Main TM activities

TM activities are abundant, but it is possible to identify a small set of processes/routines that address the fundamental and common tasks needed to manage technologies and build technological capabilities. Choosing the unit of analysis as technological capabilities, the activity name is the same as the specific technological capability it aims to develop. As shown in Figure 1.1, the general TM model is based on six generic TM activities (Gregory, 1995; Rush et al., 2007; Cetindamar et al., 2009):

1. **Acquisition**: Acquisition is how the company obtains the technologies valuable for its business. Acquisition is based on the buy–collaborate–make decision. In other words, technologies might be developed internally, by some form of collaboration, or acquired from external developers. The management of acquisition differs on the basis of the choice made.
2. **Exploitation**: Exploitation entails commercialization but first the expected benefits need to be realized through effective implementation, absorption and operation of the technology within the firm. Technologies are assimilated through technology transfer either from R&D to manufacturing or from external company/partner to internal manufacturing department. Exploitation processes include incremental developments, process improvements and marketing.
3. **Identification**: Identification is necessary for technologies at all stages of development and market life cycle. This process includes market changes as well as technological developments. Identification includes search, auditing, data collection and intelligence processes for technologies and markets.
4. **Learning**: Learning is a critical part of technological competency; it involves reflections on technology projects and processes carried out within or outside the firm. There is a strong link between this process and the broader field of knowledge management (KM).
5. **Protection**: Formal processes such as patenting and staff retention need to be in place in order to protect intellectual assets within a firm, including the knowledge and expertise embedded in products and manufacturing systems.
6. **Selection**: Selection takes account of company-level strategic issues, which requires a good grasp of strategic objectives and priorities developed at the business-strategy level. Then, the selection process aligns technology-related decisions with business strategy.

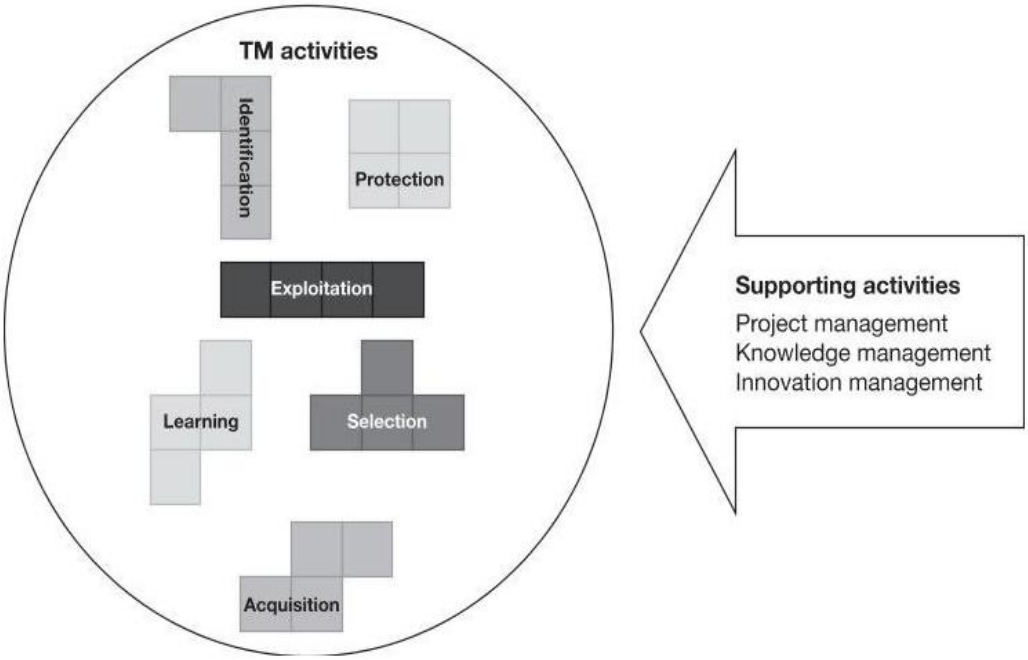

Figure 1.2 TM activities and supporting activities

Activities supporting TM

Drawing a basic framework for describing the core TM activities is useful for understanding the relationship between TM and other management activities, particularly project, knowledge and innovation management, as shown in Figure 1.2:

1 **Project management** refers to managerial activities associated with all types of projects such as product development. Each TM activity can be considered as a project, necessitating knowledge and skill to manage it.
2 **KM** is a widely used term for managing the knowledge accumulated in a company, including non-technology-based knowledge. Knowledge constitutes not only cognition or recognition (know-what), but also the capacity to act (know-how) as well as understanding (know-why) that resides within the mind (Desouza, 2005). Therefore, all TM processes are involved with knowledge at some level and they necessitate adopting KM practices.
3 **Innovation management** is involved with various innovations being financial, organizational and technological, so it naturally shares common ground with TM but it is a broader management exercise, covering the management of all sorts of innovations.

TM tools

The only comprehensive coverage of TM tools was carried out by a European Commission (EC) project published in 1998. As the outcome of this project, *Temaguide* (Cotec, 1998) had the explicit goal of explaining different TM tools, and grouped them under six headings on the basis of their functions in a company:

1. Tools for external information analysis, such as technology forecast and benchmarking.
2. Tools for internal information analysis, such as skills and innovation audit.
3. Tools to calculate workload and resources needed in projects, such as project management and portfolio management.
4. Tools to manage working together, such as interface management and networking.
5. Idea creation and problem-solving techniques, such as creativity and value analysis.
6. Tools related to improving efficiency and flexibility, such as lean thinking and continuous improvement.

most influential associations in the field of TM, four major disciplines are considered to constitute the basis for a master of science programme in a management of technology curriculum. These four disciplines show the wide spectrum of TM:

1. Management of technology-centred knowledge: management procedures associated with the exploitation of technological resources. Examples are technology acquisition, exploitation and transfer, new product development, project management, entrepreneurship, technology forecasting and planning, innovation and R&D management, KM, IP management and strategic management of technology.
2. Knowledge of corporate functions: classic business functions such as marketing, finance, accounting, operations, management information systems, human resource management and business strategy.
3. Technology-centred knowledge: topics that relate to specific technology fields or critical technology areas. Examples are information and computer technologies, pivotal and emerging technologies, manufacturing technology, petroleum and mining technology and production technologies.
4. Knowledge of supporting disciplines: important supporting topics such as national policy frameworks, economics, general systems theory, risk analysis, environmental management, ethics, human behaviour, quantitative methods, legal issues, research methods and statistics.

Deciding which tools should be in the TM toolkit is a difficult task. A recent EC study published in the journal *R&D Management* (Hidalgo and Albors, 2008) uses three criteria as the basis for selecting the tools suggested:

1. The level of standardization of a tool.
2. The level of knowledge involved in the process.
3. The free accessibility of a tool, for example not subject to any copyright or licence restrictions.

In this book, we consider three criteria as the basis for delineating the six core tools of TM:

- Simplicity and flexibility of use.
- Degree of availability.
- Standardization level.

In addition, as this book is based on dynamic capabilities, key tools should be dynamic in nature and applicable in all TM activities. So key tools will also be:

- The prevailing ones across TM processes, which capture internal and external dynamics.

Accordingly, the final list consists of six tools listed in Table 1.1: **patent analysis**, **portfolio management**, **roadmapping**, **S-curve**, **stage-gate** and **value analysis**. The initial

Table 1.1 TM tools and their applications

Tools/activities	Patent analysis	Portfolio management	Roadmapping	S-curve	Stage-gate	Value analysis
Acquisition	★					★
Exploitation			★	★		
Identification				★	★	
Learning		★	★			
Protection	★				★	
Selection		★				★

Rolls-Royce TM activities

Rolls-Royce is a leading provider of power systems and services for use on land, at sea and in the air. Its products serve civil aerospace, defence aerospace, marine industries and energy. Foden and Berends (2010) propose a TM framework driven from their exploratory interviews with the company's central technology managers as well as the survey of R&D engineers. As shown in Figure 1.4, there are six sub-processes that are aligned to the technology life cycle: (1) identification and monitoring; (2) selection and approval; (3) development research; (4) acquisition and adaptation; (5) exploitation and review; and (6) protection. The first five of these processes represent sequential stages, although several feedback loops exist, the most important being between the first and last stages. These represent the replacement of aging technologies by newer radical solutions.

The model does not directly cover learning but learning features exist in other activities, particularly in exploitation and acquisition. In exploitation and review process, the firm conducts continuous review of the ability of exploited technologies in order to continue to meet customer requirements and forward planning of more innovative replacement technologies. But more importantly, in acquisition activity, the goal is clearly set to develop capabilities of the firm that is not possible to do without learning embedded into the activity.

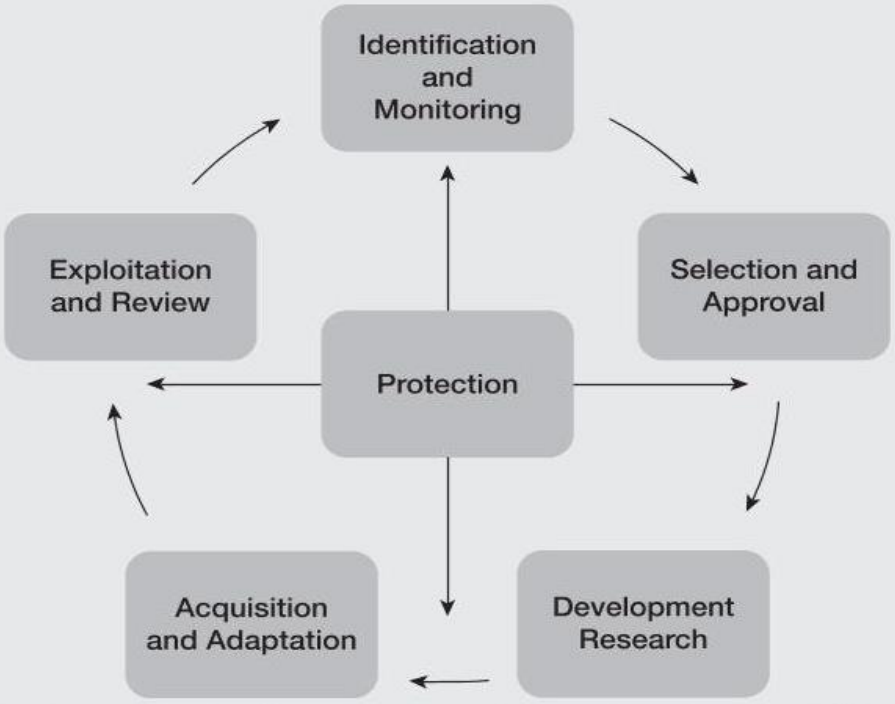

Figure 1.4 The integrated technology management framework developed for Rolls-Royce

Source: Adapted from Foden and Berends (2010), with permission.

Resources

TM is based on three groups. 'Strategic technical areas' are critical technology groups and combinations of technical skills for a particular application. They possess in-depth technical knowledge of a technology area and frequently engage with other experts (such as partners, suppliers and research centres) to explore internal and external environments. 'Product introduction engineers' lead the selection of technological solutions to satisfy new products. The final group is 'capability acquisition engineers' who own the existing technologies under study. They are responsible for technology capability acquisition by assessing the position of a technology's maturity along its S-curve/life cycle.

Tools

Effective TM requires the integration of multiple activities and tools. Examples of TM tools addressing each of the TM processes consist of the following:

Identification and monitoring: technology networking, technology watch, make-the-future (inward-facing technology opportunity identification aligned with product development programmes), technology maturity assessment (S-curve analysis), technology benchmarking.

Selection and approval: technology roadmapping

Acquisition and Exploitation: technology make-buy, capability acquisition, technology readiness scale (stage-gate).

Protection: technology risk management, knowledge base protection, IP protection.

Interestingly, these TM tools are associated not only with the activities they are used for but also with different engineering groups in the organization. Even though all tools are used with all levels of engineers and managers, some tools are used more than others by specific groups. For example, strategic technology area group is expected to use technology networking, technology watch, technology roadmapping and technology make-buy. Production introduction engineers are thought to use more of make-the-future and make-the-future selection. Capability acquisition engineers use technology benchmarking and technology maturity assessment. The tools such as risk management and IP protection are considered to be run by specialized teams central to the organization.

Source: Foden, J. and Berends, H. (2010) 'Technology Management at Rolls-Royce', *Research-Technology Management*, **53**(2), 33–42.