answer this part.

Technology transfer needs and expectations

Some questions concerning the need for technology transfer, expectation of benefits from JV, whether expectation to gain from TT did/ didn't change, was TT usually achieved through JV? etc. were raised to get the views of the experts on these fundamental aspects.

Table 2: Technology transfer needs, expectations, and effectiveness in joint venture construction companies in Hong Kong – Survey 2000.

Particulars	% SA/A	% D/SD	% SA	% A	% D	% SD
Need for Technology Transfer	83	17	0	83	17	0
Expectation of benefits from JV	50	50	8	42	50	0
Expectation to gain from TT did not change	67	33	8	59	33	0
There is measurable evidence of TT	67	33	8	59	33	0
TT is usually achieved through JV	58	42	8	50	42	0

Notes: SA = Strongly agree, A =Agree, D = Disagree, SD = Strongly disagree, SA/A = (Strongly agree + Agree), D / SD = (Disagree + Strongly disagree)

According to the responses of professionals as tabulated in Table 2, 83% of the respondents see the need to technology transfer, and only 17% did not see the need of TT. There were equal views of 50% each on expecting benefits from the joint ventures and those not expecting such benefits. Similarly those who expected to gain and not to gain from TT are 67% and 33% respectively.

Also the respondents were asked to rate the measurable evidence of TT being achieved. Among the respondents, 67% believed that there is measurable evidence of TT. When another question was asked on whether they evaluate the effectiveness of technology transfer according to their own criteria, 67% replied negatively. In response to another question 58% of the respondents thought that Technology Transfer is usually achieved through JVs.

Benefits from joint ventures and technology transfers

Various issues were raised to identify the benefits of joint ventures and technology transfer. Professionals were interviewed or questions were raised in the questionnaire to explore whether their companies have expansion programme in developing and /or developed countries, and to find out how they benefit from the JVs in construction and the subsequent technology transfer. In response 75% of the companies indicated the benefits from JVs & their expansion programme in developing countries to be significant. Similarly, of those who answered the question on having expansion programmes in developed countries (only 92% of the total respondents) 59 % confirmed perceived benefits compared to 25% who did not see such benefits. Hence, it is again significant that more than double of the respondents confirmed the benefits.

Table 3: Necessity of effective technology transfer and benefits in joint venture construction companies in Hong Kong – Survey 2000.

Particulars	% SA/A	% D/SD	% SA	% A	% D	% SD
Development of company	75	25	25	50	25	0
Competitive advantage	92	8	33	59	8	0
Increase efficiency	92	8	25	67	8	0
Company absorbs (or conveys) sustainable benefits from training	83	17	25	58	17	0
Active pursuit of technology exchange	100	0	25	75	0	0

Notes: SA = Strongly agree, A = Agree, D = Disagree, SD = Strongly disagree, SA/A = (Strongly agree + Agree), D / SD = (Disagree + Strongly disagree)

As shown in Table 3, questions raised on the necessity of technology transfer revealed that 92% of the respondents hold the idea that technology transfer is important for their competitive advantage and increasing the efficiency of the company, whereas 75% of the respondents hold the opinion that it is necessary for the development of the company.

Also 83% of the respondents believed that their companies absorb or convey sustainable benefits from training, whereas 100% of the respondents were confident that the active pursuit of 'Technology Exchange' is beneficial. This was admittedly attractive, being presented as a re-conceptualisation of technology flows (based on a broad/ holistic definition of technology) that promised mutual benefits in a win-win scenario.

CONCLUSIONS AND RECOMMENDATIONS

The analysis of research survey 2000 clearly illustrates that among various barriers to technology transfer; organisational culture barriers, lack of time, capacities of individuals, attitudes of the individuals, and lack of clear policy are the major barriers to technology transfer in joint venture construction companies.

This survey also reveals that joint ventures and technology transfers have strong linkages to benefits that may accrue to construction companies and ultimately towards construction industry development. The majority of the respondents expressed the view that these will be beneficial for increasing the efficiency and competitive advantage of the company. According to the respondents, sustainable benefits were achievable by absorbing or conveying TT from training, and it is necessary for the development of the company.

The most interesting point of this survey is that all respondents were in full agreement that active pursuit of two-way technology is beneficial for construction industry development. This is more striking in that the Hong Kong Government is quite keen on this issue of technology transfer. The Works Bureau of Hong Kong has made a special provision for looking after technology transfer, research and development as one of the major and separate task of two of their senior officials – Secretary General (Construction Industry Review Committee) and Chief Assistant Secretary of Professional Services. All respondents to this survey, whether from the private sector or the government were thus found to be equally concerned. This shows that Hong Kong has already appreciated the requirement to facilitate technology transfer/exchange for the development of the construction industry, which may be termed as a recent development. This is especially important in that technology exchange through joint ventures has the potential to increase efficiency and the competitive advantage of the company, and also of the industry, so that it can lower the construction cost in Hong Kong.

According to the respondents, 'Technology Exchange' has the potential to release more benefits, for example to joint venture partners by developing their construction companies and ultimately the construction industry through technology exchange rather than technology transfer. Joint venture construction can provide a fertile ground for improved performance, successful technology exchange and hence the anticipated enhanced benefits. As the respondents have confirmed their expansion programme in developed and developing countries, which can benefit the construction companies and construction industry of Hong Kong and their partners, if technology transfer/exchange can be adopted as conceptualised by Kumaraswamy (1995) and experienced by Shrestha from the work experience from Nepal. But the research carried out till now does not seem sufficient to provide concrete guidelines. As seen from the above results, effective evaluation of the technology gains have not been used by the professionals due to the lack of such evaluation guidelines. These are needed so that the professionals and the industry can benefit by using standard and simple guidelines for the evaluation of the technology that they are using or intend to acquire for further industry improvement.

Further research in this area is vital to fulfil the gap already realised by the government, academics and the surveyed population (professionals) in private and public construction organisations. Future research should be able to direct the industry by providing firm guidelines or a knowledge-based advisory (expert) system to facilitate benefits from two-way transfers of technology i.e. technology exchange. Hence continued research in this area is urgent and important for the construction industry of Hong Kong - in improving its

performance, increasing competitive advantage, cutting costs, gaining more profits and contributing a higher share of earnings through this sector. It may be a matter of pride for Hong Kong to demonstrate a leading role in technology exchange, improved joint venture performance and construction industry development, to attain an even higher level of development within the reach of Hong Kong. But this need more coordinated and focused research, development and implementation. This is possible through the development of stronger linkages between academia, industry and the government especially in the area of technology evaluation and exchange, improved joint venture performance and construction industry development. Rewarding outcomes and a promising future for all concerned is possible through the adoption of appropriate policies and incentives.

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