# Technology Transfer and the National Context

Thomas Grammig

Abstract:

International management should follow evolutionary economics in unpacking technology in order to devise managerial approaches and tools to enhance technology transfer. The different components of technical knowledge have higher explanatory potential than differences in the national context as such. The national context is important to understand the ability of individuals to deviate from wider socio-cultural processes determining the dynamics of technology transfer. This paper argues that national cultural dimensions help to identify the crucial knowledge components but that interpretative analysis is necessary to devise the means for particular organizations to step outside of a national pattern. The combination of positivist and interpretative analysis is considered.

A firm's internal organization reflects its environment and such isomorphic patterns can be demonstrated by assessing independently the validity of belief structures within the firm and in its environment. A transfer of technical knowledge from a foreign to a local firm is constrained by local patterns of local / global exchanges. When some firms manage to acquire technical knowledge better than others, the differences reflect the degrees of freedom of a local firm to change beliefs about local / global exchanges. Three cases of technology transfers are compared: in the Mexican energy sector, in Mexican *Maquiladoras* of consumer electronics, and in the Chadian informal sector.

**Technical Knowledge**

The revival of Schumpeterian economics has firmly established evolutionary economics as a sub-discipline. In achieving this feast, 'technology' has been unpacked into four standard components, explicit, tacit, embodied and disembodied knowledge. The four are mutually dependent, they overlap and feed upon each other (Gjerding 1998 and Senker 1996). Actually one might stop using 'technology transfer' and write about 'technical knowledge component transfer'. But let me concentrate on the analytical insights gained when cultural differences are addressed separately for these four components.

Embodied knowledge is mobilised whenever an artefact is employed, even when the user is unaware of it. Embodied knowledge is abundant, for example, in microchips where no user even grasps the knowledge involved in its production. Explicit knowledge can be put in phrases. While I might learn everything about swimming explicitly, it is only when I actually swim that I will acquire additional tacit knowledge. Tacitness is often context specific (what my arms feel like swimming), but can not be adequately described by analysing the context. To an extend, tacit knowledge can be made explicit ('knowledge management'), and disembodied knowledge can become embodied.

Technology transfer is composed of transferring explicit, tacit, embodied and disembodied knowledge. One cannot stress enough that all four components are involved when the outcome is to have any significance. It is not possible to transfer only explicit knowledge or only embodied knowledge. When embodied knowledge, say in the form of a computer programme, is used in a new organizational context, new tacit knowledge is created. Likewise, when explicit knowledge is introduced in a new firm, tacit knowledge is necessary in order to do something with the explicit knowledge.

International technology transfer is particularly complex because the differences between tacit knowledge in the two contexts are more salient. Individuals engaging in international technology transfer are producing new tacit knowledge AND new explicit knowledge. The differences between the technical knowledge providing firm and the knowledge acquiring firm become explicit and tacit knowledge about the transfer.

**Positivist and Interpretative Understanding of Cultural Differences**

Positivist understanding separates the variable and the researcher. The method is independent of the researcher and yields verifiable results. When social sciences cannot achieve this on the micro level, elaborate but reductionist aggregation of data is used. Hofstede's dimensions are classic examples and I need not describe them further. Interpretative understanding accepts that variables and researchers cannot be fully separated. The variables are subjective and relative to the research situation. Classic methods of ethnographic fieldwork use participant observation to produce data.

I propose three case studies in order to assess positivist and interpretative analysis of technology transfer: one, energy engineering from the US to Mexico, two, TV production from Japan to Mexico, and three, manufacturing of agricultural machinery from France to Chad. The differences between positivist and interpretative understanding allow to conclude on different aspects of technology transfer. First of all, ethnographic data allows to verify macro results of positivist analysis. As technology transfer is a complex object, the interpretative results are always more accurate. However, it is insightful to use interpretative results in order to determine to what extent the positivist results are applicable. Good statistics rely on good

ethnography. On the other hand, positivist results allow to distinguish idiosyncratic elements from general elements in interpretative results.

**TABLE 1: Case Studies**

| Case One | Case Two | Case Three |
|---|---|---|
| US - Mexico | Japan - Mexico | France - Chad |
| energy engineering, feasibility studies of cogeneration | TV production, operation of NC machines, testing and assembly automates | production of agricultural machinery, metal-working skills |
| successful transfer of embodied knowledge, outcome is locally used and advances organizational interests involved, no transfer of skills, thus no demonstration impact | successful transfer of embodied and tacit operational knowledge, but failure to transfer disembodied technology such as quality circles | successful transfer of skills, failure for embodied knowledge, the prototypes were not adapted, no replication but secondary transfer effects from skills transmitted |

As ethnographic methods are less consolidated, I need to introduce briefly the one I have used. The fieldwork approach of French contemporary anthropology (Augé 1995) is based on understanding being the joint product of observer and observed. Applied to technology transfer, this approach can be compared to a pressure cooker (Grammig 2001). A technology transfer exercise is an ideological pressure cooker and the ethnographer's presence functions like a little hole in that cooker, where some vapour escapes. The participants in the technology transfer manipulate the ethnographers' presence to act upon the transfer. This manipulation allows to discover the social reality. Being small in relation to the cooker, the hole does not alter the pressure inside, but allows to measure the pressure. Similarly, the observer presence does not alter the technology transfer but allows to read the ideological stakes involved. The stakes include professional careers, reputations, pride, salaries, profits, market share and so on. The methodology also addresses the impact of the observation, the reactions of participants and organizations to the results.

I now describe the positivist variables of the cases and then the interpretative ones. Hofstede's analysis defines key differences between the national context. Case One involves a transfer from high Individualism with low Power Distance (PD) and Uncertainty Avoidance (UA), in the US, to low Individualism with high PD and UA, in Mexico. A Japan - Mexico transfer represents smaller differences in Individualism, PD and UA. In other words, the cultural differences between Japan and Mexico are considerably less pronounced than those between Mexico and the US. The one major difference concerns Masculinity, where Japan has a more extreme position that both Mexico and the US. Therefore, comparing US - Mexico transfers to Japan - Mexico transfers, for Hofstede's variables, implies comparing transfers with Individualism/PD differences to transfers with smaller Masculinity differences.

Therefore the prediction would be that Japan - Mexico transfers are more efficient than US - Mexico transfers. Indeed it is plausible that in a high PD environment, where different levels in the hierarchy imply access to information and coercive influence on others, individuals will be less ambitious when they have an opportunity to master new knowledge. The recipient in Mexico is less confident in his/her skills than the US engineer who works in a low PD environment, where knowledge is meant to be more evenly distributed in a more horizontal organization with fewer levels of hierarchy. In addition, the more collectivist style in Mexico is opposed to the individualism in the US. Individual achievement is more suspicious of damaging collective interests in Mexico. Japan, with less PD and Individualism than the US would be a more versatile source of technology in Mexico. First, because PD and Individualism are the most relevant variables and there Japan has an intermediate position between US and Mexico, and second, because the Masculinity difference between Japan and Mexico is less influential for technology transfer and is smaller than the PD difference.

The ethnographic results in case One explain the key ideological link which limited the co-operation. All engineers knew that there is no definite separation between knowledge and know-how. In other words, despite all the theoretical mastery of thermodynamics, the analysis of real machines requires context specific know-how. This is precisely the difference between a successful feasibility study and a poor one. All engineers therefore readily pooled their know-how from the different industries they knew, since altogether this was still a limiting factor for their work. The superior engineering performance is made of the subtlety of the know-how. The more productive engineers were able to identify the overriding parameter to optimise between, for example, a gas turbine model (which cannot be custom designed) and a waste heat recuperator (which is custom designed). The others could not deduce the systemic parameter to optimise a system. The key ideological link concerns the identification of the one systemic optimising parameter. When a US engineer took a pedagogical approach (according to his sensibility of pedagogy), a Mexican engineer considered it a kind of deception. Presenting technical acumen in a simplified manner became in his/her eyes, a covert way of keeping him/her dependent on the US engineer. This information was part of the interface between foreigners and locals and it was actively negotiated. It was a classic example of insufficient trust to combine tacit knowledge. There is no outcome of the case One co-operation beyond this unresolved negotiation.

Lara reports for case Two (Lara 1994), that Mexican production engineers failed to adopt Japanese management methods because they felt that their hierarchical position would be weakened. Seeking to apply 'scientific' and Taylorist methods instead, these engineers did not engage in the transmission of tacit knowledge between the production workers as required by Japanese management. Both engineers and production workers had high rotation between firms because they did not identify with the TV company and its management.

The production engineers explained that their Japanese colleagues kept them excluded from decision-making and acted in a despotic manner towards Mexicans. Strikingly, the Mexican engineers qualified the Mexican workers as too individualistic to adopt Japanese management methods.

Both in case One and in case Two, expressions of PD differences limited the transfer. Even though the Japan - Mexico case involved lower national PD and Individualism differences, the Mexican engineers' stereotypes amplified the lower differences. Considering only the interpretative results from case One and Two, one would conclude that Mexican engineers are defensive and anxious about their professional status. Adding the national differences in PD for US - Mexico and Japan - Mexico transfers to this consideration helps to take the national context into account and weight the beliefs in the sophistication of skills and knowledge higher up in a hierarchy. Thereby the status consciousness is less attributed to the individual engineer but to the society. In that manner, one can add the quantitative sociology result to the ethnography, keeping in mind that this is far short of interdisciplinarity. Likewise, one can use the ethnography to conclude that the PD dimension and the Individualism dimension are not linear between the countries concerned. Smaller PD and Individualism differences do not imply that the difference would be less of an obstacle for the individuals concerned.

**Transferring Components of Technical Knowledge**

In order to assess whether the cultural characteristics of the components of technical knowledge are more important than the overall cultural differences between the national context, we use all three case studies together. These three cases cover a wide spectrum of technology types. Energy engineering knowledge is highly integrated and therefore easier to express explicitly. It is also easier to embody in machines or computer models. Nonetheless energy engineering involves tacit knowledge when actual plant operating data is gathered and interpreted. Even universal thermodynamic laws, 'phrased' in mathematics, involve some context specific knowledge when they are applied. TV production involves more tacit knowledge and cannot easily be embodied because the production is not fully automated. Behavioural habits of production workers are particularly important to make full use of Japanese management tools such as quality circles (Ringi) and other such methods. These methods have to be experienced in order to replicate them and thus tacit knowledge is vital (also the reason for the difficulty of the return transfer from Japan to the US, where quality management originated). Finally, manufacturing agricultural machinery is an even more artisanal process because it is customized, specialized production machines are unavailable in Chad and so even the most complex products are made out of standardised raw material and simple production machinery.

Regarding the components of technical knowledge then, the range of the three cases is straightforward. Case One, explicit knowledge dominates, more process technology and tacit knowledge is created in the local context; case Two, still some process technology (production chains) but tacit knowledge is more important than what is explicitly known; and case Three, all tacit knowledge, little explicit instruction and fully customized products. Before

discussing how Hofstede's variables fare regarding technical knowledge components, we clarify the national context of case Three.

Between the three cases, US - Mexico is still the most problematic because the PD and Individualism differences are the highest. France and Chad have similar PD and similar Masculinity. France - Chad is even closer on PD than Japan - Mexico. So the most important variable regarding the national context aligns the three cases, US - Mexico most difficult, Japan - Mexico less, and France - Chad least difficult cultural differences. In addition, Japan - Mexico transfers involve the highest Masculinity difference and France - Chad the second highest Individualism difference. The three case studies thus allow to verify whether PD is really the most important variable for technology transfer and whether Individualism differences or Masculinity differences are more influential.

This comparison is theoretically attractive and has been attempted before. Kedia and Bhagat (1988) are widely cited for a similar comparison. They described the successful transfer of technology to Japan, South Korea and Taiwan as evidence that high Masculinity can compensate the lack of Individualism in countries with collectivist cultures when it comes to mastering foreign technology. However, they also point to the role of social order and of cosmopolitan orientation as important factors for the absorptive capacity of local organizations, and caution researchers to be aware of ethnocentric biases when assessing the importance of PD and Individualism.

Finally, Kedia and Bhagat underlined the importance of product-embodied versus process- or person-embodied technologies. The latter two should be more difficult to transfer because "the intrinsic nature of the technologies makes it necessary that the supplier organization exercise control through various means" (*Ibid.*:562). On the contrary, Lall (2000) and Lasserre (1982) assume that process knowledge is easier to transfer than manufacturing

knowledge. I am convinced that such typologies of technology are not helpful to understand technology transfer. Rather, one should consider that all technologies contain the four components, explicit, tacit, embodied and disembodied knowledge. Technology transfers involving, for example, mostly tacit knowledge can create similar obstacles. Technology transfer is a learning activity and the learning characteristics are what distinguishes one technology transfer from another. Learning tacit knowledge is different from learning explicit or embodied knowledge. Sher, Wong and Shaw (1998) have shown that tacit knowledge learning is key to understand Taiwanese transfer success. As Gjerding (1998) suggests, experiential learning should be understood through analysing role-playing and symbol-using. Cultural differences are most influential for technology transfer when role-playing and symbol-using create prejustices and misunderstandings. Therefore, case Three appears to be the most difficult transfer, even so it concerned concrete products, and case One should be considerably easier as the technical knowledge can be explicitly exchanged. Unsurprisingly, the ethnographic evidence suggests otherwise.

Case One involved engineers with similar engineering degrees but different exposure to state-of-the-art technologies. The US engineers were well versed in the calculations whereas the Mexican engineers had to unlearn some received wisdom. Despite the explicitness of the knowledge, the PD and Individualism differences created strong obstacles for US and Mexican engineers to jointly produce local applications of technology. The creation of new tacit knowledge, reflecting industrial practices in Mexico was hampered by these cultural differences. The management of the US - Mexico transfer did not include any consideration for the need to include tacit knowledge and this disregard was the most important factor limiting the transfer efficiency. The most ambitious Mexican engineers spent weekends repeating every calculation by themselves, assuming that was the way to 'get it'. In contrast, in case Three,

the French engineers responded to any request of explicit explanation and instructions, but always assumed that only a prolonged co-operation, producing prototypes of the agricultural machines jointly with the Chadian artisans, could achieve the transfer of technology. The most important management problem for the France - Chad transfer was how to structure this production of these prototypes allowing the Chadian artisans to adapt them to the local context.

The management challenge and the limiting factor for the transfers is simultaneously how to take the local context into account so that all components of the technical knowledge are addressed. Both in case One and in case Three, tacit knowledge was the bottleneck, although case One actually involved little tacit knowledge. Theory predicts that this is the case. US - Mexico transfer involves high PD differences and therefore experiential learning between US and Mexican engineers is difficult. Moreover, Hofstede's dimensions should direct management attention to the particular conditions of tacit knowledge as the crucial component. France - Chad transfer implies only small PD and Masculinity differences but high Individualism differences. It is tempting to speculate that managerial remedies for tacit knowledge transfer in the high PD difference context are dissimilar to managerial remedies for tacit knowledge in a high Individualism context. We can not pursue this here because in the France - Chad case, tacit knowledge was a much larger knowledge component. Perhaps, the Individualism difference would result in transfer obstacles even when little tacit knowledge is involved, but this appears less plausible. French engineers and Chadian artisans both valued the experiential nature of their activity. There was an element of craftsmanship pride, frequent with tacit knowledge, which is not detrimental to individualist values. Furthermore, the key ideological link limiting case Three co-operation was related to colonial history and only indirectly to individualism.

On balance, the comparison confirms that PD is the most important national dimension. Case One was nonetheless more successful than Case Three, even so the PD difference was higher because the tacit knowledge in energy engineering was less important. The cultural obstacle in case One was higher but the lesser cultural obstacle in case Three was more extensive. This is also confirmed considering that the case One outcomes are now used by different organizations to repeat the transfer exercise, whereas in case Three the activities simply ceased.

We have already concluded that the lower PD difference in Japan - Mexico did not reduce the obstacles. In fact, the tacit knowledge transfer was as low as in Chad. France - Chad transfer has strong Individualism differences and Japan - Mexico strong Masculinity differences. This suggests that Masculinity differences are not similarly causal as PD difference (suggested by Kedia and Bhagat) nor Individualism differences. My tentative conclusion is that tacit knowledge transfer is more complex and the four national dimensions are only weakly correlated (PD being the strongest) to that particular component of technical knowledge. This conclusion would be confirmed if empirical evidence for a transfer case with neither Masculinity nor Individualism differences also shows some, but not linear PD relevance.

**Latent Processes Appearing in Tacit Knowledge Transfer**

When defining managerial tools for technology transfer, the absorptive capacity of the organization involved is the most important condition. The isomorphism (DiMaggio 1983) of a firm within its environment often determines whether the firm can take up and adapt technology. The principle objective of the case studies was to define the wider socio-cultural processes shaping the dynamics of technology transfer which in turn determines the technology transfer success or failure. Surprisingly, in all transfer cases three distinct socio-cultural processes appeared in the exchanges between the locals and the foreigners. These processes are defined in general terms and it is shown that management habits in the organizations involved actually reflect these processes in an implicit manner (Grammig 2001). While these processes are shaped by the social and, most importantly, the historical context, individuals shape their role in the knowledge transfer, and therefore they are labelled "Latent Processes". The challenge is to develop definitions of the latent processes that allow the individuals involved in a transfer case to derive managerial remedies effective in their context. It is especially necessary to do this via the individuals when tacit knowledge is to be enhanced.

The first latent process concerns the technical knowledge itself. Experts, socialized in a professional environment, find it difficult to distinguish the instrumental core of technical knowledge from socio-cultural ends of that knowledge specific to their professional environment. When different experts attempt to combine tacit knowledge, they involuntarily pretend that socio-cultural ends would be part of the instrumental core. This creates a vicious circle between the experts, the latent content process. The second and the most important latent process for intercultural co-operation consists of local / global exchanges of knowledge and goods. The national context contains

specific patterns of interpreting such exchanges. These patterns affect social identities of the individuals concerned. The third latent process concerns the experts' folk theories about their differences. Over a prolonged co-operation, they establish an interface between their folk theories, determining how they perceive the other side of the interface. Foreigners (and vice versa the locals) often appear as a coherent group despite individual differences. Frequently, foreigners hesitate to address locals as individuals because they assume that the individual can not deviate from his/her peers. Once established, the interface is rigid and limits the co-operation.

I briefly sketch only the second latent process. Friedman (1994:113) suggests two basic types with a symmetrical inversion for such local / global exchanges: consumption of modernity versus production of tradition, and other-centred versus self-centred processes. An exo-social pattern appears when the content of the knowledge (or a good) does not condition its transfer, 'the content does not shape the container', this was the case in the France - Chad transfer. The technical knowledge was used to act upon the cultural distance (alterity) and to diminish any socio-cultural ends it contained. For embodied knowledge this even implied physical destruction. The production of Chadian specificity was other-centred. When on the other hand, the transfer is endo-social, the content of knowledge does not reinforce cultural distance as it serves as an effective bridge, this was the case in the US - Mexico transfer. Whatever knowledge came from the outside was incorporated into the local perspective and vice-versa. There was no possibility of attaching "local" and "foreign" labels to knowledge. The patterns involve both knowledge and social identity. The technical knowledge is conditioned by the recognition of social identity in a specific manner. Friedman therefore qualifies these patterns as part of a *habitus*, structuring also other dimensions of social reality.

Both in the Mexican *Maquiladoras* and in the energy sector, firms were unable to modify the endo-social pattern of importing technical knowledge. The isomorphism is rigid, even when individuals succeed in acquiring technical skills, other members of the same firm did not adapt or modify their beliefs about foreign technical knowledge and tacit knowledge transfer. '*Malinchismo*' is a complex Mexican folk theory about this pattern. The exo-social pattern (France - Chad) appears to be considerably weaker and the isomorphism open to change, individual firms improved their relative autonomy towards the environment. Paradoxically, it is the other-centred process which allows to switch between consumption of modernity and production of tradition. Whereas the self-centred process (Mexico) seems to reduce the autonomy towards the environment. The respective colonial history can not explain these patterns. Alternatively, the status of the professional groups concerned can explain the difference, in Chad the skills involved did not exist in previous generations, contrary to the Mexican context. To improve technological capabilities for most firms in a particular national context, a specific organizational set-up follows. For exo-social transfer, the set-up must shift the construction of cultural distance away from the technical content to other elements which are linked to the foreigners and shared amongst the locals. For endo-social transfer the set-up should enable experts to create context specificity and tacitness, and mark their contribution as Mexican. The broader objective is to reveal the interdependencies of cultural distance.

The respective influence of the three latent processes depends on the particular context. Ethnographic fieldwork during the transfer activities is necessary to define the organizational set-up in a context because these processes are not intrinsic to technical knowledge nor to the national context. The following management tools have been derived from the ethnography of case One and case Three. These tools are instructive examples for the

differences between the two lists. In other words, it is important how these tools constitute different categories, corresponding to particular transfer contexts. Each list could be much longer but their specificity is in itself a management principle

**Indicative Sample of Tools to Shift Cultural Distance away from Technical Knowledge, for Exo-social Transfer (France - Chad):**

Differentiation of non-essential aspects related to foreign and local participants and of personal concerns such as working hours, clothing, transport, food, and so on.

Separate meetings of local and foreign experts with elaboration of a common agenda for both, while accepting only combined reports as official documents.

Extensive data gathering, data administration and elaboration, and making the results widely available.

Horizontal structure of tasks, where foreign output is also local input and vice versa.

Defining simple quality control parameters recurrently and in writing, distributing auxiliary data and intermediate calculations.

**Sample of Tools to Mark Tacitness and especially its Local Origin, for Endo-social transfer (US - Mexico):**

Non-essential aspects of participant conditions varied individually.

Technology transfer products specified separately for each group when suitable.

Organizational differences marked relative to objects, specific schedules for different applications or examples.

Separate meetings for foreign and local experts, with each group documenting the changing agenda over project period, some of these documents becoming official documents.

Data gathering and administration initiated discretionary and non-standard.

Vertical structure of tasks, where foreigners perform one application and local experts another; tasks are chosen based on differences in skills needed and available amongst the experts.

Emphasis on informal communication between experts, sharing of resources with resources remaining connected to individual experts.

Resolving role conflicts amongst the experts through requiring compromise, yet not avoiding competition.

Results and reporting arrangements with specified contributions from an expert.

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