1.4 TM activities behind technological capabilities

Many TM handbooks consist of numerous managerial tasks that are very general and have no explicit link to specific TM concepts (Dorf, 1999). This results in no clear set of TM activities and confusion as to what technology managers need to do. This book considers

the management of technology to be a professional task, and thus it focuses on a micro-level analysis of TM. This micro-focus makes it possible to understand how firms carry out their TM activities and what **tools** and techniques are needed to carry out these activities.

The initial step is to use the TM framework and dynamic-capabilities theory to find a set of core/generic technological capabilities. The firm's knowledge base includes its technological competencies as well as its knowledge of customer needs and supplier capabilities. These competencies reflect individual skills and experiences as well as distinctive ways of doing things inside firms. In other words, capabilities are gradually accumulated through various processes, procedures, routines and structures that are embedded in practice (Rush et al., 2007). Thus, the goal in this book is to identify the various common processes/routines forming the key technological capabilities that reflect what goes on within companies. An emphasis is given to processes since the dynamic-capabilities approach emphasizes the process rather than the asset per se.

Identifying a core set of TM activities naturally does not cover all possibilities. Managers can benefit from a general TM framework and its grouping of TM activities only when they consider their firms' own particular circumstances, resources and purposes. So the purpose here in offering a generic set of TM activities is to achieve four key learning objectives:

1 The core set of generic TM activities can be customized by any organization (manufacturing or services) and is applicable at any level, such as R&D unit or business unit, as well as at any size, either SMEs or large firms.
2 Knowing the main TM activities can reduce confusion between TM and other management activities such as innovation management.
3 Linear and limited perceptions on TM activities can be replaced with a dynamic view that emphasizes the links between activities.
4 Managers as well as engineers and management students who want to pursue careers in TM can conceive what skills and knowledge are necessary to manage technology.

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.

This list of TM capabilities does not include the innovation capability for two main reasons (Cetindamar et al., 2009). First, the innovation capability is the ability to mould and manage multiple capabilities (Wang and Ahmed, 2007). The set of TM capabilities is a subset of capabilities that are integrated within the innovation system. Depending on innovation type, the required technological knowledge set and the way they interact with each other will differ as well (Tödtling et al., 2008). Second, each of the TM capabilities involves an innovative element in itself. For example, the acquisition capability is to a large degree a major innovative activity, dealing with product, service, process and organizational innovations in a company.

As a final note, the level of TM activities will change over the life cycle of a firm for many reasons, such as product **diversification** or complexities in technologies. For example, Bell's (2003) study shows that organizations pass from the point of 'acquiring and assimilating imported technologies' to reach a stage where the organization is 'generating core advances at international frontiers'. Depending on the capability requirements, firms will naturally adapt their activities to meet the requirements. In addition, depending on where a firm operates (within an advanced or developing economy), the technological capabilities of firms and their degree of development will vary considerably, as shown by the mobile phone producers operating in China (Jin and Zedtwitz, 2008).

Nonlinearity of TM activities

In the TM activities model proposed here, TM activities corresponding to each technological capability are represented as individual processes like pieces of a jigsaw puzzle, as shown in Figure 1.2. The analogy of a jigsaw puzzle aims to avoid enforcing a hierarchy of processes. It also avoids a perception that 'one model fits all', as if all TM activities must exist in an organization. It is likely that some companies will focus on particular activities at any one time, and that the set might change over the course of time, depending on the needs and circumstances of the company. Another advantage of the jigsaw puzzle representation is its emphasis on showing TM as an art, where technology managers need to identify which processes are required and find ways of making them work properly together.

The links between TM activities might not necessarily follow a linear relationship. Naturally, there will be process flows among them but it is not possible to generalize the

input–output relationships in a deterministic way. Any process might be the starting point that triggers a number of TM activities to take place. For example, in contrast to the traditional product development approach, where the starting point for concept creation is the improvement of functional benefits, it is possible to develop research, products and invention ideas from the patent strategy, regardless of whether or not there are functional benefits (Nissing, 2007).

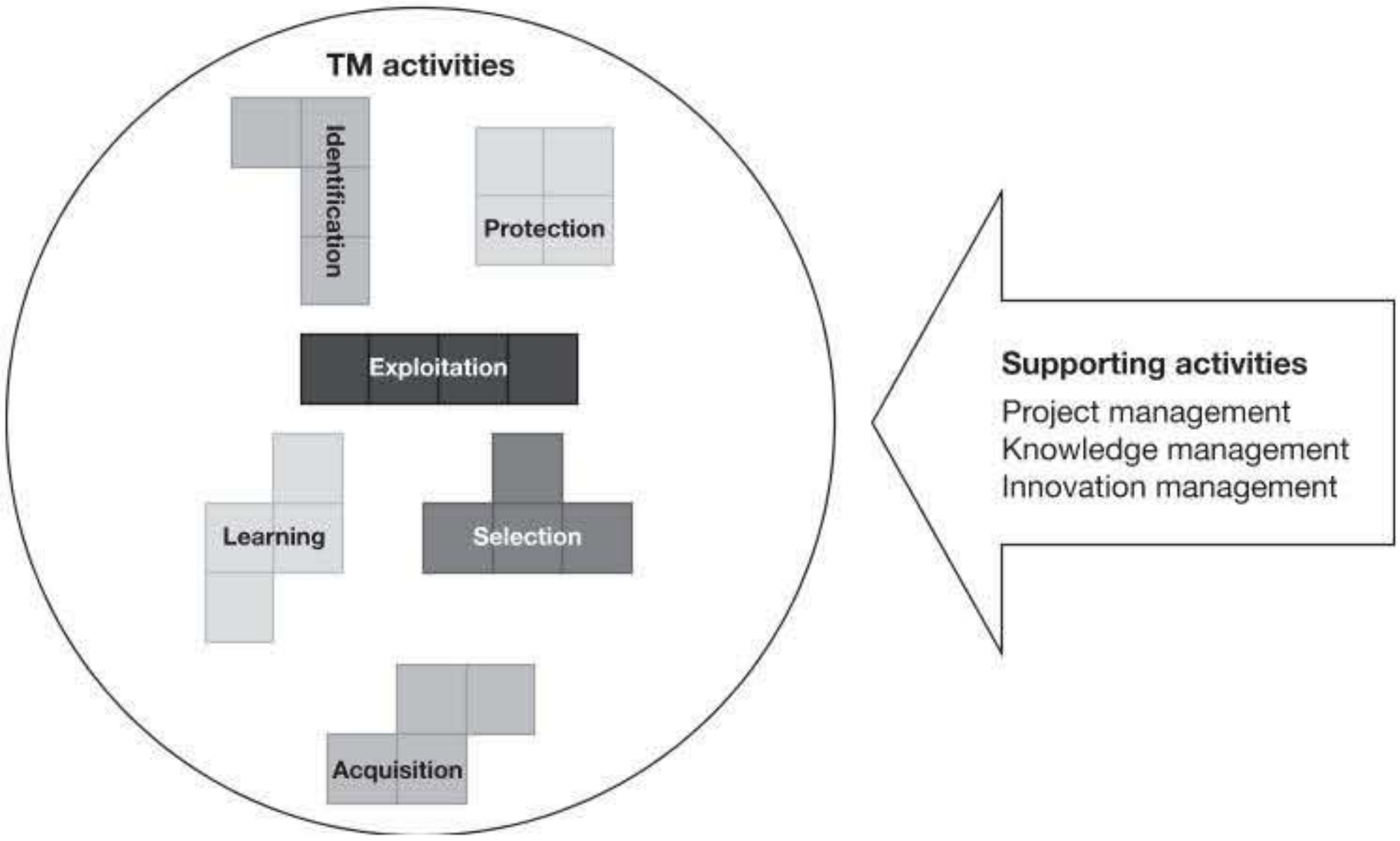

Figure 1.2 TM activities and supporting activities

The flexibility of the jigsaw puzzle concept indicates that each organization will have specific elements that show their own individual picture. If the organization is a large company with considerable R&D activity, the story/completed picture might include all elements in the TM activities model. However, if the organization has no R&D and the innovation is incremental, the corresponding activities will be different.

The recent criticisms of many innovation models focus on two critical concerns (Hobday, 2005): their static nature and their deterministic approach. The nonlinear feature of innovation activities has been highlighted. The TM activities model avoids these two criticisms at least for TM. In addition, the new model helps to draw the boundaries between different disciplines and TM activities by proposing two categories: primary/core and supporting activities, as shown in Figure 1.2.

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.

Supporting activities will vary from case to case depending on the company size, objectives and technology characteristics. For example, an SME with a few small product development projects will have different project management needs from a multinational company with multiple projects. The latter will have more structured and formal project management exercises embedded in its processes used to manage technology.