# Innovation in Technology Transfer: Host-Oriented Strategic R&D Alliance[1]

by

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**Abstract**

This paper examines a major technology transfer project in Iran that represents a departure from historical practice and may constitute a new model for technology transfer. The project involves an alliance between Iranian and German enterprises with the objective of developing and commercializing a CNG (Compressed Natural Gas) based engine for Iran. The aim of this paper is to demonstrate the central role of knowledge and competence creation through R&D alliance. It is argued that this model, which we call `host-oriented' alliance, assuming highly competent management, provides an important technique for the technological catching-up process in which many developing countries are currently engaged.

JEL classification codes: F02, 014, 033

**Key Words**: Technology Transfer, Engine Technology, Knowledge Creation, Host-Oriented Alliance, Agile Manufacturing

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[1] We would like to thank Professor Steinmueller, of SPRU, for his feedback on an earlier draft of this paper. Usual disclaimers apply.

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## 1. INTRODUCTION

Cross border technology transfer typically involves capital goods acquisition, knowledge/competence creation and commercialization of a new product in a host country. There are a number of ways in which international technology transfer takes place, both formal and informal. Among the former we can distinguish between contractual (direct) and equity modes (indirect). Contractual modes include licensing, franchise, turnkey and technical/management service contracts. Indirect ways typically involve wholly-owned or controlled foreign direct investment (FDI) by a transnational Corporation (TNC) or a joint venture between a TNC and a domestic firm (Shamsavari, et al. 2002). Informal routes include technology transfer through migration of skilled workers and reverse engineering (Shamsavari 2007). Each of these routes has its distinctive advantages and disadvantages. Some are suitable in certain sectors (e.g. franchise in the retail sector) and others seem to be preferred modes in other sectors (e.g. license and FDI in high technology areas). FDI represents a major channel in branded goods where the combined effects of highly protected intellectual property rights (IPR) and economies of scale create formidable barriers to entry thus leading to the formation of oligopolistic markets where large TNCs dominate. Both the role of FDI in technology transfer and the cost of TNC operations in less developed countries (LDCs) have been controversial subjects for a long time. Over the last two to three decades, the attitude towards FDI as a vehicle of technology transfer and TNC as an instrument of economic development has become much more favorable for a number of reasons. In the past technology transfer by TNCs was considered too expensive for LDCs and also thought to involve transfer of inappropriate technologies. We will discuss this issue in Section 2 below.

This paper reports on a new technology transfer process that represents a departure from traditional transfer models. This project also sheds some light on hitherto neglected aspects of technology transfer. We will first consider the country (Iran) and the sector (Motor Vehicle) and the main features of the project. Later in the paper, we will discuss the theoretical and historical context before attempting a general, critical overview.

In recent years, Iran, as a developing country, has launched many technology transfer projects in order to bridge technology gaps in particular industries upgrading them to international standards. Vehicle industry activities in Iran have been at the frontier of such efforts and perhaps have had the most success in comparison with other sectors.

In the past the state has strongly supported domestic car manufacturing with enacting high import tariffs leading to a heavily protected market for domestic car companies. The absence of competition has not only resulted in consumer welfare loss but also led to falling technical standards in domestic companies, potential loss of export markets and reduction in the creation of new knowledge diffused from universities and research institutes.

In the light of these circumstances, the state has lately played a dominant role in shaping the nature of competition and has recently established an open door policy to encourage domestic automobile companies to improve their overall performance and develop new products and processes[4]. Furthermore, the state has provided some incentives for specific

[4] This policy seems necessary if these companies are to survive, particularly when Iran becomes a member of World Trade Organisation (WTO).

companies which are seeking to develop new products in accordance with government fuel consumption policies, such as those based upon Compressed Natural Gas (CNG).

Several technology transfer projects have already been established in vehicle industry in the world and also in Iran. In this article one of the most recent technology transfer projects in which many organizations including several domestic companies are involved, is described. We will analyze features of the technology transfer process including capital equipment, market development and localized knowledge creation, which are some of most important issues influencing innovation diffusion and the emergence of new products in the market.

Before embarking on a review of the project, we would like to discuss the question of appropriate technology so far as it is relevant to the subject of this paper.

## 2. APPROPRIATE TECHNOLOGY ISSUE

Appropriate/inappropriate embraces three basic interrelated elements including appropriateness in relation to factor endowment of the host country, `right'/`wrong' products (consumption technology), e.g. luxury products as opposed to mass consumption goods (UNCTAD 1975, pp. 271- 274), regional/sectoral impact: e.g. urban versus rural (intermediate technology) (Schumacher 1973, Clark 1985)

Since the debates in 19960s and 70s there is another dimension added to the controversy, i.e. the environmental impact.

We can identify the following elements as some the most important ingredients of an appropriate technology package for an LDC:

1. Technology should be labour-intensive or as far as possible have minimal physical capital requirements.
2. Technology should use available domestic resources rather than imported ones.
3. Natural resources used should be renewable
4. Products should be consumable by the domestic population
5. Technology should be easy to repair and maintain

Now we offer a more developed critique of appropriate-inappropriate dimension of the technology transfer debate.

1. As far as the factor endowment aspect of the debate is concerned one can claim that the experience of TNC in low income countries show that adaptation of developed country technology to low wage economies has not been a problem e.g. American company operations in Mexico as far back as 1950s. If we focus on profit-seeking organisations such as TNCs it is clear that lack of attention to factor endowment issue, e.g. more abundant labour in LDCs will cost these companies dearly if they rely on capital intensive technology. Also historical studies of technology transfer from Britain to the US in 19$^{th}$. Century show that initiating companies, American or British, adapted imported technology to American factor endowment, e.g. greater availability of wood and waterways (rivers) [Rosenberg 1976].
2. Labour-intensive methods are not necessarily appropriate for LDC as they may require hiring expensive, highly skilled supervisory labour power. This point raises issues about the usefulness of factor intensity concept (a standard tool in

economists' toolbox) without further refinements, e.g. differences in types and grades of labour as well as capital.

3. Wrong product concept, apart from representing a `patronising' frame of mind among DC and LDC intellectuals, is misleading for a number of reasons. A luxury or in fact any consumer durable may encourage work in order to earn enough income to buy the product. If the product is also technically sophisticated, e.g. a car, it may add to skills pool in the form of car mechanics.
4. Sectoral impact, rural-urban in particular, is significant in the light of Schumacher's view on technology and society, which one can only admire. The realities of Third World industrialisation show that an initial period of `inappropriate' technology may be necessary before appropriate technology becomes both desirable and possible.
5. The creation and transmission of knowledge: the enthusiasm for appropriate qualities of traditional technology can lead to an idealisation of the latter and ignore the fact that apart from the issue of productivity, there are other skill and knowledge aspects of modern technology that will be lacking in traditional technology. In other words, the issue of appropriate technology is treated statically.
6. The supplying industries are also ignored. If the product of an industry requires inputs from other industries (not easily reducible to factor endowment issue) then it is clear that the question of technology transfer to one sector cannot be easily separated from technology transfer to its supplying industries. It is conceivable that modernisation of technology in one sector may create pressures for upgrading

of technology in supplying industries. (See Shamsavari 2007 for further discussion)

## 3. PROJECT OVERVIEW

Iran-Khodro as the largest car manufacturer in the Middle East has set out to develop new products with new types of engines to suit demand conditions in both domestic and overseas markets. Historically, Iran-Khodro has produced a limited range of product models that are mostly outmoded by contemporary global technology standards in the automobile industry, and it seems unlikely that they will be able to retain their current limited market niche (a part of domestic market) in the future. The future will include many new competitors offering a broad range of products which will enter the market as Iran joins the WTO. To retain its current market share and penetrate other markets, Iran-Khodro must develop new products that others will find difficult to match. The strategy the company has chosen is to develop an engine family with advanced technology to cover a wide range of vehicle platforms. On the other hand, the engine family must also meet contemporary fuel consumption, power and emission standards. In the Iran-Khodro engine project, named EF7, the target was to achieve EU emissions standard, which clearly identifies the maximum allowable limits of pollutants. In addition, CNG (compressed natural gas) is a more clean fuel with less pollution than petrol and it is easier to reach the emission targets using it rather than petrol. Furthermore, in spite of the fact that Iran has several petrol refining plants, there is under-capacity in domestic petrol refining and a huge amount of petrol is imported to fill the domestic demand. In contrast, Iran has plenty of natural gas resources, which potentially can lead to substantial reduction in petrol imports. Therefore, the promotion of CNG based engines is a strategy that is expected to reduce petrol imports, use gas resources and reduce air pollution.

EF7 project was set up in 2004 and was based on R&D collaboration between Iran-Khodro and FEV GmbH, one of the leading German companies in engine design technology in the world. Within the time frame in which EF7 project is developing, local suppliers are going to refit their production lines to accommodate this new type of engine in order to survive the competition from foreign supplier firms which can more easily provide the car maker with required parts and components. Iran-Khodro has had a long term relationship with these domestic suppliers and is well aware of their qualities, organizations and manufacturing capabilities. The project managers have provided an opportunity for their most reliable suppliers to implement technical changes (where it is necessary) and to adapt their products to meet required quality standards. Indeed, Iran-Khodro at the early stages of project determined a deadline for the suppliers to upgrade their production facilities and establish their ability to produce parts required for the new technology. However, there were great challenges between the project team and the suppliers in terms of project time and it was obviously clear to the corporate managers that reliance on domestic suppliers involved a great deal of effort. In this circumstance, other collaboration programmes like joint venture, licensing and etc. between local and foreign (mostly European) suppliers were considered. These diverse technology transfer methods have different implications in terms of various dimensions of transfer package such as capital equipment provision and knowledge creation among domestic parties. In the next section we will consider the technology transfer models observed in 20$^{th}$ century particularly in the automobile industry and then we will situate the new technology transfer project EF7 in this historical context.

## 4. MODELS OF TECHNOLOGY TRANSFER

According to Shamsavari and Taha (2005) and Salar-Amoli and Shamsavari (2006) in the North-South process of technology transfer in 20th century three historical models can be identified.

These models can be distinguished by certain factors, i.e. the geographical area, the route or mechanism of technology transfer, the extent of state intervention, trade strategy and policies of the host country.

1. The Soviet (East-European) Model: This was used initially by the former Soviet Union (SU). But it was copied in Eastern Europe and India and China after WWII. It aimed at Import Substitution (IS) with primary channel of transfer being licensing agreements (e.g. production of Lada cars under license with Fiat). As the SU was not a market economy tariff was not used as an instrument of protection of domestic industry. State intervention was supreme.

2. The Brazilian (Latin American) model: This model also aimed at import substitution but relied heavily on wholly-owned FDI (e.g. American Ford company investments in the 1950-60s). Trade policies included tariff, quota and tax-subsidy incentives. Thus the role of state was important but private sector also played a significant role especially in supplier industries.

3. The Korean (Asian) Model: This was a complete departure from the above two in that both the aims and routes of technology transfer were different. It aimed at export promotion (EP) and used joint-ventures with Japanese and American TNCs. The extent of state intervention was lower than LA model, while private sector played a major role. Trade policies included mostly tariff and subsidies. See Fig. 1 for a summary of the above.

According to Shamsavari and Taha (2005) technology transfer in Egypt has followed a hybrid model combining elements of the first and third models above. Salar-Amoli and Shamsavari (2006) state that the same is true about Iranian car industry.

**Figure 1: Historical Models of Technology Transfer in 20th. Century**

| | Means of Transfer | Role of Government | Export-oriented | Regions |
|---|---|---|---|---|
| Soviet Model | License | Total | Zero | SU, Eastern Europe |
| Latin American Model | FDI | Large to Medium | Small to Medium | Brazil and Mexico |
| Asian Model | Joint venture | Medium | Large | Japan, S. Korea |

## 5. NEW EMERGING MODEL

In the technology transfer models previously employed in developing countries, a foreign partner transfers technology directly or indirectly to the host country in order to establish a production line for an existing product. Then, the host country after some experience with production, or perhaps simultaneously, begins acquiring know-how from reverse engineering or other know-how generating activities. This process takes a long time and after such period, the product or process may lose its novelty and competitive advantage in the market, particularly in export markets. Although, among the current models, the Korean model has some competitive strength in catching up process, a more dynamic learning and absorptive capacity and agility are needed to switch to new models and to produce innovative new products with the current production lines. In Iranian context, this agility can rarely be found and hence, the local firm has always problems with innovation of new products and often loses competitive advantage in the market.

The new method for technology transfer represented by EF7 seems to fall in the category of 'strategic alliance'. According to Tidd (2006, pp.303) `strategic alliance' typically takes the form of an agreement between two or more firms to co-develop a new technology or product'. Such alliances may evolve into common ownership between partners and thus become 'joint ventures'. In contrast, in Iranian national engine project, the complete intellectual property of the engine belongs to Iranian side and the new product was designed and developed especially for Iran in accordance with the request of Iranian side. We may call this method of technology transfer and 'host-oriented' R&D strategic alliance. This type of alliance is primarily aimed at developing a new product with technology transfer targets and based on the host country requirements through host country ownership of R&D and cooperation between interested parties. Of course, in order to get maximum benefit from this model of technology transfer, the 'absorptive capacity' of the host country should play a significant role in the amount of tacit knowledge which is transferred from the originator company to the host firm. Due to 'path-dependency', the indigenous R&D should be enhanced to an adequate level so that the domestic firm is capable of gaining the required tacit knowledge and succeed in the catching-up process. We will discuss in detail the 'absorptive capacity' and 'path-dependency' in Iranian national engine project in the following sections.

## 6. ACQUISITION OF CAPITAL EQUIPMENT

The process of manufacturing an advanced CNG engine competitively requires technical changes particularly in the context of manufacturing in Iran, which is new to competitive forces and pressures in the global market place. In these circumstances, technical changes should be implemented in both car manufacturer companies and the supply chain. The car manufacturer company has enough determination to realize technical change in so far as such collaborative R&D projects require.

Due to political pressures which favor domestic production and supply of car parts as much as possible (involving high local content requirements), the designers faced a hard challenge in reconciling modern design and domestic manufacturability of car parts and components, requiring a long-term interaction between R&D department and the suppliers. The best that the German company is able to provide is what it supplies globally (world class standards). In practice, however, a substantial part of collaborative R&D involves adaptation of designs to local manufacturing capabilities, which in turn are influenced by the quantity and quality of local capital goods in domestic supplier companies. In some cases the supplier was able to implement technical change rapidly, i.e. the case of "agile manufacturer" (Meredith, S. and Francis, D., 2000), but in some cases there were problems with supplying the parts locally. Eventually the policy-makers understood such obstacles and switched to import policy in some inevitable situations which would result in the loss of product competitiveness (i.e. if low quality domestic parts are used). On the other side, such challenges led some suppliers to face challenges and pressures for technical change implementation. Of course some of them will be able to meet the challenge and survive in this struggle, while some others will inevitably go under.

During these technical changes, many agreements were made between local suppliers and foreign (mostly European) firms in the form of joint-ventures, licensing etc. Consequently, engine design technology as a technology transfer project was embedded in “sub-technology transfer streams” in terms of supplier issues. Thus although the R&D centre modernized engine test laboratories during the project, the main part of capital equipment is more visible when we look at the suppliers’ issues.

It is clearly evident that the government can play a vital role in supporting and assisting suppliers by providing finance. However in spite of government’s determination there is little evidence of state support for domestic suppliers in their attempt to implement technical change.

Clearly investment in supplier industries in order to implement technological change required for adaptation of existing capital stock to new model requirements is the crucial limiting factor, unless a complete openness to source supplies from foreign countries are adopted by the government.

## 7. DEVELOPMENT OF MARKET

The new engine with new fuel needs to be commercialized initially in the domestic market and then abroad in line with government's new export policy. One important consideration in marketing any new product is its price and in general life-cycle cost which is price plus the running cost. It is obvious that all these elements of cost should be competitive. Furthermore, the availability of CNG at service stations also is part of the opportunity life-cycle cost.

The state has offered many incentives to the private sector to build CNG fuel stations, including building and equipment finance. Although many large cities feature such stations, there are huge shortages in the country as a whole.

The other important issue in the commercialization of the new product is the fuel cost. The cost of CNG should not exceed that of petrol. Figure 2 shows the cost of petrol and CNG for a typical vehicle in Iran. The typical vehicle in Iran has 12.3 liter petrol consumption in 200 kilometer mileage with 90 km/h speed in highways. The figure is 12.3 kilograms of CNG consumption for the same circumstances. The cost of petrol in Iran is $0.086 per liter while the cost of CNG is about $0.0215/kg (data are valid for 2006). It can be observed from data that the cost of CNG is a quarter of the cost of petrol in Iran, making the former highly competitive in terms of price in the domestic market. It must be emphasized that petrol prices are heavily subsidized at the present.

**Fig. 2 Comparison of Fuel Type Cost in Iran (2006)**

| Fuel Type | Cost | Fuel Consumption in 200 Km | Cost of 200 Km traversal | Cost of 20,000 Km traversal |
|---|---|---|---|---|
| **Petrol** | $ 0.086 per liter | 12.3 liter | $ 1.05 | $ 1050 |
| **CNG** | $ 0.0215 per kg CNG | 12.3 kg | $ 0.2625 | $ 262.5 |

Another customer choice which plays a key role in market development is after-sales services. This involves both warranty related repair and servicing and normal maintenance. Both require new and advanced capital, which embody technological change involved in new CNG engine development. Also the degree of scale required to operate advanced equipment, the skills of service and maintenance personnel (first level of competence), possible import cost of buying the equipment from abroad and training local people to use it properly. This is one of the major challenges that Iran-Khodro, based on its prior experience, realized fairly swiftly and attended to its after-market department at the early stages of project kick off.

Finally the development of market will not succeed if the company cannot achieve a competitive unit cost for its cars. One significant issue affecting this cost is sourcing policy. Manufacturing of the new product and on time delivery necessitates that the company and its supplier have a strong relationship during the product development. This is exactly what Lamming (2000) identifies as a characteristic of ‘lean supply’ and underlines ‘the focus on value flows – the relationship, not the contract”. Although the ‘project team has been absorbing lessons from German companies, the Iranian suppliers and companies are years behind the German benchmarks. Nevertheless, EF7 project speeds up the creation of a strong relationship between the company and the suppliers.

All of these issues have a vital role to play in commercialization of the new product; however, those can not guarantee the economic side of the project as according to Granstrand (1999, pp.188) ‘commercial success does not necessarily entail economic success in terms of sufficient total rate of return on the relevant investments.’ Furthermore, Iran has not yet joined the WTO and in line of its own local car manufacturing support policy, the state still uses high tariffs against car imports and this raises the question: will the current process of design of CNG engine remain competitive once imports are allowed?

## 8. KNOWLEDGE AND COMPETENCE CREATION

The technology transfer process, particularly in the knowledge-based economy, goes beyond explicit aspects of knowledge acquisition involved in capital goods and training. The value of knowledge portion of technology transfer entails what is called `tacit knowledge’. A perfect technology transfer process should include the tacit knowledge as well as capital equipment and codified knowledge. Of course, the degree of tacitness depends upon the context. Hence, it would be more useful to discuss a bit more the context of Iranian company (Iran-Khodro) which is responsible for transferring the CNG technology. The R&D centre of Iran-Khodro has already had some research activities especially in collaboration with the universities. The R&D activities in some cases had been carried out successfully especially in areas where the ‘absorptive capacity’ had to some extent grown. In these areas, they were ready to receive an advanced knowledge about the new engine technology. These areas stood out in the transfer process. Despite these success stories, there are other areas which didn’t succeed to absorb the related tacit knowledge during the R&D process. There are two important points here: the first one is related to the ‘absorptive capacity’ as Cohen and Levinthal (1990) have labeled and described it, i.e. : “we label this capability a firm’s absorptive capacity and suggest that it is largely a function of the firm’s level of prior related knowledge”. Throughout the project, it was obviously clear which parts of the R&D had enough absorptive capacity and which parts had not. The departments with enough absorptive capacity were able to understand and implement the new advanced technology and their role in supporting local supplier for manufacturing the advanced parts was considerable to the extent that in some areas there were emerging innovative views about the German side design aspects. Thus, in the words of Cohen and Levinthal (1990) “prior knowledge permits the assimilation and exploitation of new knowledge.” In contrast, the departments without absorptive capacity fell behind during catching-up process and failed to understand and then implement what the foreign consultants were saying.

The second important point here is about knowledge ‘path-dependency’. The former research in some areas by R&D centre made the R&D people ready to acquire new knowledge and even innovate in accordance with their own background. In other words, what they were able to do in the past, defined and constrained what they could do during the transfer process. Here the cumulativeness of knowledge is prominent. Indeed, cumulative feature of absorptive capacity as Cohen and Levinthal (1990) have mentioned, implies the path-dependency of knowledge and its creation. The path-dependency also is the main consideration when we explore the learning process. If the transfer process of technology is performed correctly in terms of knowledge creation and knowledge transferring, the host firm will be able to repeat the design process for a new product as well (replication). This issue requires a 'coherent learning' process during transferring. According to Patel and Pavitt (2000), firms' learning processes are path-dependent, and this is why the R&D centre, if determined to repeat the design process for other engines in future, should have implemented the relevant research activities and added value by enunciating indigenous research activities before any attempt at technology transfer project (this is an important point only if we are determined to transfer tacit knowledge specifically). In spite of all these difficulties, many attempts were made to transfer tacit knowledge of engine design technology as much as possible, as the local R&D centre regularly sent delegates of engineers to Germany to work together with German colleagues and planned video-conferencing and teleconferencing agendas as well. There were also many codification activities to acquire tacit knowledge because as Teece (1998) described:

> Replication involves transferring or redeploying competences from one concrete economic setting to another. It can not be accomplished by simply transmitting information. If tacit knowledge fully codified, it can be transmitted and replicated, but it is often difficult.

According to Cowan et al. (2000), the codification process reduces uncertainties and information asymmetries in transactions involving knowledge. Also codification reduces some of the costs of the process of knowledge acquisition and technological diffusion and speed up of knowledge creation. They also argue that "Knowledge codification offer further research directed to public policies for science, technological innovation and longrun economic growth.” Through the Iranian national engine project, there were a lot of codification activities accomplished in the forms of codebooks, software, engineering reports, and databases. Some of these codifications were implemented in collaboration with German side and this is perhaps one of the strengths of the project. However, such codification, suffered a lack of organization and it could be more productive if a systematic programme was in place.

Finally if we articulate and then rank technology transfer achievements, knowledge creation is the most difficult part of the technology transfer process and at the same time it is the most valuable part, particularly in a knowledge-based economy. We would argue that if technology transfer process is done using R&D contracts channels, like the ‘host-oriented alliance’ which is described in this article, the knowledge and competence creation, notably tacit knowledge, is more enhanced to the extent that the host company can speed up the catching-up process.

## 9. CONCLUSION

Technology transfer can take place through many channels depending on what the host country objectives are. In contrast to the past technology transfer models, a new model, “host-oriented alliance”, has recently emerged in Iran, primarily through the engine design technology project, which can be very worthwhile in terms of knowledge acquisition and R&D enhancement using collaborative programmes and alliances. Thus, this model can speed-up the catching-up process, provided a good management especially in knowledge management areas and ex ante capability building is in place. On the other hand, when technology transfer aims to involve the host country’s suppliers, the latter can play a significant role in technological change in the supply chain, which is strongly needed to support customer firm's R&D department. This is what we call it the "right procurement policy".

We hope that this paper has highlighted the importance of environmental issues, factor endowments of host countries and the importance of supply chain development in the technology transfer process.

Finally we would argue that once developing countries identify their technological priorities, they can begin by capability building in their own countries like R&D in the prioritized areas where they have already established some competitive advantage and then move on through cooperation with firms from developed countries in furthering that competitive advantage.

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