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DOCUMENTED
BRIEFING

Innovation Procurement

Part of the Solution

Philipp-Bastian Brutscher, Jonathan Cave,
Jonathan Grant

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RAND EUROPE

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1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
4570 Fifth Avenue, Suite 600, Pittsburgh, PA 15213-2665
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Preface

This thematic report discusses the possible role and limitations of innovation procurement as an innovation policy instrument. The report complements other briefings produced under the International Observatory on Health research Systems currently being developed by RAND Europe. The research for the report was conducted with funding support from the Health Research and Development Policy Research Unit of the Department of Health (England).

The motivation for this report is the increasing interest of policy makers in procurement as an innovation policy measure, while the gap between the policy and economics literature is becoming bigger and bigger. Whereas the policy literature tends to take a relatively broad and sympathetic stance, the economics literature is typically more detailed and less enthusiastic.

The aim of the report is to narrow this gap by reviewing the two bodies of literature in the context of two very specific questions – aiming at the efficiency, effectiveness and value for money contributions of innovation procurement:

- Can innovation procurement ensure that the pace and amount of innovation is maintained through optimal investment in R&D? and
- Can innovation procurement ensure that investment in innovation is distributed to where it will be most effective?

We believe this is useful, because bringing together the two bodies of literature – policy and economics – challenges some of the current thinking on these issues on both sides and possibly contributes to a more nuanced view on innovation procurement and its potential.

The report is based on a review of the literature. We have also conducted some economic modelling which will be published separately. Although funded under the International Observatory on Health research Systems, the report will be of interest to a broad audience of government officials, research councils, charities and public and private institutions.

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Dr Jonathan Grant
President
RAND Europe
Westbrook Centre, Milton Road
Cambridge CB4 1YG
United Kingdom
Email: jgrant@rand.org
Tel: 01223 353329

www.randeurope.org

Content

Executive Summary

There is a consensus in the academic literature that innovation is at the heart of long-term economic growth and international competiveness.[1] In addition, innovation is often considered important for improving public service delivery and helping to address global economic challenges such as climate change and sustainable development at reasonable social cost.[2]

Traditional approaches for promoting innovation emphasise supply side instruments – such as R&D support. A demand side measure that has gained popularity among policy makers over recent years is innovation procurement, which is the public procurement of innovative goods and services. Since 2005, innovation procurement has played a central role in several ambitious policy reports. These include:

- European Commission (2005): Public Procurement for Research and Innovation – Developing Procurement Practice Favourable to R&D and Innovation; Expert Group Report; Pre-Commercial Procurement of Innovation;
- UK Department for Innovation Universities and Skills (2008): Innovation Nation; DIUS: Science and Innovation White Paper;
- Lord Sainsbury (2007): The Race to the Top: A Review of Science and Innovation Policies;
- Richard, D. (2008): Small Business and Government: The Richard Report; Submission to Shadow Cabinet.

All these reports point in the same direction – public procurement has a potent, but underexploited capability to promote innovation in the private sector and thereby to strengthen European competiveness. According to the reports, public procurement amounts to 16% of EU GDP, so public authorities, as major customers, are in a good position to stimulate R&D and innovation.

At the same time, the reports identify some key barriers, including risk aversion in the public sector, coordination failures between procurement and other aspects of public policy and inappropriate procurement contracts.

Despite the undoubted potential of innovation procurement, we argue that it is important to be aware of when and how to use it. Innovation procurement is only likely to promote innovation efficiently if used in the right circumstances and in the right way.

We identify two principal justifications for using innovation procurement:

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[1] Romer, P.M. (1990), Endogenous technological change, Journal of Political Economy, 98(5), S71-S102; Jones, C.I. (1995), R&D-based models of economic growth, Journal of Political Economy, 103(4), 759-784.; Porter, M. (1990), The Competitive Advantage of Nations. London.

[2] Grubb, M.; David, U. (2002): Energy, the Environment, and Innovation; Oxford Review of Economic Policy; Vol.18; No1.

- to ensure the right amount of investment in research and development (and so the pace and amount of innovation); and
- to ensure that investment in innovation is distributed to where it will be most effective.

We interpret innovation procurement as a special type of prize mechanism, and find that it should be part of a menu of prize mechanisms including first-past-the-post, best-in-simultaneous-submissions and simple contests.

Further exploration of potential outcomes suggests that innovation procurement should only be used alone when it promotes the right amount of investment in innovation. If it ensures the right distribution of innovation investment but not the right amount of investment, a hybrid mechanism combining standard procurement with another prize mechanism is indicated.

This briefing is based on the academic and policy literature in the field. It is strongly recommended that this exploratory work is followed up with a rigorous empirical study to test whether and to what extent the reasoning presented stands up to the data.

Most empirical work in the field so far has focused on the question of whether innovation procurement ensures the right amount of investment and/or the right distribution of investment in research and development.[3] Little attention has been paid to how innovation procurement fares with regard to these questions relative to alternative prize mechanisms.

[3] Edler et al (2005): Innovation and Public Procurement. Review of Issues at Stake; study for the European Commission (No ENTR/03/24). CBI/QinetiQ (2006): Innovation and public procurement: A New Approach to Stimulating Innovation; CBI Innovation Brief. Vinnova (2006): Public Procurement as a Driver for Innovation and Change; Report on Government Commission to Nutk and Vinnova; Vinnova journal number: 2006-01487

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1. Introduction

Innovation procurement is seen to have great potential

- European Commission
- UK Department for Innovation, Universities and Skills
- Sainsbury Review
- The Richard Report

Policies to promote innovation have become increasingly popular over the past decade. The European Union's (EU) Lisbon Strategy of 2000 made such policies a priority in order "to make Europe the most competitive and dynamic knowledge-based economy in the world".[4] In the UK, innovation has been a key part of science policy since the publication of the 1993 White Paper *Realising Our Potential: A Strategy for Science, Engineering and Technology*[5] which, for the first time, placed UK science policy within a broader framework of innovation policy.

More recently, Lord Sainsbury's review, *The Race to the Top: A Review of science and innovation policies*,[6] the Richard Report, *Small Business and Government*[7] and the Department for Innovation, Universities and Skills (DIUS) White Paper *Innovation Nation*[8] emphasised the need for the UK to become a knowledge-based economy in the globalisation era, with government providing stewardship for an effective science and innovation system.

Conventional approaches to innovation policy emphasise supply side instruments like research and development (R&D) support and venture capital participation.

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[4] Lisbon European Council 23 and 24 March 2000 – Presidency Conclusions – Employment, Economic Reform and Social Cohesion.

[5] Cabinet Office (1993): Realising Our Potential: A Strategy for Science, Engineering and Technology; HMSO, London.

[6] Copies of the report are available at: http://www.hm-treasury.gov.uk/sainsbury_index.htm

[7] Copies of the report are available at: http://www.conservatives.com/pdf/document-richardreport-2008.pdf

[8] Copies of the report are available at: http://www.dius.gov.uk/publications/innovation-nation.html

Innovation procurement is a more recent approach. Innovation procurement is the public procurement of innovative goods and services, and as such is a demand-side measure. The recent reports all emphasise the use of innovation procurement, suggesting that it offers a large and substantially underexploited means of promoting innovation.

In this documented briefing we argue that, despite the undoubted potential of innovation procurement, it is critical to be aware of the circumstances in which innovation procurement is used, and how it is used under these circumstances. Innovation procurement will only foster the innovation process efficiently if it is used in the right circumstances, and in the right way.

We first look at the importance of innovation and why we need policies to support it. We argue that there are two principal justifications for using innovation procurement:

- To ensure that the pace and amount of innovation is maintained through optimal investment in R&D; and
- To ensure that investment in innovation is distributed to where it will be most effective.

We interpret innovation procurement as a special type of prize and explore how it and other types of prize complement the existing intellectual property (IP) system under different circumstances.

We then look at when innovation procurement is optimal, i.e. when it meets the two justifications and ensures the right amount and distribution of innovation investment.

Finally, we argue that innovation procurement should only be used when it ensures sufficient investment in research and development. If it only promotes better distribution of investment, we suggest a hybrid prize mechanism instead.

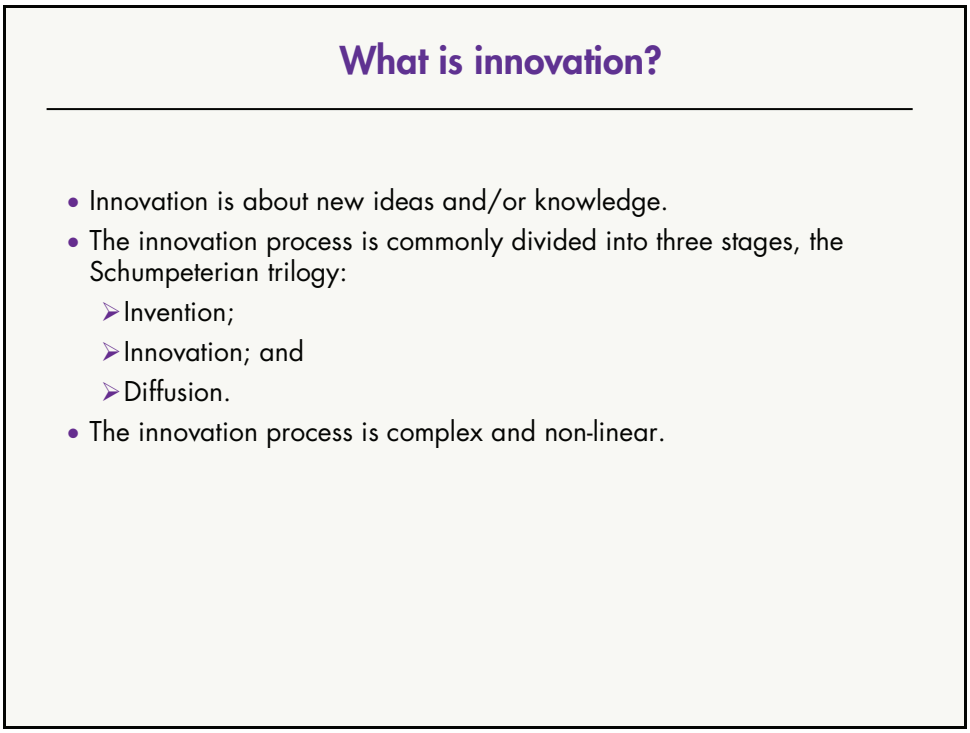
For the sake of focus and tractability, we limit our discussion in two ways:

- We focus on invention stimuli rather than the innovation and diffusion aspects of innovation procurement.[9]
- We assume that invention, or innovation more broadly, is good. That is, we exclude negative effects associated with "creative destruction", and possible "negative externalities", such as pollution, that result from innovative products and/or services.[10]

[9] This assumption is in line with much of the literature on the topic. At the same time, it is not without problems. For example, focusing on invention neglects that firms may end up under-resourced for innovation and diffusion. Similarly, it overlooks the 'unsung heroes' of non-invention innovation; deployers, end-users, etc. However, these complements to invention have traditionally been spurred or facilitated by invention. Moreover, it is important to note that none of the mechanisms *per se* encourages types of invention that are less innovation-friendly. Those aspects of the mechanism that do affect this (e.g. IPR arrangements) are a valid subject for future work.

[10] For a discussion see: Witt, U. (2003): Economic Policy Making in Evolutionary Perspective; in: Journal of Evolutionary Economics; Vol. 13; No.2; pp. 77-94.

2. Innovation and innovation policies



Innovation is about the generation of new ideas and/or knowledge. The Schumpererian trilogy divides the innovation process into three stages: invention, innovation and diffusion. Invention is the initial conception of an idea. Innovation is the first application of the idea to actual practice by a firm or a consumer. Diffusion is the process by which other firms and consumers adopt – and adapt – the innovation.[11]

The innovation process is complex and non-linear. It can occur at any point in the product/service lifecycle, and can lead to another invention or an unexpected application.

Examples of unexpected applications include the Post-it note, developed when Art Fry came up with a use for the new adhesive that his 3M colleague, Spencer Silver, had invented, and Viagra, which emerged from work on drugs for treating high blood pressure and angina.

[11] Schumpeter, J. (1947): The Creative Response in Economic History; The Journal of Economic History; *149-159.*

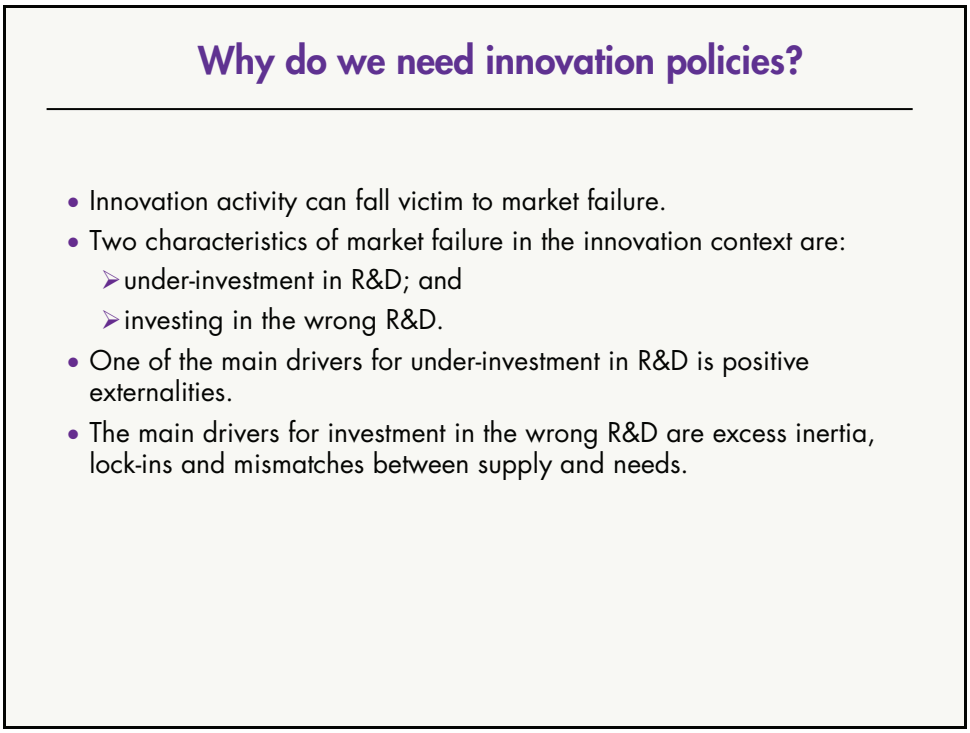
Why is innovation important?

- There is a consensus in the academic literature that strong innovation performance is at the heart of
  - long-term economic growth;
  - international competitiveness; and
  - public service delivery.
- Innovation is also seen as an important factor in addressing global economic challenges – such as climate change.

Innovation is critically important to social welfare. It is widely recognized in the academic and policy literature that technological progress and enhanced human capital – the building of skills in the labour force – are the principal engines of economic growth in industrialised countries.[12] Solow (1957) demonstrated that technological progress and increasing skills in the labour force accounted for between 80% and 90% of the annual productivity increase in the US economy between 1909 and 1949, with increases in the capital/labour ratio accounting for the remainder.[13] Denison (1985) extended and refined this analysis, reaching similar results for the period 1929-1982, attributing 68% of productivity gain to advances in scientific and technological knowledge, 34% to improved worker education, 22% to greater realization of scale economies, and 13% to increased capital intensity. These factors were offset by decreases in work hours (-25%), government regulation (-4%), and other influences.[14]

The academic literature also gives innovation a central role in international competitiveness, public service delivery[15] and efforts to address global economic challenges such as climate change and sustainable development at reasonable social cost.[16]

[12] Romer, P.M. (1990): Endogenous technological change; Journal of Political Economy; 98(5); S71-S102. Jones, C.I. (1995): R&D-based models of economic growth; Journal of Political Economy; 103(4); 759-784.
[13] Solow, R.M. (1957): Technical Change and the Aggregate Production Function; Review of Economics and Statistics 39:312-320.
[14] Denison, E.F. (1985): Trends in American Economic Growth, 1929-1982; Washington: Brookings Institution.
[15] Borins, S. (2001): Encouraging Innovation in the Public Sector; Journal of Intellectual Capital; 2(3).
[16] Grubb, M.; David, U. (2002): Energy, the Environment, and Innovation; Oxford Review of Economic Policy; Vol.18; No1.



Government policies in support of innovation are typically justified on the grounds of market failure, or the market being inefficient. We take the perspective of a Pareto-efficient market, one in which there is no further room for improvement in one part of the system without causing a detrimental effect in another part of the system. An efficient market would send the right signals regarding the amount, speed and kind of innovation needed, would provide the resources to pay for it and would ensure that it is taken up and used in the right ways – these are referred to as informational, allocation, technical, and dynamic efficiency.

Two ways in which market failure manifests itself with regard to innovation are:

- under-investment in R&D, which makes the pace and amount of innovation too slow; and
- investment in the wrong R&D/innovation(s).

There are a number of reasons why markets fail to ensure sufficient investment in R&D. Probably the most prominent one concerns the "positive externalities" of innovations, whereby the organisation creating the innovation does not get the full benefit because other entities also benefit.[17]

Arrow (1962) famously argued that competitive markets are not conducive to innovation because the innovators do not necessarily reap all the benefits of their efforts. Even if innovation is largely concerned with the production of new knowledge, that knowledge will typically be manifested eventually in physical objects. While protecting the designs of such objects is not difficult, it is harder to protect the ideas behind them because the public good properties of that knowledge include non-excludability.[18] If you have an idea, it is difficult to exclude others from using it. For instance, the ideas behind the iPod are seen in a range of MP3 players, and Teflon is only one of many different brands of non-stick cookware.

[17] See Arrow, K.J. (1962): Economic welfare and the allocation of resources for invention; in R.R. Nelson (ed): The Rate and Direction of Inventive Activity: Economic and Social Factors; pp. 609–626; NBER.
[18] Nelson, R. et al (1982): An Evolutionary Theory of Economic Change; Cambridge, MA; Harvard University Press.

Acquiring new knowledge is expensive, but its non-exclusivity suggests that, without some sort of protection or reward, an innovator is at a market disadvantage relative to his or her rivals. Those rivals may be able to[19] use the new knowledge without incurring any of the acquisition costs which, in turn, suggests that commercially-motivated innovators are likely to be dissuaded from investing in innovation in the first place. Alternatively, they may invest in innovation that fails to produce optimum societal benefit due to being overly restrictive or proprietary. From a societal perspective this means that, in the absence of some sort of protection or reward, aggregate investment in innovation will probably be too low.

Another type of market failure is when the market steers investment towards the wrong R&D. The main barriers to optimum distribution of investment include excess inertia, lock-ins and mismatches between supply and need.

Many innovative goods and services exhibit network effects, where the more users there are, the greater the value to each user. Sometimes these effects result from physical networks, such as a telephone system, where the value of a phone is greater the more people are using the system. In most cases, however, the effects are virtual – the value of the Windows operating system increases for every user, "For example, the more users buy the windows operating system, the more complementary products and service (e.g. software) will be available for Windows users".[20]

Strong network effects can lead to two similar but distinct types of market failure: excess inertia and inefficient lock-in.

Excess inertia refers to the situation where a new, superior technology fails to displace an older, inferior one. Strong network effects mean that users of the old technology or standard are afraid to switch – a new technology with few followers is worse than an old one with a good solid installed base.

Inefficient lock-in refers to the situation where the market favours the adoption of an inferior version of a new technology or standard, and typically results from similar self-reinforcing dynamics. Video cassette recorders provide a classic example of an inefficient lock-in. Many industry experts agreed that the Sony Betamax system was superior to the JVC VHS system, but VHS was the winner when video rental stores picked a standard in the 1980s. Once most video stores offered VHS tapes, even users who would otherwise have preferred Betamax caved in and opted for VHS.

Mismatches between supply and need result from information asymmetry between innovators and potential customers or users. A lack of mutual understanding can hamper both R&D and the diffusion process. At the R&D stage, innovators lack knowledge about their customers and so fail to respond to their customers' future needs. Georghiou found that "User-producer interaction and communication is often poor, with scattered demand not articulated sufficiently to make suppliers read the signals and translate them into innovation".[21] Diffusion problems mean that innovative start-up firms are unable to get a foothold in the market – even if no network external-

[19] Cohen, W.M. et al. (1990): Absorptive Capacity: A New Perspective on Learning and Innovation; suggest that, in order to benefit from research efforts undertaken by others, individuals (firms, industries, economies) have to invest in research themselves (hence do incur "costs"). For a formal presentation of this point see: Leahy D.; Neary, P. (1997): Public Policy Towards R&D in Oligopolistic Industries; in: The American Economic Review; Vol.87; No.4; pp.642–662.

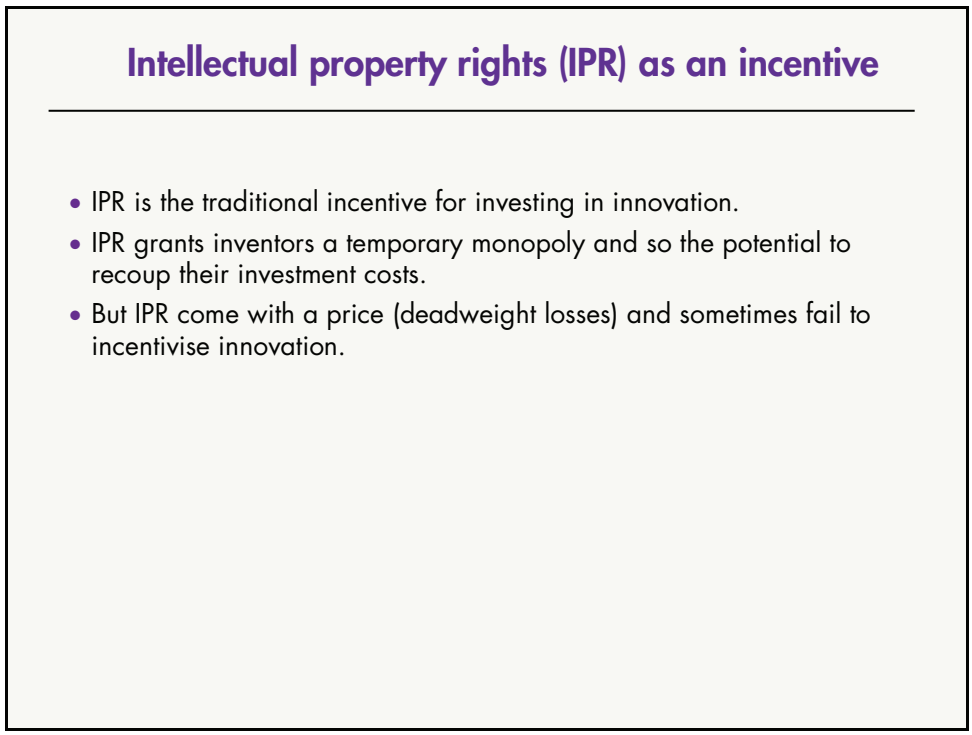
[20] Motta, M. (2004): Competition Policy – Theory and Practice; Cambridge: Cambridge University Press.

[21] Georghiou, L. (2007): Demanding Innovation: Lead Markets; Public Procurement and Innovation; NESTA: Provocation 02.

ities exist – because customers are reluctant to adopt an innovation knowing little about the viability of the firm and/or the innovation itself.

If innovators anticipate inertia or lock-in problems, they are likely to invest less in total and more likely to direct their investment towards those innovations that have the edge in the market rather than those which are technologically superior. We get a similar effect if innovators can foresee customer problems and needs. Both effects result in a sub-optimal distribution of R&D investment.

3. Preventing under-investment in innovation: using a range of incentives



Granting intellectual property rights (IPR) in the form of a patent, trademark, copyright or other certification, is the traditional approach for dealing with the problem of appropriability – the fact that innovators may not get the full benefits of their inventions. Intellectual property rights grant authors and investors limited exclusive rights to control the use of their innovation for a fixed period of time, which theoretically removes the competitive disadvantage, and thus encourages investment in R&D.

Yet, intellectual property rights come with a cost. The temporary monopoly can result in a deadweight loss, where consumers with marginal valuations higher than marginal costs are priced out of the market. Cabral et al (2006) gives the following illustration: "in the AIDS vaccine case, monopoly pricing of a patented vaccine might result in some people being excluded from the care – with social costs that might amount to thousands if not millions of deaths. Were the vaccine priced at marginal costs – a much smaller number of people would be excluded".[22]

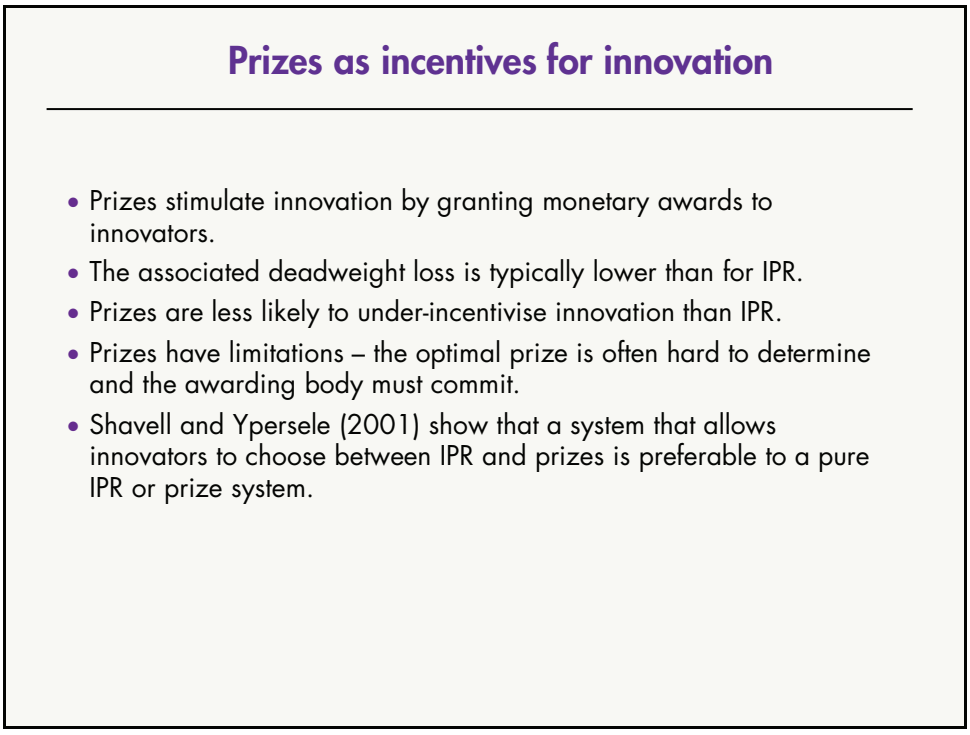
An associated cost is a reduction in the incentive to innovate. Economic theory suggests that optimal incentives provide marginal expected returns equal to the marginal expected social surplus of an innovation. There are two reasons why IPR might keep marginal expected returns below marginal expected social surplus for an innovation and hence provide insufficient incentive for innovation:

[22] Cabral et al (2006): Procuring Innovation; CEPR Discussion Paper; no.5774.

- Sometimes IPR may not be granted, e.g. because the innovation does not satisfy all criteria for originality, etc;
- Even if IPR is granted, the corresponding incentive to innovate may be too low due to monopoly deadweight loss, problems in extracting all consumer surplus (because the ability to price discriminate is imperfect), or the possibility of other firms coming up with similar innovations that do not infringe IPR.

As a result of these and other limitations, both the academic and political spheres have begun to seek alternative mechanisms for dealing with the problem of appropriability. Suggestions include speed, secrecy and reputation, but the most prominent is prizes, which grant a monetary return to innovators. [23]

[23] Maurer, S.M.; Scotchmer, S. (2003): Procuring knowledge; NBER Working Paper Series; Working Paper 9903.



The main advantage of prizes over IPR is that generally, under optimal tax conditions, the excess burden of funding prizes is smaller than the deadweight loss from monopoly pricing of new goods. In addition, there is no restriction over what innovations can be awarded prizes, or an upper bound on the size of a monetary prize – which means that prizes should provide sufficient incentive to innovate.

But prizes are not without limitations. While no one pays more than he or she benefits in the case of IPR, for prizes, especially those financed out of general fiscal revenue, some individuals may end up in effect paying for something they do not use or value. (It is worth bearing in mind, however, that users of innovations in disjoint domains may well all be better off by making reciprocal subsidies – each contributing their tax money towards the innovation that is useful to the other group – under the condition that no one is excluded from use.) [24]

Another possible limitation of prizes is the need to link them to the social value of an innovation in order to provide an optimal incentive to invest in research and development. In the case of IPR, even though the rewards conferred by for instance a patent are low, they should increase with the invention's usefulness, since as more people use a product and/or service, the value of the associated IPR increases. Prizes, however, are specified before they are won and are thus less well linked to the innovation's social value.

It is important to note, however, that to the extent that investment decisions are made before returns to innovations are realized, the fact that the value of IPR is linked to the social value of an innovation is of little help in providing an optimal incentive to invest in R&D before the IPR is granted. Innovators have to guess what returns to expect from their IPR just as government officials have to guess the social value of an innovation in order to set the monetary value of the prize.

This suggests that the problem for government in linking the value of a prize to the social value of an innovation constitutes a problem only to the extent that innovators are better informed and

[24] Maurer, S.M.; Scotchmer, S. (2003): Procuring knowledge; NBER Working Paper Series; Working Paper 9903.

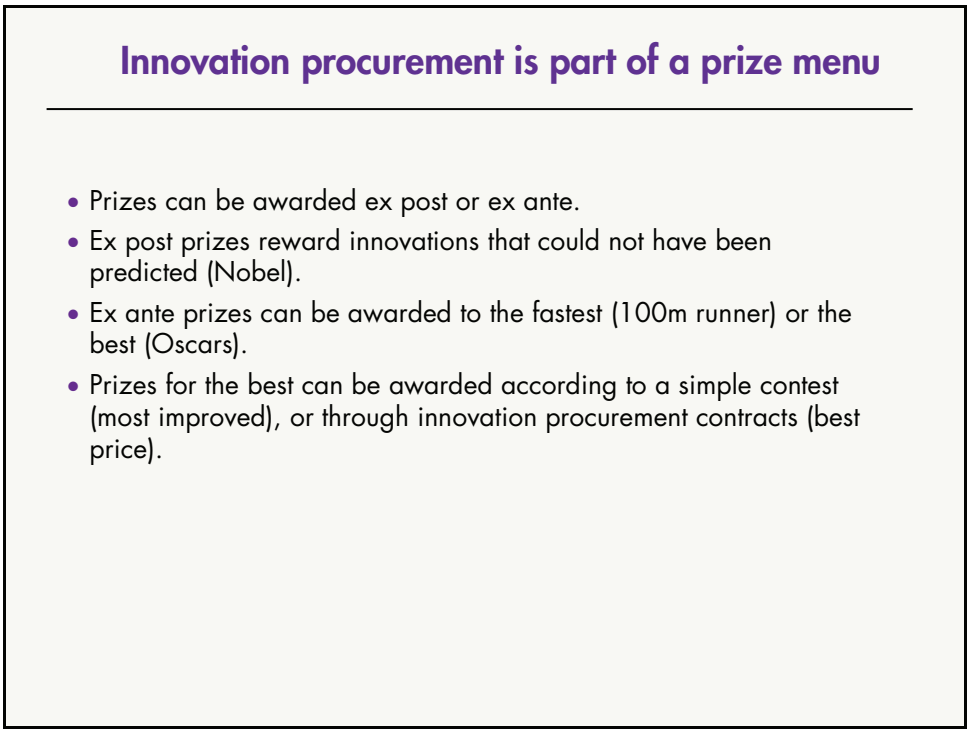
hence better at guessing the returns to their IPR than government officials are at guessing the social value of an innovation. In other words, a prize mechanism might have an extra cost due to information asymmetry between government and innovators, but this vanishes if information between the two is symmetric.

Leaving aside distributional concerns, the comparison between patents and prizes therefore boils down to a comparison between the distortions associated with monopoly pricing on the one hand and the distortion created by asymmetric information about the social value of an innovation on the other hand. This suggests that:

- monetary prizes (rather than IPR) are the preferable option when deadweight losses from monopoly pricing are large, for instance in cases of high demand elasticity, and informational asymmetry between government and innovator is low;
- the opposite is true when deadweight losses are small and informational asymmetry high.[25]

It may sometimes be hard to distinguish between these two cases, so Shavell and Ypersele (2001) suggest giving suppliers a choice between IPR and monetary prizes. Using a mathematical model, they show that such a system dominates a pure patent system and may also be preferable to a pure prize system.[26] Film actors face such a choice when deciding whether to receive a fee or a percentage of box office takings when agreeing to a film project.

[25] Cabral et al (2006): Procuring Innovation; CEPR Discussion Paper no.5774.
[26] Shavell,S. Ypersele, T. (1999): Rewards Versus Intellectual Property Rights; NBER Working Paper 6956.



Prizes can be designed a number of ways, and the choice of design can determine the extent to which the prize will stimulate investment in R&D. Thus even in an optional system, such as that suggested by Shavell and Ypersele (1999), it is important to pay attention to prize design if the prize is to drive the optimal amount of investment in innovation.

Ex post prizes are retrospective – they are awarded when no need has been identified or described in advance. Examples of ex post prizes include the Nobel and the Pulitzer. Such prizes can also be used when normal prize mechanisms cannot be used – the U.S. Atomic Energy Act of 1946 set up a Patent Compensation Board to award monetary prizes for militarily valuable innovations in atomic energy because such innovations could not be sold commercially. Davis (2004) reports that the former Soviet Union often rewarded individual innovators for valuable ideas, typically as a percentage of the cost savings achieved.

Ex ante prizes are offered before an innovation exists and can be subdivided based on how the prize is awarded:

- 'first past the post' (FPTP); or
- the 'best in simultaneous submissions' (BISS), which is subdivided into:[27]
  - a simple contest to find the entrant that has made the greatest progress; or
  - innovation procurement, which rewards the supplier that bids the lowest price per unit of innovation.

For FPTP, the prize is awarded to the first competitor to achieve a stipulated goal. No other considerations are taken into account.

The Longitude Prize is a famous example of a first-past-the-post prize. In 1714, the British government announced a series of prizes for anyone who could invent a way to measure longitude accurately. Excessive losses of men, ships and battles through navigational disasters had made this

[27] Ibid

ability essential. A range of prizes were offered, the largest being £20,000 for a method accurate to within five-tenths of one degree; £15,000 for a method accurate to within 40 minutes; and £10,000 for a method that reliably measured longitude to within 1 degree.[28] The Longitude Prize prompted a boom in research, with several people being given smaller awards for significant contributions. Clockmaker John Harrison was the eventual winner of the main prize.

In BISS prizes, competitors have a given period of time to develop their idea and are then judged on the basis of how much progress they have made towards a pre-specified objective based on a set of criteria. No particular level of technological achievement is specified.[29]

Best-in-simultaneous-submissions prizes can be divided into simple contest designs and innovation procurement contracts. When using simple contests, the government sets both the prize and a time deadline, and awards the prize to whichever entrant has made the greatest progress when the deadline is reached. For procurement contracts, only the time deadline is fixed,[30] competitors are invited to submit their innovative solution together with a bid for the right to sell the innovative good to a public sector procurer.

Two main differences arise when comparing simple research contests with innovation procurement contracts: "First, [for procurement contracts] the prize is not specified in advance, but is determined as a result of […] competitive bidding. Second, the highest quality innovator is not sure of getting the prize; the winner of the contest will instead be the supplier that bids the lowest price per unit of quality supplied".[31]

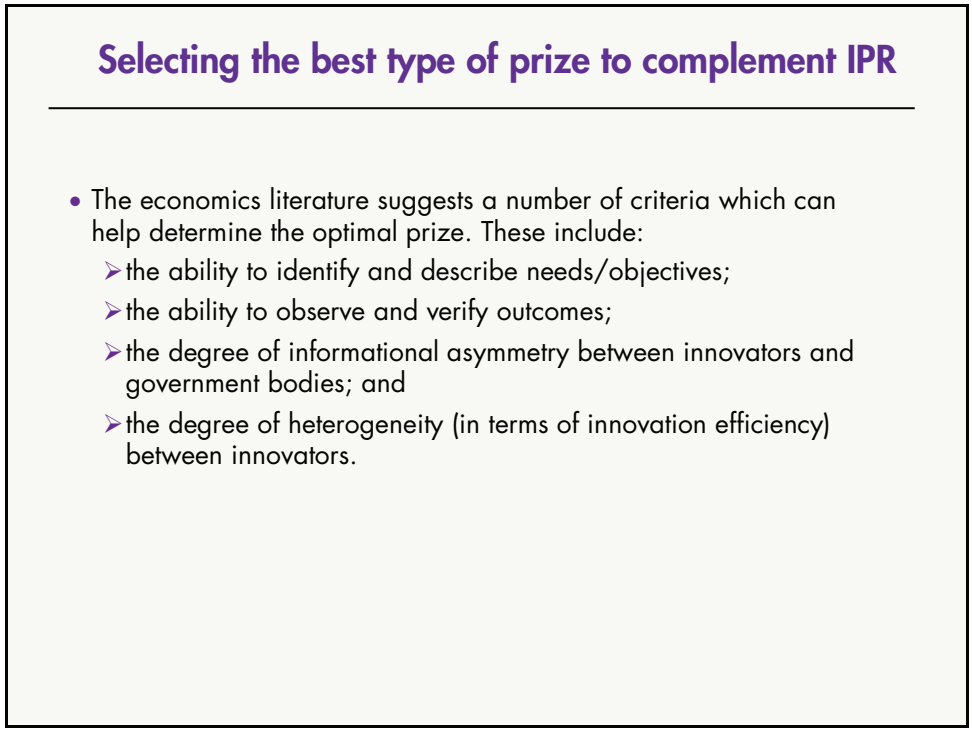
All four types of prize can be used to complement an IPR system and thus drive investment in innovation.

[28] Davis, L.N.; Davis, J. (2004): Optimal design of research contests; Paper presented a the DRUID Summer Conference.

[29] In the mathematical model we distinguish a further case.

[30] We take a simplified view of procurement contracts. In practice, further elements come into play – including eligibility conditions, requirements, explicit evaluation criteria, sample contracts, milestone requirements, IPR clauses etc. The main results apply to these more general situations as well.

[31] Cabral et al (2006): Procuring Innovation; CEPR Discussion Paper no.5774.



The economics literature suggests a number of criteria which can help to identify what type of prize will complement an IPR system under different circumstances.

Sometimes governments are unable to identify or describe what needs an innovation might address before someone thinks of an idea. In such a situation, ex ante prizes are not an option because no clear performance objectives can be specified, so ex post prizes are the necessary choice. For instance, the value of a Nobel prize-winner's work is rarely understood soon after it is published, and it may be many years before their contribution is recognised.

It is important to note, however, that the extent to which government can be aware of its needs can vary. Various reports[32] suggest surveys and competitive procurement as ways for government to gather market intelligence to help determine what is feasible and/or what is needed.

The ability to observe and verify outcomes throws up a limitation of ex post prizes. When the value of an innovation is not observable or verifiable, the procurer can set the prize amount quite discretionally. This suggests that innovators have an incentive to engage in opportunistic behaviour – and, as a consequence, that the whole system of ex post prizes is prone to corruption.[33]

Should ex post prizes be the preferred or only option, Mauerer and Scotchmer (2003) suggested that the commitment problem could be dealt with by making ex post prizes more similar to contests. The government would set a prize and commit to awarding it at a pre-specified date, but would not define a clear objective, formulating a few evaluation criteria instead. This would leave little room for opportunistic behaviour.

The problem of information asymmetry gives rise to another problem – the ability to value an innovation, which is significant in setting the level of a prize or award. Kremer (1998) proposed

[32] European Commission (2005): Public Procurement for Research and Innovation – Developing Procurement Practice Favourable to R&D and Innovation; Expert Group Report; Pre-Commercial Procurement of Innovation.
[33] Ibid

that the government initially grants IPR to the innovator; but then auctions the IPR to rival firms. In a small number of cases, the IPR would be delivered to the winning bidder in return for the bid price. In the majority of the cases, however, the government would acquire the IPR – at a price determined by the tendering process.

The idea of this mechanism is that the rivals participating in the auction bid the same regardless of whether the probability of receiving the intellectual property (after winning the auction) is very low or one. This allows the government to extract any additional information private firms may have on the social value of an innovation at relatively low social cost. All it has to do is to use the winning bid to make inferences on the private value of an innovation to the bidder – and from this infer the social value – taking into account the limited patent duration and appropriability of the social value.

The problem with this method is that, if we assume that the innovator knows more than the government about the value of the IPR – the information is asymmetrical – then they can use this to extract an information rent. More troubling is the possibility that this rent may encourage the innovator to pursue lines of R&D that the government is likely to know least about, even when they do not result in a better innovation. The Kremer mechanism relies on rivalry between innovators, and a two-stage auction can be used to induce the rival firms – each of which wishes to conceal its own information – to reveal information about each other. [34]

An example of a Kremer-type buy-out occurred when the French inventors of photography, Daguerre and Nahin, sold their rights in an ex post negotiation in 1839. Maurer and Scotchmer (2003) reported that the two inventors received pensions totalling 10,000 francs per annum in exchange for revealing the secrets of the process at a joint meeting of the French Academies of Art and Science. Afterwards, the process was put into the public domain.[35]

The main problem with the Kremer mechanism is that it is not collusion-proof.[36] Because of this weakness, Cabral et al (2006) warn: "it seems prudent not to apply the mechanism systematically (or at least carefully) especially in those industries in which there is a relatively small set of players that remain active for a long time".[37]

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[34] In a simplified example, suppose that two firms have IPR that has either high or low cost, and that the probability that both are high or both are low is 1/3 each, while the probability that one is high and the other low is 1/6 each. In the first stage, the government asks the firms to bid 'High' or 'Low' – if both firms bid 'High' or both bid 'Low', the firms receive a prize of P; if they differ, they are charged 2P each. In the second round, the government awards the contract to the best firm and pays the cost revealed in the bid. The key to the mechanism is this: conditional on its own information (say 'High') a firm expects its rival to be twice as likely to bid (truthfully) 'High' as 'Low'. Thus the expected payoff to telling the truth in the first round is 0 =(2/3)*P + (1/3)*(-2P). If it lies, it expects (2/3)*(-2P) + (1/3)*P = -P; thus each tells the truth and the first round has an expected transfer of 0. In the second round, the government pays exactly the lowest cost, so there is no informational rent.

[35] Maurer, S.M.; Scotchmer, S. (2003): Procuring knowledge; NBER Working Paper Series, Working Paper 9903

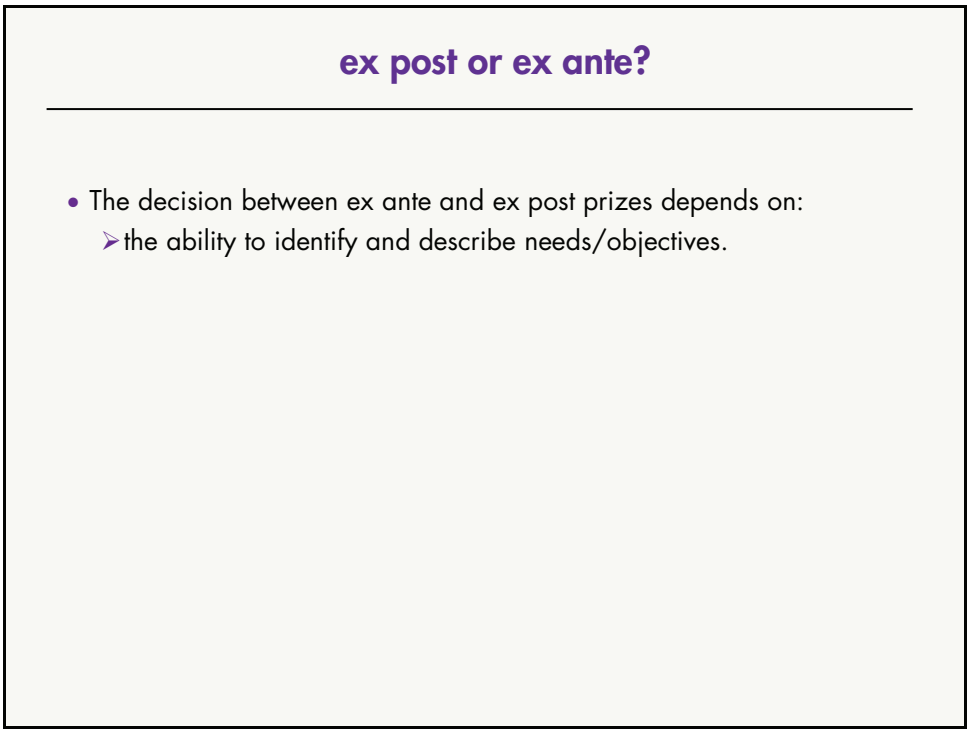
[36] To see this consider the following example provided by Cabral et al (2006): "Suppose that firms A and B enter a bilateral agreement whereby firm B systematically bids in excess of the value of A's patents and A does the same when it comes to B's patents to be competitively procured. Even if there are many bidders and no other firm participates in the agreement, firm B's (over-valued) bids will determine the price that the government pays for A's patents, and in like manner A will determine the price that B gets for its own patents". In the rare event that B must really purchase A's patent in the example, the patent can be re-sold to A; alternatively, B can wait for A to over-pay one of B's patents to be compensated. Because such bilateral agreements are easier to reach than multilateral agreements, are self-enforcing irrespective of the size of the discount factors (there is no temptation to deviate), and there can be several bilateral agreements in place, the government may very often end up paying an excessive price for the intellectual property right it buys out.

[37] Cabral et al (2006): Procuring Innovation; CEPR Discussion Paper no.5774.

Menell and Scotchmer (2005) suggested making the prize a function of a verifiable performance standard as another way of dealing with the valuation problem. An example of this approach can be seen in the Lyonnaise silk-weaving industry. During the *ancien regime* in France (14th to 18th centuries), members of the *Fabrique Lyonnaise* could make improvements to weaving on their own initiative, and then petition a prize committee for remuneration. The prize committee would set the terms of the rewards for successful applications based on performance criteria, such as the number of weavers who adopted the new method.[38]

We find heterogeneity when one or a few innovators have a significant efficiency advantage over all other innovators. In such a situation, prizes using only one evaluation criterion, such as the functionality or quality of an innovation, are of limited use. With heterogeneous suppliers, the efficiency gap between the most and least efficient contestant can be so large that there is little incentive for all but the most efficient competitors to invest in an innovation. If, on the other hand, a second criterion is taken into consideration, and firms are, for example, allowed to submit a price bid with their innovation, any disadvantage with regard to the first criterion can be balanced by means of the second criterion (for instance offering a lower price), resulting in a neck-and neck race which increases the incentive to innovate for all competitors.

[38] Menell,P.; Scotchmer, S. (2005): Intellectual Property; in: Polinsky, A.M.; Shavell, S. (ed): Handbook of Law and Economicsl North Holland.



Ex post prizes, such as the Nobel, are awarded when no need has been identified or described in advance and are thus discretionary – "judges are allowed to know it when they see it".[39]

Ex ante prizes are offered before an innovation exists. They have clear performance standards and reward solutions to needs that are originally identified by governments.

When it comes to deciding between ex ante and ex post prizes, the choice seems relatively straightforward. Generally, ex ante prizes appear to be preferable because it is easy to observe whether the government has kept its promise, and so a simple reputation mechanism can provide enough incentive for the government to stick to the commitment.[40]

With ex post prizes, there is always the risk that government might renege on its promise to award a prize, or the full value of the prize, even though the desired innovation has been accomplished. John Harrison spent many years proving his claim to have met the original criteria for the Longitude Prize before he was finally awarded the last tranche of the award money.

With ex post prizes, therefore, the government is systematically tempted to under-reward innovators and, since this will be anticipated by some potential innovators, it could result in under-investment in research.[41]

[39] Davis, L.N.; Davis, J. (2004): Optimal design of research contests; Paper presented a the DRUID Summer Conference.
[40] Cabral et al (2006): Procuring Innovation; CEPR Discussion Paper no.5774.
[41] Ibid

BISS – simple contest or innovation procurement contract?

- The choice between simple contest design and innovation procurement contracts depends on:
  - the heterogeneity of suppliers; and/or
  - the degree of informational asymmetry between public sector and innovator.

	Informational Symmetry	Informational Asymmetry
Homogeneous bidders	Simple Contest	Procurement Contract
Heterogeneous bidders	Procurement Contract	Procurement Contract

Deciding between FPTP and BISS prizes depends to some extent on the choice between simple contest designs and procurement contracts for a BISS prize, because when innovation procurement turns out to be a better option than a simple contest, it is often better than FPTP as well. So in order to choose between FPTP and BISS, we first need to examine the two possibilities for a BISS prize.

The main criteria for deciding between a simple contest design and a procurement contract are the heterogeneity of suppliers in terms of their efficiency in innovating, and the degree of informational asymmetry between public sector and innovator.

If innovators are homogenous, i.e. no innovators have a significant efficiency advantage, and information is symmetrical, i.e. the government's understanding of the innovation is the same as or very close to that of the innovator, a simple contest mechanism seems better than a procurement contract. Competitive bidding is of little additional value in this case, but comes with a cost: it inevitably reduces the prize associated with winning the race, and thereby reduces the benefit from investing in R&D.[42] To the extent that R&D responds to incentives, this is likely to lower the innovative effort of all suppliers participating in the race.

A procurement contract is usually preferable when suppliers are heterogeneous (regardless of whether government and innovators are equally informed about the value of an innovation) because it stimulates competition. With heterogeneous suppliers, the efficiency gap between the most and least efficient contestant(s) can be so large that the outcome of a contest would be largely independent of research efforts, which reduces the incentives of all suppliers to invest. In this case, letting less efficient suppliers bid for a lower price (producing a lower quality innovation) makes the contest more similar to a neck-and-neck race and increases the incentive to innovate.

A risk for such a race is the so-called "winner's curse", where the winner may be the one who most overestimated the value of the innovation. This can lead entrants to under-invest, and pos-

[42] See also: Cabral et al (2006): Procuring Innovation; CEPR Discussion Paper no.5774.

sibly the wrong firm winning or a payment that is too high. The winner's curse is less problematic for procurement contracts because the tendering process involves exchange of information.[43]

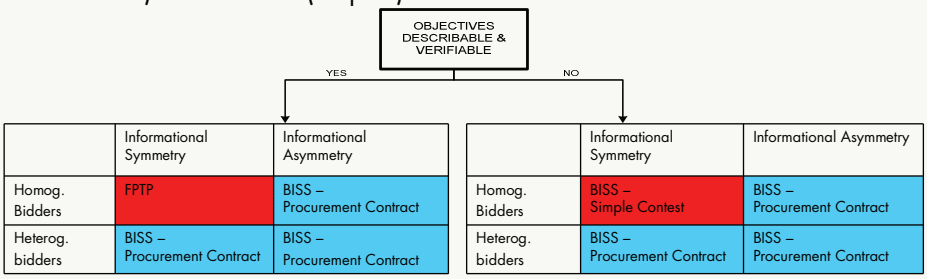
If government and innovators are asymmetrically informed, the simple contest design can be complemented with a Kremer type buy-out mechanism or the prize linked to a verifiable performance standard to deal with the problem of associating it with the social value of an innovation. In most cases, however, the preferable solution is to use a procurement contract, because the value of the prize can be inferred from the bids submitted.[44]

[43] The arguments favouring the procurement contract when suppliers are heterogeneous are strongest when the innovation has a 'private value' character – when each innovator is capable of producing a distinct innovation (the innovation would have a 'common value' if part of its value is the same regardless of who discovers it).

[44] While most situations featuring heterogeneous bidders and information asymmetry suggests a procurement contract, there are special circumstances under which a simple contest is the best option. If the bidders' heterogeneity is independent and identically distributed, and the sponsor cannot charge an entry fee, our model suggests that the simple contest is better because it reduces information rents, especially when the innovation technology is subject to large random factors.

ex ante – FPTP or BISS?

- The decision between first-past-the-post and best-in-simultaneous submission prizes depends on:
  - the heterogeneity of suppliers; and/or
  - the degree of informational asymmetry between public sector and innovator and/or
  - the extent to which an innovation outcome can be described (ex ante) and verified (ex post).



	Informational Symmetry	Informational Asymmetry
Homog. Bidders	FPTP	BISS – Procurement Contract
Heterog. bidders	BISS – Procurement Contract	BISS – Procurement Contract

	Informational Symmetry	Informational Asymmetry
Homog. Bidders	BISS – Simple Contest	BISS – Procurement Contract
Heterog. bidders	BISS – Procurement Contract	BISS – Procurement Contract

Choosing between FPTP and BISS prizes relies to some extent on the same criteria for choosing between simple contests and procurement contracts – heterogeneity and information asymmetry. If there is a high degree of heterogeneity among innovators and/or informational asymmetry between government and innovator, then a BISS prize (or more specifically a procurement contract) seems preferable to an FPTP mechanism.

The reason is that FPTP prizes, like simple contests, don't incentivize a broad range of innovators if there is a significant gap between the most efficient contestant and all others. Similarly, FPTP does not provide any insights as to how to value a prize if there are significant informational asymmetries between government and innovators.

From a more general perspective, BISS mechanisms also seem preferable if innovative outcomes are not verifiable, regardless of issues around heterogeneity and/or information symmetry. Best-in-simultaneous-submissions prizes are less demanding than FPTP because the prize is awarded to whichever entrant has made the greatest progress towards a set objective. There is no need to ascertain whether a prescribed target has been reached or not, all that matters is that a prize is awarded to a contestant.

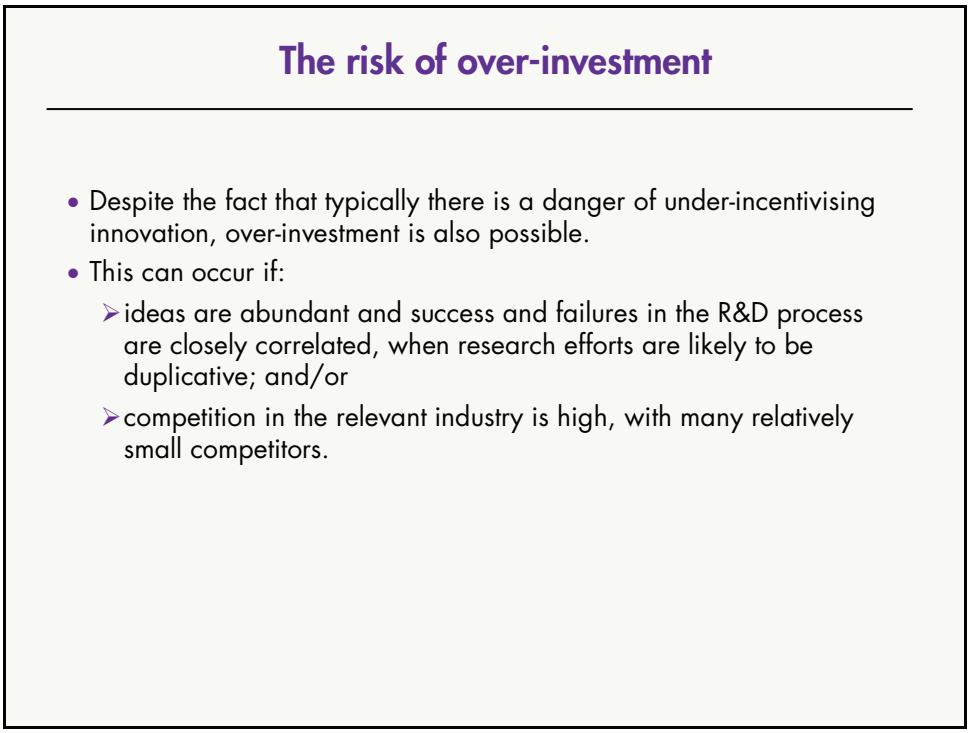
If, on the other hand, there is a low degree of heterogeneity between innovators, little informational asymmetry between government authority and innovator, and innovative outcomes are clearly verifiable, an FPTP mechanism seems preferable. In this situation, it provides a strong incentive to innovate at relatively little cost to the government, since the prize is only awarded if the contestant actually provides a solution (as opposed to a partial solution), and there is no additional competitive element in the form of price bids that may make the incentive too low.

FPTP prizes have the additional advantage in these situations that they are less prone to favouritism. Given the 'post' is well defined, FPTP prizes leave little room for subjectivity. Either a competitor is the first to meet a certain technological threshold, or he/she is not. "Although this may

not guarantee that the prize will be awarded promptly […] it does curtail the extent to which political or other elements could influence the prize decision."[45]

In addition, in situations in which a requisite innovation depends on the prior solution of a basic problem; FPTP prizes have the positive characteristic to favour speed. A more diverse and deliberate (i.e. slow) course of innovation may be preferable once this (basic problem) is solved.

[45] Davis, L.N. (2002): Should We Consider Alternative Incentives For Basic Research? Patents Vs. Prizes; Paper presented a the DRUID Summer Conference on "Industrial Dynamics of the New and Old Economy – who is embracing whom?" Downloaded from: http://www.druid.dk/uploads/tx_picturedb/ds2002-595.pdf.



Using incentives to encourage investment in innovation comes with a caveat. An optimal incentive for innovation sets marginal (expected) returns equal to marginal (expected) social surplus, and depends on the right choice of prize mechanism. It is important to note, however, that while the incentive is designed to increase investment in R&D, there are circumstances where this results in too much investment in R&D.

Two such cases are:

- When ideas are abundant and success and failure in the R&D process are closely correlated; and
- When competition in the relevant industry is high, with many relatively small competitors.[46]

Maurer and Scotchmer (2003) explain: "[There are] two types of creative environments: those where the creation of knowledge addresses a known need, and those where the need has not been identified, or at least articulated by a sponsor, prior to someone thinking of the idea. In the latter [case], it is natural to call the idea *scarce*, in the sense that there are no substitute ideas that would address the same economic need".[47] For simplicity, we can think of a scarce ideas environment as one in which ex post prizes are used, and an abundant ideas environment as one in which ex ante prizes are awarded.

In the first type of over-investment (abundant ideas and success and failure in the R&D process closely correlated), having a greater number of innovators does not increase the probability of success – and so the parallel research efforts are simply duplications.

In the second type of over-investment (high competition), the private value of winning a prize is likely to be higher than the social value because winning the prize in this situation comes with

[46] The same effect may also happen if there are only two companies – but because of the so called "elasticity effect" we expect the argument to be strongest for the situation with many, relatively small competitors.

[47] Maurer, S.M.; Scotchmer, S. (2003): Procuring knowledge; NBER Working Paper Series, Working Paper 9903

substantial, additional benefits from the ability to steal business from competitors. Under these circumstances, a prize set equal to the marginal social value of an innovation is likely to trigger over-investment in R&D.

Avoiding over-investment

- Over-investment due to duplication can be addressed by either:
  - reducing the number of competitors (e.g. by asking for an entry fee); or
  - awarding the prize to several competitors.
- Over-investment due to a prize having a high private value can be addressed by:
  - reducing the size of the (monetary) award; or
  - awarding the prize to several competitors.
- In both cases, awarding the prize to several competitors seems to be the preferable approach.

The most intuitive way to address the issue of over-investment due to duplication is to reduce the number of competitors. This could be done by charging potential competitors an entry fee. The advantage of this approach is that it should primarily discourage the participants with the lowest expected return to their investment, and so reduces duplication with a relatively low risk of eliminating the most promising innovators.

The main problem with entry fees is setting them at the right level. If the entry fee is set too low, there will still be too many entrants and duplication; if it is set too high, competition may be hampered to the extent that the associated costs outweigh the reduced costs of duplication. Fullerton and McAfee (1999) suggest a competitive entry tendering process as one way of finding the right fee.[48]

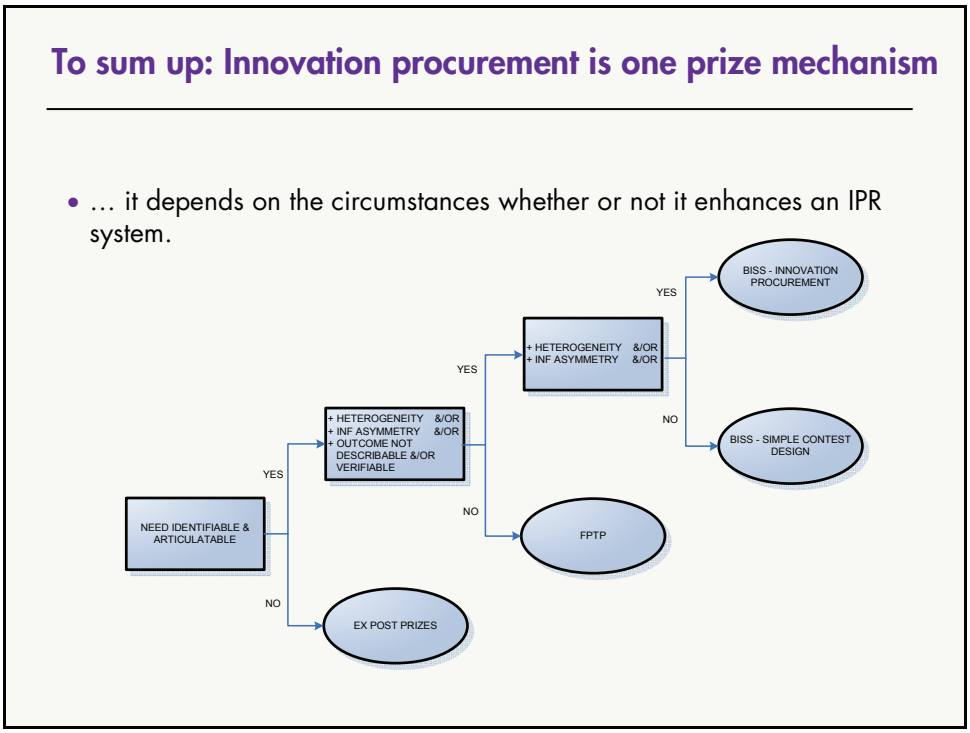
Another approach is to abandon the classic winner-takes-all outcome and select several winners instead. This gives competitors a common as well as a competitive interest, and so reduces wasteful duplication without eliminating the competitive struggle to be *primes inter pares*. The idea is that, in such a scheme, innovators can trade off the additional returns of being first (relative to second or third) against the effort required to be first (rather than second or third).

In the case of a procurement contract, this cooperative approach could take the form of a collaborative design contest, in which entrants compete to produce a prototype, and the resulting production order is split among the winning contestants on the basis of either a fixed allocation or, where circumstances permit, a multiple-sourcing arrangement in which contract shares are periodically adjusted on the basis of delivered performance and new innovations (which also serves to keep the competition alive).

Over-investment due to the private value of a prize exceeding the corresponding social value could be prevented by reducing the monetary value of the prize. As before, however, determining how much to reduce the prize money by may not be straightforward. An alternative (and possibly

[48] Fullerton, R.L..; McAfee, R.P. (1999): Auctioning Entry into Tournaments; Journal of Political Economy; Vol.7; No3; 62-84.

simpler) approach is to award the prize to several innovators. This reduces the potential for stealing business from other competitors and reduces the private value of the prize by dividing it among the winners, so decreases the likelihood of over-investment. Indeed, it can be shown that such an award can improve participation by small firms and that the resulting "cooptation" will increase investment by and expected returns to all firms.

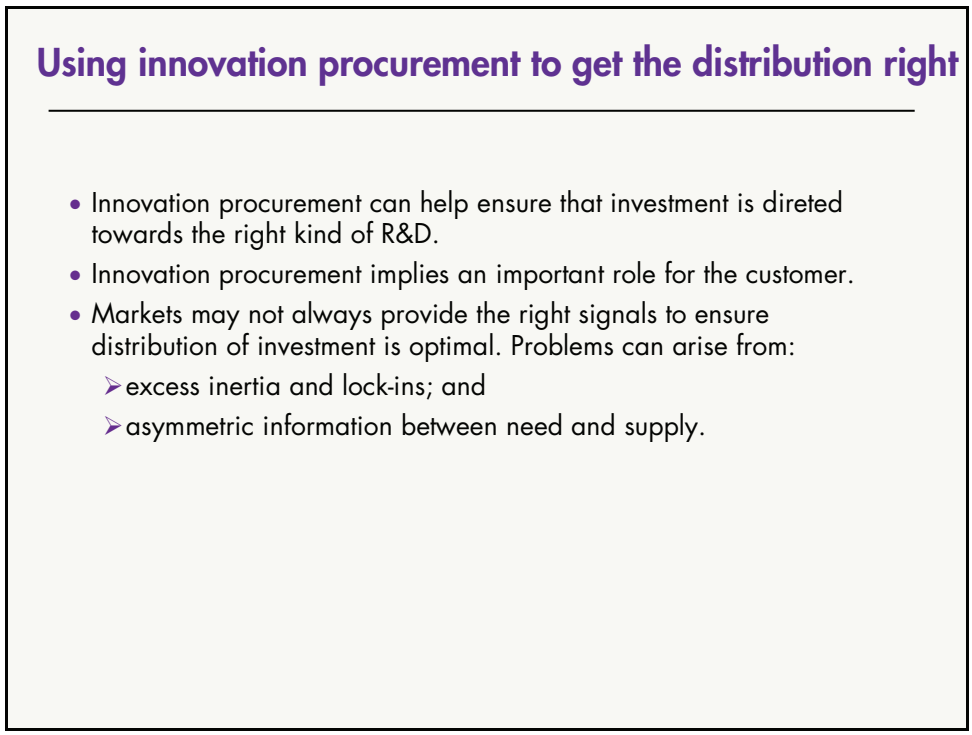


Using a prize mechanism to drive innovation procurement could complement an IPR system and therefore provide an incentive to invest in innovation. However, selecting the type of prize, or indeed whether one should be offered at all, must be done carefully if the desired end result is to be achieved.

The decision tree above summarises the criteria in selecting the most suitable prize mechanisms.

- Ex post prizes are likely to be the optimal design if needs cannot be clearly identified or described.
- If needs can be identified and described but there is neither ii) heterogeneity nor iii) information asymmetry, then BISS simple contests or an FPTP design is likely to be the preferred option.
- Innovation procurement contracts seem the optimal choice if i) needs are clearly identifiable and describable, and ii) innovators are heterogeneous and/or iii) information asymmetry prevails.

4. Preventing investment in the wrong innovation: using innovation procurement



Innovation procurement implies a major role for the customer in driving and directing innovation investments. The importance of customers was underlined in a recent study for the European Commission, which showed that changing customer needs are three times more important than other factors in creating innovation opportunities for companies, and that more than half the companies surveyed used customers to obtain feedback on ideas.[49]

A role for the customer, however, brings us back to the problems of market failure, in this instance excess inertia and lock-ins, such as the Windows and VHS-Betamax examples described earlier, and information asymmetries, where there is a mismatch between need and supply.

Innovation procurement is often cited as a method of dealing with these problems.[50] But while innovation procurement can address these issues, it is rarely the only possible solution.

[49] Business Decisions Limited (2003): The Power of Customers to Drive Innovation; Report to the Enterprise Directorate General; European Commission.
[50] Edler et al (2005): Innovation and Public Procurement. Review of Issues at Stake; Study for the European Commission No ENTR (03/24).

Innovation procurement is sometimes the best way forward

- Innovation procurement can help to address the problems of excess inertia and lock-in by:
  - increasing the product base; and/or
  - providing a focal point of coordination.
- Similarly, innovation procurement can help to overcome problems due to the mismatch between need and supply by:
  - increasing producer-user interaction.
- Yet, in most of these cases, there is little reason to believe that the same problems could not also be addressed using other mechanisms.

Innovation procurement is expected to counteract problems of excess inertia and lock-in because, when government purchases sizable amounts of an innovative good and/or service, it increases the value of that good and induces greater adoption by other users. In addition, a choice made by such a large agent as the government may act as an important focal point for coordination whenever there are several options available, which again helps overcome excess inertia and lock-in.[51]

At the same time, it is important to note that, in most cases, innovation procurement is not the only option available to address these issues. When all that is needed to overcome excess inertia and/or lock-in situations is a focal point, an FPTP or any other prize mechanism can have the same effect as an innovation procurement contract. There are also policy measures other than prizes, such as standard setting, that can help to address these problems.

The literature suggests that innovation procurement can also be helpful when there is a mismatch between need and supply. At the adoption stage, innovation procurement provides credibility through the installation of the innovation. As Georghiou (2007) argues: "In effect, the early user has not only had the benefit of using the technology first, but provided revenue to the innovator, assuaged the concerns of the second purchaser, and (assuming that the innovation is successful) allowed the second purchaser to enjoy the benefits of the innovation which they would not otherwise have purchased".[52]

At the R&D stage, innovation procurement can foster user-producer interaction, with the government feeding back its adoption experience. In addition, to the extent that innovation procurement is preceded by a competitive dialogue – in which government and potential innovators' needs and possible solutions are discussed – firms get first hand information on future customer needs.[53]

[51] Ibid
[52] Ibid
[53] European Commission (2005): Public Procurement for Research and Innovation – Developing Procurement Practice Favourable to R&D and Innovation; Expert Group Report; Pre-Commercial Procurement of Innovation.

Examples of bodies that have used competitive dialogue include the UK Department of Trade and Industry (DTI) and National Health Service (NHS). The DTI has applied this practice in the construction industry. The DTI and the NHS have implemented ProCure21, a healthcare facilities construction project. The objective of ProCure21 is to encourage long-term cooperation between procurer and constructors in order to match users' needs. The programme aims to improve quality and safety, reduce costs and guarantee delivery dates.[54]

Again, however, it is important to note that innovation procurement need not be the only or best mechanism for addressing these problems. An FPTP prize (with a reputable assessment panel) may signal credibility just as effectively as a procurement contract, possibly even better due to the higher publicity. Other prize mechanisms can also be preceded with a competitive dialogue stage, so providing firms with first hand information on customer need is not the sole preserve of procurement contracts.

Even though innovation procurement may be a good way of addressing a number of problems that result in investment being directed towards the wrong type of R&D, in most cases, there is little reason to believe that the same problems could not also be addressed by other mechanisms.

[54] From Cabral et al (2006): Procuring Innovation; CEPR Discussion Paper no.5774.

Innovation procurement *is* the best way forward when:

- Market failure induces:
  - problems of lock-in; and
  - there is uncertainty around which technology is superior; and
  - the innovation is expected to have a long life-cycle
- Innovations include a high degree of novelty, so consumer needs are very uncertain.

One situation where innovation procurement may play a central role in ensuring that R&D investment goes into the right kinds of innovation is when:

- there are strong network externalities and problems of lock-in;
- there is some uncertainty over which technology is superior; and
- the innovative product and/or service is expected to have a long life-cycle.

In this situation, it is not helpful to have other prizes serving as focal points, nor to use standard setting to force convergence towards a particular technology when we do not know if that technology is superior to any others being developed.

When innovative products and/or services have a short life-cycle, it is possible that the benefits of solving a problem quickly outweigh the costs of investing in a potentially inferior innovation. This is unlikely to be the case with innovations that have a long expected life-cycle, where the cost of not picking the highest quality innovation is very high and unlikely to be outweighed by the benefits of a shorter R&D stage.

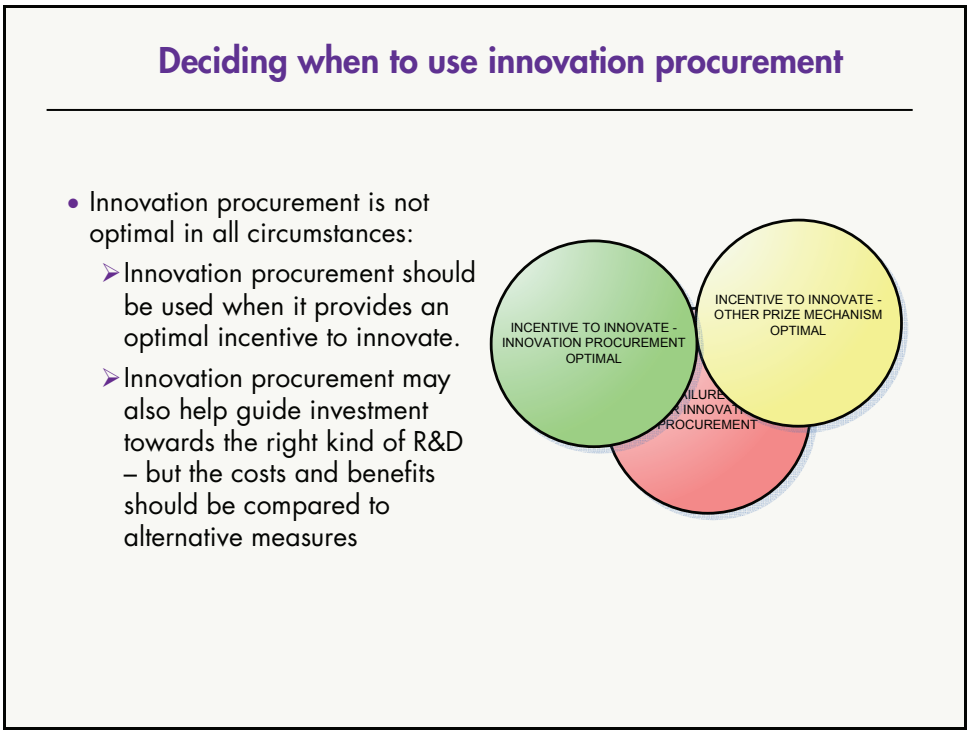
Innovation procurement seems the optimal solution for dealing with the problem of lock-in. It delays the convergence process by supporting lagging technologies until it becomes easier to determine which technology is better, effectively increasing the probability of convergence towards the superior technology. Cabral and Kretschmer (2004) refer to governments adopting a "patient planner" role[55] when they use innovation procurement to this effect.

The second situation in which innovation procurement seems to play a central role in ensuring optimal distribution of investment is when innovators need direct feedback from consumers. This

[55] Cabral, L.; Kretschmer, T. (2004): Standards Battles and Public Policy; Working Paper, forthcoming in Greensteing S.; Stango, V. (ed), Standards and Public Policy; Cambridge: Cambridge University Press

is likely to be the case when innovations include a high degree of novelty, where innovators cannot draw on past experience to make inferences about likely consumer needs or preferences.

5. When and how to use innovation procurement

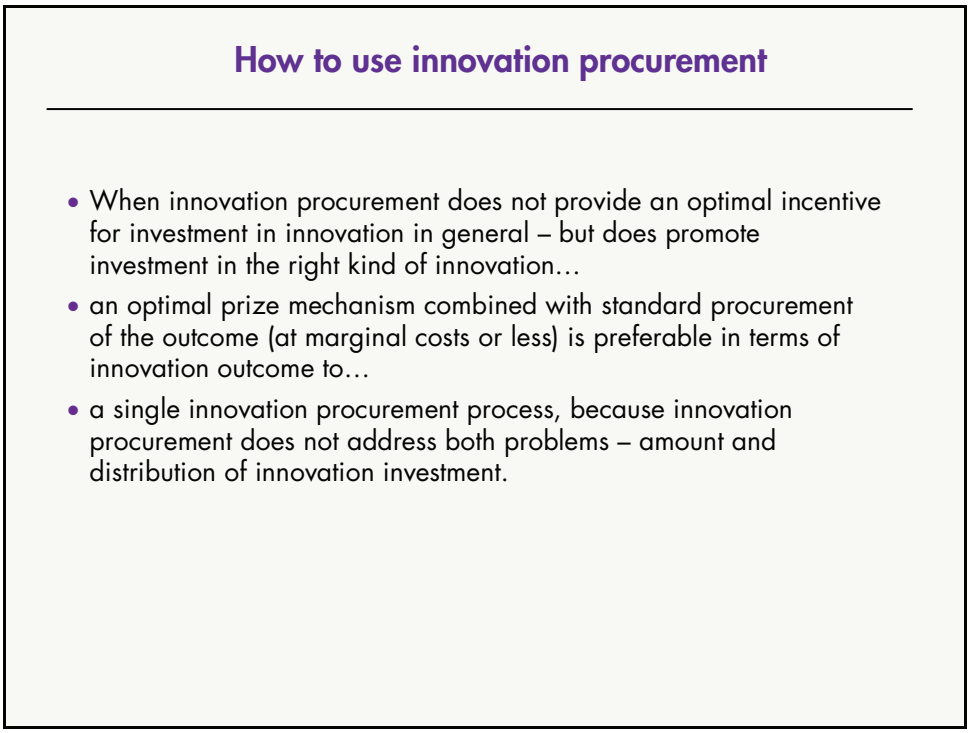


Innovation procurement can clearly be used to stimulate innovation in some circumstances, but is not always the optimal solution. Similarly, innovation procurement can be the only measure to promote an efficient distribution of R&D investment, but is not always. This naturally begs the questions:

- When should innovation procurement be used? and
- How should innovation procurement be used?

Innovation procurement should be used whenever it provides an optimal incentive to invest the right amount, whether or not it is also the only measure to ensure the right distribution of investment. That is, it should be used in all cases falling in the green circle in the graphic above.

When innovation procurement is uniquely suited to overcoming a sub-optimal distribution of investment in R&D (when neither the alternative, optimal prize mechanism nor another policy measure such as standard setting can serve as a substitute), but *does not* provide an optimal incentive to invest the right amount (i.e. in all cases falling in the red circle but not the green one), the situation is less straightforward. In this case, we need to ask how to use innovation procurement and/or the prize mechanism to ensure the right amount of investment.



As outlined earlier, the literature suggests that innovation procurement provides a uniquely suited policy measure for addressing problems around distribution of investment in R&D when:

- i) there are problems of lock-in; ii) there is uncertainty around which technology is superior; and iii) the innovation is expected to have a long life-cycle; and/or
- the innovation is highly novel and consumer needs are highly uncertain.

Since innovation procurement does not always provide an optimal method for ensuring the right amount of investment in R&D in these situations, a conflict arises. Should the prize mechanism that would ensure an optimal amount of investment be used – even though it does not address the distributional problems; or should innovation procurement be used – even though it does not ensure the optimal amount of investment in R&D?

It can be shown that, in such a situation, the better solution is to use the prize mechanism that ensures the right amount of investment, and to complement it with a standard procurement process, in which government purchases the product and/or service at, say, marginal costs as soon as it is developed – rather than purchasing it at the stage where it still is an idea.

Standard procurement does not stimulate R&D investment directly because it occurs at a stage where the technology is already developed. However, it does address the issues of strong network externalities, uncertainty in the market, a long life-cycle and/or a high degree of novelty. Therefore combining standard procurement with a prize mechanism that provides an optimal incentive to invest in innovation in the first place allows us to have both the right amount and the right distribution of investment in innovation.