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RATIONALES AND INSTRUMENTS FOR PUBLIC INNOVATION POLICIES

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ABSTRACT: Economic interest in innovation policy largely arises from the fundamental importance of innovation to social welfare and from well-known inefficiencies in innovation in a competitive market environment. As a result, a wide variety of public innovation policies are used in practice. This report reviews the economic justifications for public innovation policies and compares the existing policy tools, paying particular attention to the Finnish innovation policy environment.

1. Introduction

At least since the works of Solow (1956, 57) and Arrow (1962), it has been widely acknowledged that innovation is the principal engine of economic growth but that it is fraught with market failures (inefficiencies).[1] These observations have created tremendous interest in innovation policy both among academics and policy-makers. The economic problem has, however, been recognized much earlier, and a wide variety of public policy tools to affect technological progress have been developed over the past millenia. The goal of this report is to overview the economic justifications for innovation policies and available policy tools, especially to the extent they reflect the Finnish institutional environment.

Social and business sciences have proposed a numerous rationales for public innovation policies (see, e.g., Georghiou et al. 2003 and Chaminade and Edquist 2006 for reviews). The starting observation is usually that innovation in unregulated market environment is inefficient, creating a *prima facie* case for government intervention. However, the potential failure of government policies is also often recognized. Any public innovation policy tool should only be judged on whether it yields a (expected) net increase in social welfare.[2]

The economic theory has indentified two broad sources of market failures: financial market imperfections and externalities. The report argues that innovation policies aimed at correcting financial market imperfections hardly pass the criterion of net welfare gain in normal times outside crisis periods and that the externalities provide a much more sound rationale for an innovation policy. The problem with the externality rationale is the opposite –

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[1] The report uses the standard economics terminology (which has little to do with so called neoclassical economics). For example, the term market failure refers to any (allocative or productive) inefficiency in the market outcome that is not due to governmental regulation. It hence encompasses the classic failure of competitive markets to obtain socially optimal outcome but also inefficiencies due to imperfect competition, imperfect information and other systemic problems that are not automatically solved by market forces.

[2] The benefits and costs of a policy are seldom known when it is planned so what matters at that stage are expected benefits and costs. When the policy is in place the criterion is that it actually constitutes a net welfare improvement. While the distinction between expected and actual benefits and costs is important in designing and evaluation of policies, it is inconsequential for this report and hence no distinction is made.

it is too general to successfully provide detailed innovation policy advice and the expected welfare benefits of policies must be evaluated case by case.

The report then reviews the major innovation policy tools used in practice: intellectual property, subsidies, tax incentives, prizes and contests, and public production and procurement. The tools can be classified according to their ability to provide incentives to innovate *ex ante* and diffusing innovations *ex post*. It turns out that intellectual property and tax reliefs are in principle better in mitigating the ex ante problem than the other policy tools, but fare worse in solving the ex post problem. However, since the reality is more complex than the theory, many theoretical advantages of the policy tools in solving the ex post problem might be wiped out by the way they are used in practice.

The Finnish innovation policy system is currently based on a subset of main tools: intellectual property, subsidies and public production. For example, tax reliefs and prizes are at best used in a very restrictive manner. It appears that the tools are used simultaneously and uncoordinatedly (like in many other countries), resulting in outcomes that are sometimes at odds with the standard predictions of economic theory.

The next section summarizes the economic justifications for innovation policies, and Section 3 compares the available policy tools. Section 4 reviews the Finnish practices and Section 5 concludes.

2. Rationales for Public Innovation Policies

Several rationales for the innovation policy have been proposed by policy makers and academics. Economics textbooks begin with the benchmark of a competitive market without public innovation policies. It is then observed that the rate of innovation in the competitive market environment is generally inefficient, justifying an innovation policy aimed at improving the market outcome. While the real world is typically far from this ideal textbook benchmark (e.g., the markets are virtually never competitive and unregulated), the reasons that render innovation in competitive markets inefficient also render innovation in the real world inefficient. Hence these reasons – so called market failures - form a necessary condition for public innovation policies. But precisely because the idealized textbook case does not match the real world, the market failures do not form a sufficient condition for government intervention. In particular, it is possible that government innovation policies – even if they are benevolent – have unintended consequences, worsening the market outcome.

The economic science has indentified two broad sources of market failures, financial market imperfections and externalities.

2.1. Financial Market Imperfections

It is a widely held view that corporate R&D is held back by insufficient private sector funding, necessitating public innovation finance policies. On the face of it, the argument sounds unobjectionable. R&D activities are inherently opaque, human capital intensive, and involve soft information. It is hard for outside investors to assess the creditworthiness of R&D projects and verify their returns. Hence the markets for innovation finance are plagued by problems of adverse selection and moral hazard, both stemming from the informational asymmetries between insiders and outsiders.[3] Such problems of asymmetric information are known to hamper efficient allocation of finance. For example, the celebrated contribution by Stiglitz and Weiss (1981) suggests that adverse selection leads to credit rationing and insufficient lending to entrepreneurs, and may even lead to the collapse of the market for entrepreneurial finance. Moreover, the standard market solutions provided to adverse

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[3] Loosely speaking, adverse selection tend to arise in situations where entrepreneurs have better information about expected project returns than financiers, and moral hazard in situations where actions taken by entrepreneurs cannot be verified to third parties (e.g., to courts).

selection and moral hazard – signaling, reputation and monitoring by financial intermediaries - may fail especially in the case of science and technology-based new firms that have neither acquired reputation nor assets that could be offered as collateral.

That financial market imperfections create inefficiencies in innovation finance clearly constitutes a necessary condition for government intervention. However, it is neither clear that they would also constitute a sufficient condition nor that they would call for public R&D funding. Indeed, there is a sound theoretical argument, first advanced by de Meza and Webb (1987) that, in the absence of externalities, adverse selection leads to *overlending* to R&D activities. Since outside financiers cannot separate good projects from bad ones, they typically end up with financing both kinds of projects. Thus good projects will cross-subsidize bad ones and too much bad projects will be funded. The overinvestment problem worsens when funding becomes cheap to come by (e.g., when financial markets are competitive and liquid). Hence in this kind of environment the proper government intervention arising from financial market imperfections is that external funding of R&D investments or their returns should be *taxed*, not subsidized. Moreover, the private sector has created sophisticated organizations and instruments to overcome the problem of adverse selection and if such private sector mechanisms are unsuccessful, it is difficult to see why public funding agencies would be able to perform better.

Recent literature syntheses such as de Meza (2002) and Boadway and Keen (2005) confirm that it is difficult to come up with a theoretically coherent argument for public innovation finance arising from adverse selection. Researches have had to resort to quite creative arguments to rescue the adverse selection rationale for public innovation support policies. It has been proposed that to the extent public innovation finance institutions are centralized and engage in screening activities, they are in a better position to aggregate information about R&D innovation projects than dispersed private sector financiers

(Niinimäki and Takalo 2007). Moreover, the public sector screening activities can have a certification role: even low quality screening by a public agency may provide an informative signal to private sector financiers, hence mitigating the adverse selection problem (although this could dilute the private sector financiers' incentives to screen) (Lerner 2002 and Takalo and Tanayama 2009).

A somewhat sounder rationale for public innovation finance comes from moral hazard. In an influential work, Holmström and Tirole (1997) show that outsider investors are wary of investing in the projects of the entrepreneurs who cannot put down a sufficient amount of their own capital. If the entrepreneurs do not keep a sufficient stake in the project outcomes, the financiers cannot be sure about the entrepreneurs' motivation. This creates a funding gap where even unambiguously profitable projects are not launched if the entrepreneurs do not have enough liquid assets. Especially human capital intensive start-ups may lack assets and therefore suffer from funding gap. Monitoring by banks or specialized innovation-finance organizations such venture capitalists helps to mitigate the moral hazard problem, but may or may not be sufficient to eliminate it.

Empirical evidence about whether investments in R&D are held back by insufficient finance is broadly speaking consistent with the theory. Hall (2002) and Hyytinen and Pajarinen (2003) suggest that only small, R&D intensive start ups may face financial constraints in industrialized countries with well developed financial markets. Empirical researchers, however, encounter the same informational problems than outside financiers: it is hard to separate good projects from bad ones. Hence the observation that some firms suffer from funding difficulties may be meaningless, merely indicating that the market is doing its job and trying to wipe out bad projects. It is also easy to come up with examples such as the U.S. subrime mortgage market in this decade, which show that even massive overlending to risky activities is not implausible.

In sum, economic theory and the scant empirical evidence do not offer unambiguous support for public innovation finance policies that are motivated by financial market imperfections. Only policies that are targeted at solving the moral hazard problem or those that involve project screening have some justifications. There could also be a case for counter-cyclical funding policies which increase public innovation finance when liquidity in financial markets dries up and, similarly, reduce it when liquidity is abundant. Otherwise, using financial market imperfections as a rationale for R&D support policies is challenging.

2.2. Externalities

Externalities arise when a firm investing in R&D does not or cannot take fully into account the effects of its R&D investments beyond the firm profits. There are various forms of externalities. R&D knowledge may spill over to other firms, e.g., via departure of personnel. Such (technological) *spillovers* play a crucial role in modern growth theory (see, e.g., Aghion and Howitt 2009). Another important externality is *consumer surplus*[4]. When the output of R&D is sold in the market, the vendor cannot fully capture the value of its innovation to all users. The technology vendor can seldom perfectly discriminate among its customers so that it could charge a higher price from the customers who value its innovation more. Since new digital technologies can also easily copied, some users of the technology pay nothing to the vendor. In network industries where the value of an innovation depends on the number of its users, consumer surplus also includes the network benefits (or network externalities).

[4] The term "consumer" here refers to all buyers and users of the new technology so a consumer can be another innovative firm or a user that has not bought the technology.

A related externality comes from *cumulative innovation*, which is, besides spillovers, another key ingredient of modern growth theory.[5] An innovation of a firm may enable another firms to build on the firm's innovation to make further innovations. Consider for example the case of research tools and other basic general purpose technologies. They have little value in itself but they facilitate firms to develop innovations with commercial applications. In some cases an original innovator cannot even foresee how its innovation is used in the future. Since the chain of cumulative innovations may be in the case of pioneering, path breaking innovations be enormous (think, e.g., world wide web), the original innovator may capture only a small fraction of the social value of her innovation.

Note that externalities can also be negative from the welfare point of view. It may for example turn out that some new technologies cause such a large environmental damage that the social value of the new technology is negative. At least theoretically important negative externality in the case of R&D arises from the duplication of R&D costs. For example, a firm investing in a developing new drug and obtaining a patent for it does not take into account that its investments reduce the probability of other firms to come up with the same drug patent.

Both theoretical and empirical economics literature agrees that the growth enhancing effects of R&D largely arise from its positive externalities outweighing the negative ones. Externalities, however, by definition hamper the functioning of market mechanism, creating a wedge between social and private value of innovations. If the firm cannot fully appropriate the social return of its investments, it will invest too little and hence public support is warranted.

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[5] There are two important families of modern endogenous growth models (see, e.g., Aghion and Howitt 2009). The product-variety model of Romer (1990) emphasises technological spillovers. The Schumpeterian model due to Aghion and Howitt (1992) adds cumulative innovation on the top of the spillovers.

R&D activities generate particularly large externalities because new knowledge, technologies, and creative works have properties of *public goods*. They do not wear out in use and it is both hard and socially wasteful to exclude others from using them once they exist. However, new knowledge, technologies and creative works can be very expensive to produce in the first place, and firms are not willing to invest in innovative activities if they know that once they are successful, their rivals and consumers can use their innovations freely. From the public policy point of view, this gives a rise to the trade-off between the provision of adequate incentives to innovate ex ante and the smooth diffusion of existing innovations ex post. As will be discussed in the next section, the various innovation policies can be classified according to their ability to overcome the ex ante problem of providing incentives and the ex post problem of promoting the use of innovations.

The problem with externality rationale is that it is rather broad and cannot easily provide a clear-cut policy advice. Almost all R&D activities create externalities and almost all R&D investments would then warrant public support. Note that even commercially failed projects can generate positive externalities. Even if financial markets imperfections would justify taxation of R&D investments as the proper policy intervention, externalities can reverse the policy conclusion and justify R&D subsidies. In theory the amount of public support to a given R&D project should be tied to the amount of externalities generated by it. But it is difficult to estimate the level of externalities generated by a given R&D activity. If this cannot be done, the externality rationale neither pins down the amount of public support nor what kind of instruments should be used.

3. Public Innovation Policies

Over the past millenia, rulers and governments have come up with numerous policy tools to support innovation. Using a broad classification, the main policy tools are intellectual property, R&D subsidies and other public R&D funding, tax incentives, prizes and contests, and public procurement and production including innovation services. We first briefly review each policy tool, focusing on their most basic economic dimensions, and then compare them against each other. For brevity, the review is restricted to direct innovation policies, ignoring related policies with major implications for innovation such as competition policy and financial market regulation.

3.1. Intellectual Property

Intellectual property is probably the most ubiquitous innovation policy tool of modern societies.[6] It attempts to solve the externality problem by legal means, allowing exclusive use of the protected knowledge.

Intellectual property has many facets that have been extensively analyzed in the literature (see, e.g., Menell and Scotchmer, 2007, for a survey). A unique virtue of intellectual property is that every invention funded with intellectual property creates a Pareto improvement. In other words, only the users of an innovation pay its R&D costs, and no other party is taxed to subsidize the development of the innovation. Decentralization of decision making constitutes another great benefit of intellectual property. Finding ideas for invention are left up to the firms and innovators themselves, not to public servants. Although the innovators do not pay attention to the social value of innovations, the private value of an

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[6] The term intellectual property is used generically, covering patents and other industrial rights such as utility models and protection of topographies of semiconductor products, as well as copyrights and related rights such as database rights. Economically, if not legally, trade secrets are also an important form of intellectual property. In contrast, the discussion does not apply to trademarks, which differ in their economic function and purpose.

innovation derived from intellectual property typically correlates with its social value, and hence the R&D effort is directed to socially valuable projects.

The basic disadvantage of the intellectual property is the dead-weight loss.[7] The economic point of intellectual property is to allow the property right holder to try to exclude others from using the innovation without permission. This almost by definition hampers the use and diffusion of innovations. Another major drawback of intellectual property is that the boundaries of intellectual property rights are inherently imprecise and are ultimately defined by courts. This not only creates legal and administrative costs but also uncertainty in business environment and scope for opportunistic behavior. Such social costs arising from imprecise boundaries of intellectual property rights are rising and can be substantial (Bessen and Maurer 2008).

The observation that intellectual property should provide ex ante incentives to innovate but restrict the use of innovations ex post has led to the quest of a proper balance of the scope of intellectual property rights, as if there were an inverse-U shaped relationship between social welfare and the strength of intellectual property protection. For example, Alan Greenspan has frequently (e.g., April 3, 2003 and February 27, 2004) pondered the question 'If our objective is to maximize economic growth, are we striking the right balance in our protection of intellectual property rights?' While this is not an easy question to answer, it seems that, as an innovation policy tool, intellectual property might be useful in solving the ex ante problem of providing incentives to innovate, but it performs much worse in solving the ex post problem of efficient diffusion of existing innovations.

[7] When the market price of an innovation is above its marginal production costs, there are potential users who would be willing to purchase the innovation for a price that is higher than marginal cost but below the market price. That such consumers are rationed out constitutes a deadweight loss in economics jargon.

3.2. Subsidies and Public R&D Funding

R&D subsidies are typically given as direct grants (including equity investments) or subsidized loans (including guarantees), whose economic effects are qualitatively similar (see Klette, Møen, and Griliches 2000, Tanayama 2007, and Ali-Yrkkö 2008 for overviews of the literature on R&D subsidies). They are one of the largest and fastest growing forms of industrial aid in the OECD countries. The goal of awarding subsidies is encourage firms to invest more (so called "additionality") or in a different way (so called "behavioral additionality") in R&D activities than they would do otherwise.

In an ideal world where governments were omnipotent and benevolent, subsidies constituted an efficient innovation policy tool, since they would be allocated to the projects yielding the highest social rate of return on subsidies. In a less idea world, subsidies should be granted only to the projects where the social rate of return exceeds the opportunity costs of public funds, including the distortionary effects of taxation.

Subsidy policies often involve screening of R&D projects. While such screening is costly to both the applicants and the government, it in return reveals information to policy makers who can then tailor the subsidies according to the policy objectives, e.g., the projects' potential to create externalities. Since screening activities exhibit large scale economies, information gathering can be more efficient when the allocation of subsidies is centralized.

In theory subsidies would not only be an efficient tool to solve the ex ante problem of providing correct incentives to invest in R&D but also the ex post problem of use of existing innovations. The subsidy policies could be designed so that they maximize externalities and diffusion, e.g., by prioritizing projects where intellectual property is waived or put in the public domain or projects which are based on collaborative research.

The weakness of subsidy policies is that their effectiveness heavily hinge on public servants' honesty and ability to implement effective subsidy policies and pick up the right projects. Moreover, subsidies need to be applied for, and application process can involve large indirect opportunity costs, resulting in a selection problem: all relevant R&D projects will not be subsidized, either because subsidies are not applied for in the first place, or because applications are rejected (Takalo, Tanayama and Toivanen 2008). The application process, however, conveys an element of decentralization, since it is up to the firms to propose the subsidized projects. In principle the public agency running the subsidy program should leave the evaluation of commercial potential of proposed projects to the market and concentrate merely on the evaluation of the social benefits of the projects. In this task public servants could have a comparative advantage

Being discretionary and monetary, subsidies are also particularly vulnerable to misappropriation both by recipients and public servants. There are no guarantees that the public agency grants subsidies to socially beneficial R&D and the firms use them accordingly. To mitigate moral hazard temptations, subsidy policies are typically accompanied by extensive safeguards against misappropriation. But such safe-guards are costly and reduce the social rate of return of subsidies.

3.3. Tax Incentives

Tax credits are increasingly popular form of public R&D support in industrialized countries. The goal of tax credits is to reduce the marginal cost of R&D so the firms are likely to invest more than they would do without tax credits. There is no hope of behavioral additionality of encouraging particularly socially valuable projects, since firms decide what projects to undertake themselves and the tax credit percent typically does not vary over projects. Nonetheless, this decentralization of decision making is a virtue which tax credits share with intellectual property. Since the private and social values of R&D projects are typically correlated, giving incentives to invest more should be a step to the right direction. Correctly designed tax credit schemes might hence be fairly effective in providing ex ante incentives to invest.[8] But using tax incentives to encourage diffusion of R&D results ex post is challenging, unless they cannot be made industry (if not project) specific, favoring industries with higher externalities.

There is an argument that tax credits would be administratively cheaper and more predictable than, say, direct R&D grants (see, e.g., Møen 2007). While the argument has its merits, it should be kept in mind that tax credits are also vulnerable to misuse by the firms and protections against this, e.g., special auditing and accounting schemes, are costly and, as pointed out by Georghiou et al. (2003), that tax schemes are also subject to change, and tend to become complex (indeed, economic theory generally suggests that optimal tax schemes are complex).

3.4. Prizes and Contests

Prizes are an old way of supporting innovation.[9] Targeted prizes are posted ex ante by a sponsor (e.g., a public agency) who has identified a problem to be solved. If the rewarded solution is put in the public domain so that everybody can use it freely, the prizes completely solve the ex post problem of diffusion of innovations. The disadvantage of prizes lies with the ex ante problem. Since the public agency awarding targeted prizes does not elicit information from innovators, the public agency should know ex ante what should be invented. The better an unsolved need can be identified and specified in advance, the better targeted prizes work. For example, Clay Mathematics Institute offers $1.000.000 prize for the first completed proof of the Riemann Hypothesis. But, as the famous example of the longitude prize shows, even when the need is clearly specified and known ex ante, it is vulnerable to ex post opportunism by the sponsor (see Sobel 1995 for an entertaining description of the pursuit for the longitude

[8] The early empirical evidence on the effects of tax incentives on R&D investments is surveyed by Hall and van Reenen (2000). The subsequent research includes Bloom, Griffith and van Reenen (2002), Russo (2004) Hægeland and Møen (2007) and Baghana and Mohnen (2009).

[9] Scotchmer (2004b) reviews the theory and practice of the use of prizes in promoting innovation.

prize). For example, it is not necessarily trivial to determine when the posted problem solved in an adequate manner. And once the problem is solved, why should the sponsoring pubic agency give the reward?

Setting up contests for targeted prizes helps to aggregate information from innovators, as then the sponsor can compare the proposals. But the public agency should still identify ex ante the need to be solved. Such contests also inherently involve duplication of R&D costs when the participants race against each other to obtain the prize.

Some of the weaknesses of targeted prizes can be overcome by awarding so called blue-sky prizes. Such prizes are not awarded for innovations that are identified in advance but rather ex post for innovations that the sponsor considers particularly valuable. A blue-sky prize could be granted in an *ad hoc* manner each time the sponsor observes a particularly valuable innovation, but this makes them also particularly exposed to opportunism: why should the sponsor ever grant the prize? Thus, the agencies awarding blue-sky prizes today typically commit to grant the prize, e.g. to the best innovation in a technology class annually. The Nobel Prize is probably the most well-known example of blue-sky prizes.

Another tricky task with prizes is to make sure that they reflect the social value of innovations so that they are of proper size. Over the centuries clever ways to tailor the prizes to the value of innovations have been used. But estimating a proper size for a prize is difficult since this not only depends on the social value of an innovation but also the costs of creating it.

3.5. Public Procurement and Production

Governments can also provide services to complement private sector innovation, directly produce innovations themselves, or buy innovations from private contractors. Such public procurement and production of innovations and complementary services have been widely used thorough the economic history (see, e.g., Scotchmer 2004b). Public sector today produces a number of innovations in public universities and research laboratories, and is engaged in partnerships with equivalent private entities. It also provides advice, tools and other services to private sector innovators. Armed forces and public hospitals are major sources of innovation procurement.

In theory, some public innovation support services, direct public production and procurement share the benefits and costs with targeted prizes. On the one hand, the ex ante incentives to innovate are inefficient, since the decision of what to invent and of what information is produced is made by the government. But on the other hand, nothing prevents efficient diffusion of innovations ex post. Indeed, traditionally one major goal of public universities has been to diffuse information freely and some public innovation support services share this goal. However, a part of public procurement and production is concentrated on nationally strategic sectors with the purpose of *minimizing* the diffusion of research results.

Some public innovation support services such as advice broadly speaking share the benefits and costs of subsidies, putting a burden on the public servants' abilities and leaving the ultimate decision of what to invent to the private sector.

3.6. Discussion

As Sections 3.1-3.5 suggest, all innovation policies encounter the trade-off of encouraging investments in innovative activities ex ante and promoting the use of innovations ex post. Some instruments such as intellectual property and tax reliefs are better in solving the ex ante problem and some instruments such as prizes better in solving the ex post problem. In practice, a single instrument can hardly solve both problems simultaneously, calling for simultaneous use of multiple instruments.

The simultaneous use of multiple instruments requires an overall strategy that recognizes the relative advantages and disadvantages of the instruments. Otherwise, if the instruments are planned and used in isolation from each other, there is a risk that the effects of innovation policies cancel out each other. For example, firms committing opens source licensing and other weaker forms of intellectual property should as a default rule be prioritized when granting R&D subsidies. If not, the combined policy of intellectual property and R&D subsidies wipes out some of the theoretical advantages of the policy tools making it more likely that the combined policy does not increase welfare. As another default rule, prizes should be awarded only if the prize winning innovator commits to waive intellectual property and put the innovation in public domain. Otherwise the major welfare advantage of prizes is eliminated. To some extent similar considerations apply to public production. [10]

Another danger in the design of public innovation policies in the absence of clear overall plan is that the outcomes tend to arise as part of political equilibrium, reflecting the political influence of various interest groups rather than social welfare gains.

The discussion so far has been restricted to the existing instruments. Academics have however put forward many novel instruments that should in theory improve upon existing ones.[11] In a much discussed contribution, Kremer (1998) comes up with a fairly simple public patent-buy out mechanism which would combine the advantages of intellectual property and prizes.

Ultimately the efficiency of existing and novel instruments is tested in practice. There is no better way to explore the benefits and costs of various innovative policies in practice than running a carefully designed randomized policy experiments. [12]

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[10] Obviously there are circumstances where public funding of innovative activities must be combined with intellectual property incentives. Such a combined policy will create strong incentives to innovate and hence elicit innovations that would not otherwise be created (Maurer and Scotchmer 2004). But these exceptional circumstances are easier to isolate when the correct default rule is applied.

[11] Designing a truly optimal innovation policy mechanism poses a daunting task for theoretical research. An advance to this direction is made by Gallini and Scotchmer (2002)

[12] Randomized experiments have become an important part of the development policy design (Duflo and Kremer 2005), and they are likely to be incorporated in the innovation policy design in future.

4. Innovation Policies in Finland

While all major forms of innovation policy have been employed in Finland through the history, the current innovation policy is based on intellectual property, subsidies, and public production.[13] As will be discussed in the next subsections, neither R&D tax reliefs nor prizes are used systematically as an innovation policy tool.

Globalization brings an important dimension to the Finnish innovation-policy environment. Since Finland is a small open economy, the Finnish innovation-policy makers should emphasize the ex ante problem of providing incentives to innovate and the ex post problem of creating externalities only to the extent it matters the Finnish economy. In particular, the foreign incentives to innovate and consumer surplus should be ignored. As pointed out by Scotchmer (2004a) and Toivanen (2008), the small open-economy aspect modifies the standard predictions of economics of innovation. Consider for example the combined policy of awarding R&D subsidies together with intellectual property. While the standard theory suggests that the firms waiving intellectual property should be prioritized when granting R&D subsidies, in a small open economy the argument does not apply to exporting firms. Similarly, even if strong intellectual property rights were conducive for innovation globally, there would be less need to base the Finnish intellectual property system on strong protection, since this would harm domestic consumers without increasing the exporters' incentives to innovate.[14]

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[13] Lemola (2001) describes the formation of the Finnish innovation policy and Georghiou et al. (2003) provide details of the more recent innovation policy environment. Both of the works, however, abstract from the role of intellectual property in the Finnish innovation policy system.

[14] Again this is merely a default rule from which deviations are plausible in some circumstances. For example, a weak domestic intellectual property system would generally harm the non-exporters' incentives to innovate, and a weak trade secret and other intellectual property laws facilitating technological spillovers abroad could also jeopardize the exporter's incentives to innovate.

4.1. Current Issues in the Finnish Innovation Policy: Tax Reliefs and National Intellectual Property Rights Strategy

There are some interesting on-going reform processes on the Finnish innovation policy, of which two are touched upon here. First, the Finnish Government is considering the possibility of introducing tax incentives for R&D investments in addition to the existing R&D subsidy schemes. While there is plenty of research on R&D subsides on the one hand (see Section 3.2.) and R&D tax reliefs on the other hand (see Section 3.3.), and some comparisons of these instruments (see, e.g., Møen 2007 and Pajarinen, Rouvinen and Ylä-Anttila 2007), there is very little work on the design of a system where R&D tax reliefs and subsidies are used simultaneously. There is at least a good theoretic reason for the absence of such research: subsidies, if set optimally, are a superior technology policy tool. Moreover, if a R&D tax credit scheme is introduced on the top of an optimal subsidy policy, its only effect is that subsidy rates will be adjusted accordingly.[15] As a result, there will be no impact on the R&D investments or social welfare.

But, of course, in practice the subsidy rates are not set optimally nor are all R&D projects subsidized because of selection (see Section 3.2). Let us thus consider briefly the potential effects of the introduction of R&D tax credits to complement an existing subsidy policy, keeping the prevailing subsidy rates unchanged. One likely effect is that most firms taking advantage of tax reliefs will increase their R&D spending, but the increase is larger in the case of the projects that are not subsidized. The tax credit scheme should nonetheless take into account the existing subsidy policy: roughly speaking, an "average subsidy rate" should be deducted from the tax credit percent that would be "optimal" in the absence of subsidies.

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[15] A back-of-the-envelope calculation suggests that if the corporate tax rate is 30% and R&D investments enable a deduction of 20% against corporate taxes, the optimal subsidy percent should be reduced by 8.5 (0.2*0.3/0.7) percentage points.

Another topical issue in Finland is a national intellectual property rights strategy. The Finnish Government has frequently reformed intellectual property legislation and policies over the past decade but this has been done in an ad hoc basis. As already argued, such policy making is particularly exposed to lobbying, and unforeseen, counterproductive effects arising from the interaction with other policies. Hence the Finnish Government Resolution for a National Intellectual Property Rights Strategy (26 March, 2009) is a welcome attempt to provide a coherent framework for guiding policymaking. However, it appears that the experts drafting the strategy mainly represent various industry interest groups. As against this background, the strategy is fairly balanced but, nonetheless, it is not surprising that intellectual property rights are not viewed as an innovation policy tool to promote domestic economic growth. For example, the international dimension of the strategy does not appropriately recognize the aforementioned open-economy aspect, nor does it consider how to ensure the Finnish consumers' and firms' ability to adopt innovations made abroad. In line with the predictions of political economy, the strategy pays relatively little attention to consumer or user rights. It is also evident that the strategy draws more from the industry practices and intuitive ideas rather than established research results.[16]

4.2. Looking ahead: Prizes in the Finnish Innovation Policy

Besides tax credits, prizes constitute a notable absence from the array of innovation policies employed in Finland. Finland does award the world's biggest technology prize (the Millenium Technology Prize) but, generally, prizes are neither seen nor used as an instrument of

[16] In some cases research results support the strategy recommendations, but in some cases they do not. Consider, for example, the aim of making the Finnish Market Court as the centralized special court hearing all intellectual property cases. Such centralization has intuitive appeal, enabling specialization and thereby raising the standards of arguments presented in the court. However, there is a substantial body of evidence suggesting that the formation of the centralized appeals court (the Court of Appeals for the Federal Circuit) for the patent and trademark cases in the U.S. had unintended, adverse consequences, dramatically weakening the functioning of the U.S. intellectual property system and potentially seriously slowing down the rate of innovation in the U.S. (see, e.g., Jaffe and Lerner 2004, and Bessen and Maurer 2008).

innovation policy. Moreover, the Millenium Prize is an example of a blue-sky prize without clear effects on incentives or diffusion of innovations. Instead, there would be an argument for including targeted prizes in the innovation policy toolkit, especially in areas where they should work but other innovation policies are at risk of failing. For example, there are numerous diseases that are more prevalent in Finland than elsewhere in the world. Given the small market size, pharmaceutical firms lack the incentive to develop new drugs for such diseases. Many innovation policy instruments such as intellectual property, subsidies and tax incentives perform poorly in such an environment. But since the need for new drugs and therapies is clearly identified, posting a correctly designed prize would be a simple means to complement the market incentives.

5. Conclusions

It has been long recognized that innovation is crucial to social welfare but that a competitive market economy produces an inefficient rate of innovation. As a result, numerous policies have been developed to promote innovative activities. This report reviews commonly used innovation policies and their main rationales, paying particular attention to the Finnish institutional environment.

The report argues that using financial market imperfections to justify public innovation finance policies is challenging. For example, financial market imperfections creating adverse selection seem to suggest that private funding of innovative activities or the activities themselves should be taxed, not subsidized. There might, however, be a room for counter-cyclical innovation finance policies that increase public funding when liquidity in financial markets becomes scarce and restrict it when private sector funding is cheap to come by.

In contrast, externalities such as technological spillovers, consumers surplus, and cumulative innovation provide a sound rationale for innovation policies. R&D activities generate large externalities because of the public good aspects of new knowledge, technologies and creative works: it is both difficult and socially wasteful to restrict their use. Hence, profits in a competitive market economy will be driven towards zero, not accounting for sunk R&D expenditures. From an ex post point of view this is a good outcome as it keeps the price low for users. But from an ex ante point of view, it dilutes the incentives to innovate as the firms realize that they cannot recover their R&D expenditures.

All innovation policies encounter the trade-off of providing ex ante incentives to innovate and diffuse innovations ex post. A single instrument can hardly solve both problems simultaneously, calling for the simultaneous use of multiple instruments. As a result, the use of each instrument should not be designed in isolation from each other but designing their simultaneous use requires an overall economic strategy that recognizes the relative advantages and disadvantages of the instruments. In the Finnish case, such a strategy should also take into account the small open economy aspect, which affects the relative efficiency of the policy instruments in solving the ex ante and ex post problems Otherwise, there is a risk that the effects of innovation policies cancel out each other or that they merely reflect political influence of various interest groups rather than economic efficiency.

The current Finnish innovation policy hinges on intellectual property, direct R&D subsidies, and public production. Other major forms of innovation policy such as R&D tax reliefs and prizes are used at best in a very restricted manner. Clearly there would be scope for carefully designed randomized policy experiments of the use of new instruments and the new uses of current instruments.

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