However disparate in content and method, the contributions in this book have all interpreted technological change as a process of institutionally structured learning. Supportive institutions – firms, occupations, patenting systems, governments and universities – foster the acquisition of knowledge in ways that lead to changing techniques. Learning is thus the medium of ongoing productivity increase. Not all institutions support such learning; indeed, some obstruct it. The presence, type and outcome of technological change therefore vary with the structure and activities of institutions. It is thus fitting to conclude by considering the ways institutions, learning and technological change are connected.

THE FIRM

For the innovating firm, new techniques involve several complementary activities: inventing or acquiring inventions from others, developing techniques to practicality, discovering appropriate needs, identifying and utilizing marketing methods that can diffuse the technique or its product, arranging financing, and building or adapting production facilities. Each of these activities involves learning. Moreover, these types of learning are linked. Advances in one activity can be hampered by deficiencies in others, while fostering changes in yet others. When firms are organized to accomplish this learning, they can become and remain industrial leaders.

As Chandler shows (Chapter 3), these learning processes were bound up with the birth and growth of the modern, managerial firm. The managerial firm neither was nor is the only kind of firm to develop new techniques, but it proved particularly adept at organizing the development of techniques. Its marketing innovations widely diffused new techniques or the products made with them, thereby spreading the benefits – and the knowledge – of new techniques. Its mass production techniques lowered costs and augmented sales, making full use of the possibilities opened up by the new technique. In turn, through the spread of the technique, the managerial firm grew rapidly and positioned itself for further growth.

Firms must learn how to learn; experience does not necessarily lead to learning. Lazonick (Chapter 10) argues that there are two key requirements
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for learning in the managerial firm. First, the firm must hire skilled labourers and train them in its specific technology, marketing procedures and routines. The firm must also organize to make use of employees' skills. Developing new techniques involves interaction between individuals with the right kinds of specialized knowledge, so the firm must foster communication between production, marketing and research staffs.

Feedback from the commercialization of invention plays a central part in such communication. Invention, of course, precedes commercialization, but it also continues afterwards. As Smith argues (in Chapter 5), the linear view of technological change as a one-directional process from invention to commercialization ignores critical reverse information flows. During or after the original innovation, needs can be identified that will trigger changes in the product or process. Except when technical change targets clear problems in existing processes or products, innovators cannot avoid uncertainty about future market niches. This is particularly true for major inventions; their effects, as radio and cellophane illustrate, are not anticipated until the invention has first reached the market. The communication network of successful innovators thus extends outside the firm to its customers and suppliers.

When the firm has effectively organized communication flows between marketing, research and production staffs, it embarks on several learning paths. Learning by doing, which leads to incremental improvements in the production process, depends on both management and labour. If firms overly rely on the skills of managers or on workers' self-training, they may limit their prospects for such learning. Learning by using can create knowledge of the capability of equipment which can improve equipment utilization and design. Learning by selling is another crucial path to technical improvement. When the firm has clear communication channels with its customers, overcoming initial product deficiencies becomes easier and quicker. Customers and sales staff can also help identify potential targets for new products.

Each of these learning paths gives direction to inventive activity. Learning by doing overcomes deficiencies in the flow of production. Worker involvement is especially important for reducing waste of materials, smoothing production flow and adding to product quality, as Peter Lazars demonstrated for the case of Xerox in a paper presented to the conference. Learning by using can improve equipment utilization in a capital-saving manner, as Nathan Rosenberg showed for commercial aircraft (1982). Thomson notes in Chapter 6 that learning by selling developed shoe machines to practicality, further refined them and directed attention to new machines. The interactions around sale and servicing can also lead to marketing improvements, increased scale of output and thus direct invention towards new mass production techniques.

Technological innovation spurs two kinds of positive feedback that support further invention. First, by reducing costs or improving products, it raises profits and hence potentially increases investment in innovation. Second, the process of inventing augments the innovative potential of the