STRATEGIC DECISION-MAKING FOR TECHNOLOGY IMPLEMENTATION IN DEVELOPING COUNTRIES

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ABSTRACT
Researchers and managers stress the importance of long-term technology strategies to develop technological capabilities for global competitive advantage. This paper explores the relationship between technology decision-making and strategy in technology transfer (TT) in developing countries, with special reference to South Africa. Earlier research by the authors considered technology and operations integration in developing countries and identified factors that were important to managers in the management of technology. The paper proposes five decision-making levels as the basis of a framework for TT, and investigates the strategic issues pertaining to TT at these levels. Four South African cases studies are used to propose a framework that combines important items in technology transfer and levels of decision-making. The research suggests that technology plays a limited role in strategic decisions in developing countries, and that expectations from new technology are largely operational. Broader implications for managers are identified.

Key words: technology, strategy, operations

INTRODUCTION
Globalisation presents formidable challenges to developing countries as they struggle to compete in world markets. As technology assumes importance in many businesses, technology policy is crucial in strategic decision-making and increasingly focuses on global considerations (Lall, 1993). The extent to which firms in developing countries are able to enter the global market depends on their ability to acquire and use new technology, and on how they can foster knowledge-based competitive advantage. A decisive feature

will be the extent to which managers meet such demands by developing core technologies into a knowledge, competence and high-tech skills context (Wang, 1997).
Developing countries are less likely to benefit from factors that, in the developed world, typically lead to the increasing availability of technology from external sources: (1) rapid global growth in scientific and engineering knowledge; (2) availability of venture capital and the formation of numerous start-up companies; and (3) an expanding pool of displaced talent resulting from reengineering and corporate downsizing (Chatterji, 1996).
The purpose of this paper is to study the strategic component of TT in developing countries, with specific reference to the manufacturing environment in South Africa. A model is derived from links and associations established between factors that are important in technology decision-making, and the levels at which decisions are made, based on a framework by Salami and Reavill (1997). Four case studies are used to study the relationships between elements in the proposed model. The paper concludes with a discussion of the broader implications for technology managers in developing countries.

TECHNOLOGY STRATEGY IN DEVELOPING COUNTRIES

Technology decisions are a critical component in strategic portfolio selection (Gagnon and Sheu, 2000). First-mover advantage through technological capability is achieved by combining internal and external resources that lead to faster access and exposure to new technologies located beyond an individual firm's boundaries (Harris et al, 1996). Competitive advantage may further be gained by opening or exploiting windows of opportunity through knowledge and intangible assets that typically focus on external technology relationships and the application of physical assets. When a new portfolio of products renders existing technologies and competencies obsolete, first-mover status is eroded through the change from what was once a new product into a commonplace commodity. A broader range of products appears, appealing to additional markets that demand flexibility and quick responses (Lee et al, 2000).
When technology policies result from upfront negotiation between users in developing countries and prospective suppliers, the latter frequently emerge as indispensable business partners (Carayannis, 2000). A major challenge for manufacturing firms is to reach short and long-term compatibility of strategic objectives, and to embed order qualifying and order winning criteria. In conditions of technological and environmental uncertainty, relationships should be flexible with a limited need for control (Hoffman and Schlosser, 2001). While this emphasises the importance of articulating and restating strategic objectives, the danger exists that excessively prescriptive objectives narrow the focus of the technology user and restrict the scope for innovation. In high-technology operations, competitive advantage is increasingly derived from the transfer of knowledge and intangible assets between acquirers and suppliers, as knowledge-based products become pillars of competitive strategy.
Collinson (1999) proposes three "domains" in technology and knowledge products: technology-as-hardware (products, machinery), the knowledge-base (systems, suppliers, customers, environment), and routines (to develop and apply the knowledge-base of the firm). Routines are observable and transferable, and are a major focus of restructuring and change as firms improve their performance or respond to new conditions. While it is appealing to study a routine as a relatively stable knowledge construct, the forces of routinisation can be disrupted by events that raise new issues and require re-examination

of old problems. This emphasises the importance of studying the dynamics of inter-organisational processes (Judge and Ryman, 2001).

At an operational level managers in developing countries are under increasing pressure to produce better results more efficiently, despite the adverse effect of a lower technology base on learning and knowledge acquisition (Lado and Vozikis, 1996). Firms in developing countries do not possess skills, capabilities and financial resources to develop new technology. Structural and political changes such as deregulation and privatisation have stimulated the flow of technology to developing countries, where the role of new technology extends beyond cost-efficient production processes. Customers expect quality and conformance to specifications, reliability and flexibility of supply, and confidence in the ability to provide long-term innovative capacity and to ensure financial viability (Barnes and Kaplinsky, 2000). Kumar and Jain (2001) claim that a technology 'anchor' should be established and remain within a country to propagate further technological development. It is possible to identify certain technological bases in some developing countries, but these have yet to develop into broad operational improvements.

Salami and Reavill (1997) propose a framework showing TT as a series of steps. The first step addresses decisions for selecting technology, macro-level agreements between the technology owner and acquirer, and identifies the needs of the acquiring country and the acquirer's goals and objectives. The second step evaluates available technologies. The third step is concerned with technology selection, considers human factors, and evaluates costs and benefits. The fourth step studies the actions of the supplier and acquirer during implementation, in terms of guidelines for human resource and management issues, and criteria for appropriate adaptation of new technology. The fifth step re-evaluates factors pertaining to performance criteria, modifications, and innovative developments. This study concentrates on strategic issues at levels 1 and 2, with some reference to levels 3 and 4.

THE EMPIRICAL RESEARCH

The framework described in the previous paragraph is useful for understanding TT. In order to establish which specific issues require investigation at each step, the authors conducted a survey to ascertain factors deemed to be important in TT in a developing country context (see Hipkin and Bennett (2002) for detailed results). A combination of the framework by Salami and Reavill (1997) and the survey results is used in this paper to analyse strategic issues pertaining to TT in four manufacturing companies in South Africa.

The preliminary survey

A sample of 230 South African managers attending management development programmes at the University of Cape Town from 2000 to 2002 was used to determine important items in TT. The 30 managers attending the first course selected for the study were asked to list the issues they believed were important in TT. After the authors had eliminated overlapping items, 80 items were used. All managers then scored how important these 80 items were in TT. Follow-up interviews, structured around the factors, were held with 42 managers in order to clarify and explain emerging results. Using factor analysis, the items were grouped into 14 factors, as shown in Table 1, which also shows the number of items grouped into each factor heading. The items specifically grouped under the strategy factor are also listed.

Table 1 - Factors identified as important in TT

Factor heading	No of items under each factor heading	Factor heading	No of items under each factor heading
Technology	9	Maintenance	5
Economic/political	8	Technology integration	5
Knowledge	7	Maintenance planning	5
Supply chain	8	Management policies	4
Strategy*	10	High-tech issues	3
Operations management	7	Financial	3
Contractual	4	Resistance to change	2

***Items grouped under strategy**	**Level in framework**
Statement of clear objectives to be achieved by new technology	1
Technology implemented because of market demand (demand-pull)	1
Technology as strategic resource for competitive advantage	1
Technology to assist in shift from product to process base	1
New business climate (global markets)	1
Alignment of business goals, systems and technology	1
Distinctive competency to be derived from technology	2
Technology permits revisit of vertical integration	2
New relationships with stakeholders	3
Ways of managing new technology (FDI, licensing, JV, partnership, etc)	4

The case studies

Four South African case companies were studied to analyse the items deemed to be important in relation to the steps identified by Salami and Reavill (1997) in TT. In these companies new technology took the form of replacing, upgrading or automating existing lines, with the objective of improving quality and achieving consistently higher output. Interviews were held with 3 or 4 individuals in each organisation, and also with 2 technology suppliers. The following paragraphs contain brief details of the cases.

Flourmill

"Flourco" is a flourmill with 50-year old equipment and new control systems introduced to automate the process. The control system was upgraded because the mill had to meet tighter delivery schedules and achieve consistently higher quality standards. Changes in the government regulations presented the mill with many new challenges.

Manufacturer of plastic film

"Plastico" manufactures food packaging plastic film for the retail markets that have exerted pressure to reduce prices. The product range was expanded to include fast-food customers and exports. Recent plant upgrades were aimed at improving equipment availability and monitoring quality to meet export quality requirements.

Food processing plant

"Foodco" installed new technology for processing vegetables for supermarkets and fast-food outlets. The company adheres to international quality standards laid down by American fast-food corporations. Flexible production is essential because customers have different quality standards and demand freshly processed products on a just-in-time basis.

Manufacture of aeroplane seats
"Airco" produces fibreglass structures for passenger aeroplane seats that are exported to Boeing, BAe and other aircraft manufacturers. IATA regulations require strict adherence to deflection and structural standards. Airco purchased a semi-automatic machine to assist in the manufacturing and curing process as this is essential for correct bonding and layering.

Methodology and derivation of a revised model
As part of a larger research project to link the Salami and Reavill (1997) framework with the items identified as being important by South African managers in the preliminary research, this study looks at strategic issues. Each item from the preliminary research was categorised by the authors at a certain level (e.g. each item grouped under the strategy factor was allocated to a level of the framework, as shown in Table 1), and discussions with the case organisations concentrated on decisions and activities at each level.
It became apparent that respondents did not see the applicability of certain items in the original framework. At Level 1 needs, capabilities, advantages and disadvantages of the acquiring country are sought, as well as the acquiring firms' goals. Managers did not consider the question relating to country needs to be relevant to them, although they acknowledged that these might be appropriate when governments were setting technology policy for a country. At Level 2, reference is made in the original framework to an analysis of basic economic and technical factors affecting TT. Again, managers did not see the relevance of this question in their firms.
An interview template was created with the items from the preliminary research allocated to an appropriate level, and assessed in conjunction with the questions at that level from the Salami and Reavill framework. A model is proposed (Figure 1), where the items relating to strategic issues from the preliminary research are summarised at the appropriate level. Of the ten strategic items in Table 1, six are categorised at Level 1, two at Level 2, and one each at Levels 3 and 4.

SUMMARY OF RESEARCH FINDINGS

The discussions with staff in the case organisations provide a number of useful perspectives at each level in the model shown in Figure 1. This section considers the strategic items identified in the preliminary survey in relation to the elements in Salami and Reavill's model (other items are not discussed in this paper).

Level 1
Managers saw the introduction of their new technology purely in the context of their own organisations so macro-economic and national issues were not considered in decisions for selecting technology. In all case organisations, new technology was required to meet increased market demand in terms of production output and quality. All cases were subject to rigorous quality standards. Flourco's products had to comply with state regulations as well as customer quality specifications. Foodco was subject to standards laid down by international fast-food chains. Clingco was obliged to meet the standards of its European and South African customers. Airco's specifications were set by IATA regulations.
The shift from a product to a process base was only significant in Airco's case. The use of new technology to cure the product correctly during manufacturing greatly improved its

structural characteristics and led to considerably fewer rejects. The superior manufacturing process was evident in many ways, such as avoiding air entrapment that produces microbubbles and the removal of creases that would otherwise lead to poor bonding. Results from destructive testing demonstrated to the customer the value of the new technology. Airco managers were convinced that new technology placed the company in a position of considerable competitive advantage over competitors.
In the other case organisations, the processes whereby flour was milled, food was processed, or film was made, were not important to the customer. Quality was measured solely through inspection of the finished product. The process itself had no effect on the inherent functionality of the final output.
Decisions for selecting technology were aligned with business goals in terms of satisfying customer requirements. Flourco and Plastico were limited in their choice of technology as new systems and machines had to be directly compatible with existing production lines. Flourco, Plastico and Foodco set their business aims as production targets (e.g. tons per hour or specified quality levels). Airco's goals were also production-related, but the company was further looking to keep ahead of its competitors. Only Airco viewed the technology from a strategic perspective. The other cases saw no direct link between technology decisions and strategic direction, suggesting they investigated technology in terms of meeting operational objectives. At Level 1 none of the firms had paid much attention to the management system requirements of the new technology.

Level 2
At this level technology acquirers undertake surveys of all technologies capable of meeting their goals. For Airco it was essential that the new technology should achieve a distinctive competency whereby its production process would yield superior products to those of the competition. In the other case firms, competencies were sought that would render the products as good as competitive products. Foodco's strategy considered the extension of activities in terms of vertical integration by undertaking all screening and cleaning of raw products, packaging (and ultimately, delivery on a just-in-time basis).
When considering alternative technologies, firms were unable to undertake rigorous cost-benefit analyses, and the differences in output and quality produced by one technology over another could not be dimensioned with any great degree of accuracy. Managers were unable to quantify the benefits of new technology. They could not definitively ascribe the retention of a customer to one new technology or be sure they would have lost a customer if the technology had not been acquired. While the cost of technology was readily available, firms indicated they were unable to identify and quantify other costs, such as setting-up internal systems to support the technology. As long as the technology could deliver operational requirements, managerial intuition determined the final choice.
The case organisations were aware of the shortages of technically skilled staff in South Africa, as well as political and labour issues, such as increased workforce unionisation and affirmative action, but did not specifically consider human resources at the technology analysis and survey stage of technology selection. Managers were concerned that the novelty and complexity of some technology presented difficulties for an unsophisticated workforce, but a specific technology would not be rejected just because it introduced unknown concepts and processes.

Level 3

Final selection of technology takes place at Level 3. The important stakeholder relationships were those with suppliers. A supply chain concept was not utilised as main and subsidiary technology suppliers were managed on a project basis through contractual agreements. Project managers were instrumental in installing and commissioning the technology, but were not charged with assuming the role of promoter or champion. Generally managers waited until the new lines were operational before establishing specific reporting and management information systems. As with Level 2, formal cost-benefit analyses were not carried out.

When firms were negotiating with suppliers, training and support were always raised. In deciding on a technology, respondents chose the most appropriate and affordable technology, assuming their staff would develop the requisite skills. Managers were passive in their technology selection in that a supplier's solution to the acquirer's requirements was accepted with little debate on the applicability of the technology. Acquirers did not influence the level of complexity or robustness of the technology. Compatibility was considered a technical interface issue, and not viewed from a human resource perspective. Training courses and familiarisation sessions were used to 'diffuse' knowledge.

Level 4

Implementation and maintenance (Level 4) are not strategic issues, although managers did feel that strategic objectives influenced the way they managed new technology. Production output and quality determined policies towards maintenance, rework, and performance measurement. Difficulties arose because of widespread lack of knowledge at all levels. It is understandable that managers are not familiar with the detailed operation of a new production line, but for example, Flourco managers did not know the capabilities of the new control system, expecting far more from the plant than the design parameters allowed. Operators attended training programmes, but training needs had not been analysed. There was insufficient opportunity to work with suppliers during commissioning, resulting in limited technology assimilation. While no supply chains were in operation, respondents reported good relationships with suppliers. Discussions with some suppliers revealed their frustration with the lack of commitment and technical competence of many operations staff. This was exacerbated by skills shortages, especially in instrumentation and control.

Level 5 (evaluation and modification) is not considered in this study as none of the Level 5 items in the preliminary research were deemed to have strategic implications.

IMPLICATIONS FOR MANAGERS

The activities set out in the framework by Salami and Reavill (1997) constitute one aspect of TT. A second aspect includes other important items in TT. From a strategic perspective, the case firms were preoccupied with internal matters, and not broader factors pertaining to politics and the national economy (crime, infrastructure, and so on). Apart from Airco (which sought to improve its distinctive competency advantage over its competitors), the other cases wished to match competitors' core competences. Rather than viewing technology as a strategic resource, managers only considered the operational side. This limited perspective does not look beyond existing products, and only seeks greater operational efficiency. This agrees with much of the literature, which suggests that output,

quality and delivery are the most important aims for developing countries when acquiring new technology.

It appears from three of the cases that technology is acquired to produce more of a better product. The implication for developing countries is that this may meet the low cost demands of consumers, but that there is limited innovative thinking that seeks competitive advantage through process technologies. Operational efficiencies generally support strategic objectives in a passive and neutral way.

At Level 2, technology was instrumental in expanding strategic thinking in two instances. Airco sought distinctive competency and Foodco's extended its activities through vertical integration. The other firms used technology for operational purposes (quality and output). Technology was not selected on the basis of cost-benefit analyses because of the difficulty in quantifying benefits. Human resources were not taken into account when analysing new technology options. Managers, particularly at Airco and Plastico, did acknowledge that a degree of automation was introduced to compensate for poor operator skills, but the more complex equipment in turn exposed deficiencies in maintenance abilities and skills. Familiarisation through training was part of the solution. Suppliers felt in some instances that 'first world' technology was too complex for some 'third world' applications. While the long-term solution is a general upliftment of skills, developing countries will continue to suffer from poor education and training. Managers were adamant that if developing countries are to compete globally, their technology must be comparable to that of their competitors. Lower production costs give developing countries some advantage, but lower labour costs will not compensate for inferior quality or poor delivery and service.

Human resource considerations at Level 3 include contentious issues such as affirmative action and black empowerment, but these did not directly affect TT. Technology was selected on the basis of cost and the ability to meet output specifications. Suppliers determine the details of the technology, within overall contractual constraints, implying a passive acceptance of a supplier's technology. Knowledge was acknowledged as a valuable asset, but managers did not consider this as a strategic resource in a developing country context. Knowledge would only play a role once skills levels had been raised, and this will take years to achieve.

Respondents felt that implementation and maintenance (Level 4) were poorly managed. Supplier training during commissioning was undertaken, but greater benefits would have resulted from more extensive contact with suppliers. Acquirers underestimated the training required, and the basic education and skills of some technical staff were too low for them ever to become fully competent. Little adaptation of technology was undertaken because suppliers installed equipment as they would anywhere in the world, apart from making allowances for specific operating context requirements.

CONCLUSION

The model illustrated in Figure 1 proposes a number of strategic items corresponding to the appropriate levels in the Salami and Reavill framework, suggesting that technology decisions should take market demand into account and the importance of shifting from a product to a process technology base to achieve competitive advantage. These should be aligned with business goals, systems and technology in order to achieve strategic objectives. Analysis of technology should consider distinctive competency and vertical

integration requirements. Final selection should accommodate stakeholders to ensure effective management of the new technology.

The research suggests that operational demands rather than strategic considerations determine technology selection, with limited regard for shifting to a process base. Objectives for new technology are stated in operational rather than strategic terms, in order to achieve parity with competitors rather than a distinctive competitive advantage. Technology was not extensively used in vertical integration decisions. The main stakeholders were technology suppliers who have an essential role in training user staff, particularly as developing countries suffer from severe shortages of skilled personnel. The research suggests that developing countries do not yet use technology for strategic advantage, and that technology decisions focus excessively on operational considerations.

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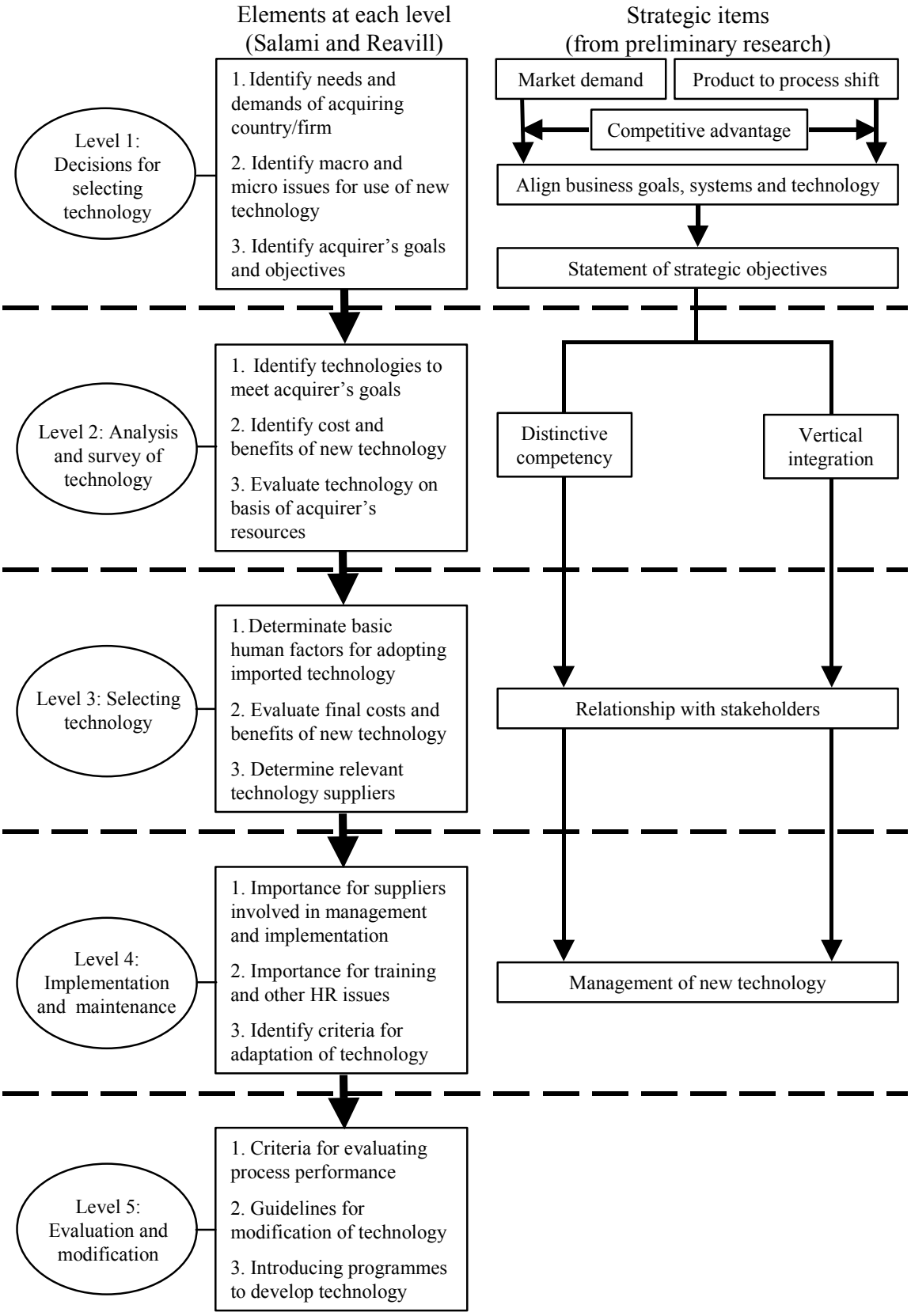

Figure 1 – Levels of decision making in technology transfer and strategic activity