Government Technology Procurement as an Instrument of Technology Policy

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Government procurement practices are known to have significant economic consequences beyond the proximate objective of acquiring commodities and services. For example, when governmental authorities place orders for products and systems that have yet to be developed, the resulting technological development work may generate benefits that spread beyond the contracting firms or their industry. That portion of government procurement that involves substantial technological change has the potential to be an important governmental policy instrument for both innovation and industrial strategy. This *government technology procurement*[1] has great potential to contribute to technological infrastructure.

This chapter develops the concept of government technology procurement and shows how government technology procurement has historically been a very powerful policy instrument in Sweden in two respects. First, it has played an innovation-policy role, triggering technical change and thus contributing to the satisfaction of social needs and solving societal problems. Second, technology procurement has played an industrial policy role through the development of new products and systems which have strengthened the competitiveness of Swedish industry.[2] Traditional government support for research and subsidies for technology development operate on the supply side, seemingly distant and somewhat disconnected from the satisfaction of immediate societal needs. By contrast, government technology procurement works from the demand side and results in specific products. This characteristic makes government technology procurement politically attractive and widely

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[1]Other terms used to describe the same phenomenon are: *user-governed technical change*, *technology-developing government procurement*, and *innovative procurement*. The defining element is that the supplier is obliged to undertake technological development work in order to satisfy the requirements of the buyer.

[2]Examples include ASEA's technique for transmission of high-voltage direct current; Ericsson's development of the AXE electronic telephone exchange system; and ASEA/ABB's development of the X2000 rapid train. These are discussed more fully below.

M. Teubal et al. (eds.), Technological Infrastructure Policy, 141–170.

accepted by the general public, by a large segment of industry, by trade-unions, and by most Swedish political parties.

Primarily, technology procurement is undertaken to satisfy a specific social or economic need through technical change. As a result, the technology base of the contracting firms is enhanced. The *protodemand* articulated by the public procurer greatly contributes to the generation of technological capability at the firm level. In the Swedish case, this market building substantially contributed to the consolidation of large multinationals like ABB and Ericsson. Government technology procurement has stimulated user-led capability creation.

The competence to specify functional characteristics of products and systems is a crucial element in technology procurement and can be considered to be a part of the technological infrastructure (TI) in a country. So can the technological capability which is generated within a specific firm as a result of the procurement process, if it becomes available to other firms as well. This technology diffusion may occur for a variety of reasons: spill-overs to other firms or to technology centers; collaboration in R&D consortia; or movement of employees between firms or between firms and public organizations.

Provided that government technology procurement is practiced in areas where there are genuine socioeconomic needs, and therefore an authentic and sustainable demand follows upon the protodemand, this competence can greatly enhance the competitiveness of national firms in export markets. Technology procurement can, in other words, be an important part of technological infrastructure policy (TIP) which stimulates user-led capability creation. Implementing government technology procurement so that it contributes to TI is not uncomplicated. Among the problems that need to be solved are:

- How is the necessary buyer competence developed?
- How can technology procurement best be organized?
- Does technology procurement imply that technology develops in different directions, or only that the process of technical change is speeded up?
- How are relevant societal needs identified and translated into functional requirements of new products and systems?

Solutions to these problems all require that the procurer has a "vision of the future" (defining needs) and can then translate this into functional characteristics (implementing the policy). Research projects that include natural scientists and engineers, as well as social scientists, can be created with such aims. Such projects could be a way to both systematically articulate needs –

what is socially desirable, technically possible, and economically feasible – and develop implementation mechanisms. This requires organizational innovations such as the creation of public organizations in which procurer competence is generated and recreated. In this way government technology procurement involves generating infrastructures which, in turn, create capabilities at the firm level and support competitiveness. Government technological procurement may also be an important element for building a technological infrastructure for specific strategic industries, although it must normally be combined with other instruments.

This chapter begins with a brief discussion of various kinds of technology policy instruments followed by the presentation of a number of historical examples of government technology procurement in Sweden. We then turn to the future of government technology procurement, including possible examples of procurement projects. Finally, practical issues which affect the implementation of technology procurement are addressed, including suggestions for dealing with problems that are likely to arise in the future.

1. Innovation Theories and Government Technology Procurement

Theories of the innovation process are often classified as being *linear* or *systems* oriented. Further, technology policies themselves can address the *supply side* or the *demand side*. A detailed treatment of the relationship between government technology procurement and theories of technological innovation and diffusion would ideally require extensive systematic treatment. In this section, we only attempt to place government technology procurement in its theoretical and policy context before turning to the Swedish case.

According to the so-called linear view of the innovation process, basic research leads to applied research and then to diffusion, including production and sale of products embodying the new technology. The resulting improvement in dynamic efficiency is thought to lead to economic growth and welfare. We now know that this model is overly simplistic and even an incorrect depiction of the innovation process, especially in regards to the causal factors which lie behind innovation and technical change. Despite this, the linear view is – often implicitly – common among research policy makers. This leads to an overemphasis of factors which operate on the *supply-push* side – at the expense of *demand-pull* side factors – of the process of technical change.

Technological change is far more complex than a sequential innovation process wherein different stages follow in a well-behaved and organized fashion. Instead, technical innovation and diffusion is an elaborate and often obscure process relying on interaction and feedback between different stages and with a great number of actors involved. Innovations can be seen as the result of dynamic, cumulative, and path-dependent processes. Both institutional and market forces are important in the systems where these processes occur. In this *innovation systems* perspective, the interactions between users and producers of new technologies are often considered central (Klein and Rosenberg 1986; Lundvall 1985; Cohen and Levinthal 1990; von Hippel 1988; Teubal, Yinnon and Zuscovitch 1991). These interactions are not limited to the mechanism of price signals as in classical market models, but also include exchange of qualitative information between a variety of agents, including users, producers, and nonfirm organizations which serve facilitating or catalytic roles in technology development.[3]

Effective design and implementation of innovation-policy instruments is critically dependent upon a correct understanding of the nature and characteristics of the innovation process. A linear view leads to innovation-policy instruments that emphasize the supply side of technology development and diffusion. Conversely, theories which are characterized by interaction and a systems-view tend to feature prescriptive instruments that work from the demand side to a larger extent. If the distinction between supply- and demand-side policy instruments is combined with a distinction between *technology development* and *technology diffusion*, we can classify technology policy instruments by the resulting four combinations shown in Figure 1 (Edquist 1993a, 55-58; Edquist 1994a).

(1) **R & D Policy**: Directing research and development activities is the most common technology policy instrument on the supply-push side of technology development. Typically this has taken the form of government funding for basic research at universities and public research institutes, or as subsidies to private-sector initiatives.

(2) **Accessing Technology**: This refers to expanding the spectrum of technologies – whether created locally or abroad – which is accessible to users. One method used in Sweden is the system of technical attachés abroad. They are located in important technologically advanced countries

[3]The *system of innovation* approach has developed during the last several years. Some contributions are: McKelvey 1991, 1994; Carlsson and Stankiewicz 1991; Lundvall 1992; Nelson 1993; Edquist and Lundvall 1993; and Edquist 1993b.

and report home to Sweden on the existence and use of new technologies, thus increasing the technological choices accessible by Swedish actors.

Figure 1: Technology Policy Instruments

	Technology Policy Instruments Operating on:	
	The Supply Side	**The Demand Side**
Technology Development	(1) **R & D Policy:** (Government Funding of Research)	(4) **Commanding Technology:** (Government Technology Procurement)
Technology Diffusion	(2) **Accessing Technology:** (Technical Attaches)	(3) **Implementing Technology:** (Government Procurement of Goods and Services)

(3) **Implementing Technology**: The determination of which technologies will be implemented is critically dependant on the market demand for goods and services. Government procurement is an innovation-policy instrument on the demand side which significantly influences the choice of technology and thus its diffusion. Examples of these influences include specification of energy sources that determine which (existing) energy conversion technologies are used, as for instance, when streetcars or subways are chosen instead of diesel buses. Government can also influence private demand indirectly through laws, taxes, and subsidies. A ban on direct-acting electric heating or higher taxes on certain energy forms obviously influence the choice between different energy conversion technologies.

(4) **Commanding Technology**: When the requirements of clients necessitate the development of new technologies, the technologies can be said to have been indirectly *commanded.* This demand-pull incentive originates from both private and public sector activities; but it is a powerful innovation-policy instrument when used by government to specifically influence technology development. Unlike *simple* government procurement which affects the choice between existing technology alternatives, *government technology procurement* also influences the development of new technologies. When undertaken systematically,

government technology procurement enables governmental authorities to use their own future demand as an instrument of TIP.

Despite the powerfulness of the demand-side instruments, technology or innovation policy is too often considered to consist only of R&D-policy, that is, public research funding.[4] This means that the supply-push perspective dominates the demand-pull oriented view of technological change and technology policy,[5] whereas it is the very interaction between demand-pull and supply-push forces which is central in innovation processes. Technology procurement is an important force on the demand side, precisely because it involves interaction between users and producers. One of its principal advantages lies in the fact that it establishes a direct connection between innovation policy and usable outcomes. Government technology procurement not only has great potential, but as we shall see in the next section, historically in Sweden it has been extremely effective.

2. Examples of Government Technology Procurement

This section presents four cases of government technology procurement in Sweden in order to illustrate the nature of the process. The cases described here deal with civilian government technology procurement, although military technology procurement is also very common in the areas of weapon systems, military aircraft, etc. The examples that follow stand out as relatively successful, although this not always the case. Government technology procurement projects may be unsuccessful for either technical or market reasons.[6] Nonetheless, the effectiveness of government technology procurement as a component of technology policy should be judged by the overall contributions that it makes to technological infrastructure.

[4]This can be traced back, at least in part, to the theory of market failures and the linear view of technical change. See Nelson 1959, Arrow 1962; and Edquist 1994a, section 3.1.

[5]If this dominance were broken it would probably become easier to integrate social and environmental elements and objectives into technology policy.

[6]Two Swedish examples of unsuccessful government technology procurement are: the TUDIS project, in which a personal computer for school use (COMPIS) was ordered; and the Tjorven project, involving a specially designed car for postmen. Outside of Sweden, one of the most famous failures of government technology procurement has been the Concord, the civilian supersonic aircraft. After the development of the plane, initiated by the French and British governments, market demand proved to be too low for successful commercial production of the aircraft.

Two of the cases involved ASEA,[7] an industrial equipment manufacturer whose main products include equipment for power generation and transmission, transportation, and other industrial applications. Traditionally, a limited number of customers in Sweden purchased the major part of ASEA's output, and many of these customers developed close relations with the producer, helping to increase the effectiveness of existing products and to develop new ones. ASEA's technological history is, to a large extent, the result of very successful interaction between the company and several technologically oriented clients requiring diverse electrical equipment. Initially, the majority of these clients were private Swedish companies – electrical power producers, steel works, paper producers – and later also included foreign companies. Two government clients, Vattenfall and Statens Järnvägar, became key partners in ASEA's development of new technologies, and their cases illustrate the potential gains from government technology procurement (Glete undated; Fridlund 1993).

2.1 Vattenfall and Electrical Power Transmission

During the period 1930-1950 ASEA and Vattenfall collaborated very successfully. At the time ASEA produced mainly for the domestic market and was not exposed to especially strong competition from abroad. ASEA's technological advances during this period are, to a great extent, explained by the demands of their Swedish customers who were increasingly requiring technologically improved equipment; Vattenfall, the largest producer of electric power in Sweden, was one such customer. The company had as its task the exploitation of Sweden's substantial waterpower resources, located mainly in the north. Since most electricity consumers were in central and southern Sweden, this created a need for safe and effective systems of power transmission over very long distances. In order to solve this problem Vattenfall chose to collaborate with ASEA, the largest domestic producer of electrical equipment, in the area of breakers for high-tension current. In comparing ASEA's product with those of foreign competitors, Vattenfall discovered that ASEA was not leading. Vattenfall therefore invited ASEA to take part in a research project in order to catch up (Glete undated, 17; Fridlund 1993).

In 1940 ASEA started a development program for high-tension direct current. Although considered a possible alternative to alternating current for electrical transmission over long distances, ASEA had been unable to

[7]Through a merger with Brown-Bowery of Switzerland ASEA was transformed into ABB in 1989.

successfully develop the technology for practical use. Vattenfall became interested in the technology, seeing a possible solution to its long-distance electrical transmission problem, and the two entered into a long-term collaboration wherein Vattenfall provided the test resources and ASEA the material. The project was successful and in 1956 the first system in the world for high-tension direct current was inaugurated between the mainland and the island of Gotland. (Ironically, the system was finished too late to be used for transmission between northern and southern Sweden.)

Following World War II Vattenfall and ASEA also developed a system for high-tension alternating current at 400,000 volts, improving on the existing highest capacity system (285,000 volts). In 1953 the thousand-kilometer-long 400,000 volt line between Harsprånget and Hallsberg was put into operation. Its capacity was three-times larger than a line of 200,000 volts, with 40% lower transmission costs.

The collaboration between ASEA and Vattenfall is a classic case of government technology procurement. The development of the new technology was in response to specific long-term demands from a government authority to solve specific problems. The collaboration between the supplier and the customer had shown itself beneficial for both partners. ASEA's research and development program was adapted to Vattenfall's future demands and this client remained a faithful buyer of the new systems and products. The collaboration also contributed greatly to the generation of technological capability within ASEA and helped the firm to establish a very competitive position in export markets. These achievements gave ASEA a leading position in transmission technology which it could then exploit in international markets. During the following three decades ASEA was the world's leading producer of equipment for high-tension direct current (Glete undated; Fridlund 1993).[8]

2.2 Statens Järnvägar and Rapid Trains

Once electrification was completed in Sweden, domestic demand decreased for ASEA's power generating and transmission equipment; ASEA sought to compensate by expanding into new export areas, including the market for transportation equipment. Until the middle of the 20th century, domestic sales of rail equipment to Statens Järnvägar (SJ) – the Swedish state railway

[8]Collaboration between ASEA and Vattenfall in the field of nuclear power was not as successful. The Swedish government supported a government-owned company (AB Atomenergi) and thus the ASEA – Vattenfall collaboration did not receive any government support in this field.

company – had consisted of "old-fashioned" equipment that had been specially designed for Swedish conditions. ASEA was concerned about not being able to offer locomotives that were as advanced as those available in other countries. Following a period of research and development, ASEA succeeded in interesting SJ in ordering a light and fast locomotive. Although the design was successful, no serial production for SJ was in sight. However, the development of new diode technology made it possible for ASEA's new locomotive to be used on railway lines with different electric systems. During the 1960s ASEA received large orders for these products from Eastern Europe (Glete undated, 20-21).

During the 1960s ASEA worked on thyristors – a technology area in which ASEA was a pioneer – and offered to design and produce a thyristor locomotive for SJ. SJ ordered a prototype and also a series of finished locomotives. ASEA-SJ thus became world leaders in thyristor locomotives, which have been exported to a large number of countries. Again, the protodemand from SJ gave rise to a capability which resulted in increased international competitiveness (Glete undated, 20).

In 1978 SJ began to investigate the technical and economic possibilities for using rapid trains on existing rail lines in Sweden. Very-high-speed train technology – as for example in Japan (Sinkansen) and in France (TGV) – requires building new, straight track. Because of Sweden's low population density, the cost of massive track replacement would be too high. If Sweden were to have any rapid trains at all they would have to run on the existing tracks lines with their curves, slopes, and inclines. The technical problem was to obtain rolling stock that suited the existing rail lines while allowing higher speeds. New technology was needed.

SJ's economic calculations not only included the costs of rolling stock, but also costs for infrastructure, workshops, education, personnel, and maintenance. Other factors that were considered included quality, repair costs, and delays. This approach focused on the total or *life-cycle cost* (LCC), meaning that the notion of quality was brought into the picture. Taking into account projected increased traveling and income, SJ's calculations showed that the project would be profitable, both privately and socially (Andersson 1982, 46-47).

SJ solved part of the technical problem by developing the ATC (automatic train control) system and by supplying its lines with heavier, fully welded rails without joints. In order to "eliminate or at least reduce the centrifugal forces effect on the passengers we must slope the carriage bodies in relation to the frame with a certain angle depending on the 'over-speed' in the curve" (Andersson 1982, 45-6). However, other requirements also had to be fulfilled in order for the train to conform to the Swedish tracks (e.g., reduced axle loads and softer bogies with radially adjustable axles). A train that met these specifications did not exist; it had to be developed.

Gradually, SJ formulated specifications for a rapid train, including exacting requirements regarding size and performance characteristics. SJ provided ASEA with the following types of information:

- drawings and specifications for interiors, cross-sections, and all equipment to be included;
- performance characteristics on all technology;
- time tables and circulation plans (i.e., the production that the train should manage);
- characteristics of the railway lines including curves, track quality, and acceptable noise levels; and
- both interior and exterior design.

The intent was to provide the supplier with a clear picture of what the train was expected to accomplish and how the trip would be experienced by the passengers. The demand specification also included information on LCC in the form of a model with around sixty equations that described the cost relationships for purchase, maintenance, and operation. ASEA's top management was, however, initially not particularly interested in calculations based on LCC (Andersson 1982, 47).

Despite the detailed articulation of functional requirements, the demand specification still did not contain any definition of the technical design. It was incumbent on the ASEA to design every detail in accordance with functional requirements. The result of this technology procurement process is the X2000, Sweden's high-speed train designed and produced by ASEA/ABB, which has been operating on Swedish railroads for several years. The X2000 has become a very successful competitor to air travel in Sweden, although it has not yet been sold to any other countries.

2.3 Televerket and Telephone Exchanges

Collaboration between the telecommunications equipment producer, Ericsson, and Televerket, the Swedish national telephone operator, started at the beginning of the 20th century. In the early 1920s L.M. Ericsson developed an automatic exchange system which proved to be internationally competitive.

This development was built in large part on experience that Televerket had acquired through extensive experimentation. From this time, Televerket and Ericsson collaborated, rather informally, in the development of telephone systems (Glete undated).

In the 1960s the two firms began joint development of electronic systems. The collaboration was formalized in 1971 by the founding of a joint development company, ELLEMTEL, to develop the electronic and flexible AXE-system. The AXE-system was first installed in Saudi Arabia in 1978 and is now used in nearly 100 countries; it developed into the most important base for Ericsson's current international competitive position. The system is so central to Ericsson's activities that the company would probably not have existed as an independent company without it (Vedin 1993). Once again, the demands of the procuring firm led to the generation of a crucial technological capability within a Swedish firm, a competence that was later used in export markets.

2.4. NUTEK: Technology Procurement with an Energy-Saving Aim

In 1991 the Swedish Parliament decided to implement a five-year program to promote more effective energy use. In 1993 the program was extended to seven years. The Unit for More Effective Energy Use, which is a part of the Swedish National Board for Industrial and Technical Development (NUTEK), is responsible for the program. The program includes technology procurement, demonstration projects, and efforts to bring new technology to the market.

An example of this activity was the procurement of a new refrigerator in the early 1990s with two specific requirements. The first was to reduce the use of freon because of its damage to the earth's ozone layer. The second was to substantially reduce energy use in the operation of refrigerators in comparison with earlier designs. A bidding contest was announced with a commitment to order at least 500 refrigerators from the company that could satisfy the procurement requirements. A satisfactory design was presented by Electrolux within a relatively short time. This refrigerator example illustrates clearly that innovation policy through technology procurement can have environmental (or other) objectives as well as economic ones.

In this case it was not a question of using the government's own demand as it was in the earlier examples. Instead support was given to the buyers, builders, and administrators of apartment buildings, so that they could influence the suppliers. It was a matter of organizing and directing customer demand.

The individual buyers' interest in better products was stimulated and combined to get the suppliers more interested. This process eliminated a part of the risks that are associated with technology development. The state agency contributed to the formulation of the functional demands and to the administration of the procurement. The product-development potential of supplying companies was, in this way, mobilized.

NUTEK has also used this type of technology procurement for other household appliances and equipment: refrigerators and freezers, washers and dryers, windows, ventilation equipment, control equipment for fluorescent tubes, and automatic-shut-off computer monitors. The primary aim of the procurement in these cases has been energy conservation.

An important difference from the earlier examples is that NUTEK – which initiated and organized the technology procurement – was not the end user of the products that were developed. This was not a case of a skilled buyer, like SJ or Televerket, which contacted a few potential suppliers in order to procure a complex product or system; instead, NUTEK's role was that of a coordinator and technical resource to facilitate the procurement of simpler mass-market products that met socially desirable specifications. This places special demands on the organization of the procurement process which will be discussed further in subsection 4.3.

In both types of procurement the technological capability is generated in one or a few firms and may remain locked in there. This begs the question of transforming firm-based capabilities into technological infrastructure (TI). The answer requires the creation of an organization responsible for making the technology capability available to other actors and associations.

3. The Policy Roles of Government Technology Procurement

The case studies in the previous section illustrate the two important but distinct roles that technology procurement has played in Sweden. First, government technology procurement helped to develop physical infrastructure systems, influencing technical development so that socioeconomic problems could be solved and societal needs could be met. This function we call the *innovation policy role* of government technology procurement. Of course, not all societal problems have technical solutions, and thus the effectiveness of government technology procurement to solve those problems is limited by political, economic, and social constraints as well. Government technology procurement has also been instrumental in the growth of major Swedish companies, contributing to their international competitiveness through the formulation of user demands that led to product development. This aspect we call the *industrial policy role* of government technology procurement.

Although these two roles of government technology procurement are very closely connected, it will be useful to distinguish between them as we explore how government technology procurement can be employed as an important element of technological infrastructure policy. The fact that technology procurement historically worked well as an innovation and industrial policy instrument does not necessarily mean that it will in the future. This section examines the types of problems that can be addressed by government technology procurement in the future, discussing both its potential uses in innovation policy and industrial policy.[9]

3.1 Technology Procurement as an Innovation Policy Instrument

Government technology procurement is distinct from ordinary market demand in three ways: the nature of the needs that are being satisfied, the direction of technological change, and the pace of technological change. When used as an innovation policy instrument, technology procurement is an effort to directly meet specific societal needs that are unlikely to be met by the market. Further, government technology procurement can stimulate the development of alternative technological paths that will expand the range of technical solutions that become available in the future. And finally, government technology procurement should shorten the rate at which new technologies are created and implemented both by early identification of specific needs and by assuming a share of the supplier's risk.

The point of departure in the application of government technology procurement must be the satisfaction of *genuine* social needs; the products and systems that are developed – and the technical change that enables their provision – as the result of government technology procurement must be targeted to solve specific problems. Although the specific targets of government technology procurement should be narrowly defined, the potential set of

[9]Annex I briefly lists a number of areas where technology procurement can be used in the future in the Swedish context. In all cases the procurement would contribute to solving societal problems while at the same time strengthen both the technological infrastructure and technological capabilities at the firm level. These examples are dealt with more extensively in Edquist (1994b).

objectives is extensive. Historically, the principal goal of civilian technology and innovation policy has been increased economic growth, but this need not always be the case. Innovation policy can certainly be used to solve environmental and social problems, as for example, promoting less dangerous and more stimulating work life or a better environment.[10] Thus, to be effective innovation policy requires clearly and distinctly formulated objectives; otherwise, the work will lack consistency and fall victim to a variety of pressures.[11]

Government technology procurement should ultimately provide something the public "wants", but which it is unable to articulate effectively through the market. What distinguishes the needs being fulfilled is that they require *intermediation* and *interpretation* by a political process, and that the solutions must then be specified and "translated" into functional requirements. In this process the future users ought to play an important role. In this respect government technology procurement supplements ordinary private demand. It differs in that the perspective can be more long term; qualitative information can more easily be exchanged between buyer and seller; and the supplier's risks can be reduced by guaranteeing markets for the resulting products or services. The buyer simply creates incentives for the supplier to invest in the development of new systems and products. As we saw in Figure 1, these incentives come from the demand side.[12]

Given that government technology procurement results in some specific technological outcome – say for example, the development of energy efficient refrigerators – questions arise whether the policy has influenced the direction of technical change (would the innovation have come about as the result of market forces) or whether it has influenced the speed of technical development (how much sooner was the innovation introduced than it otherwise would

[10]That innovation policy can have noneconomic objectives is evidenced by the long and substantial history of defense-related government intervention in the process of technical change. Such policies have by no means been governed by goals of economic growth or increased competitiveness, but rather by national security, military strength, and independence objectives (Edquist 1993a, 19).

[11]Clearly articulated objectives are also necessary for effective evaluation in order to decide if the policy has been successful or unsuccessful (Edquist 1993a; 19).

[12]This does not exclude the possibility that the initiative to technology procurement in certain cases can come from the potential supplier. Neither does it preclude the use of supply-side policies – as for example, financial support for the technology development itself – in coordination with the demand-side use of government technology procurement. The distinguishing characteristic here is that the expected result of the procurement must nevertheless be the satisfaction of a specific need or the solution of a well-defined societal problem.

have been). Successful government technology procurement influences firm behavior in a nonmarginal way by creating incentives for firms to try different ideas. If the direction of technological change is substantially affected, then in an evolutionary theoretical perspective, technology procurement leads to increased technological variety and the development of additional *technology paths* that would not have otherwise been available. If a part of this increased technological diversity survives the internal firm and market selection, then government technology procurement has effectively added new technological choices to those already existent. In turn, these new paths can give rise to further innovations that would not have been possible otherwise. In this way, government technology procurement may accomplish the realization of technological change that far exceeds the specific shift in technology induced by the policy. On the other hand, even if government technology procurement only accelerates the development and diffusion of new technologies, its impact may be felt far into the future through its effect on the rate of economic growth.

The extent to which government technology procurement in practice can influence the direction and pace of innovation and technical change is difficult to determine with precision, requiring detailed empirical studies that are beyond the scope of this chapter. Nevertheless, casual observation of one of the most famous examples of government technology procurement indicates its potential impact on the direction of technical change.

Space technology would never have developed without government orders. Enormous efforts to "put a man on the moon", among other things, led to the realization of a new technological trajectory. This in turn led to new innovations that are used outside of space activities, for instance, certain types of integrated circuits and Gore-Tex clothing. In principle, there is nothing that precludes such grandiose efforts from being employed to solve environmental problems among others. This type of innovation policy would influence the character of innovations and the direction of technical change.

3.2 Technology Procurement an Industrial Policy Instrument

We next turn to the question of how government technology procurement can promote industrial competitiveness by generating technological capabilities within firms. Previously we saw examples of technology procurement strengthening the competitiveness of Swedish companies: ABB's high-tension current-transmission system and Ericsson's AXE-system. A general form of the argument was expressed in a report published by the Swedish Academy of Engineering Sciences in 1982:

> Technology procurement which is correctly implemented means an indirect support of the development capacity of industry, often more to the purpose than other forms of public support to the development of industry. The industrial capability generation which technology procurement implies, can have large industrial policy significance as a basis for export production, etc. (IVA 1982, 6)

The phrase "indirect support" implies that strengthening the competitiveness of Swedish industry has not been the primary objective of technology procurement. The primary purpose of government technology procurement has been *innovation policy* rather than *industrial policy*; regardless, the implications for industrial structure and competitiveness can be substantial. The crucial element of government technology procurement that makes it an important tool of industrial policy is that it exposes the industry to demands to do something new. If firms can fulfill these demands they can gain a competitive advantage in international markets.

It is crucial that the procurement involve a substantial element of competition among potential suppliers. The requirement for competition is usually met where the procurement takes place through open – and even international – bidding. If orders are given to a single company with whom the supplier has a long-term relationship, there is a risk that the procuring firm becomes "locked" into a collaborative arrangement which leads to the development of inferior products and systems. In such a case, technology procurement may fail in both its innovation policy and industrial policy goals. Neither should procurement be restricted to host-country firms; rather, for the sake of efficiency, bids must be solicited from abroad as well. Since successful industrial policy necessitates that the products that are developed meet international standards in order to be competitive in other countries, this element of international competition creates a necessary and effective pressure on potential domestic suppliers.

When the submission of bids is genuinely open and international, orders will sometimes go to foreign companies. If neither the development of the technology nor the resulting production take place domestically, it may be argued that the procurement failed in its national industrial policy function, although it may still be successful in its innovation policy role. Historically though, government procurement orders tend to go to domestic firms, even when bidding is international; this has most often been the case in Sweden. This is natural on account of the importance of geographic, linguistic, and cultural proximity as well as due to the existence of networks of long-standing relationships between suppliers and users. One mechanism that tends to favor domestic firms is the fact that firms active in Sweden are most likely well informed about plans in the earliest stages of a procurement process. There is, therefore, reason to believe that despite internationalization of bidding, a large part of government technology procurement will continue to be filled by domestic firms.

Once procurement becomes "national" (Swedish) in this sense, its indirect industrial-policy function operates through several mechanisms. First, government technology procurement promotes a structural transformation of national (Swedish) industry as the newly developed systems and products lead to new economic activities. Second, these newly developed products are often (almost by definition) characterized by a high R&D intensity. Hence government technology procurement can change the R&D-intensity of industrial production. High-technology sectors are usually characterized by higher productivity, higher productivity growth, faster market growth, and even higher salaries, in comparison with industry as a whole (Edquist 1993a, 44-45). This is a very important objective in Sweden since the R&D intensity of Swedish industry is considerably below the OECD average and decreasing (Edquist and McKelvey 1994).

Thirdly, technology procurement leads to increased demands for a highly skilled and technically trained labor force. In this respect, technology procurement accordingly promotes structural change towards an economy which is characterized by high productivity, high qualification demands, and high salaries.[13]

Therefore while at the same time that technology procurement presents interesting possibilities for solving specific social or environmental problems, it also creates opportunities for changing the structure of industrial production with respect to product attributes, technological intensity, and employment characteristics. This process of structural transformation creates important technical capabilities at the firm level which serve as an important basis for international competitiveness. As part of an technological infrastructure policy,

[13]It can also be shown that technology procurement often leads to more jobs, thanks to investments in new activities and new production. This means new employment if the new product does not functionally replace an old one which demanded more labor for its production and – in the case of an investment good – if the investment good does not save more jobs when used than were needed for its production. The ability of product innovations to create jobs distinguish them from process innovations. The very complex relations between different kinds of innovations, productivity, and employment is investigated in Edquist (1993c).

government technology procurement thus contributes to the increased competitiveness of Swedish firms.

4. Technology Procurement in Practice

Having examined the theoretical and policy implications of government technology procurement, as well as having described several cases, we now turn to the practical matter of implementing government technology procurement as part of a coherent technological infrastructure policy. We examine issues of timing, functional requirements, buyer coordination, developing buyer competence, organization of design work, and issues related to internationalization

4.1 The Phases of Technology Procurement

Because the development of new products and systems is often very time-consuming, government technology procurement is normally a long-term process. Often the process continues over several election periods, making it vulnerable to political determinations regarding continuation or termination of the project. The long maturation process also leads to the risk that the boundary between the purchaser and the supplier becomes obscured, a situation which is problematic for the management and control of the procurement process.

These factors advise the conceptual partition of the process into phases, from the formulation of the product-concept that embodies the technology to the ultimate delivery of the product or system. The purposes for dividing the procurement process into steps include controlling costs and estimating (and distributing) risks. It is most convenient to divide the technology procurement process into four phases:

- study phase,
- project phase,
- design phase, and
- production phase.

Of course, certain time overlaps can occur, but the sequence is useful (Linder 1982, 7).

During the *study phase* the need to be satisfied or the problem to be resolved by the procurement is identified. At this point the specific objective is articulated through the identification of the function which the system or product is to perform. During the *project phase* this function is specified. This function specification must be done very thoroughly. During the *design phase* the solution is worked out in detail and a prototype is often produced. Finally, serial production follows during the *production phase*.

A clear distinction must be made between the first two phases and the last two; the buyer must be responsible for the identification of needs and specification of the functional demands while the supplier takes responsibility for product development and production. These two roles must be clearly separated from each other.

4.2 Functional Requirements and Buyer Competence

Technology procurement requires that the buyer can clearly identify the need to be satisfied or the problem to be resolved by the procurement; the objective of the procurement must be clear. With this condition as a starting point, the buyer must be able to formulate and articulate his requirements concerning function and performance characteristics of the product, equipment, or system being procured. The needs to be satisfied consequently must be translated into functional demands and these clearly communicated to the supplier.

In government technology procurement the functional requirements are formulated by the national, regional, or local public purchaser. As illustrated in the case of Sweden's X2000 rapid train, the formulation of these specifications and functional demands can be extensive and very detailed. This is especially the case if the specifications include the requirements concerning real operating conditions and focus on the total or life-cycle cost, an approach which is becoming increasingly common because of its substantial advantages. It is thus important that the buyers are knowledgeable and exacting, capable of formulating precise and rigorous functional requirements. At the same time, these requirements must not become so detailed that the buyer does the design job himself.[14] In other words, *buyer competence* is absolutely central.

It is by no means self-evident that government organizations have the necessary buyer competence which is needed to formulate the functional demands. This is especially the case if the buyer is a small unit or if procurement of the specific commodity is uncommon for the buyer. These problems tend

[14]It can sometimes be difficult to find engineers who understand the importance of formulating specific functional demands, but avoid doing the design work themselves, i.e., provide the solution.

to be greater for local and regional administrations than for large national government agencies. This can require coordination between buyers, as discussed in the following section. At the same time, this problem also argues for systematically developing buyer competence, as will be discussed in section 4.4.

4.3 Buyer Coordination

Different types of government technology procurement call for different organizational forms. These organizational forms can revolve around development work (see section 4.5) or the initiation of the procurement process, i.e., the demand itself. Here we address coordination of potential users.

As has already been mentioned, procurement tends to be more difficult when buyers are fragmented. The simplest case is when the procurer is a large government agency (e.g., SJ or Televerket), while problems are the greatest when end users are individual consumers. Intermediate cases include county authorities and municipalities. There are strong reasons to coordinate procurement for intermediate-size buyers. This could be achieved through existing organizations such as the Federation of County Councils and the Association of Local Authorities. Further initiatives can, however, be justified.[15] Increased coordination between the technology procurement of various county councils could lead to exciting developments in the field of medical technology, for instance. Alternatively, more temporary coordination forms can also be useful. For example, the many medium-sized (around 100,000 inhabitants) cities in Sweden which are interested in an energy efficient and environmentally friendly system of passenger transportation could create a temporary organization to prepare and carry out a procurement project.

Earlier we saw that the NUTEK-organized procurement of energy-efficient technology was largely a matter of coordinating many small and fragmented end-users who individually neither represented a large enough demand nor possessed enough buyer competence to initiate a technology procurement process. NUTEK's coordination was a necessary precondition for the procurement. There are certainly many other opportunities where similar organizational forms can be developed and applied to other areas of technology development.

[15]The County Council's fund for technology procurement and product development (LFTP) has existed since 1982, but the problems with getting a coordination between different county councils have shown themselves to be rather large.

The observation that fragmentation of organizations leads to technology procurement being more difficult has significant import for current Swedish policies of decentralization and privatization. For instance, when the National Swedish Board for Public Building is organizationally split into several separate companies and regions, technology procurement is made more difficult. The same is true for the transformation of state-owned agencies into companies, as has been taking place in Sweden in the early 1990s. This can mean that the boundary between state and private activities becomes blurred within many areas, complicating the distribution of responsibility regarding planning and implementing technology planning efforts which are motivated by long-term societal interests (Andersson et al. 1993, 68)

Similarly, by transforming the state agency Televerket into the company Telia, the government no longer has a natural coordinator for the continuous build-up of Swedish infrastructure in the field of information technology. There are also plans to transform the Post Office (Posten), the State Railway Agency (Statens Järnvägar), and parts of the road works (Vägverket) and rail works (Banverket) agencies into companies. This has diminished the strength of the public sector, a tendency which will continue as long as the process of privatization continues. This process will weaken the capacity to pursue a far-sighted and long-term government technology procurement policy with the dual objectives of solving societal problems and indirectly strengthening Sweden's competitiveness.

Government technology procurement as part of a technological infrastructure policy requires forceful public actors who can identify needs, formulate demands, and thereby influence technical change. An active technological infrastructure policy which includes government technology procurement as an important tool, thus requires either a break in the trend toward decentralization and privatization, or an alternative strategy that would establish new procurement coordinating frameworks. One area where such an organization can be justified is in infrastructure for information technology. In this field Televerket once had over-arching responsibility, which it applied in a visionary and well-administered fashion, as evidenced by the initiative to collaborate with Ericsson on the AXE project. Though the need for long-range and visionary planning is even greater now, it is being neglected because no institution has been assigned the responsibility.

These examples demonstrate that user coordination and other organizational aspects of technology procurement are important components of a technological infrastructure policy. The specific conclusion in the case of Sweden is that some type of coordinating organization with responsibility for creative long-range planning and pilot projects ought to be created.

4.4 Support for Development of Buyer Competence

We have seen that the existence of buyer competence is a precondition for effective government technology procurement. Generic procurer competence can greatly enhance technological capability at the firm level and thereby strengthen competitiveness of firms. Government's role in supporting the development of these competencies is an intrinsic part of a technological infrastructure policy.

There are several ways in which the government can support the generation of procurer competence. The most direct is to subsidize the employment of competent engineers in those public administrations and agencies which carry out technology procurement. A similar approach is to require every such organization (government department, regional or local administration) to appoint a person to be responsible for technology procurement.[16]

A third way to support the development of buyer competence is to systematically educate those who are responsible for technology procurement in the various public administrations. Such training is important, since lack of appropriate project leadership is often a limitation to well-planned technology procurement. A large part of this education can consist of diffusing the experience and knowledge from those public administrations that have successfully undertaken substantial programs of technology procurement.

The organization of research projects as part of the study and project phases of technology procurement is a fourth method of developing of buyer competence. These projects could focus on special "needs and technology areas" that have previously been identified as having exceptional potential for technical, social, and economic achievement (see Annex I for examples). Targeting specific needs or problems which could be satisfied or solved by technical development, such projects should ideally include interdisciplinary research teams and operate over relatively long periods. The interdisciplinary composition – including behavioral scientists, economists, engineers, natural scientists, and innovation researchers – is critical for synthesizing the social and technical aspects of technology procurement. The long-term nature of the research projects is essential for participants to develop their own long-term perspectives for identifying needs and potentials.

[16]Technology procurement must then be separated from procurement of standard products.

Drawing on the diverse expertise of the professional staff, the research projects should investigate a wide array of issues, including questions of what products and systems are socially desirable, technically feasible, and economically viable. The results should form the basis for the formulation of specifications and functional requirements. By explicitly anticipating future needs, research will be directed toward identifying how industrial competence can be developed to satisfy those needs. The long-term perspective implies that those involved in the project can – and should – consider factors which normal market actors disregard.[17]

Representatives of potential suppliers should not participate in these research groups since competition between potential producers is a necessary part of government technology procurement. Too close a relationship between potential suppliers and those involved in the specification of the technology to be procured is undesirable from both the innovation policy and the industrial policy perspectives. On the other hand, having mentioned the advantage domestic firms may have due to the existence of national networks and early access to information, it may be justified to strengthen this advantage by inviting potential domestic suppliers to take part in reference groups of the research projects. However, it is critical that potential suppliers not be given influence over the project, and that open competition in bidding not be compromised.

Conversely, potential users ought to be encouraged to take part in the research projects. While during the identification of appropriate areas for preparatory research projects needs and problems ought normally to have the initiating role, nothing should stop industry representatives or researchers from suggesting projects themselves. The key criterion is that needs and potential technological solutions are matched in the process.

4.5 Organization of the Development Work

When the objective of the procurement is clear and the functional demands clearly specified, the product or system can be developed and designed. When it concerns the organization of the development phase, there are reasons to show openness and flexibility. It was earlier argued that the design phase

[17]Government intervention shall always be a complement to the market and never replace it. Intervention can only be justified if the result can be expected to be better with it than without it. The division of labor between markets and governments is discussed in detail in Edquist (1994a).

should be clearly separated from the formulation of functional requirements. In the simplest case the supplier develops the product on the basis of the functional demands, but still completely independently. However, when the expected product or system is complicated, it is advantageous for the design phase to also be clearly separated from the production stage. The end result of the design phase should then be a functioning prototype.

In the cases of high-tension current transmission and rapid trains the organization of the procurement was relatively simple; the buyers and the suppliers simply negotiated with each other. However, each individual procurement project requires its own suitable organizational forms. For example, in the case of AXE, a joint company (ELLEMTEL) was created, despite the fact that the procurement involved only one purchaser and one supplier. ELLEMTEL is an example of a specially modeled organizational solution. The case of NUTEK and energy-saving technology procurement of refrigerators illustrates a more complicated specially modeled organizational solution where the role of the government agency was to be a catalyst and a coordinator of potential users.

4.6 Technology Procurement, Internationalization, and European Integration[18]

It is often alleged that government technology procurement is becoming increasingly difficult because of the ongoing processes of internationalization and European integration. From the perspectives of both innovation policy and industrial policy, this claim is unwarranted.

Since its entry in the European Union in January 1995, Swedish public procurement has been subject to new regulations. In principle, these changes make Swedish procurements of substantial size more open to European suppliers.[19] The purpose is to increase competition and thereby reduce prices.

[18]This section is partly based on a conversation with Hans Sylvén at the Swedish Committee for Technology Procurement.

[19]Specifically, every procurement tender which is larger than 1.9 million Swedish crowns and all construction projects larger than 47 million crowns must be announced in the EU's Supplement to the Official Journal of the European Communities. Bids can be received within 52 days and the advertisement in the journal must be written in one of the EU's nine official languages. The procurer can, however, request that the bids shall be rendered in Swedish. In Denmark the request that the bids be rendered in Danish has lead to considerably decreased interest from foreign suppliers. In many EU countries – especially in southern Europe – a practice has developed not to follow all of the EU rules in detail.

According to various estimates it is expected that local Swedish authorities will be able to save 10-15 billion crowns per year as a result of these new procurement procedures.

Previous Swedish laws on government procurement (i.e., requirements for procurement on business lines, for competition, and for nondiscrimination) remain in effect. With regard to basic principles, the differences between the two regimes are not especially great. On the other hand, the new rules have changed the forms for procurement and have enlarged the category of procurement units to which the rules are applicable.

With regard to government technology procurement as an *innovation policy* instrument, the EU rules are only an advantage. Their effect is to increase the number of potential suppliers, as well as to strengthen openness and competition among them. This can only enhance the ability of government technology procurement to satisfy societal needs and solve specific problems.

The effects of the new procurement rules on government technology procurement as an *industrial policy* instrument are more complicated. As noted earlier, technology procurement as an industrial policy instrument requires openness in tenders and competition between potential suppliers, including foreign firms. The procurement law therefore forbids that Swedish-controlled companies are favored intentionally in government procurement.[20] The law also prohibits requirements from the buyer that a foreign supplier shall carry out the development work or the production operations in Sweden.[21] This however does not prevent the foreign bidders from offering to carry out production in Sweden. To the extent that the new rules enhance the relative competitive position of non-Swedish EU firms in Swedish technological procurements, the industrial policy role of those procurements is diminished.

Recall though, that we previously argued that it can be expected that Swedish suppliers will naturally be overrepresented in Swedish government technology procurement. To the extent that this advantage is not completely overwhelmed by the increased openness to foreign bidders, this means that technology procurement can still function as an industrial policy instrument from the Swedish point of view.

[20]This, however, does not apply to technology procurement of defense material which involves the country's security and which does not have any civilian use.

[21]Since the Swedish law is general, it even concerns non-EU suppliers. This means that procurers in a country outside the EU – e.g., the U.S. or Japan – can demand that Swedish suppliers carry out local production there, but that Swedish procurers can not require the same from a company controlled from that country.

Additionally, the law even allows indirect discrimination of foreign companies in a number of ways. As mentioned earlier, it can be required that the bid be rendered in Swedish. Similarly, the entire detailed basis for the bid (demand specifications, technical descriptions and other conditions) can also be provided in Swedish. It is also possible – and even natural – that information from the buyer is given selectively before the formal procurement process begins. Swedish procurers can, for instance, inform Swedish manufacturers of their plans for the next three or five years.[22] Another compensating advantage is that employees sometimes move between Swedish authorities and Swedish companies. Specialists in different government agencies and companies are also inclined to exchange information informally. These are natural processes and underscore the argument that domestic manufacturers are often favored in government technology procurement.[23]

Government technology procurement can thus continue to be an important industrial policy instrument at the national level in an integrated Europe because of the geographical and cultural closeness between domestic procurers and suppliers. In light of these observations, we conclude that the rules that are associated with EU membership will not significantly decrease the potential to use government technology procurement as either an innovation or industrial policy instrument. The earlier Swedish rules did not constitute an obstacle for effective government technology procurement and neither will the new ones.

However, it appears that many European Union countries are currently too small for handling technology procurement in certain technological areas. For example, there is no need for 15 rapid train systems or commercial aircraft designs in Europe. There are, therefore, strong arguments for using technology procurement at the EU level. If the EU, in this way, is seen as one unit, technology procurement certainly has the potential to serve as an innovation policy and industrial policy instrument for the community as a whole. Earlier experience at the national level is of great value in an attempt to develop such a new policy option for the EU.

[22]On the other hand, a procurer cannot advertise in any other journal than Official Journal before the same day as the advertisment is sent to this journal. The Official Journal has to publish the advertisement within 12 days. Normally it is published within 5-6 days. Swedish bidders can thus have an advantage if the buyer advertises in a Swedish journal at the same time as the announcement is sent to Official Journal.

[23]In addition, procurement within the water, energy, transportation, and telecommunications sectors are subject to special rules, implying that domestic suppliers can be favoured to a larger extent. These sectors account for a large part of the government technology procurement.

5. Summary and Conclusions

What roles the market and the government respectively ought to play within innovation activity varies between countries, regions, sectors, and functions. In this chapter we have discussed how state, county, and local authorities can use their orders for products and systems to influence innovations and technological change through government technology procurement. We have shown that the government activities can be used powerfully and to long-term advantage in this respect.

Through technology procurement the government sector plays an important industrial policy role by providing important support to the development of the competitiveness of Swedish companies. The government sector can also play an important innovation policy role by using its demand to influence technological development so that it can help to satisfy important societal needs, by solving, for example, environmental or social problems.

The competence to specify the functional characteristics of products and systems and the technological capabilities which are generated as a result of government technology procurement can be considered to be important parts of the technological infrastructure (TI) in a country. The protodemand which the public procurer articulates has had a market-building effect. This requires, though, that the procurer has "a vision of the future" and can translate these into functional characteristics. This may require organizational innovations, whereby the government creates public organizations where procurer competence is generated and recreated. In this way government technology procurement involves generating infrastructures which, in turn, create capabilities at the firm level and support the competitiveness of firms. Technology procurement can, in other words, be an important part of a technology infrastructure policy (TIP).

Annex: Possible Future Procurement Projects

- Infrastructure for information technology: information superhighways.
- Interactive television systems.
- IT-based security alarm systems for elderly and disabled.
- "Electronic assistants" for intellectually retarded people.
- Energy-effective and environmentally sound urban traffic systems.
- "The clean car".
- Systems for renovation of old apartments and houses.
- Systems for renovation of old water and sewage networks.
- New energy conversion technologies.
- Software for administrative systems.
- Specific kinds of medical technology.

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