Chapter 2
The Art of Defining, Pricing, and Marketing Advanced Multidimensional Products that Spill Technology

Advanced engineering products such as aircraft distinguish themselves by a number of characteristics. Most obvious is that they are complicated as products to develop and manufactured under very complicated circumstances. They have also been designed to be robust, safe, and capable of operating under extremely demanding conditions, and to still have a very long life. This means that the purchase price of the product is only a part of the total user cost over its life cycle. The value of these products to the user furthermore, is larger, the more cost-efficient repair and maintenance features that have been built into them, and the easier they are to service and modernize. Hence, the value of the product to the user should be based on the user value and the cost of the user services it delivers over its long life cycle. Producers of such advanced products have also begun to follow the logic of this characterization, changing the property rights characteristics of their product; they increasingly own it and sell their services; hence, minimizing lifetime cost for the same use of the product and maximizing their net income of the product by postponing some of the charges to later stages of product life, and the aftermarket of servicing and updating the product.

Some military products such as aircraft, however, take so long to develop that considerable financial commitments and risks cumulate between initiation and delivery. Payments are therefore normally made in installments as defined milestones are passed. Also this changes the ownership characteristics of the product.[1] The military customer therefore owns an increasing part of the product as its development edges closer to final product and delivery. Also this early involvement in the design and engineering process means that the lifetime cost of the product to the user is being considered and minimized already in the product design.[2] In both cases, the customer is normally intimately involved in the product design and often contributes significant user knowledge, thereby directly influencing the definition of the product.

Civilian procurement of aircraft and aircraft engines and of other complex systems products with a long life has increasingly adopted a similar ownership logic. For the same reasons as in military procurement the large development risks and financial demands are forcing the large commercial aircraft makers Boeing and Airbus and aircraft engine makers GE, Pratt & Whitney, and Rolls Royce to demand significant risk sharing and financial contributions of their subcontractors

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(see further Chap. 5). The role of the *competent customer in shaping new technology* development therefore must be addressed in any analysis of economic growth, and, as we will see, the changing relative roles in that respect between public and private customers have to be specially considered.

In general, I argue, there will be no more sophisticated products developed than there will be customers who understand the usefulness of the products and are willing to pay for them. As concluded already by Burenstam-Linder (1961); *a sophisticated and wealthy customer base represents a competitive advantage*[3] *of the economy.*

Economic and political commentators have often neglected these positive industrial externalities of defense production altogether.[4] This neglect of well-established facts to a large extent depends on the ignorance of factual circumstances embodied in the models that economists have used for decades to structure their thinking, and to voice their opinions on. Models on industrial development that leave no room for spillovers cannot explain economic development. Hence, when the world changes and there suddenly seems to be no need for military aircraft, analysts and politicians suddenly become ready to scrap it all, aircraft and spillovers. This is one reason for presenting in this book the second and never-planned industrial role of military aircraft development and production, namely *aircraft industry as a technical university*. The magnitude and degree of sophistication of the development of a combat aircraft such as JAS 39 Gripen drives technology development over a broad range. The extreme technical requirements placed on the developers of such products are normally significantly above the current levels of competence and practice over a wide range making it necessary to solve many technical problems along the way to satisfy the customer's requirements, technical solutions that have a general application area in industry at large.

As will be seen in Chap. 6 devoted to the South African purchase in 1995 of 26 Saab 39 Gripen Aircraft and 24 BAE Systems Hawk trainer jets from the joint venture between Saab and British Aerospace,[5] the additional "procurement" of modern industrial technology (a spillover benefit) to help turn an isolated South African arms industry into a modern commercial engineering industry was an explicit part of the deal.

The role of military industry in economic development has, however, been a controversial topic. Some literature argues that the industrial wealth of Western economies would not have developed without the critical support of technologies developed for military ventures and defense.

In a fairly influential article Dunne (1990) distinguishes between three theoretical schools each of which embodies a voice of the economic significance of military production entered by assumption and used extensively to support argument in one or the other direction, two of them being decidedly negative to military production by prior assumption. *First*, the neoclassical model features a frictionless reallocation of constantly fully employed resources from one industry to another, so if you do not want or need the military products you can almost costlessly move the resources over to other politically more desired production. This pure neoclassical model is the standard of "modern" economic analysis. It ignores spillovers altogether and it is often used to argue against them. The introduction of spillovers, or positive externalities in this model already by Marshall 1890, however, was an attempt to remedy a serious shortcoming of the pure neoclassical model, a modification that resurfaced in the 1980s under the title of "new growth theory" (see below and Technical Supplement S2). All the spillover econometrics referred to in this text rests on the neoclassical assumptions.

The *second*, now old-fashioned Keynesian macromodel offers an opportunity for Government to increase total demand through increased military spending thereby raising the utilization of the resources of the economy and creating multiplier accelerator growth and more employment. Even though that model in its standard form is completely misleading in an economic growth analysis it keeps being referred to in arguments to create employment through military spending. There is also a related export stimulation argument.

Only the *third* Marxist model has something positive to say on military production. The Marxist economic model views capitalism as having an inborn tendency (a technological property) to produce a surplus the absorption of which is constrained by an insufficient effective demand for commodities. Under this theory military spending is needed to overcome underconsumption and to keep economic development going. This, so far, is also a view that Batchelor and Wilett (1998) tend to lean on through parts of their book on the defense industrial adjustment in South Africa (see further Chap. 6).

These theoretical presentations illustrate how the choice of one particular set of assumptions, or a greatly simplified model, can decidedly influence one's thinking and conclusions. This to some extent always has to be the case within academia the rationale of which is to formulate and communicate ("teach") principles, a task that requires great simplification and makes the arguments hover safely above reality. That task sets academe apart from industry, which is organized to earn a profit from developing and manufacturing goods and services that function. Industrial practice therefore has to accommodate all the complexity that is needed to achieve that.

Within most economic models there is little positive to say on a weapons industry if you don't need its products. However, two additional theoretical views that Dunne (1990) never mentions can be offered by changing the assumptions of the simplified models somewhat toward more realism. The spillover theory (*fourth*) that I will refer to extensively in the text (see further Chap. 3) is arrived at through some slight modifications of the neoclassical model, modifications based on Marshall's (1890) early criticism of the original neoclassical model and more recently embodied in growth theory. Since the mid-1980s Marshall's criticism has appeared (unrecognized, however) in what has come to be called "new growth theory." This theory introduces industrial knowledge as a factor behind economic development. The modifications of the neoclassical model needed to view the technical and industrial knowledge accumulated within an advanced military industry as a knowledge asset are minor. This knowledge asset can, however, only be expanded through further knowledge accumulation within the same industry or through knowledge accumulation in equally advanced industries. This extended neoclassical model, as we shall see, will be the methodological basis for one calculation of the spillover effects to come, and one critical factor behind that calculation is what you assume about the returns from further investments in knowledge accumulation (read R&D); Are they increasing or decreasing? (see Technical Supplements S1 and S2 and Chap. 8). The economic value of spillovers will now be seen to be potentially very large, and worth more, or much more than the cost of the original development of the military product.

But there is a *fifth* Schumpeterian evolutionary type model that I will also rely on in expounding on the spillover economics of a modern capitalistically organized market economy. This model rests on some further relaxations of the assumptions of the neoclassical model which turn the negative conclusions on military procurement upside down because of the dynamics introduced. We keep all basic assumptions of the neoclassical model, except for its technical definition of an equilibrium determined outside (externally to) the economy,[6] but the analysis now gets quite complicated (see further Eliasson 2005a:74ff).

The neoclassical model is a measurement and calculation theory that has little explanatory power when it comes to understanding the dynamics of a capitalistically organized market economy. Actors are assumed to be almost fully informed about everything that matters to optimize their economic decisions, and hence lie inactivated in equilibrium. There is nothing more of value for society to capture beyond what they know. They take prices offered in the market for given (price taking assumption). The link back to prices from changes in the physical allocation of resources is however absent. There is no place for the unpredictable entrepreneur with special insights who discovers industrial opportunities no other person has seen, and no economic mistakes are made by assumption. The neoclassical model is structured such that it can be located on an externally known (by the policy maker) equilibrium. It is therefore very centralistic in its policy advice. While this may be a required property of a calculation model for central government it does not help understanding the dynamics that goes on in the economy. Above all the analyst/planner using such a model will miss a number of factors that play important roles in the behavioral dynamics of a real economy that pop up as spillovers and explain economic growth. However, simply by removing the assumptions that make all actors fully informed and all markets constantly cleared clears the way for new insights. Then the entrepreneur and all the well-known specialist actors that are needed to commercialize innovations surface and decidedly change the framework of understanding and analysis.

Within this new model economic world that I have created the policy maker will become aware of the fact that s/he risks missing an industrial opportunity of enormous dimensions if she/he simply allows the defense industry to go.

2.1 The Pricing of Complex and Multidimensional Systems Products

The multidimensionality of advanced products is only one complicating factor. Advanced products such as aircraft also distinguish themselves by another collective characteristic, namely a "cloud of new technology" (spillovers) more or less available to external users free of charge, but only to the extent they possess the *receiver competence* (Eliasson 1986:47f, 1990a; Cohen and Levinthal 1990) needed to commercialize them. The producer of these technological services would be happy to be able to charge for the spillovers. Spillovers are, in fact, a part characteristic of the product but they cannot be charged for directly because of weak property rights, i.e., if the firm cannot come up with an *Innovative Pricing* (IP) method (Jonason 1999, 2001; Eliasson and Wihlborg 2003). In studying the production and supply of advanced products we are therefore confronted with an interesting pricing problem. Industrial participation programs, including offset trade agreements can be organized to benefit both the customer and the producer by sharing the value created from the spillovers the supplier has created. This is in contrast to the conventional view that offset trade is only a cost to the supplier.

The above characteristics of advanced systems products are usually associated with the public procurement of, for instance, military aircraft (Eliasson 1995), submarines (Eliasson 1999) or public telecommunications systems. Three circumstances, however, have made the public dimension of these spillovers more general and private. (1) Previously public, or semipublic activities, like telecommunications are increasingly becoming privatized. (2) Traditional private industry is increasingly using very advanced and complex systems products of the kind we are talking about, for instance large commercial aircraft or telecom systems. Many parts of the media and entertainment industry, large and complex private banking payment systems, internet-based trading systems and advanced, global transport coordination systems belong here. It is to be expected that the health-care industry will soon move into this category of advanced systems builders (Eliasson 2007). Products for the growing markets of civil security also belong here. The existence (3) of an advanced industry, such as a complete aircraft industry in one country therefore not only serves as a source of technological development and learning (a "technical university"). It also becomes a positive "brand" that signals the existence of competence, a brand that spills over to the entire industry of the country, that, if cleverly used allows related firms to charge extra for their own products. We will pay special attention to that possibility below.

The increased mixing of public and private goods and services production using common technologies have brought change to previously specialized customs production of, for instance, military aircraft. With common components and sometimes also common subsystems military aircraft producers are increasingly composing their products from components supplied "off the shelf." Going from tailor made inhouse components and subsystems to commoditized products from the shelf characterizes the shift from the third to the fourth generation of military aircraft, i.e., in Sweden from the Saab 37 Viggen, first delivered in 1971, to the JAS 39 Gripen, first delivered in 1996.[7] South African arms industry (discussed in Chap. 6) provides an interesting "anomaly" in this respect. Because of the UN arms embargos in 1963 and 1977 South African arms industry developed its own arms manufacturing capacity built largely on proprietary technology, own industrial standards and the need to manufacture practically all components within South Africa. This was neither an economical organization of production nor a good way to achieve internationally competitive product performance. Similarly product obsolescence will occur more rapidly because the larger costs of remanufacturing and upgrading components and subsystems.[8] South African arms producers, even though innovative and efficient in their own ways, therefore moved further and further away from the manufacturing practices that developed in the international engineering industry. An important part of the Saab South African purchase deal of 26 JAS 39 Gripen aircraft in 1995 therefore included explicit technology transfer to support South African industry in getting out of its "proprietary technology lock-in" and to adjust to modern industry standards and practices (see further Chap. 6). The new practice of commoditization means increased economies of scale for specialized subcontractors and in general a greater potential value of spillovers.

In this chapter, I define the nature of the spillover problem strictly and discuss – in principal terms – the dependence of the commercial value of the total product (the aircraft plus the cloud of spillovers) on the competence of the local industry to commercialize the spillovers and to capture the rents. In Chap. 3, I present a survey of related theoretical and entrepreneurial literature. Special attention is paid to the commercialization of spillovers and the macroeconomic consequences. A key concept emerging from this analysis is *the advanced firm as a technical university* providing educated and experienced engineers and workers to industry at large and *production technology for future engineering industry.*

Chapter 4 covers the same theme empirically in the form of a case study of Swedish aircraft industry and its ex post impact on the Swedish economy, an advanced industrial economy. I trace the origin of observed spillovers ex post, which means that they have mostly originated in the third generation 37 Viggen development program.

To isolate the spillovers from the JAS 39 Gripen project a different method has to be used, since most of the spillover flow has yet (after 2007) to be realized in the form of volume industrial activity. The only parts that we can observe with certainty are the projects that have failed or been picked up by foreign firms. In this context, I will also touch upon spillovers around foreign military aircraft industry such as Dassault and the Eurofighter project, even though no case studies have been carried out on them within this project. Chapter 5 is therefore devoted to assessing and quantifying the *future* macroeconomic consequences of the JAS 39 Gripen development program that was initiated in 1980 and that is expected to stretch into the 2040s.

Chapter 6 is devoted to a similar case study analysis of technological spillovers around aircraft industry in an industrially less-developed economy; South Africa. Here the capacity of the local economy to commercialize spillovers is in focus. South Africa is a developing economy with at places very advanced inhouse technology. South African firms, however, have a limited experience from commercializing technology. Their ability to participate in the emerging global production networks is therefore correspondingly limited. Such participation demands the use of common standards, precision manufacturing, sophisticated quality controls and the strict honoring of delivery commitments. Part of the South African purchase of the Saab JAS 39 Gripen system and the accompanying offset deals were explicitly negotiated to provide support for those conversion and commercialization ambitions. How this has been done makes up the main story of Chap. 6. We therefore pay special attention to joint customership programs in which the producer engages for a profit together with the customer and local firms in the commercialization of spillovers from its own business deal.

Chapter 7 briefly introduces the European perspective and addresses the additional benefits of public procurement in, and the macroeconomic consequences of, an enlarged European spillover pick up area. In Chap. 8 a general method to calculate the private and social benefits from industrial development programs is presented verbally, or the social and private profitability of public purchasing. I estimate the macroeconomic effects on the JAS 39 Gripen development on Swedish industry. The methods are presented and discussed in more precise mathematical terms in Technical Supplement S2 which also includes further references to the spillover literature.

Advanced public purchasing of, for instance, military aircraft has certain unique and interesting features; the product and the spillovers are produced under a regime of *joint production*. However, we also have a situation of *joint customership* in the sense that the Government (the country) is both buying the product and benefitting from the associated spillovers as a collective good. Hence, *the advanced firm* in practice functions *as a private technical university* supplying both technology and experienced labor to the economy at large (Eliasson 1996b). The book therefore concludes (in Chap. 9) with a summary assessment of the macroeconomic effects of public purchasing and advanced firms functioning as technical universities in terms of their usefulness to industry at large. In that assessment I also discuss how their academic "competitors" compare on the same terms. With public purchasing, an indirect public funding of that "private university" occurs to the extent Government pays extra for the cloud of spillovers such that a satisfactory private profitability is achieved. Government and society, however, obtain the joint product at a very low price as a partly free spillover. Innovative pricing in this case amounts to the ability of the advanced firm/producer to demonstrate credibly the value to a user or to society of the total product, to bundle the spillovers with the product and to charge for the whole package, including an extra charge for the spillovers. If this extra charge has been successfully negotiated, the producer may be said to have strengthened the property rights to the spillovers it has produced through innovative pricing. Public procurement often represents such a form of joint consumption and customership.

On the surface it may look as if the producers of advanced aircraft are selling the intangible spillovers they produce as a byproduct at rock bottom zero prices. However, if the producer can offer support in commercializing these spillovers to the public buyer (for instance, in the form of an offset trade arrangement) there would be an extra economic value creation for society. That extra value will have to be shared between the supplier and the public customer, since otherwise the commercialization support will not be forthcoming. Offset trade therefore represent a form of innovative pricing, and needs to be supported by appropriately designed incentive contracts.

2.2 The Joint Manufacturing of Products and Intangible Spillovers

Any product can be defined in terms of its (FRs)

1. User functional requirements.
   (a) Performance
   (b) Availability
2. Life cycle costs,[9] that depend on the development and manufacturing process $[(A) \times DP]$.
   (a) Acquisition costs
   (b) Life support costs for use, repair, servicing, and maintenance
3. Flexibility of product design over time (updation, modernization).
4. Intangible spillovers.

When purchasing contracts are negotiated focus is on (1) and (2). Life support costs are increasingly becoming an issue, notably in private purchasing (of, for instance, large aircraft engines) where the producer increasingly owns the product and charges for the services of its use. The more the user is involved in the product design the greater his concern about product life cycle costs. In fact, as much as 70–80% of manufacturing productivity (Suh 1990:41) is determined at early design phases. Flexibility demands of the customer (3) often are a difficult task for the producer. Since such a large part of total product costs can be reduced by measures taken at an early design stage, the costs for engineering flexibility in future product updation should be correspondingly reduced. Hence, the art or technology of simultaneously minimizing the costs of life cycle maintenance and service and of future functional flexibility must have great priority in designing products such as aircraft with a very long service life.[10] Integrated production is a method to achieve that (see Sect. 5.3).

The matrix (A) can be structured to represent the various processes that link design parameters (DP) to desired functional requirements (FRs). One point is that there are many such designs, (A)s, and the art of clever design is to know about, and know how to apply the best.[11] This principal design architecture can be further developed to accommodate built in product flexibility, when not all FRs are known initially, but can be to some extent anticipated. Holmberg (2003) has done that in a fashion that takes the design process close to the cost–benefit analyses of real options theory (Trigeorgis 1996). Holmberg (2003) has also developed Suh's search for an optimal design architecture through an iterative process where existing knowledge feeds into a concept creation process that is validated and then adds to the knowledge base, and so on.

There are two types of uncertainty associated with the development and manufacturing of an advanced product.

1. Performance up to FR (*technological uncertainty*).
2. Calculability of costs, or the control of factor prices and of the $(A) \times DP$ relationships (e*conomic uncertainty*).

If the customer desires new functionalities that require radically new technology development greater uncertainty is associated with the matrix A and (1). Normally the producer then has no method of reliable calculation. *When the producer has no information advantage over the purchaser a (technological) risk-sharing contract is the common solution*. In fact, in advanced public military purchasing, the customer is often a significant user knowledge contributor who understands the product technology and the production organization well. Once product technology (A) is under control, costs of development and production become more easily calculable. Here, the producer has the information advantage. The balance between (1) and (2) is, of course, reflected in the contract.

With much new, untested product technology and flexibility in design (that is in determining the FRs) there will be a drift toward *cost plus pricing* with a larger part than normal of the risk being taken on by the customer. Since new untested technology should be expected to spill more technology when developed, it would therefore be in the interest of a rational public purchaser to cover a larger share of the risk, since the public economic value of the spillovers would become larger.

When functional requirements (FRs) are standard, tested, and normal, calculable flexibility is asked for and we have a case for *design-to-cost pricing* or fixed cost pricing. The buyer negotiates a price for specific minimum product performance characteristics (FRs). The negotiation, or the competition, may also include what more the producer can offer at that price, for instance in the form of support in commercializing spillovers.

Various forms of *incentive contracts* define intermediate forms between the cost plus and design-to-cost pricing methods. Incentive contracts are designed to make the producer commit himself to a maximum feasible performance and to share the profit and losses with the procurer in relation to the negotiated price. Cost and delivery performance are the common benchmarks. Incentive contracts always have a bias in favor of one of the parties that depends on their relative competence to understand the technicalities and economics of the project. This is where the *competent customer* enters in his capacity not to require the impossible, but what is feasible to achieve, and some more in the negotiation. An *incentive contract* was used in an early phase of the Gripen negotiations (see Sect. 8.4).

Intangible spillovers (4) have normally been forgotten altogether even in the large and complex public procurement contracts we are studying, and are rarely entered directly into the contract, except sometimes as local employment commitments on the part of the seller or as offset trade commitments. Such commitments are, however, often inefficient arrangements for both parties to the contract, frequently unrelated to the main contract and of little long-term value to both parties.[12] Hence, the development of a rational way of calculating the costs and benefits of technological spillovers and the design of contracts that maximize the potential economic value of these spillovers to be shared by the supplier and the customer should be a prime concern for the producer of spillover-intensive products and services.

One would also expect the clever producer, facing a tough negotiation on the purchasing side to use his information advantage and accept a low price for well-defined FRs, but save on (2b) and resist demands on (3) and then capture part of the profit on later maintenance and upgrading. From the customer point of view this is, however, less efficient. The buyer and the producer could also negotiate a real option (of well-defined flexibility) at a price (see further Chap. 5).

As a rule spillovers are determined by the product specification and not negotiable (excluding offset requirements), but the less of new technology development associated with achieving the FRs desired by the customer, the smaller the cloud of spillovers. Hence, the producer might get a better deal on the (1) and (2) sides if it can give a credible presentation of the value of the intangible spillovers under (4) and offer support to the public customer in capturing the spillovers, that may be large, or very large under the right incentive arrangements. The economic value of the spillovers to society, however, is not realized until it has materialized in the form of a profitable (sustainable) production activity. To a large extent this has to be the result of entrepreneurial activities in the market and especially so for an advanced industrial economy. But for a less-developed economy (see Chap. 6 on South Africa) lacking the infrastructure of commercializing agents the producer of spillover-intensive products may find it profitable not only to offer the product itself, but also to establish production based on some of the spillovers that come with the product. *A rational and informed public customer might therefore find it socially profitable to focus on achieving spillover value (4) and pay for the support in capturing the spillovers.*

Obviously, having an information advantage the outcome for the producer/seller improves with its ability *to present a credible story on the potential value of spillovers* (4). Risk sharing and incentive contracts become optimal when each party is equally informed about the value of spillovers. For instance, the Swedish Government defense procurement agency, or Defense Materials Administration (FMV) demanded[13] that the JAS 39 Gripen consortium should get the most efficient low-cost subcontractors, thus reducing the resources available to the subcontractors to develop new technology compared to earlier procurements. Consequently contracts often went abroad to foreign subcontractors of complex components that could modify already developed components, expand volume, and capture related technologies for themselves. With one exception only the large Swedish partners in the IG JAS group (Ericsson, Volvo, and Saab themselves) were willing or able to take on the risks of large development projects and finance them internally. This also meant that the by far dominant part of spillover values were created within those firms (See Supplement 2). An interesting question to ask is how well informed about the economics of advanced purchasing the public purchaser was when it squeezed the JAS 39 Gripen consortium so hard [under (2)] that less margin than before was available for product development, and, hence, most probably fewer spillovers were generated.

2.3 The Economic Nature of Intangible Spillovers

Advanced firms are surrounded by a cloud of new technology (Fig. 1) that they have generated as part of their ongoing business, that they unintentionally spill over free of charge to other firms in related industries, and that they can only appropriate for

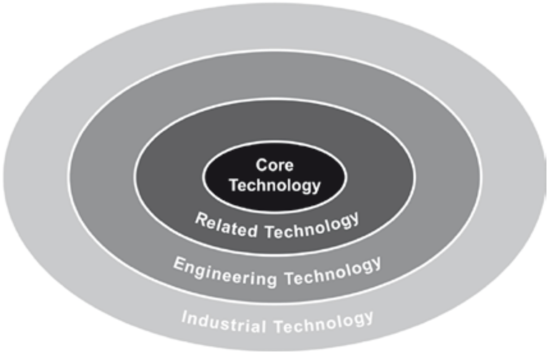

Fig. 1 The four waves of spillovers (The technology cloud)

themselves to a limited extent because there are few ways of effectively claiming the property rights to those spillovers. It can to some extent be done through bundling the spillovers with the product to be sold (see Chap. 9 on policy). The economic value of these spillovers to firms and society, however, depends on the local receiver competence, or the local ability of whoever comes by to capture and commercialize them.

2.3.1 The Existence, Magnitude, and Economic Value of Spillovers

A large economic literature documents the existence of positive production/productivity effects of the cloud of spillovers around advanced firms, most of the literature originating in the USA. Chapter 3 includes a survey of this literature. Two results from these studies should be observed already here. *First*, advanced firms in these studies practically always mean firms that have a high R&D intensity in production. *Second*, practically all studies refer to positive relationships between high R&D intensity and productivity in own and related firms estimated on North American data. For firms and industries that are spillover intensive a related econometric literature also reports on very large positive differences between social and private returns to R&D investment. Such large econometrically determined differences mean that society benefits from private R&D investments that create, in fact, very large additional economic value. Jones and Williams (1998) are quite straightforward in their conclusion that advanced industrial nations such as *the USA* for those reasons *underinvests in industrial R&D,* a conclusion earlier drawn by Nadiri (1993). And the underinvestment is large. The optimal level of R&D investment is at least, Jones and Williams conclude, two to four times larger than the current level.

A few qualifications to these results should however, be mentioned already here (I will come back to the methodological problem later in Chap. 3 and in Technical Supplement S2). I distinguish between *spillovers as the technology supply* (technological spillovers) of a R&D process broadly defined and as social value creation as the output that has resulted when the technology has been filtered commercially through a competence bloc. The US is a market economy with less nonmarket influence, such as public sector production and subsidies to firms than in most other industrial countries, including Europe. Hence, R&D allocations in those mostly North American studies have been filtered by more efficient markets and by more efficient commercializing agents than would be reflected in a similar study on continental European data (Eliasson 1996b, 2003). A selection effect therefore afflicts these results in the sense that firms that have engaged in R&D spending with positive commercial outcomes tend to dominate statistics. This is so since failing R&D intensive firms have either reduced R&D spending, contracted operations, or dropped out of the market. An increase in R&D investment therefore does not necessarily increase long-run output. The spillovers first have to be identified as economically interesting and commercialized successfully. Spillovers that have been tested in the market therefore embody both technology and the economic or commercial knowledge that have gone into those selections. Competence contributions from the customer when it comes to specifying the appropriate design of the product improve both the technological and economic content of the spillovers. Competition from several suppliers for the same procurement contract also raises both the technical performance of the selected project and lowers its costs.

The policy method to raise spillovers from R&D spending in advanced firms hence is to support competition in the local economy (Eliasson 1996b). Technological spillovers – the common term – therefore, is a misnomer. The right term should be *industrial (knowledge) spillovers*, industrial signifying a dynamically integrated combination of technical and economic knowledge. I therefore introduce the distinction between technology supply, or the spillover intensity of the cloud, on the one hand side, and the share of the cloud that is commercialized and entered as the numerator in the spillover multiplier, on the other.

Some additional results from the empirical literature should also be noted here. The strongest economic filtering of technology is to be found in the financial markets. The strongest industrial spillovers therefore originate in R&D carried out in private firms, being privately financed. Publicly funded research carried out in private firms come in second, and the lowest spillover effects are recorded for publicly funded research in publicly run research laboratories (Nadiri and Mamuneas 1994; Eliasson 1997a:241f; Hall et al. 2010). Hence the largest spillover potential is achieved when the supplier carries both the technical and economic risks, preferably in projects conducted in cooperation with an involved and competent customer. When the customer is not involved and the Government contributes funding of R&D without any demands on specific outcomes, spillover intensity decreases. The lowest spillover intensity is recorded when the public funding agency also takes over the customer role and directs R&D spending. I have no further documentation on this, but if there is any substance in these results they need further empirical inquiry considering the vast public resources, especially in Europe, that are allocated in that way.[14] This, hence, is a negative result for university research and runs against the implicit suggestions of Arrow (1962a) that (static) efficiency in research allocation will be achieved when technical research is carried out in publicly run laboratories, and the results are made public to private industry for free (c.f. the story of *Daguerre* in Sect. 8.3.2). The empirical results thus rather support the theme emphasized in this book of "*the advanced firm as a technical university*" (Eliasson 1995, 1996b). Still, *the Arrow (*1962a*) proposition* has permeated much industrial policy discussion and associated publicly sponsored R&D programs for decades, and still lingers on in some literature and in many policy institutions. This is a technology supply-based policy advice based on economic models low on economics and often devoid of market recognition.[15]

2.3.2 Receiver Competence

The value of spillovers has a collective (social) and a private part. Both depend on the capacity of actors to build a business on them.

The capacity, or *receiver competence* to commercialize technology (Eliasson 1986:47f, 1990a; Cohen and Levinthal 1990) is both technical and economic. Hence, capturing the rent depends on (1) the possibility to link property rights to the spillovers, (2) the capacity to build a business on them and/or (3) the ability to charge for them (Innovative Pricing). Patent or copy rights are the most common designs to link property rights to spillovers. Vertical integration[16] or joint ventures (items 3 and 4 in Table 1) are common attempts to control or protect property rights and the external availability of spillovers during technology transfers, and to capture the rents based on asymmetric information or knowledge. Saab has done it (see next section) through starting companies on the basis of technologies developed around its military aircraft business. Another way is to build a new division to appropriate own spillover technology and later spinning it off as a separate company [for instance *Datasaab*, see Eliasson (1998b) and Dassault Systems (based upon the Catia system from French Dassault)]. A third way is to organize a joint venture with a group of internal innovators and contribute venture financing. The concern in all three cases is that of asymmetric information, or rather asymmetric knowledge, and the resources needed to achieve speed to market before competitors/imitators pick up the idea. Many large firms have therefore established their own venture capital arms to appropriate the rents from their own spillovers. The problem is, however, that a sophisticated venture capital industry, such as the one on the US west coast that consists of a varied assortment of firms defining together a broad range of specialized industrial experience, is needed to identify, select, and foster winners (Eliasson 2005a: Chap. 4). Internal venture capital firms, on the other hand, always, in one way or another are limited in their outlook by their own origin, which will rarely reflect what is needed to capture and commercialize the odd technologies that tend to emerge spontaneously from creative industrial research labs.

Compensation from successfully commercialized technologies comes in different ways. Capital gains on joint ownership arrangements is one form of compensation. Another is to allow an internal inventor/entrepreneur to do it on his own, and charge a license fee for what has been developed in the company, or just (which is not uncommon) to let the inventor/innovator take his/her idea and do it on his/her own. Then the innovator/entrepreneur will keep the profits in the form of capital gains if the spinoff is a success. But this path or diffusion channel (common in the USA, notably in Silicon Valley) is a high-risk path and depends critically on the support of a complete and viable competence bloc (item 2 in Table 1).

A corporate group composed of several companies operating in different markets, such as GE or the Swedish Investor group,[17] to which Saab belongs should have, if cleverly organized for it, a potential for commercializing spillovers from Saab. In the same way the Volvo Group has been quite successful in commercializing spillovers from the production of military aircraft engines. Such a capturing business could occur spontaneously, as in the case of Ericsson mobile telephony (see Chap. 4) or, be managed as a separate business.

Intangible spillovers come in different shapes. *First*, to exemplify from our case study, we have the closely related, within industry spillovers, one step beyond internal firm use (the *core industry* in the inner circle of Fig. 1). Here, we would expect to find spillovers between (both ways) aircraft manufacturers and aircraft engine manufacturers. The more fragmented by outsourcing the industry becomes the more important these spillovers, and the more urgent it becomes to find a way of mutual recognition and compensation. In public purchasing, we have a case of joint customership and it becomes easy for Government to motivate a higher price for the product as a compensation for spillovers. Silicon Valley and the South German luxury car production cluster offer similar examples of competence blocs populated with advanced firms that both benefit from the spillover source and contribute to it (Eliasson and Eliasson 1996, 2005a; Kelley and Cook 1998).

The next step (*second*) takes us further out to the second circle; *related* (to aircraft industry) *technology* including air navigation and safety, air traffic control, etc.; a rapidly growing IT-intensive industry. If unmanned air traffic becomes a reality this might constitute an important growth area, as will security industry in general. Recent firm interviews conducted within this project also indicate that the aircraft industry is moving in this direction.

Third, however, many devices and technological developments in the core aircraft industry have found profitable applications in the third *engineering general* circle. It is no coincidence that a Swedish computer industry originated among the advanced users of numerical calculation techniques (industrial simulation) among the Saab engineers. Already in the 1950s they constructed their SARA[18] computer. Digital computing was used in aircraft design work already for the 32 Lansen and the 35 Draken in the early 1950s and a fast and fully transistorized computer, the first in Europe, called Sank (or D2) was ready for the civilian market in 1960, less than a year after IBM in the USA. The Viggen combat aircraft was developed in the 1960s. When it was first delivered in 1971 it used on board computerization extensively. The on board computer, to begin with a central computer, not only became the prototype for Saab's commercial computer D21 (see further Sect. 4.6) but also laid a foundation for technology that would later be used to support distributed manufacturing. This was notably the case in later Viggen versions that used microprocessor technology and distributed computing extensively (see further below). This generic quality of aircraft technology makes it appropriate to say that *aircraft industry already today uses the technologies of future engineering industry* (Eliasson 1995, 1998a).

Finally we have the unpredictable serendipitous spillovers in the *industry general* outer circle. The word serendipity originated in Horace Walpole's (ca. 1754) *The Three Princes of Serendip* who had an aptitude for making fortunate discoveries accidentally. For instance, while it does not come as a surprise that a Swedish aircraft engine manufacturing activity developed within Volvo[19] as a spillover of Swedish aircraft industry, it is more difficult to understand that the digitalization of Ericsson mobile telephony owes a lot to military digital electronics development in the context of the Viggen and later JAS 39 Gripen projects (see below).

The ability to capture the spillovers in the different circles also requires different receiver competencies on the part of local industry and the econometric spillover studies to be further discussed in Chap. 3 tend to limit their attention by prior data classification to closely related industries. Hence, the more peripheral the spillovers that have been commercialized but not captured in those spillover studies the more underestimated the total magnitude of the effects. This will be more the case in an economy with a competent commercialization industry, such as the USA, than in other industrialized economies. (c.f. the social vs. private return estimates on this in Technical Supplement S2). The total economic outcome thus depends on the efficiency of available channels of diffusion (see Table 1) of the same spillovers and the capacity of local entrepreneurs to identify and commercialize them.

Receiver competence is thus critical for the value of spillovers. The more important receiver competence, the less of a problem of charging for the information. If the imitator is unable to pick up your idea (knowledge) without your help you can sell the knowledge over and over again because you have to provide user (receiver) competence each time. This bundling we call innovative pricing. Technology transfer programs and offset trade arrangements – if competently organized – are illustrations (item 5 in Table 1). The really valuable offset trade to the receiving country is offset trade that involves support in implementing the industrial user competence in the local economy.

2.3.3 Diffusion Channels

Table 1 lists the six main channels of technology diffusion. The most discussed channel is outright imitation – the Japanese, or now rather the Chinese way – (item 5),

Table 1 New technology is diffused (Source: Eliasson 1995)

1. When people with competence move (*labor market*)
2. Through new establishment by people who leave other firms (innovation and *entrepreneurship*)
3. When subcontractors learn from systems coordinating firm, and vice versa (*competent purchasing*)
4. Technology is acquired through strategic acquisitions of small R&D intensive firms (*strategic* acquisitions)
5. When competitors learn from technological leaders (*imitation*)
6. Through organic growth and learning in incumbent firms

when development costs are carried by US firms and the rents captured by the Japanese firms. Econometric research – as mentioned – lends support to the existence of that channel of diffusion. It is also a well-known fact that the bulk of R&D, and in international firms in particular, is devoted to sourcing new technology and that the ability of the firm to capture free-floating technologies (its receiver competence) is a critical competitive advantage of the advanced firm (Eliasson 1990a, 1991a; Kokko 1992; Lichtenberg and van Pottelsberg de la Potterie 1996). Some results, underlining the critical importance of receiver competence, are reported by Bernstein and Mohnen (1994). In their study of R&D activity in advanced US firms they looked at (1) effects of own R&D spending on productivity, (2) productivity effects in related US firms and (3) productivity effects in related Japanese firms. They found that the Japanese firms were better than the "closer" US firms to exploit technology developed in advanced US firms and "released" unintentionally as intangible spillovers.

Technology diffusion, however, it is necessary to emphasize in this context, only to a minor extent is about the diffusion of "solutions" already developed ("patents"). *The important form of diffusion occurs when people who have learnt to solve a particular type of technical problem, move on to another job to solve related problems there.* The most important avenue of technology or competence diffusion, therefore, is the *market for competence*, when people with competence move between jobs and firms (item 1). The same type of learning (item 3) occurs when firms/subcontractors learn from one another when working together.

Increasingly, firms also acquire complementary technology (item 4) through strategic acquisitions. This latter form of technology diffusion has increased in importance in the last decade as large specialized volume producers have found it increasingly difficult to innovate their technology base through own R&D investments (Eliasson and Eliasson 2005b).

Another form of diffusion and/or activation of technologies (item 2) occurs through spin offs from larger firms. In times of radical industrial restructuring this has been a triggering factor. It may have been more important than the movement of people, since it has often meant that winning technologies about to be shelved by conservative big business firms have been activated by understanding entrepreneurs. Most of Silicon Valley, in fact, has that origin. At the same time university entrepreneurship, meaning the industrial exploitation of university research results, while probably being less important (Eliasson 1997a, 2000b, 2005a: Chap. 4) has been more discussed in literature (Jaffe 1989; Nelson 1986; Stankiewicz 1986). University research to become industrialized requires strong complementary support of commercialization competence of a complete and broad-based competence bloc (next section).

Finally, research and internal learning in incumbent firms (item 6) is a not to be forgotten source of long-run growth because it involves considerable diffusion of technology both within the company and to outside companies through spillovers. A varied career within a firm and/or between firms is a carrier of knowledge and experience and an important form of executive learning.

2.3.4 Accessing the Global Pool of Technology

To summarize, the bulk of R&D expenditures in advanced firms is devoted to picking up internationally available complementary technology to integrate with their existing knowledge base, and only a small fraction is allocated on genuinely new technology development. The multinational firms are specialists in this field (Eliasson 1991a, 1997a:12ff), and, supporting this, Keller (2001) observes that recent research shows the major source of technical change leading to productivity growth among OECD countries to be foreign, not domestic. He also adds (op. cit.: p. 3) that learning through international economic activity might be particularly important for industrially less-developed economies, for instance through foreign direct investments (see further Chap. 6 on South Africa).

Klenow and Rodriguez-Clare (2004) have constructed what they call a hybrid model of some recent growth models including that of Jones (1995) and Jones and Williams (1998). Their model features a global technology frontier that is moved by R&D investment in all countries, that individual countries (or rather firms, I would say) can access in proportion to their receiver competence, being dependent on their own R&D. They find, through a series of calculations, that a high investment rate in physical and human capital explains the persistent differences in productivities and per capita income between countries, that complementarities among physical, human, and R&D capital are strong and that international knowledge externalities (the technology frontier) explain the fairly uniform rates of growth in the different economies irrespective of levels of per capita income. Without this global availability of knowledge, Klenow and Rodriguez-Clare conclude, the world GNP would be much smaller.

The notion of a *knowledge-based economy* (Eliasson 1987b, 1990b; OECD 1996) has become a particularly popular parable in the past decade when discussing technology or knowledge diffusion through markets, in contrast to the diffusion of information using modern computing and communications (C&C) technology.[20] Spillovers have been demonstrated to be particularly strong and more easily diffused in industries that are intensive in their use of C&C technology (Greenstein and Spiller 1996; Lichtenberg 1993; Mun and Nadiri 2002).

Part of the discussion has centered around the relative importance of tacit or noncodable knowledge versus codable knowledge or information. While information can easily flow through a wired economy tacit knowledge embodied in the heads of people requires personal contacts to be diffused and therefore tends to be more efficiently diffused within close metropolitan areas (Feldman and Lichtenberg 1997) and where labor markets are efficient in moving people on to better jobs. Hence, trade in advanced intermediate products and foreign direct investment tend to diffuse tacit knowledge more efficiently and explain international differences in productivity performance between countries.

The notion of tacit incommunicable knowledge, however, has not been well-received among traditional ("neoclassical") economists because tacit knowledge, as distinct from information, causes serious formal problems in the mathematical models they use.

A number of attempts to overcome this problem have been made. On this Mankiw (1995) rather believes that technical knowledge is generally available to all in an international pool. He wants to explain differences in the use of technical knowledge in terms of differences in complementary factor accumulation. Keller (2001) doesn't find this view particularly helpful in explaining productivity differences between countries. It should however be noted that commercialization competence is a critical complementary knowledge that is needed to commercialize freely available technical spillovers from R&D in advanced firms.[21]

Parente and Prescott (2000) want to explain the same differences in exploiting internationally available knowledge in terms of differences in actually used technical knowledge, something that can be explained in terms of differences in countries' resistance to the adoption of internationally available technology. Neither does this policy explanation find any sympathy with Keller (2001). Keller rather exhibits a strong preference for Quah's (2001a, b) weightless economy in which technical knowledge is disembodied, codified, and information globally available, while human capital is embodied, tacit, local, and difficult to communicate. This is quite speculative and to be on the safe side Keller (2001) suggests more research. Let me therefore note here that my interpretation of technological spillovers and the capacity of the local economy to identify and commercialize them combines the ideas of Mankiw (1995) and Quah (2001a, b) all being embodied in the competence bloc theory to be presented in the next section.

2.4 Competence Bloc Theory and the Critical Role of the Advanced Customer

Competence bloc theory deals with costly economic selection and growth. Selection implies the possibility of economic mistakes. Economic mistakes do not occur by assumption in the standard neoclassical economic model, except as costless stochastic random incidences. Competence bloc theory therefore has no role to play within the neoclassical model. To deal with costly selection a much broader theoretical framework than the neoclassical model has to be used, and this can be achieved through relaxing a few seemingly innocent but critical assumptions of the neoclassical model, essentially those assumptions that makes it a static equilibrium model where prices reflect, and (therefore) all actors can be fully informed about, everything there is to know.[22] We thus find ourselves in what I call the theory of the *Experimentally Organized Economy* (*EOE*) which is the home of competence bloc theory. Relaxing those neoclassical assumptions means that tacit knowledge becomes a reality, that difficult to communicate knowledge is no longer identical to codable information and that the economy will never come to rest in an exogenously determined equilibrium.[23] Competence bloc theory now has an economic role to play.

Creation, commercialization and diffusion of technology are largely a matter of costly transactions in tacit knowledge embodied in intangible assets over markets and, therefore, require both strong market support (economic *incentives*) and market

Table 2A The dominant selection problem (Source: Eliasson and Eliasson 1996)

Error type 1: Losers kept too long
Error type 2: Winners rejected

Table 2B Actors in the competence bloc (Source: Eliasson and Eliasson 1996)

Demand
1. Competent and active *customers*
Technology supply
2. *Innovators* who integrate technologies in new ways
Commercialization
3. *Entrepreneurs* who identify profitable innovations
4. *Competent venture capitalists* who recognize and finance the entrepreneurs
5. *Exit (Private Equity) markets* that facilitate ownership change
6. *Industrialists* who take successful innovations to industrial scale production

enforcement (*competition*). For the market dynamics of the experimentally organized economy to come into play a reasonable protection of intellectual property rights (Eliasson and Wihlborg 2003) and incentives to create and commercialize innovations have to be in place. Winning projects have to be exposed to a maximum of varied and competent evaluation to minimize the risk of losing a winner and of keeping losers for too long in the budget (Table 2A). A viable and complete competence bloc (Eliasson and Eliasson 1996, 2009; Eliasson 2009) is needed to perform this "optimization" of the selection process that results in the entry (Table 2B) of winning projects/firms and more competition from incumbent firms. The competent customer plays a both unique and critical role in that selection process.

2.4.1 Customer Competence Contributions

In the long term – such is the fundamental understanding of competence bloc theory – the quality of products will be limited from above by the quality of customers' understanding of the usefulness of the product, their willingness to pay, and their contribution of user knowledge to the development of new product technology.[24] *A competent and wealthy customer base constitutes a competitive advantage of an economy*.[25] The availability of specialist subcontractors within the competence bloc, furthermore, allows individual firms to enjoy economies of scale or networking externalities through the system. A complete competence bloc, hence, allows through an optimal mixture of market and hierarchical coordination a dynamically efficient combination of innovative ability and industrial-scale production (Eliasson and Eliasson 2005b).

In the end, this paper will highlight the different interests of the public and the private customer, in effect meaning that they regard the same product differently. A rational public customer should be concerned that the cloud of spillovers be commercialized locally to a maximum possible extent, indirectly making public procurement an instrument of industrial policy. The private customer cannot be expected to entertain the same social concerns, even though it may be interested in commercializing the spillovers, alone or together with a partner, to the extent it makes (private) economic sense.[26]

The availability of specialist subcontractors within the competence bloc allows individual firms to enjoy economies of scale through the system. A complete competence bloc, hence, allows through its mixture of market and hierarchical coordination a dynamically efficient contribution of both innovative ability and industrial scale efficiency.

2.4.2 Technology Supply

The complete competence bloc features competent *customers* (item 1 in Table 2B) that contribute technology to producers by participating in development work. This is typical of aircraft industry. *Innovators* in the competence bloc are technically defined. They combine old and new technologies into new composite technologies and are important actors in the creation process (item 2). It makes economic sense to give innovators a technical definition even though the pioneer of entrepreneurial economics Joseph Schumpeter (1911, 1942) was not clear on this point.[27]

Technological spillovers appear in the competence bloc and in my analysis as technology supply. But technology supply is not sufficient to guarantee economic growth. Technologies have to be identified and commercialized to result in economically and socially valuable output (industrial spillovers) or growth, and this is the phase when critical project selection by economic criteria occurs, large resources have to be mobilized and business mistakes are committed.

2.4.3 Commercialization

Entrepreneurs (item 3) have to be present in the own firm (“intrapreneurs”) or in the market to identify the commercial potential of the innovations offered. The entrepreneur, however, also needs funding, and for entrepreneurs in radically new industries the *venture capitalist* that provides the funds has to understand the commercial potential of what the entrepreneur has to offer to provide funding at reasonable costs. The venture capitalist in turn will want to *exit* (item 5) and return to new ventures, and hand over the task of taking winners to industrial-scale production and distribution to the *industrialist* (item 6). That last transaction may be thought of as taking place in the private equity markets.

Standard economics disregards these three functions in the commercialization process, or lumps them together in an undefined technical factor. Above all, little recognition in literature can be found for the large resource use associated with the commercialization of innovations, not least business mistakes.[28] In the theory of the experimentally organized economy (EOE) that I use to structure my analysis business mistakes become a normal cost for economic development. *First* of all, not until innovations have been selected by the entrepreneurs will large amounts of resources begin to be invested. *Second*, and perhaps more important, the rate of business failure at this stage is high. We are now talking about economic or business selection mistakes, rather than technical errors committed before a prototype product has been shown to function technically. To get the aircraft successfully into the air is one thing. To have developed the right aircraft for the user that "also works" is quite another thing, as the competitive outcome of the giant Airbus A 380 and Boeing's functionally different Dreamliner will eventually demonstrate.

The role of competent venture capital provision has slowly began to capture an academic interest, but largely as provider of early finance to newly established firms and as a complementary provider of management support, support that is generally available in the market. *Competence bloc theory features the venture capitalist as an industrially competent selector of entrepreneurs*, who reduces the incidence of business mistakes and charges for that competence service in the form of capital gains on his equity position. The other roles of the venture capitalists are secondary. Integrating the entrepreneurial, venture capital, exit market, and industrialization selection sequence is still missing in literature. It is captured in competence bloc analysis.

Ponder the following. In the early 1990s the Swedish industrial policy discussion was dominated by a concern about the "lack of entrepreneurship." This was a first realization that something serious had happened to the economy and standard Swedish macroeconomics was unable to tell anything meaningful about what was happening. However, not until the late 1990s was the argument brought onto the policy scene that perhaps the problem was not one of lacking entrepreneurs but one of missing industrially competent venture capitalists. Without industrially competent venture capitalists participating in the entrepreneurial selection process few successful entrepreneurs would get funding, and be seen. This was a more troublesome policy concern since ideological Sweden for decades had preferred to see no wealth accumulation through industrial entrepreneurship among private individuals, had taxed away profits with great gusto and returned some financial resources to industry in the form of selective grants and subsidies, directed by public hands and washed clean of industrial competence (see Eliasson 2003, 2005a: Chapter IV).

In competence bloc analysis an industrially competent venture capital industry figures as a competitive advantage for the national economy. This is the industry that had boosted US economic growth through the 1990s and most of the first decade of the new millennium. Policies directed at preventing private wealth accumulation through industrial entrepreneurship in continental Europe at large and in Sweden in particular have deprived those economies of an industrially competent venture capital industry capable of fostering the emergence and growth of new industry. European countries such as Sweden have therefore been relatively deficient in commercialization

Fig. 2 Decision and market structure of the competence bloc

capacity when it comes to capturing and building businesses on spillovers from advanced firms.[29]

Sweden may have been more successful in developing a private equity market of sorts, but private equity transactions are less demanding of industrial competence. This time the projects have already been sorted through the industrial competence filter of the venture capitalists and have been awarded a provisional economic quality grading by them.

The complete competence bloc has been put together in Fig. 2 to show how the technology supply and allocation processes map into the strategic, tactical, and operational decisions of a firm or a hierarchy.

At the operational level those selections have been made and the various skills needed to manufacture click in, such as skilled labor, shown at the bottom of the diagram.

2.4.4 The Allocation of Tacit Knowledge and the Limits of a Firm

Standard economics makes no distinction between knowledge and information. Knowledge is simply accumulated information. Standard economic theory therefore has great problems dealing with the transfer or diffusion of difficult to communicate tacit knowledge, as not only a costly process, but also a process fraught with economic mistakes. Standard economics treats business mistakes, if at all recognized, as stochastic noise. Hence, they are insurable in an actuarial sense, a notion that Knight (1921) rejected outright. In the real world a widely distributed portfolio of assets provides no such insurance coverage to the portfolio holder. To account for the tacit knowledge that cannot be fully commercialized in business decision making statistical insurance principles will not do. A different method and different principles are needed. Also, the further up at strategic business decision levels you go the more important tacit and difficult to communicate knowledge becomes.

Tacit knowledge can only be diffused through the interaction of knowledgeable people in hierarchies or in markets, not in coded form through, for instance, electronic communications channels. Competence bloc theory represents the dynamic interaction of people or groups of people embodying tacit knowledge. The competence bloc is inhabited by actors with the necessary tacit functional competences. They are driven by incentives and forced by competition to act in their self interest. If incentives are cleverly introduced into the economy through private contracts and institutional rules this competition will also be in the interest of a larger group of parties, including the nation. This was the idea of the invisible hand of Adam Smith (1776). Incentives and the competition process can be modeled even without defining the exact nature of tacit knowledge capital. Then, however, the exact outcome of the economic process cannot be calculated even in stochastic terms. This is what distinguishes the theory of the EOE from the standard neoclassical model,[30] namely that the maximum macroeconomic outcome cannot be calculated since everything that can be known and be reflected in the prices of the economy is not determinable and beyond analytical representation. (If the actors in the competence bloc chose to do something different in expectation of what all the different actors will do, a different set of prices will be the result and everybody will again revise their expectations and do something different and so on. In the nonlinear reality of a dynamic economy there will be an infinite regress and no convergence to an external, static equilibrium). All the different actors with multidimensional competences can do is to experiment their way through a largely unknown universe of opportunities (the Opportunities Space, Eliasson 2009).

In principle, the entire competence bloc can be internalized within one hierarchy. This was almost the case with IBM in its hey day during the early 1980s. IBM was even the competent customer of some of its own products, that it considered to be of such outstanding quality that it withheld them from the external markets, and potential competitors. In principle (again) the limits of a hierarchy or a firm will be set when the costs on the margin from coordinating businesses internally rises above those incurred when outsourcing and coordinating the production in markets (Coase 1937). Formulated so, there will be no such thing as a stable hierarchy or firm structure. The internal structures of a firm will constantly be in a state of flux, something every firm manager knows well from experience.

Internalizing too much of the value chain might raise static operational efficiency, but that improvement in cost efficiency is normally achieved only at the cost of lost innovative ability, and vice versa. A large and operationally oriented production hierarchy is rarely the habitat of innovative technology creation. Its capacity to discover innovations outside its routines is low and *the loss of winners the largest transactions cost* that is rarely part of neither internal management attention nor the economists' concern. However, by distributing the discovery process (and the competence bloc) over the market greater diversity of business evolution will be achieved as well as a smaller loss of winners. Total transactions costs will be reduced as a consequence (Eliasson and Eliasson 2005b).

Outsourcing of production and the sourcing of new technology in markets, however, carry other costs. Transactions in knowledge assets between actors in the competence bloc are market transactions. Market transactions in intangible knowledge assets (technology assets) require that they are tradable, meaning that the innovating firms can claim ownership to the technology they have created as tradable property (Eliasson and Wihlborg 2003). If not, it rather opts for internalizing the use of the technology, or establish property rights to the technology through bundling it with other products/services. Not well represented property rights to knowledge assets make trading in them risky and costly. This is one basis for understanding the role of spillovers in economic growth.

2.4.5 Critical Mass

The functions of the competence bloc support one another synergistically. Vertical *completeness* of the competence bloc therefore determines the dynamical functionality of the entire bloc. Without functioning exit markets the venture capitalist has no way of capturing the full profit potential of his venture, except through becoming an industrialist. And he is normally not the right person to do that. So the existence of competent industrialists to carry the winners selected at earlier stages determines the incentives of the entire system. But the entrepreneurs are dependent on the existence of venture capitalists and so on. The absence of one actor group tends to make the whole incentive structure of the competence bloc collapse.

However, *the creative supply of innovations cover a broader range than the supply of experience-based commercialization competence. So business mistakes are unavoidable* (Eliasson 2005a:40ff). The more horizontally varied a competence bloc the lower the incidence of business mistakes. One competent venture capitalist does not possess a sufficiently broad industrial competence range to understand and evaluate the entire supply of innovative propositions from an entrepreneurial society. *Many competing actors of each kind (in the competence bloc) are needed to maximize the exposure of each innovation to a competent evaluation.*

Furthermore, the more winners that are carried through the competence bloc the larger the potential for learning and creating new combinations of technologies (innovation potential). The competence bloc becomes a *spillover source*. When the *critical mass* for endogenous industrial development has been reached the competence bloc will become an *attractor* for new entrants looking for new complementary technology, but because of competition, only competent entrants that also contribute competence to the bloc, will survive. A vertically complete and horizontally sufficiently varied competence bloc that has reached critical mass will minimize the risk of losing a winner. Formulated differently, *a potential winner faces increasing returns to continued search for resources through the competence bloc.*

The competence bloc has an end product market definition. Technology or technology systems (Carlsson 1995), on the other hand, generate a supply of technology spillovers that are an input that enters an economic evaluation process through the innovation slot 2 in the competence bloc (Table 2B). After the commercial selection spillovers become industrial and economically valuable output.

2.4.6 Going from Micro to Macro (Aggregation)

After the spillovers have been identified and commercialized I go on to estimate their macroeconomic effects, or the spillover multiplier.

New technology introductions can take different forms. It has become common to postulate a production function of innovations that is fed with R&D investments. Most of the spillover literature and the literature on social and private rates of returns belong here, and even though I regard that literature as rather mechanical and free of dynamic considerations, this is where most econometric research is to be found. So I will draw on that literature in the next chapter. Another part of literature is, however, more dynamic and therefore more interesting in this context that is predominantly concerned with entrepreneurship and the entry of new firms. On the latter Jenner (1966) argues convincingly that the entry phenomenon should be approached much more broadly than in terms of the entry of firms. It should also include the launching of a new product within an existing firm, or in the market. Entry in any form, however, causes technical problems in standard economic modeling to the effect that Jenner (1966) was soon forgotten and entry, or the turnover of firms was neglected for a long time.[31] After decades of neglect and the post 1970s stagflation experience, innovative firm entry and the turnover of firms have been gradually recognized in parts of economic literature as a moving force behind economic growth (Eliasson et al. 2005; Eliasson 2007). And I have to integrate this Schumpeterian view with the more mechanical econometric studies to get the macroeconomics of spillovers relevantly addressed.

Table 3 offers one stylized way of representing that dynamic that I will return to in more detail in Chap. 3 and in the Technical Supplement S2 where I will also discuss the commercialization of spillovers through the entry and turnover of firms as a vehicle for economic growth.

Table 3 The four mechanisms of Schumpeterian creative destruction and economic growth (Source: "Företagens, institutionernas och marknadernas roll i Sverige," Appendix 6 in A. Lindbeck (ed.), Nya villkor för ekonomi och politik (SOU 1993:16) and Eliasson (1996a:45))

1. Innovative entry enforces (through competition)
2. Innovative reorganization or
3. Rationalization or
4. Exit (shutdown)

New entry imposes competitive pressure on incumbent firms. Incumbent firms have to respond by innovative investments and reorganization of their businesses, or rationalize. If they fail to do that they eventually fail altogether and exit. The outcomes over the longer term are more productive and superior than earlier populations of firms. Macroeconomic growth occurs. Table 3 however, also tells that in estimating the growth effects of new technology introductions, for instance based on spillovers from advanced firms, the *opportunity cost* of production that would have been generated with those resources in the absence of spillovers has to be deducted. Such dynamical systems effects may in fact mean a negative growth effect in the short term since the negative competitive fall out is often immediate, while the positive effects take a long time in showing.

This S shaped effect curve (first a negative effect and then a positive effect), has been documented in recent econometric literature (Batisch and Fritsch 2008). I have also simulated similar S-shaped curves on the Swedish micro- to macro-model,[32] and this time the effects are sustained long term beyond 50 years in the sense that new competitive entry leaves a permanent positive net growth effect on the macro economy at least up to 75 years. To this I return in Chap. 3.

2.5 Aircraft Industry as a Spillover Source: A Preview of the Industry Case

The case of my spillover story is Swedish military aircraft development and manufacturing. Table 4 gives an overview of the spillover cases I have identified and classified on the four categories of the spillover cloud in Figure 1. The listed cases will be presented in detail in Chapters 4 and 5. An aircraft is an extremely complicated product with a very long life that requires an immensely complex and distributed production organization (Table 5). It therefore provides an excellent illustration of the economics of industry spillovers.

The product itself integrates advanced mechanical technology with electronics, sensors and new materials (Table 6) and the software that achieves that integration also determines the performance characteristics of the product and its flexibility in functional specifications. In this sense, aircraft industry already today uses the technologies of future engineering industry (Eliasson 1995). This is also one rational reason for the advanced industrial nation to be concerned about having an inhouse aircraft industry. It functions as a technical university that provides research, education, and training services free of charge to other firms in related industries and of a kind close to the most sophisticated manufacturing operations that the more theoretically inclined technical university is normally incapable of developing and providing (Eliasson 1996b).

The long life of the aircraft means that to enjoy its services as a user maintenance and repair services have to be delivered over its long life cycle and the product may have to be updated and modernized now and then. The increasing importance of software that integrates electronics and mechanical technologies has dramatically enhanced flexibility in that respect between the JAS 39 Gripen aircraft and the previous

Table 4 The spillover cloud around Saab military aircraft

Core technologies (see Fig. 1)
1. Saab civilian aircraft (Case 1)
2. Volvo Aero's transformation from military to civilian aircraft engine manufacturer (Case 2)
Related technologies
3. The early innovation market around Saab (Case 3)
4. Secondary related spillovers from development and modification of aircraft engines (Case 4)
5. Commercial gas turbines (Case 2)
6. Civil Security (Case 21)
7. Space technology, Saab Space and VAC (Case 19)
Engineering general
8. Hydraulic engines, VAC and VOAC (Case 5)
9. Manufacturing light weight technologies and high-speed machining, ACAB, and Modig Machine Tool (Case 16)
10. Integrated and flexible manufacturing (Cases 6, 14, 18)
11. Systems integration (Case 14)
12. "Maintenance-free" products (Case 6)
13. Engineering consultancy, Combitech AB (Case 23)
Industry general (serendipitous spillovers)
14. Digital mobile telephony, Ericsson (Cases 8, 13)
15. Telecom Control Systems, Ericsson–Hewlett Packard Telecom AB, EHPT (Case 9)
16. Swedish automotive safety industry, Autoliv (Case 17)
17. Computers and information systems (Cases 10, 11)
18. Medical technologies, Sectra (Case 12)
19. Electronic noise reduction (Saab A2 Acoustics)
20. Remote oil volume measurement in tankers (Rosemont Tank Radar)
21. Traffic toll systems (Kapsch Traffic Systems)
22. Individualized TV entertainment (Saab Trackab)
23. Creating specialized industrial competence blocs (Cases 8, 24)

Table 5 A military aircraft is

1.	An extremely complicated product with
2.	A very long life that is
3.	Produced under very complex circumstances

Table 6 An advanced engineering product integrates

1.	Advanced mechanical devices
2.	Sensors
3.	Electronics
4.	Hydraulics and
5.	New materials through
6.	Software

generation of aircraft. In fact, the electronics of a modern military aircraft and a large commercial aircraft is normally replaced one or two times, sometimes three times during its often more than 50-year life span, and software reprogramming occurs many times in between. The definition of the product, hence, should include the features that lower maintenance and repair costs and facilitate upgrading and modernization.

But this is not enough. Compared to a university an industrial firm delivers technologies embodied in products that both function (are operational) and are more or less tested in a market for commercial viability and/or usefulness. This means that an aircraft that has gone through both a functional and a market test spills industrial knowledge that has a greater value for civilian production than spillovers that are only technological. This again means that technological spillovers (see Eliasson 1996b) is a misnomer. *The spillovers* documented econometrically around advanced US firms *are industrial, i.e., both technological and commercial*.[33] The commercial dimension of knowledge represents great economic value.

Two critical parts of a globally competitive engineering firm are (1) advanced product design and marketing competence and (2) ability to organize *integrated production* over global markets. Product design, international marketing and organizational competence are typically developed in industry. Complex integrated production was pioneered in (military) aircraft industry (Eliasson 1996b). Such generic industrial knowhow cannot be taught in classroom. It diffuses as people who have learned it on the job move between jobs and firms in the market.

An aircraft, hence, is not only a very complex product. It is multidimensional in the sense that it is composed of (1) the product itself as a physical entity, (2) many years of service, maintenance and upgrading and (3) a "cloud of valuable spillovers" that is difficult to charge for. Advanced firms, such as the aircraft manufacturers, therefore, generate different indirect (spillover) benefits over and above the product itself being purchased. In the short term local employment will be created, but this carries local value only if extra people employed cannot be gainfully employed elsewhere and the effects are only temporary. Sustainable export and employment growth can only be achieved as a result of a sustainable increase in overall productivity and production growth generated by the spillovers.

Effects of lasting value, however, are only gained if local people and firms learn skills and industrial knowledge that can later be gainfully used in other production. Effective such learning requires local receiver competence (Eliasson 1990a), local entrepreneurial ability and a well-endowed competence bloc. The *first* learning item has to do with the level of education and experience of the workforce and the type of production in which they are occupied compared to the new knowledge being spilled from the project.

The *second* entrepreneurial ability is the same and (in addition) requires the existence of a complete competence bloc (see Eliasson and Eliasson 1996; 2008b) to select winning project ideas and to carry them to industrial scale production, notably venture capital competence. The critical policy issue is how to organize a positive sum game. The large benefits to both parties do not arrive if the receiving party does not gear up its competencies to receive and exploit the spillovers. Passive participation yields less.

I will illustrate this feasible win–win case for the three large partners in the Industry Group IG JAS that have also been the large receivers of Gripen spillovers; Saab, Volvo Aero Corporation and Ericsson, and also some smaller spin-off firms in related industries. Finally, I will also say a few words on French military aircraft maker Dassault, which has created two large civilian businesses on its military spillovers; the hugely successful Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) system Catia and Falcon business jets. Dassault also claims to have invented the Product Lifecycle Management (PLM) method to calculate lifelong costs and to rationally price the use of services from products with a long life such as aircraft.

As it looks, most successful and observable attempts to commercialize spillovers have taken place through vertical downstream integration within large companies, notably the large participating companies of the IG JAS and through secondary spin offs from the same large companies.

More rarely, underlining the common inadequacy of local competence blocs even in advanced industrial economies, have spillovers taken the form of new and unrelated entrepreneurial start ups. This latter conclusion may partly have to do with the long time it takes for a small winner to enter the market, grow, and eventually develop into a statistically visible large company. At that time, furthermore, it may be almost impossible to identify the origin of the successful business venture since along the way many other complementary contributions have entered the picture. We have not yet seen more than a few such small business success stories outside the world of big business.

Sometimes, as we shall see in Chap. 6 on South Africa, spillovers have been commercialized as a consequence of offset trade agreements in which the supplier helps the public customer to capture and commercialize the spillovers, sharing in the extra values created.

2.6 Boosting Receiver Competence Through Policy

The value of the dual product being delivered to the local economy (including spillovers) depends critically on the competence of the local economy to identify and commercialize the spillovers profitably, i.e., on the local entrepreneurial ability to establish new businesses on the spillovers. The value to society of the military aircraft being sold in the case studies in Table 4 to be presented in Chaps. 4 and 5, therefore, is the product, or the *hardware equipment itself plus the economic value of the spillovers*. The total value of this "dual product" (Joint production) can however be raised by policy aimed at improving the local commercialization capacity. Such policy includes the possibility of a deal between the public customer (the government) in particular and the producer whereby the producer agrees on a price to support the commercialization of spillovers. Looked at this way the local economy around an advanced public product procurement program faces a potential positive sum game that if properly organized will benefit both parties to the deal.[34]

2.6.1 Capturing the Rents from Spillovers: Joint Customership and Industrial Participation Programs as a Joint Policy and Business Opportunity

Spillovers diffuse because of the potential rents they carry. There are incentives for both parties to the transaction to capture these rents, but the difficulties are large because of weak property rights (for the producer) and lacking receiver competence, or incomplete local competence blocs (on the part of the buyer).[35] This very fact, however, also establishes a situation of mutual interest. The situation of mutual interest is further strengthened if a Government is the buyer and a situation of *joint customership* prevails. We then have a case for explicit producer–customer cooperation as a general policy case and the opportunity to create a win–win situation through policy. This opportunity is most characteristic of advanced industrial nations and has to do with the existence there of reasonably complete competence blocs to support the capturing of the peripheral "further out" (in the outer circles of Fig. 1) spillovers. Developing industrial economies (see Chap. 6) require complementary commercialization support. However, even advanced industrial economies, such as Sweden and continental Europe, are often deficient in some competence block features, for instance industrially competent venture capital provision.

Industrial economies may exhibit great performance in picking up spillovers that fall inside the competence range of their large firms, but tend to experience a loss of winners when spillovers fall outside that range. In fact, Ericsson almost missed its mobile telephone opportunity and Astra (now AstraZeneca) almost world's best selling stomach ulcer prescription substance Losec (or Omeprazol in the USA). IBM missed the Xerox opportunity and Microsoft almost missed the Internet train. The larger the captive area, however, the higher the probability that radically new technologies will be identified and commercialized. All Scandinavian economies are therefore more "efficient" in that respect than Sweden alone. The argument in Eliasson (1999) was that a joint Nordic purchase of submarines (The Viking Project) would increase the pickup rate of spillovers in the area as a whole, even though it would be impossible to predict how the successful spillover captures would be distributed over the different economies. Europe at large, for the same reason, would create an even better such industrial policy opportunity, even though it would be difficult/impossible to predict "which country" would capture which spillovers (see further Chap. 7). A reasonable assumption is that the more entrepreneurial the local regional/national economy the more efficient in identifying and commercializing spillovers it will be. But geographical distance to the spillover source will work in the opposite direction and the local domicile of the successful spillovers commercialized need not be the location chosen for establishing production. In fact, and following up on the argument above, competition among the countries to capture the spillovers industrially would raise the positive economic effects in the pick up area as a whole because a broad spectrum of spillovers will breed cumulatively on one another.

The cooperation case is focused on the inner circles in Fig. 1. Here, the producing company contributes management competence and receives profitable cooperation within an industrial participation program in return. The business opportunity is that there is a profit to be earned from making the spillovers valuable for the local or receiving economy. To do that the producer/seller has to support local receiver competence as a profitable business in itself. For a developing economy well-designed offset trade arrangements are a method to create such a mutually beneficial win–win situation. For this to be successful policy offset trade agreements have to be oriented toward capturing technology, acquiring industrial competence and developing related and new production. Hence, part of the innovative pricing strategy on the part of the producer includes *the art of presenting a convincing case for the long-term industrial benefits of the deal*.[36] Bundling the aircraft sale with an offset program designed to capture the spillovers locally is our example from South Africa in Chap. 6. Encouraging the establishment of local venture capital firms to induce foreign and local investors to establish on the basis of the spillover flow is another example. In one sense, such an "agreement" means establishing a commercially based industrial park (Eliasson 2000a).

2.6.2 Summarizing on Joint Production and Joint Customership as a Policy Opportunity

It is in the interest of the public customer to see the spillovers commercialized. But while the public customer will be satisfied with only seeing the spillovers picked up, the private customers will only be interested and willing to "pay extra" if they can earn a private rent from the spillovers. In the case of advanced public purchasing the role of the policy maker, therefore, is to see to it that the local receiver competence is satisfactory, i.e., that the competence bloc is vertically complete and horizontally varied. The policy maker, however, can do very little to actively contribute to the competencies of the bloc. In the modern high-tax welfare economies the main task rather will have to be to avoid the policies that prevent the creative market forces from developing those competences. The US venture capital industry, for instance, is made up of a large population of industrially competent and privately wealthy (from industry entrepreneurship) individuals. If government prevents individuals from becoming wealthy through industrial entrepreneurship and instead taxes away their wealth and uses the taxes to fund its own venture capital industry, which is common in Continental Europe, it washes the money clean of the critical associated industrial competence. The business risks increase as do the risks for business failure. We have a case of policy failure (Eliasson 2000a).

Hence, to make full use of spillovers from advanced firms the local economy faces the general policy problem of supporting the *local receiver competence* to identify and commercialize winning technologies. This most likely involves the ideological trauma of backing away from excessive egalitarian policy ambitions. At the same time it is in the interest of the advanced firm to establish in a local economy well endowed with industrial receiver competence, since that receiver competence raises the total value of its product (including spillovers) to the local economy. However, only in the case of public procurement is the weak property rights problem (to its spillovers) satisfactorily solved since the government/customer is then directly interested in seeing the economic value of its spillovers raised. A broad industrial base, an educated and entrepreneurial labor force and a complete and varied competence bloc are supportive of that ambition. For industrially less advanced and developing countries the difficulties of taking advantage on their own of the opportunities created often become overwhelming. It should therefore *be mutually advantageous for the advanced firm gearing up for large-scale production and distribution and the receiving country to engage in a mutually advantageous industrial participation program aimed at both boosting local receiver competence* (of spillovers) and offering profitable business cooperation contracts to develop new businesses (c.f. item 5 in Table 10, See page 226). Such considerations offer a rational economic argument for offset trade arrangements, but only for contracts that trade long-term industrial development for profitable business deals. The JAS 39 Gripen (Saab) sale to South Africa created opportunities of this kind (see Chap. 6). Spillovers are positive characteristics of an advanced product. They carry extra value for the buyer and the local economy that depends on the local receiver competence to create businesses on them.

I have now presented (1) a brief executive summary of the entire book and the Saab aircraft industry spillover story (Chap. 1) and (2) a condensed nontechnical version of the book (this chapter).

The rest of the book will document the theoretical underpinning of the analysis (Chap. 3), the (Chaps. 4 and 5) case presentations in concrete detail for Sweden (an industrially developed economy) and for South Africa in Chap. 6 (an industrially less-developed economy). In Chap. 7, the European perspective is briefly discussed. In Chap. 8 the method of calculating social and private returns to investments in spillover-intensive public procurement is presented verbally, and technically in the supplements.

The book concludes (in Chap. 9) with a discussion of public procurement as industrial policy.

2.7 Notes

1. Similar financing arrangements characterize other very long-term civilian development projects, for instance between biotechnology and pharmaceutical firms that may last for a decade and more. Payments are made at agreed-upon milestones, contracts are renegotiated, bonuses paid if obligations have been honored and the customer pharmaceutical firm has a predetermined option to take over the new technology/patent, also at preset intervals.
2. This practice was particularly elaborate during the development of the Swedish JAS 39 Gripen multipurpose combat aircraft that was initiated in 1980.
3. Or rather a “comparative advantage,” since Burenstam-Linder (1961) conducted his analysis in terms of traditional static international trade theory.

4. Thus, for instance, the Swedish weekly magazine *Fokus* (No. 16, 2007) had a cover article on the Swedish JAS Gripen military project that was generally negative. There was no mention whatsoever of the scientifically well-established positive industrial spillovers that are larger than the development budget of the aircraft. Was the journalist unaware of this? If so very few Swedes will know. Or did he not want to mention it? See instead the article in Swedish *Veckans Affärer*, April 17, 2008 where the editorial notes with surprise that those positive spillovers are indeed large.
5. In 1999, British Aerospace and Marconi Electronic Systems merged into what is currently BAE Systems.
6. This externality of the equilibrium is what makes both the old neoclassical and new growth models static. The mathematics used in these models is the same as that of Newtonian celestial mechanics that leaves little scope for human influence on both the universe and the economy (Eliasson 2009).
7. But conceived and designed in the early 1980s. On the new procurement method, see Technical Supplement S1.
8. Because of the high domestic content of military equipment demanded at French public procurement the products are likely to suffer from the same problem. Not even the USA is large enough to be able to maximize product performance over the life cycle on the basis of its own subcontracting industry alone.
9. This is all in terms of axiomatic design (Suh 1990) language. Functional requirements stand for a vector of product characteristics, and DP (Design Parameters) for the minimum of design parameters needed to achieve FR through the production and technology matrix {A}.
10. I will return to this real options pricing of functional flexibility in Chap. 5.
11. Compare with Table 8 (on page 139) on integrated production.
12. Commitments to produce part of the good or system delivered locally may be profitable for the producer, but the production is normally inefficient, it ceases with the final deliveries and leaves little future social value for the public customer.
13. See, e.g., Bill to Parliament *Prop.1979/1980:117, p. 23ff*. Also see Eliasson (1995:155f) and Technical Supplement S1.
14. There is a related problem associated with public venture financing. When the private wealth earned from industrial ventures is taken away and redistributed through public funding institutions (which is a typical policy in Continental Europe and Scandinavia) the money has been washed clean of the industrial competence associated with the original industrial creator of the same private wealth.
15. For instance, in Swedish Vinnova and its heralded notion of a triple helix policy within which government, universities, and industry are urged to work intimately together. Not until recently have notions related to the commercializing of technology been plastered onto the triple helix jargon.
16. Instead of outsourcing. On this see Lewis and Sappington 1991 and Desai et al (2002).
17. Investor AB is the investment holding company of the "Wallenberg group" of firms the portfolio of which includes large and/or majority holdings in among

other firms ABB, AstraZeneca, Atlas Copco, Electrolux, Ericsson, Gambro, Saab and SKF, but since 2007 no longer Scania. See also Day et al. (1993, "Introduction" p. xiii ff).

18. For Saabs Automatiska Räkne Automat.
19. Volvo acquired *Nohab Flygmotor* (founded 1930) in 1941. After a couple of name changes it is, since 1994, called *Volvo Aero Corp*.
20. I specifically introduced the term "the knowledge-based economy" in my study for the OECD (Eliasson 1987b) to distance myself from the ongoing "information economy" discussion and to emphasize that (tacit) knowledge diffuses through the movement of people in careers, through the labor market and through sales and acquisitions of bits and pieces of companies in the markets for strategic acquisitions. My argument was that such diffusion of human embodied knowledge was economically more important than the communication of coded information (Eliasson 1991c).
21. It is more broadly defined than receiver competence (Eliasson 1986, 1990a, b) and absorptive capacity (Cohen and Levinthal 1990) that covers the entire range of technologies needed to identify, select and transfer technology supplies into profitable industrial production. See next section on competence bloc theory.
22. This is the definition of an efficient market (Fama 1970; Fama 1976). If all that can be known (commonly denoted Ω) changes (to a new Ω^*) an efficient market immediately establishes a new equilibrium where agents know everything that can be known and prices fully reflect that knowledge Ω^*. The critical problem however is to clarify all that can be known, which is not possible in the EOE (see Eliasson 2009).
23. See Eliasson 1990a, 1991b, 2005a; Eliasson and Eliasson 2005b, 2009 and below.
24. As argued by Day (1986) this latter interdependence of demand and supply poses difficult methodological problems in economic theory.
25. The comparative advantage for a nation of an advanced local customer base was recognized already by Burenstam-Linder (1961).
26. Again, to anticipate the industrial policy discussion to come, there will always be a general policy argument for supporting the development of local commercialization/receiver competence to capture spillovers from public and private procurement. It is more difficult to argue generally for more advanced public purchasing since it means arguing for a larger public sector and it is by no means obvious that the public purchaser is more competent as a customer than the corresponding private one. Only if the market is not responding to a private demand, or if the product is a pure public good will there be a rational economic argument for a representative public customer to step in, for instance in defense procurement. We leave this difficult issue at that here.
27. This technical definition of the innovator and the distinction between an innovator and an entrepreneur has its origin in von Mises (1949). On this I prefer to think in terms of innovations as being generated by a technology system (Carlsson 1995) or a technology production function (Griliches 1979, 1984, 1986). Normal language use makes it awkward to talk about a new aircraft

as an invention. Innovation is a more appropriate term, that also covers the concept of an invention. So I don't need both terms.

28. That cannot occur by definition in the mainstream economic model, except in the form of costless random losses in an economic lottery.
29. It should be added that most of continental Europe suffers from the same problem, (Eliasson 1997b, 2003 and 2005a; Chap. 4). Its new innovative high tech firms therefore have become a target for the more competent US commercializing industry that understands how to profit from investments in new technology (ISA 2003).
30. The standard neoclassical model "solves" that dilemma by assuming that all knowledge or accumulated and measurable information needed is available. Then even the optimal outcome can in principle be calculated using analytical methods. See further Eliasson (2009).
31. Dasgupta and Stiglitz (1981) are an example of the awkward assumptions needed to construct a static equilibrium model with entry and exit.
32. Which builds its endogenous growth on the competitive interaction of the investment categories in Table 3. See further Sect. 3.3.
33. Read commercially tested (in the market) technology.
34. On incentive contracts in the case of JAS 39 B Gripen development see Sect. 8.4.
35. The notion of weak property rights is discussed in a similar context in Eliasson and Wihlborg (2003).
36. *Innovative pricing* (IP) is the art of identifying a base on which to price a product with weak property rights, for instance different kinds of digital services or (our case) spillovers that have to yield a return to make the whole product (aircraft and spillovers) profitable for the producer (see further Eliasson 1995: Chap. 15). Innovative pricing is practiced in situations with difficult to define multidimensional products, many dimensions of which not only being unknown to, or unavailable for most customers but also constantly changing. IP then amounts to defining the base (the dimensions of the product) to charge for. Jonason (2001) uses the theory of the experimentally organized economy (EOE, see e.g., Eliasson 1991b, 2009) to price products the quantities of which cannot be defined because of the many quality dimensions, a phenomenon recognized as normal already by Hayek (1937). Hart et al. (2001) addresses the related problem of pricing multidimensional products with difficult-to-specify quality features for which complete contracts cannot be drawn up. A private contractor under competitive pressure (in their case a private operator of a prison) that is forced to cut costs will have an incentive to shirk on noncontractable quality.

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