Innovation market failures and state aid: developing criteria

Report prepared for
DG for Enterprise and Industry
European Commission

November 2005
This report has been produced by Oxera as a project ordered and financed by the European Commission [Enterprise and Industry Directorate-General].

The views expressed are those of the authors and do not necessarily reflect those of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of the following information. Nothing in this publication implies or expresses a warranty of any kind.

Oxera Consulting Ltd is registered in England No. 2589629. Registered office at Park Central, 40/41 Park End Street, Oxford OX1 1JD, UK. Although every effort has been made to ensure the accuracy of the material and the integrity of the analysis presented herein, the Company accepts no liability for any actions taken on the basis of its contents.

Oxera Consulting Ltd is not licensed in the conduct of investment business as defined in the Financial Services and Markets Act 2000. Anyone considering a specific investment should consult their own broker or other investment adviser. The Company accepts no liability for any specific investment decision, which must be at the investor’s own risk.

For further information, contact
European Commission
Enterprise and Industry Directorate-General
Unit A4 – Competitiveness Aspects of Competition Policy
B-1049 Bruxelles
Fax: + 32-2-2966814
E-mail: entr-competitiveness-competition@cec.eu.int

© European Communities, 2005.
Reproduction is authorised provided the source is acknowledged
Executive summary

This report constitutes an independent analysis by Oxera on what is meant by innovation, when market failures might be expected to occur, and when, in turn, state aid might be justified.

The aim of the report is to develop an economic framework for assessing state aid proposals put forward in the field of innovation, in the specific context that innovation may be sub-optimal due to market failures. The findings of the report may be used to complement the process being undertaken by the Commission, which seeks to improve the existing rules such that state aid is targeted more effectively at resolving identified innovation market failures.1

Drawing on the lessons learned from the theoretical and empirical literature on innovation and innovation market failures, five case studies explored by Oxera and a number of further discussions with relevant market players, the report identifies relevant and measurable dimensions of innovation market failures, and develops criteria, indicators and questions that allow the ex ante identification of when:

- an investment or scheme put forward by a Member State that is to be a recipient of state aid is likely to result in innovation in the economy;
- such investment or scheme is a priori unlikely to take place in the absence of government intervention due to the existence of market failures.

The starting point for the analysis is the Community Innovation Survey (CIS) definition of innovation (European Commission 2005e). Here, innovation in the economy is taken to mean changes that deliver either new goods or services—ie, product innovation—or the same goods or services but at lower costs (or higher quality for the same cost)—ie, process innovations. This definition of innovation is therefore broad, and is independent of sector, radical or incremental innovation, firm size or activity. There is merit in adopting a wide definition when considering whether innovation has occurred. However, this report aims to address a different question—ie, when state aid for innovation might ex ante be justified. In this respect, the definition does not lend itself readily to the ex post measurement of innovation. Also, because the definition is wide, it captures aspects of innovation that are unlikely to suffer from market failures. The focus of the current study is to explore aspects of innovation that are both measurable ex ante, and are ex ante likely to be associated with innovation market failures.

In addition, there remains considerable theoretical and empirical uncertainty about what causes or hinders innovation. One area of debate relates to how critical are some of the general conditions of the economic system for innovation to take place at all in an efficient manner. These general conditions include the development of the education system in the economy, general levels of entrepreneurship in the economy, and the stage of the regulatory framework. The lack of such conditions is often known as ‘systems failures’. In many cases, the development of these pre-conditions would not be expected to involve state aid due, for example, to their general nature, or because they do not involve a transfer of government resources. However, given their potential importance, there remains the possibility that, even if state aid policy were successful at overcoming innovation market failures, the actual, additional, amount of innovation that would be achieved would be limited.

1 See European Commission (2005c).
Thus, better targeting of state aid per se may be necessary, but may not be sufficient, for Member State governments to raise the innovation rate in their economies. As recognised by the Commission in the state aid action plan (European Commission 2005d), state aid is generally a ‘second-best’ option to ensuring that the fundamental prerequisites for innovation are present.

Taking an economic approach, this report concentrates on justifying state aid on the basis that, a priori, innovation market failures might be expected to occur. Although non-linear theories of innovation and the systems failure literature characterise the innovation process as being particularly complex, it is still nonetheless possible (and desirable) to identify a limited number of market failures that hinder the process of innovation, and to determine ex ante when these market failures are likely to be significant, and thus reduce the degree of innovation significantly below its optimal (economic) level. In turn, this could assist in the process of approving (or rejecting) specific proposals put forward to the Commission by Member States.

Hence, the report focuses on market failures in a reasonably narrow sense. Factors that might constitute system failures are also identified, but only where these are sufficiently close to, and are of particular relevance to, the market failure being considered. The systems literature emphasises not only that the components of the system need to be adequate (for example, the education system), but also the links between these components. In this report, coordination market failures and network failures that may arise when firms need to interact with other agents for successful innovation are discussed. However, the report does not develop criteria for ‘macro-level’ factors at the system level that may hinder coordination and networking between firms, such as the level of entrepreneurship in the economy or the regulatory framework. The discussion of financial market failures does, nonetheless, touch on the issue of institutional barriers to venture capital financing, such as the lack of an equity culture, which might be regarded as more macro in nature.

Innovation market failures

The report identifies four major market failures that may have a significant impact on the innovation process.

– Technological or knowledge spillovers—the process of undertaking innovation, or the end result of the innovation process (eg, a product), often generates wider benefits (positive externalities). Left to the market, projects that, from a private perspective, are unprofitable, but would generate large social benefits, may not be taken forward.

– Public goods and appropriability—knowledge and ideas are often non-excludable: it can be difficult to exclude others from using the innovation and to make them pay individually for the benefit they receive. Again, firms may give up projects as a result.

– Coordination or network failures—firms rarely innovate alone. However, problems may exist that have an adverse impact on the ability of companies to coordinate or at least interact, and so deliver innovation. A wide range of problems may arise, including difficulties in coordinating R&D and inadequate access by smaller firms to the innovation system.

– Imperfect and asymmetric information—this affects, in particular, financial markets. Due to information problems, SMEs engaged in high-tech innovative projects with good prospects may find it difficult to obtain funding.

If an innovative project or scheme is likely to be affected by these market failures, there is an a priori indication that innovation is sub-optimal and that intervention in the form of state aid has the possibility of increasing the level of innovation.
Five relevant descriptors of (or proxies for) innovation are developed in the report, which are ex ante measurable and which are likely to be associated with innovation market failures. In this regard, firm size, the stage in a firm’s life cycle, and the sector in which it is active are identified as crucial variables, since market failures appear to be broadly concentrated in the following types of firms.

- **Small-scale firms**—small firms are more likely than larger firms to find it harder to appropriate the new knowledge created in the innovation process and hence are likely to suffer from a more severe spillover problem. In addition, small firms are likely to encounter difficulties as a result of imperfect and asymmetric information in their need for risk capital, to carry out the innovation process, and are likely to find it harder to coordinate and network successfully.

- **Seed or start-up firms**—this type of firm is more likely to suffer from the imperfect/asymmetric information problem in gaining access to risk finance (as a result of lack of internally generated revenues).

- **Firms in the high-tech sector**—due to the nature of their business, the market position of high-tech companies depends to a significant extent on the degree to which they can innovate successfully. As a result, they need to devote a higher proportion of their investments to innovation and, therefore, any market failure that applies to innovation will be magnified in these sectors. In particular, they are more likely to be affected by coordination failures, financial market failures, and difficulties in appropriating the knowledge they generate.

In addition to the characteristics of the firm, two features of the specific investment project or scheme appear to influence the severity of market failures: the activities required to realise the innovation; and the significance of the innovation resulting from the investment (i.e., the degree and geographical scope of innovation).

- **R&D activities, particularly those further away from the introduction of the final product into the marketplace** (e.g., early-stage R&D compared with marketing) are more likely to produce spillover effects, to be affected by lack of appropriability, and to suffer from coordination and financial market failures.

- **Projects intended to introduce radical innovations new to the EU** are more likely to generate significant spillovers, face a higher degree of economic and technical uncertainty, and require more complex coordination between companies.

The report then develops in more detail the criteria, indicators and questions that allow ex ante identification of the cases in which an innovative project or scheme is likely to be affected by the four market failures. Whether specific state aid schemes are justifiable on the grounds of innovation market failures can then be determined. The tables developed:

- explore each of the four market failures in turn, taking account of the theoretical and empirical evidence, and the discussions with interested parties;

- take account of the descriptors of innovation developed above—firm size, firm stage in the life cycle, sector, activity, and the radical or otherwise nature of the innovation;

---

2 There is an element of circularity in seeking to explore the relevant dimensions of innovation (which requires some analysis of market failures) and relevant dimensions of market failures (which requires some analysis of innovation). The report addresses this in a structured manner, by first identifying the relevant descriptors of innovation relevant to market failures, and second exploring in more detail the criteria, questions and indicators that can be used to identify the market failures.
– employ a methodology that uses information at the country, firm, sector and project level.

In the last respect, country-level criteria are useful only for ‘scene-setting’. The question is then how far to drill down into the firm-, sector- and project-level criteria, to obtain a more in-depth understanding of whether a proposal is aimed at tackling innovation market failures. In this regard:

– a priori innovation market failures are more likely to affect smaller firms than larger firms;

– Member State assistance to smaller firms is more likely to be in the form of schemes covering many qualifying firms (which may not have a track record or the resources to provide detailed information);

– Member State assistance to larger firms (which have a track record) tends to concern a specific project or investment (around which a detailed business plan will have been developed).

Thus, in the case of SMEs (and schemes to assist SMEs), higher-level metrics should be both necessary and sufficient for this task (eg, down to the firm and sector levels). In the case of large firms or investments, higher-level metrics are necessary, but a greater number of metrics should be used. In such cases, criteria at the project level should be applied, and further questions outside of the framework developed below should be asked, which will vary on a case-by-case basis.

The tables developed are useful for exploring state aid proposals put forward in relation to schemes or investments to support small and large innovative firms. A separate treatment is employed for large-scale innovative investments, since additional issues arise, and this area is particularly controversial.

Throughout, a number of controversies regarding conventional wisdom are identified, and the framework developed takes these into account. For example:

– **R&D spillovers**—both large and small firms undertaking R&D generate spillovers, but there is evidence of selection bias towards supporting large firms;

– **appropriability**—patents are often neither necessary nor sufficient for delivering innovation and, in the sectors where they are important, have the potential to harm innovation;

– **coordination and network failures**—the literature on R&D coordination failures is patchy. As regards network failures, the lack of geographical clustering is not necessarily symptomatic of market failures (and the artificial establishment of clusters may fail). The evidence on the impact of incubators is incomplete;

– **financial market failures**—there is a disjoint between the innovation and finance literature, and it is not always clear if the lack of financing of innovative SMEs is due strictly to financial market failures or other factors;

– **large-scale investments**—there is very little literature on market failures associated with large-scale investments. There is, however, extensive evidence that large projects systematically underperform against forecasts.

It is possible to outline a higher-level picture of the situations in which innovation market failures might a priori be expected. In theory, the outcome is a multi-dimension matrix that makes it easier to identify when innovation market failures are likely to be present. In
practice, this matrix can be summarised in high-level cross-tabulation tables, which are presented below. In each table, the measure of innovation is presented in the rows. The four main types of market failure that might occur (spillovers, appropriability, coordination/networks, and financial) are then presented in columns.

The tables are deliberately very general, and are grouped into pairs. Comparisons within the pairs are more informative than across pairs. Caution should be adopted in making comparisons between pairs of tables, since it is not possible for any one table to capture the multiple dimensions of innovation market failures. A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances.

The tables are organised according to the following characteristics that affect the incidence of innovation market failures:

- firm size (small versus large) and R&D activity—Tables 1A and 1B;
- firm size (small versus large) and sector (low versus high-tech)—Tables 2A and 2B; and
- sector (high-tech versus low-tech) and stage in the firm’s life cycle (start-up versus later-stage)—Tables 3A and 3B.

### Table 1A  Small firms (innovation by R&D activity)

<table>
<thead>
<tr>
<th>Innovation</th>
<th>Spillovers</th>
<th>Appropriability</th>
<th>Coordination/ network</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic research</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Applied research</td>
<td>✓</td>
<td>✓</td>
<td>✓ (✓)</td>
<td>✓</td>
</tr>
<tr>
<td>Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances. 1 Regarding appropriability, protecting intellectual property is important, but is probably most important at the early stages of the R&D process. Patents are very important for small firms in the biotech (or high-tech more generally) sectors. Source: Oxera.

### Table 1B  Large firms (innovation by R&D activity)

<table>
<thead>
<tr>
<th>Innovation</th>
<th>Spillovers</th>
<th>Appropriability</th>
<th>Coordination/ network</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic research</td>
<td>✓</td>
<td></td>
<td>✓ (✓)</td>
<td></td>
</tr>
<tr>
<td>Applied research</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances. 1 Large firms are more able to use the intellectual property rights (IPR) system effectively. However, patents are neither a necessary nor sufficient condition for innovation. Patents are important in biotech and high-tech more generally, but questionable patents may also be a problem. 2 Coordination failures are not generally problematic unless coordinated R&D is required—large firms tend to have sufficient networking and potential access to the science base. Clusters and incubation appear to be less relevant to larger firms. Source: Oxera.
Table 2A  Small firms (innovation by sector)

<table>
<thead>
<tr>
<th>Market failure</th>
<th>Innovation</th>
<th>Spillovers</th>
<th>Appropriability</th>
<th>Coordination/ network</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low tech</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Hi tech</td>
<td>✔</td>
<td>✔</td>
<td>⬤</td>
<td>✔</td>
</tr>
</tbody>
</table>

Note: A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances. ¹ Many different types of firm innovate, but the role of knowledge spillovers is more limited in low-tech or traditional sectors. These tend to use others’ innovation (input users). ² Patents are crucial to high-tech SMEs (especially start-ups). ³ All SMEs may lack access to networks, but life-style SMEs in low-tech sectors should not face the same difficulties as innovative SMEs in attracting finance, are less likely to require the same level of financing, and are more likely to have retained earnings. Spillovers are higher in high-tech sectors, appropriability is more important (especially at early stages), networking is crucial, and financial market failures are higher.

Source: Oxera.

Table 2B  Large firms (innovation by sector)

<table>
<thead>
<tr>
<th>Market failure</th>
<th>Innovation</th>
<th>Spillovers</th>
<th>Appropriability</th>
<th>Coordination/ network</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low tech</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Hi tech</td>
<td>✔</td>
<td>✔</td>
<td>(✔)</td>
<td>✔</td>
</tr>
</tbody>
</table>

Note: A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances. ¹ Large firms face fewer financing problems than smaller firms. Spillovers are higher in high-tech sectors. Appropriability is important in high-tech sectors, but larger firms have a good awareness of the IPR system, and patenting is neither a necessary nor sufficient condition for innovation (eg, networking is more important). Also, in high-tech sectors, questionable patents are more common. Coordination failures are not generally problematic unless coordinated R&D is required—large firms generally have sufficient networking and potential access to the science base. Clusters and incubation are less relevant to larger firms. For larger firms, financial market failures would not be expected to occur, except where the projects are particularly large and risky.

Source: Oxera.

Table 3A  High-tech SME (innovation by firm stage in the life cycle)

<table>
<thead>
<tr>
<th>Market failure</th>
<th>Innovation</th>
<th>Spillovers</th>
<th>Appropriability</th>
<th>Coordination/ network</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seed/start-up</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Growth</td>
<td>✔</td>
<td>(✔)</td>
<td>(✔)</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Maturity</td>
<td>✔</td>
<td></td>
<td>(✔)</td>
<td></td>
</tr>
</tbody>
</table>

Note: A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances.

Source: Oxera.
Table 3B  Low-tech SME (innovation by firm stage in the life cycle)

<table>
<thead>
<tr>
<th>Innovation</th>
<th>Spillovers</th>
<th>Appropriability</th>
<th>Coordination/ network</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed/start-up¹</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Growth</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Maturity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances. ² A number of the issues faced by innovative start-ups are not faced by start-ups or SMEs in general. Although financial constraints and inadequate networking (including business-to-business) relationships may lead to problems for the generality of start-ups, these are unlikely to be as severe as for innovative start-ups. Lifestyle SMEs should not suffer from appropriability concerns, and innovation spillover effects are likely to be limited.

Source: Oxera.

These tables can be used as a quick reference point to guide decision-making: given the situation, practitioners can see, at a glance, which of the four innovation market failures need to be explored further using the detailed tables provided in section 2.4. The tables do not, however, capture some of the more idiosyncratic determinants of innovation market failures discussed in section 2.4. In addition, the tables are most readily applicable to comparing small and large firms undertaking innovation. Particularly large innovative investments raise some additional issues—refer to the separate discussion in section 2.4.6.

**Existing state aid frameworks**

The ideal state aid policy (from an economics perspective) towards innovation could be defined as one that:

- allows the Commission to encourage innovation that would otherwise not take place because of the existence of identifiable innovation market failures;
- recognises that state aid may be a second-best to other measures that might be employed by Member States;
- ensures that state aid is necessary for innovation, including that it is proportionate to the market failure it is intended to correct, and is likely to be additional to, rather than crowd out, private sector investment;
- has a transparent and robust economic framework supporting this decision-making process within the context of the state aid rules;
- has clear information requirements, and a balanced burden of proof;
- does not distort competition.

In view of this, how can state aid practice and policy be improved, to meet these objectives, such that the Commission can ask Member States the right questions, and Member States can develop good schemes aimed at tackling innovation market failures in the first instance?

The analysis of the conditions under which innovation market failures are likely to occur can provide a basis for better targeting of state aid. This could assist both the Commission in assessing state aid proposals put forward by Member States, as well as Member States in presenting proposals to the Commission. The analysis may be used to complement the
guidance on innovation issued by the Commission, which is currently in the form of a consultation document.\textsuperscript{3}

Oxera has analysed a number of the existing state aid frameworks, to identify potential gaps in assessing innovation market failures. Discussions with key market players have also informed this analysis.\textsuperscript{4} In summary, the key insights from this analysis are as follows.

- \textit{Broad versus narrow frameworks}—some of the state aid frameworks are, by design, more focused on innovation market failures than others. For example, the regional aid and SME aid rules naturally have somewhat broader agendas than the risk capital and R&D aid rules.\textsuperscript{5} However, the criteria, questions and indicators developed in this report could be used alongside \textit{any} of the existing rules to assist decision-making. Moreover, improving the way in which existing rules are applied by adopting the concepts outlined in this report may even mean that the de minimis regulations,\textsuperscript{6} which require very little analysis of innovation market failures, are used less often. In respect of targeting of state aid, this should lead to better aid. The potential problem lies not so much, for example, in the de minimis provision per se, but in the fact that gaps in the existing frameworks may lead to recourse to the provision.

- \textit{Risk capital}—of all the state aid rules, the Risk Capital Communication\textsuperscript{7} best captures the innovation market failure agenda, employing largely a checklist approach. Through transparent guidance, it adopts a number of the criteria and questions developed in this report. The framework also recognises the important role of financial intermediaries. The current framework does not appear to place an undue information burden on Member States, and there may be scope for further considering the factors developed in this report to supplement the analysis, and to use these as a complementary checklist. However, there is the potential for the framework to lead to a high information burden if, given the aid intensity, an opening procedure is triggered. Consideration might be given to adopting a more flexible approach, in which an opening procedure is not triggered as readily, so long as the Member State has provided sufficient evidence upfront against this (in effect) expanded checklist, and the aid is sufficiently targeted.

- \textit{R&D framework and large versus small firms}—the R&D Framework,\textsuperscript{8} which adopts upfront criteria, takes into account several relevant factors for assessing innovation market failures, developed in this study, although there are some gaps. In particular, the Framework is not explicit about the types of market failure that arise in different circumstances, and may not require sufficient detailed analysis of innovation market failures in assessing proposals involving support to larger firms. Following the findings of this study, there could be more scope for approving schemes aimed at small firms based on higher-level metrics, given that smaller firms would a priori be expected to suffer from a wider range of market failures than larger firms. Changes to the R&D Framework per se are not necessarily required.

- \textit{Incubators}—no specific framework currently exists that recognises the important role of incubators as intermediaries, or which provides guidance on assessing incubators. As such, good quality schemes may not be readily permitted under existing rules (eg, under

\textsuperscript{3} European Commission (2005c). The reform of state aid rules more generally, including regarding innovation, has recently been discussed in European Commission (2005d).

\textsuperscript{4} Indeed, the gaps identified are conditional on the insights obtained from these discussions. Although Oxera interviewed a number of stakeholders, a different picture might emerge from a more comprehensive survey of state aid cases, and, in particular, further interviews with Commission officials.

\textsuperscript{5} See European Commission (1998), (2001b), (2001c) and (1996), respectively.

\textsuperscript{6} See European Commission (2001a).

\textsuperscript{7} See European Commission (2001c).

\textsuperscript{8} See European Commission (1996).
the R&D or SME Aid Frameworks), and concerns have been expressed over the lack of transparency (regarding a scheme that has been put forward). Reliance on the Regional Aid Framework, SME aid and the de minimis provisions is not ideal. The report identifies guidance that could be used to assess and approve incubator schemes. This guidance might potentially be considered in the context of Article 87(3)(c).

- **Large-scale investments**—in appraising very large-scale investments that might qualify for state aid under Article 87(3)(b), which provides a potential exemption for projects of European importance but which has been little used to date, a transparent and robust economic framework supporting this decision-making process is probably required. In respect of ‘mega-projects’, detailed questions on innovation market failures could be asked, and the criteria developed in section 2 might be used (although the theory and evidence is limited in this area). Nonetheless, it should also be recognised that whether a particular investment qualifies for treatment under Article 87(3)(b) will often be essentially a political decision.

- **Evidence**—greater use of independent experts to assess innovation market failures might also be helpful in the context of proposals put forward to assist larger firms.

**Options for change and operational proposals**

What are the implications of the above analysis in terms of the broader options for modifying the way in which intermediaries, small firms, large firms, and large-scale investments are currently treated under the various state aid frameworks? The options are outlined below.

1. **No change in approach**—the status quo is retained, with no changes to the existing frameworks or guidance around these frameworks.

2. **Strict criteria**—the Commission defines upfront stricter criteria and indicators for making decisions, requires a higher burden of proof, and analyses in detail individual proposals put forward against these criteria.

3. **Broad criteria**—as an in-between case, the Commission might publish upfront guidance on the issues it would examine, which a Member State should bear in mind if claiming that a particular scheme was aimed at resolving innovation market failures.

What the above discussion shows is that ‘no change’ is unlikely to be an option. Broadly speaking, in relation to intermediaries (aimed at assisting small innovative firms) and small innovative firms per se, there are, a priori, more likely to be innovation market failures, less information available, and greater potential for additionality via government support.

By contrast, for larger firms and large-scale investments, a priori, market failures are less likely, there is more likely to be information available, but less potential for additionality.

It is for the Commission and Member States to decide how they would wish to operationalise the policy options put forward in this study. However, some specific suggestions for using the economic criteria are proposed. The following takes the type of firm/agent and investment in turn.

- **Incubators**—potentially, option 3 could be adopted. The guidance would outline what would be expected of any proposals put forward by Member States for assistance to incubators. A short checklist approach could be used, in which incubator schemes meeting a higher proportion of the following positive factors might be considered for state aid approval directly under Article 87(3)(c). Positive factors include incubator schemes:
with the objective of fostering entrepreneurship (and with systems in place to measure this);

- operated at the local or regional (rather than national) level;

- with well-defined entry and exit criteria, focused on (but not necessarily limited to) high-tech start-ups;

- aimed at resolving finance, client access, mentoring, and facilities network failures, and which house a sufficient number of other firms;

- where sufficient evidence has been put forward on the existence of property market failures.

- Financial intermediaries—option 3 could be adopted. Broadly speaking, the Risk Capital Framework, which adopts a checklist approach, already incorporates a number of the concepts discussed in this report, although Member States might be encouraged to differentiate further between demand-side, institutional and informational/transaction cost factors. This should not increase significantly the information burden. A more flexible approach might be adopted whereby an opening procedure is not triggered as readily, so long as the Member State has provided sufficient evidence upfront against an expanded checklist, taking account of the tables outlined in this report, and the scheme is sufficiently targeted. This would depend on whether the Member State concerned has, upfront, put forward sufficient evidence that financing problems for SMEs are closely related to information/transaction costs (and potentially institutional) factors, and the aid is sufficiently targeted. In respect of the latter, a more flexible approach might be adopted where the aid meets all of the following upfront criteria:

  - it is no greater than the plausible upper bound of the financing gap;
  - it is aimed at providing finance to early-stage innovative (especially high-tech and biotech) SMEs;
  - it is provided via intermediaries through competitive tender;
  - government support is structured as part of a risk-sharing arrangement.

- Young innovative or start-up SMEs—option 3 could be adopted, depending on the sector. SMEs are a priori more likely to suffer from innovation market failures than larger firms. Furthermore, little information may be available, and thus determining whether a particular project of a young innovative SME might suffer from market failures may be difficult (and seeking the necessary information would increase the administrative burden on the SME). Schemes that seek to address market failures in relation to smaller firms might therefore be approved on the basis of higher-level metrics, such as firm activity, size, sector, and stage of development. Thus, there could be greater scope for approving schemes that meet all three of the following upfront criteria:

  - schemes aimed at young SMEs or start-ups below a certain age;
  - where such SMEs are undertaking a given percentage of R&D;
  - where the SME operates in a high-tech (or science-based) sector.

- Larger firms—stricter criteria (option 2) could be adopted in approving state aid to large firms for undertaking innovative investments. The extent of spillovers, coordination, and financial market failures might be explored in more detail using a checklist approach. Particular attention should be paid to the issues set out in certain tables of the report. Questions beyond these assessment frameworks could also be asked, and will vary on a case-by-case basis.

- Large-scale investments—these raise additional considerations. In appraising large-scale investments that might qualify for state aid under Article 87(3)(b), detailed questions regarding the presence of innovation market failures could be asked, and the criteria developed in the report could be used (option 2). As in the case of larger firms, a checklist approach could be adopted to appraise whether innovative large-scale
investments might qualify for state aid, on the basis of innovation market failures, under Article 87(3)(b). All of the detailed questions set out in the report regarding large-scale investments are of relevance, and detailed questions beyond these assessment frameworks could also be put forward, which will vary from case to case. Ultimately, however, it should be recognised that whether an investment qualifies for treatment under Article 87(3)(b) is a political decision. Furthermore, compatibility with the Treaty would not necessarily be judged against innovation market failure criteria factors alone, and might take account of wider economic and social criteria.

Conclusion

Although successful innovation can in itself be complex, and can fail for a variety of reasons, the analysis undertaken in this report indicates that it is possible to target state aid more effectively so that innovation market failures are addressed. The application of the criteria set out herein provides a mechanism for the Commission to target state aid more effectively to complement existing Frameworks and Communications, or to modify them.

The choice of the optimal policy instrument is outside the scope of this report, but there are a number of considerations that should be applied. In particular, the operation of any specific policy instrument may vary with the underlying economic characteristics of the country (or region) concerned, and this should be taken into account.

In addition, differences in innovation in the economy cannot all be attributed to market failures. Underlying system-level characteristics may be more significant. For example, the existence of an equity culture and good exit mechanisms for venture capitalists may be more important than providing government support through state aid in addressing the perceived financing problems faced by small innovative firms. Also, where government assistance is provided, general measures to enhance the IPR regime, support to universities and the science base, and ensuring a good quality entrepreneurial base, may not actually involve state aid measures. Thus, policy-makers should not overlook the issue that state aid may not be the most efficient way of tackling any perceived lack of innovation in an economy.

The analysis presented in this report may be used to complement the guidance on state aid for innovation issued by the Commission, which is currently in the form of a consultation document (European Commission 2005c). In this, the Commission considers that a new and separate framework for innovation would not be in line with the objective of simplifying state aid rules. Rather, its focus is on how the current rules might be improved to better enable targeting of state aid at innovation market failures. There are a number of similar themes developed within the independent analysis undertaken by Oxera in the current report and in the Commission’s recent consultation, although there are naturally also differences in the approach undertaken, and in the options for change developed.9

9 The European Commission Consultation was published subsequent to the main analysis undertaken by Oxera as part of the current report.
Table 2.11 Assessing innovation financial market failures (information/transaction costs definition) 57
Table 2.12 Large-scale investments: assessing spillovers 67
Table 2.13 Large-scale investments: assessing financial problems (institutional and historical factors) 69
Table 2.14 Large-scale investments: assessing financial market failures 70
Table 2.15 Small firms (innovation by R&D activity) 72
Table 2.16 Large firms (innovation by R&D activity) 72
Table 2.17 High-tech SME (innovation by firm stage in the life cycle) 72
Table 2.18 Low-tech SME (innovation by firm stage in the life cycle) 73
Table 2.19 Small firms (innovation by sector) 73
Table 2.20 Large firms (innovation by sector) 73
Table 2.21 Innovation market failures by activity 75
Table 2.22 Innovation market failures by firm size 79
Table 2.23 Innovation market failures by stage in the firm’s life cycle 80
Table 2.24 Innovation market failures by sector 81
Table 3.1 Potential policy options 114

**List of figures**

Figure 2.1 Innovation market failures 5
Figure 2.2 Dimensions of significance of innovation 14
Figure 2.3 Market failures and their relationship with innovation 25
Figure 2.4 Criteria for assessing innovation projects: an operationalisation 28
Figure 2.5 The financing life cycle 52
Figure 3.1 Framework for assessing state aid 90
Figure 3.2 State aid rules and innovation market failures 91

**List of boxes**

Box 2.1 Radical versus incremental innovation 15
Box 2.2 The non-linearity of the innovation process 17
Box 2.3 Later- versus early-stage R&D 19
Box 2.4 Spillovers generated by large-scale firms 30
Box 2.5 Selection bias 31
Box 2.6 When is appropriability a problem? 36
Box 2.7 Risks of coordination in R&D projects 41
Box 2.8 Networking in biotech 45
Box 2.9 The role of clusters 45
Box 2.10 The role of incubators 48
Box 2.11 Divergent views on the causes of the lack of innovative SME financing 59
Box 3.1 Rolls-Royce engines 100
Box 3.2 Italian pharmaceuticals 101
Box 3.3 Young innovative SMEs 101
Box 3.4 EU state aid policy towards incubators 104
Box 3.5 Incubator scheme in Germany 105
Box 3.6 The UK Enterprise Capital Fund scheme 108
1 Introduction

1.1 Policy objectives

Oxera Consulting Ltd (Oxera) is pleased to present this report to the DG for Enterprise and Industry, on the criteria for assessing innovative investments or projects for state aid purposes. This comes at a pertinent time for the Commission: several frameworks for assessing state aid, such as the R&D Aid and Risk Capital Guidelines, are coming up for renewal. Importantly, the Commission has recently published a consultation document on state aid for innovation, which seeks to gather stakeholders’ views on potential improvements to the existing state aid rules, including new funding possibilities for innovation, the formulation of criteria to target aid more effectively, and simplification of the regulatory framework.\(^\text{10}\)

The current report represents an independent analysis by Oxera on what is meant by innovation, when market failures might be expected to occur, and when, in turn, state aid might be justified.\(^\text{11}\) The aim of the report is to develop an economic framework for assessing state aid proposals put forward in the field of innovation, in the specific context that innovation may be suboptimal due to market failures. The findings of the report may be used to complement the process being undertaken by the Commission, which seeks to improve the existing rules such that state aid is targeted more effectively at resolving identified innovation market failures. Within its recent consultation, the Commission considers that a new and separate framework for innovation would not be in line with the objective of simplifying state aid rules; rather, it focuses on how the current rules might be improved, to better enable targeting of state aid at innovation market failures.

By way of background, over recent years, the Commission has stressed that the level of innovation in Europe is suboptimal. At the same time, it has voiced concerns that Member States have not put forward schemes that sufficiently target innovation market failures. For example, the Commission’s 2004 Communication, ‘A Pro-active Competition Policy for Europe’ (COM 294 final), emphasised the role of competition as the principal process for delivering lower costs and prices, and spurring innovation in individual Member States and across the EU. In addition, the Communication identified that research and development (R&D) is indispensable for generating productivity growth, and that the EU lags behind its trade partners in terms of both investing in R&D (as a proportion of GDP) and in generating productivity growth. The Commission has stated that the provision of state aid by Member States has contributed to these conditions, and that there is ‘ample evidence that Member States often subsidise industries in an inefficient manner, and do not sufficiently address [innovation] market failures’ (European Commission, 2004a).

Thus, there is a drive within the Commission to re-focus state aid towards 'less and better aid'.\(^\text{12}\) In the specific context of this report, state aid related to innovation should be targeted at clearly identified innovation market failures. Indeed, in this regard in December 2004 the Commission published some guidance for practitioners in the form of a working document (European Commission 2004d). This presented a summary of where the Commission’s state aid rules stand to date (such as the R&D Framework and Risk Capital Communication), and the possibilities that Member States have at present for providing aid for innovation

\(^{10}\) European Commission (2005c). The reform of state aid rules more generally, including those affecting innovation, has recently been discussed in European Commission (2005d).

\(^{11}\) The analysis was undertaken prior to the publication of the recent European Commission (2005c).

\(^{12}\) See, for example, Kroes (2005a).
purposes. The working document represented a very initial overview of the issues involved, noting that:

While fostering competition and market opening is generally considered as the most efficient instrument to stimulate the innovation process, situations exist in which the market fails to deliver the incentives necessary to reach the desirable level of activity contributing to this process in view of the social returns it generates. In such cases government interventions may be appropriate to correct existing market failures, bearing in mind that the benefits of State intervention must always be assessed against its costs, particularly in terms of distortion of competition.

Despite these initial moves, there is as yet no consistent definition of what constitutes an ‘innovation’, the different types of market failure that occur in the innovation process are not fully understood, and there is no overall methodology for determining whether investments might be deemed innovative and whether market failures are relevant, for the purposes of appraising state aid.

There is therefore a need for a more coherent economics-based framework for assessing innovation and innovation market failures, using relevant and measurable indicators, and which recognises the information available (and the information burden) in different circumstances. Importantly, many state aid proposals are notified to the Commission ex ante, rather than ex post, and any practical framework needs to be capable of dealing with this.

1.2 Structure of the report

To achieve the above, section 2 in this report draws on the lessons learned from the literature on innovation and innovation market failures, to identify more robustly ex ante when an investment or scheme put forward by a Member State is likely to be innovative, and when the proposed investment or scheme is a priori unlikely to take place in the absence of government intervention due to market failures. After discussing the methodology used for the analysis (section 2.1), the section:

– explores overall definitions of innovation and innovation market failure (section 2.2);
– discusses relevant dimensions of innovation (section 2.3);
– provides detailed tables covering innovation market failure criteria, questions and indicators (section 2.4); and
– presents a series of reference overview tables (section 2.5).

The issues are analysed not simply in relation to SMEs, but also to intermediaries, large firms and large-scale investments. There is much conventional wisdom on when innovation market failures occur, and the available evidence base is therefore relied on wherever possible. In respect of innovation, the theory indicates that this can be a very broad concept. In addition, some indicators in the literature are more useful for ex post assessment purposes than for ex ante assessment. Therefore, the approach adopted in the current paper is to narrow down the dimensions of innovation that are both relevant to market failures and readily measurable ex ante.

In respect of market failures, there is extensive literature on the underlying theory, but this is incomplete, and the evidence base is mixed. There is also very little literature specifically analysing market failure indicators, except perhaps in the case of financial market failures. Nonetheless, four key market failures are identified from the literature: spillovers, appropriability, coordination/network failures and financial market failures. The current report uses the important lessons learned from the innovation market literature to develop the ex ante criteria.

Moreover, in more general terms, the Commission’s State Aid Action Plan consultation paper reiterates that ‘one important justification for state aid is … the existence of a market failure’. See European Commission (2005d).
The available literature facilitates an understanding of the issues to only a certain extent: crucially, to inform the current study, Oxera undertook four case studies, encompassing discussions with interested parties, and to obtain further insights. The case studies, which cover government assistance to incubation facilities, SMEs and large firms, are summarised in Table 1.1. These involved specific examples of where a state aid proposal put forward by a Member State was examined and approved by the Commission. In addition, Oxera interviewed an incubator in north-east England, which did not relate to a specific case considered by the Commission but highlighted potential problems when incubators seek government support. Appendix 1 explores these case studies in more detail.

### Table 1.1 Summary of case studies undertaken by Oxera

<table>
<thead>
<tr>
<th>Type of firm</th>
<th>Recipient of aid</th>
<th>Jurisdiction and year of approval</th>
<th>Form of aid</th>
<th>Framework under which aid approved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>Young innovative SMEs¹</td>
<td>France (2003)</td>
<td>Social security exoneration for qualifying small young firms undertaking R&amp;D</td>
<td>R&amp;D aid and de minimis regulation</td>
</tr>
<tr>
<td>Medium</td>
<td>Enterprise and technology centres (incubators)²</td>
<td>Germany (2005)</td>
<td>Grants for construction and/or extension of incubators, paid to ‘responsible bodies’</td>
<td>SME aid and de minimis regulation</td>
</tr>
<tr>
<td>Large</td>
<td>Industria Farmaceutica Cesore Serono (IFS)³</td>
<td>Italy (2003)</td>
<td>Grant to support product and process innovation, concerning development of new molecules</td>
<td>R&amp;D aid and training aid</td>
</tr>
<tr>
<td></td>
<td>Rolls-Royce⁴</td>
<td>UK (2001)</td>
<td>Product innovation: advance paid by UK government for the development of two new aircraft engines, to be repaid if successful</td>
<td>R&amp;D aid</td>
</tr>
</tbody>
</table>


Source: Oxera analysis, based on the European Commission decisions given above.

Oxera conducted interviews with state aid case handlers in the Commission, Member State government departments, independent state aid experts, an incubator, entrepreneurs, large firms, and venture capitalists, with 14 parties interviewed in total. The interviews were particularly helpful in understanding, from a practical perspective, what is meant by innovation and innovation market failure, and the problems perceived in the current frameworks for assessing state aid. The lessons from these discussions are drawn out throughout section 2 (and section 3).

Having developed criteria, questions and indicators for assessing innovation market failures as part of an economic framework, section 3 provides suggestions on how the existing state aid rules might be complemented by further guidance, or modified, to target state aid more effectively. This could assist both the Commission (specifically, DG Competition) in assessing state aid proposals put forward by Member States, and Member States in presenting proposals to the Commission in the first instance. Furthermore, section 3:

- explores what the overall objectives of state aid policy might be in an ‘ideal’ world from an economics policy perspective (section 3.2);
- analyses, using largely desktop research, a number of the current state aid frameworks, which tend to be used to approve innovative schemes or investments (section 3.3).¹⁴

¹⁴ These include rules that deem government assistance to be ‘not state aid’, Communications and Frameworks (Risk Capital, R&D Aid, SME Aid, and Regional Aid), and other provisions (in particular, Article 87(3)(b)).
This enables an initial assessment to be undertaken of the potential gaps in the current rules;
- explores in more detail what, *in practice*, the gaps in the current state aid rules might be, drawing on more specific lessons learned from Oxera’s discussions with a number of interested parties (section 3.4); and
- presents policy options for assessing intermediaries, SMEs, large firms and large-scale investments (section 3.5), and provides some suggestions regarding policy instruments (section 3.6).

It is for the Commission and Member States to decide how they would wish to operationalise the policy options put forward in this study. However, some specific suggestions for using the economic criteria are proposed.

As noted in section 1.1, this report seeks to achieve its aims through independent analysis. However, there are several areas of common ground between the issues discussed herein and the Commission’s September 2005 consultation on state aid for innovation. The Commission’s consultation emphasises that:
- effective competition should be the first priority in fostering innovation;
- state aid (as opposed to more general measures) is not necessarily the first-best solution to tackling innovation problems;
- state aid, when used, should be aimed at addressing a well-defined market failure;
- ‘picking winners’ should be avoided;
- aid should be granted where innovation would not have otherwise be undertaken and should be proportionate to the market failures identified.

In particular, the consultation argues that aid to innovative start-ups could be subject to lighter-touch procedural rules than at present, since they are likely to be seriously affected by many innovation market failures, in contrast to larger firms. Higher-level criteria are proposed by the Commission for allowing aid to be granted to these types of enterprise (for example, that the company is small, a start-up, and undertakes R&D). The Commission also argues that there should be greater flexibility in the use of the Risk Capital Framework. In addition, the consultation highlights that intermediaries (including incubators) are not sufficiently covered by state aid rules, and that there is a need to define more clearly these intermediaries. Similar themes are developed in this report, although also there are differences in the areas explored throughout the report, and in the conclusions and options presented in section 3. As noted above, the findings of the report may be used to complement the process being undertaken by the Commission.
2 Operational analysis of innovation market failures

2.1 Methodology

Innovation itself is a very broad concept. The focus of the current study, however, is on when state aid for innovation purposes might be justified. Taking an economics approach, this section concentrates on justifying state aid on the basis of the existence of innovation market failures. Drawing on the lessons learned from the literature on innovation and innovation market failures and the case studies conducted by Oxera, the section therefore identifies relevant and measurable dimensions of innovation market failures, and develops criteria, indicators and questions that allow the ex ante identification of when investment of scheme put forward by a Member State is:

- likely to be innovative; and
- unlikely to take place in the absence of government intervention due to market failures.

These criteria and indicators enable the investments in the intersection of Figure 2.1 below to be identified.

![Figure 2.1 Innovation market failures](image)

Source: Oxera.

The issues that arise in the field of innovation and market failures are examined in this section; however, the section does not necessarily seek to identify gaps in the current European Commission frameworks (e.g., the R&D Framework, risk capital, SME and de minimis exemption\(^{15}\)) for assessing state aid, or examine further issues such as distortion to competition. These are further explored in section 3.

In addition, firms rarely innovate alone, and innovation often requires firms to interact with other agents, including input suppliers, consumers, and competitors. Furthermore, as proposed by Lundvall (1992), in the ‘systems approach to innovation’, innovation is supported by socio-economic, political and cultural systems because it is affected by literacy rates, the disciplinary structure of education, the entrepreneurial base, and the quality of regulation, among others. As noted by Gristock (2000), the way in which systems work depends on the state of a number of institutions (e.g., universities, business organisations,

\(^{15}\) See European Commission (1996), (2001c), (2001b), and (2001a), respectively.
government departments) and the incentives and pressures to which these institutions have to respond.

The first-best option to correcting market failures may be to ensure that the underlying components of the system are present and work well (e.g., the degree of development of an equity culture, and a healthy entrepreneurial base and regulatory framework), rather than necessarily employing a more specific measure that constitutes state aid (i.e., one that has the potential to distort competition). The European Commission’s 2005 state aid action plan consultation paper notes that, in line with the Lisbon Strategy:

> When markets do not achieve economic efficiency, Member States or the Union may want to intervene in order to correct the market failures. Some [...] situations may be solved by regulatory or other means. In certain cases, however, Member States may envisage to use state aid. One important justification for state aid is therefore the existence of a market failure [...] However, it is not enough for state aid to target a market failure. Before resorting to State aid, which is in general only the ‘second best’ option to achieve optimal allocation of resources, it should be verified whether other less distortive measures could remedy the market failure. State aid should be the appropriate policy instrument and should be designed so that it effectively solves the market failure, by creating an incentive effect and being proportionate. In addition, state aid should not distort competition to an extent contrary to the common interest. (European Commission, 2005d)

In what follows, factors that might constitute system failures are also identified, but only where these are sufficiently close, and are of particular relevance, to the issue being considered. In particular, this report discusses the coordination market failures and network failures that may arise when firms need to interact with other agents for successful innovation—such as the access of firms to the science base, the existence of business angel networks (BANs), the role of incubation facilities in networking, and preconditions for financing to be made available to innovative SMEs. This discussion overlaps extensively with the systems failure literature. However, it is beyond the scope of the current report to develop comprehensive criteria for ‘macro-level’ factors at the system level that affect innovation more generally, such as entrepreneurship and the underlying education system, although ‘institutional’ factors are considered in the discussion of financial market failures.

The following methodology is employed.

- **Definitions**—building on the preceding analysis, section 2.2 provides overall definitions of innovation and innovation market failure.

- **Relevant dimensions of innovation**—section 2.3 identifies measurable and relevant dimensions of innovation that provide ex ante information on whether innovation-related market failures are likely to occur. By the same token, the process filters out aspects of innovation that are not measurable ex ante, or are not relevant to innovation market failures. Four main descriptors of (or proxies for) innovation are selected, which are useful for practical purposes—i.e., innovation activity, firm size, firm stage of the life cycle, and sector in which the firm is active. The significance of the innovation (in terms of its radical or otherwise nature, and its geographical scope) is also pinpointed as being potentially relevant.

- **Innovation market failure criteria**—for operational purposes, section 2.4 identifies more detailed criteria, questions and indicators, to determine ex ante when innovation market failures are likely to occur. Some of these can be related directly to the innovation descriptors outlined above. Others, however, are more idiosyncratic in nature. Four categories of market failure are discussed in turn: spillovers, appropriability, coordination/network failures, and financial market failures. In the last two market failure categories, the criteria, questions and indicators become particularly idiosyncratic to the market failures concerned. The criteria, questions and indicators can be used to assess proposals to assist small firms (either directly or through intermediaries), large firms and large-scale investments. However, additional more specific issues arise regarding large-
scale innovative investments and, for this reason, these are treated separately in section 2.4.6.

Overview tables—in section 2.5, the analyses of the preceding two sub-sections are brought together. For ease of reference, cross-tabulations of the descriptors of innovation and categories of market failure are provided. Practitioners can use these to see, at a glance, which of the four innovation market failures need to be explored further using the detailed tables provided in section 2.3. The tables cover, in particular, issues relevant to considering large versus small firms.

There is an element of circularity in seeking to explore the relevant dimensions of innovation (which requires some analysis of market failures) and the relevant dimensions of market failures (which requires some analysis of innovation). This section addresses this issue in a structured manner. The criteria, questions and indicators developed in sections 2.3 and 2.4 can be used on their own, or in conjunction with the cross-tabulations provided in section 2.5.

Before discussing further each of these stages, some words of caution are required.

First, most of the existing literature on innovation and market failures predominantly concerns ex post analyses. However, in many cases where the Commission needs to approve state aid, an ex ante analysis of when innovation market failures are likely to arise is required. The indicators and questions must be capable of eliciting this, but will only ever provide a probabilistic answer. There will always be ‘Type I’ and ‘Type II’ errors in any evaluation methodology.\(^{16}\) Owing to information constraints, schemes that are innovative and that suffer from market failures may be missed by the evaluation methodology (ie, ‘Type I’ errors), or a particular scheme might be identified as being innovative and suffering from market failures, whereas, in the event, it may not (ie, ‘Type II’ errors).

The indicators that might be used in practice will be constrained by the available information, and an element of judgement outside of the methodology will always be required. However, in respect of state aid innovation proposals that tend to be put before the Commission, the level of ex ante information available differs according to whether the proposals involve state support to large or small firms. Proposals involving assistance to large firms tend to concern a specific investment (for example, to develop a new type of aircraft engine). A detailed business plan will have been developed around the investment, and the large firm will have a track record and more resources to provide information to government and thus to the Commission. In contrast, proposals involving state support to small firms tend to be in the form of schemes across several potential qualifying firms (for example, grants for SMEs undertaking R&D or support to financial intermediaries). Less detailed information will be available ex ante on the qualifying firms.\(^{17}\) Small firms will tend to have less of a track record (start-ups, by definition, have no track record) and fewer resources to provide detailed information. As discussed below, a priori, innovation market failures would be expected to be more serious for smaller firms than for larger firms.

This all points towards a more rigorous and in-depth approach being adopted to assess proposals put forward for assisting larger firms than for smaller firms, in terms of identifying whether the proposal is likely to be innovative, and whether it is likely to suffer from market failures. In the case of SMEs, higher-level metrics are both necessary and sufficient for this task. In the case of large firms or investments, higher-level metrics are necessary, but a greater number of metrics should be used, and more specific questions should also be asked about the proposals. These considerations are reflected in the analysis developed here. Exactly how these metrics might be used within the context of state aid policy, and the options for the Commission, are discussed further in section 3.

---

\(^{16}\) A Type I error occurs when a null hypothesis that is in fact true is rejected in the analysis. A Type II error occurs when a null hypothesis that is false is accepted in the analysis.

\(^{17}\) Some information may, however, be available ex post through the nature of the scheme—eg, the UK R&D tax credit provides corporation tax relief on profits earned by SMEs that have undertaken R&D in science-related areas.
Second, there is no one definition of innovation. There is also controversy about when, according to conventional wisdom, market failures actually occur, and whether lack of innovation is due to specific market failures or the result of more underlying system failures. These issues are returned to in section 2.2, and indeed throughout section 2. The underlying theories of innovation market failures are somewhat incomplete, and the evidence base on when market failures occur is also mixed. The criteria, questions and indicators developed are, where possible, based on the available evidence. In other areas, judgement has been required.

Third, in some situations, defining indicators is more straightforward than in others. As discussed above, while there are established ex post indicators of innovation, many of these are not as useful for determining ex ante whether a project or scheme is likely to be innovative. As illustrated below, the assessment of coordination failures and network failures lends itself more to qualitative indicators or questions being posed on the issue. In the assessment of whether financial market failures exist for innovative SMEs seeking modest amounts of money, there are many quantitative indicators that might be used to assist decision-making.

2.2 Defining innovation and market failure

The complexity of the innovation process and the different forms in which it can occur make it difficult to provide a clear-cut, universally accepted definition of what constitutes an innovation. Alternative definitions of innovation have been proposed and used depending on the context—ie, whether the definition is needed for statistical purposes, such as in the case of surveys, or whether it is required for policy-making. No one definition of innovation is perfect. However, the definition proposed by the Community Innovation Survey (CIS) is a useful starting point for the analysis that follows. According to the CIS:

Innovation is a new or significantly improved product (good or service) introduced to the market or the introduction within an enterprise of a new or significantly improved process. Innovations are based on the results of new technological developments, new combinations of existing technology or the utilisation of other knowledge acquired by the enterprise. Innovations should be new to the enterprise concerned; for product innovations they do not necessarily have to be new to the market and for process innovations the enterprise does not necessarily have to be the first to have introduced the process. (European Commission 2005e)

The main advantage of this definition is that it covers a variety of important dimensions of the innovation problem without constraining its applicability. The definition incorporates various types of innovation (product versus product process) and recognises that innovation takes place in both the manufacturing and service industries. The definition emphasises the ‘success’ of the innovation process, in terms of the new product or process actually reaching the end-user (ie, consumer or firm). In its treatment of what is ‘new’, the definition encompasses both incremental and radical innovation (in so far as there is a relationship between this and the geographical scope of innovation, in respect of new-to-firm versus new-to-world innovation), and recognises that agents use the innovations of others. The definition is also independent of the characteristics of the innovating firm (size of the firm or stage in the life cycle), the sector in which the firm is active, and the activities undertaken by the firm to innovate successfully.

Therefore, the definition is deliberately wide. It has been influenced by more recent non-linear theories of innovation, which emphasise that innovation takes place in different situations and at different levels.

---

18 The definition does not necessarily require that a product concerned is successful in the marketplace, or that a new process is sustained.

19 Innovation can take place at many stages; occurs wherever knowledge is generated (and therefore in many different activities); relies on the interaction of agents (firms do not innovate alone); involves non-linear processes and feedback; and
There is merit in adopting a wide definition in considering whether innovation has occurred. However, the current report is aimed at addressing a different question—ie, when state aid for innovation might be justified. Taking an economic approach, this study concentrates on when state aid for innovation can be justified on the basis of the existence of market failures. Thus, despite its advantages, there are two main problems with the CIS definition of innovation in the context of this report, both stemming from the definition being too wide.

The first is that it is a definition which lends itself more readily to the ex post measurement of innovation. Several of the concepts of innovation encompassed by the definition are simply too difficult to measure ex ante. For example, how is it possible to tell whether an invention will be successful, via the innovation process, in terms of reaching the market? The second problem is that, because the definition is wide, it captures aspects of innovation that are unlikely to suffer from market failures. For example, introducing a product to the market is a later stage of the innovation process and, as will be discussed, is much less likely to entail market failures than earlier stages.

Section 2.3 focuses on dimensions of innovation that are consistent with the CIS definition, can be measured ex ante, and are likely to be directly associated with innovation market failures. These are the dimensions relevant for assessing state aid proposals.

However, what exactly is meant by the term ‘market failure’? Innovation generates wider benefits for other firms and for the economy as a whole (with regard to employment, productivity and economic growth). Two possible definitions are then as follows.

- **Economic definition**—market failures may mean that the level of innovation in the economy is ‘suboptimal’ and, consequently, that these wider benefits of innovation for the economy are not realised.

- **Objectives-based definition**—another interpretation is that market failures occur when the level of innovation in the economy is not at a level that the government concerned would like.

These concepts are not necessarily equivalent. This report focuses on the first definition.

Because the innovation process is complex and non-linear, by the same token, identifying when market failures occur can also be difficult. This is somewhat problematic, since the rationale for government intervention in the innovation process rests on the existence of market failures. Indeed, there is some controversy about whether problems are caused by individual market failures or by system failures (see, in particular, section 2.4).

Although examining system failures is valuable in identifying the underlying problems in the system that should be tackled (rather than necessarily using measures that constitute state aid), it is useful for clarity to first consider the basic market failures that can occur. There are four main types of market failure that are relevant, as outlined below.

- **Technological or knowledge spillovers**—the process of undertaking innovation, or the end-result of the innovation process (eg, a product), often generates wider benefits (positive externalities). Left to the market, projects that from a private perspective are unprofitable, but would generate large social benefits, may not be taken forward.

- **Public goods and appropriability**—knowledge and ideas are often non-excludable: it can be difficult to exclude others from using the innovation and to make them pay individually for the benefit they receive. Again, projects may be given up by firms as a result.
– **Coordination or network failures**—firms rarely innovate alone. However, there may be problems that impair the ability of the firms to coordinate or at least interact, and so deliver innovation. A wide range of problems may arise, including difficulties in coordinating R&D and inadequate access by smaller firms to the innovation system.

– **Imperfect and asymmetric information**—this affects, in particular, financial markets. Due to information problems, SMEs engaged in high-tech innovative projects with good prospects may find it difficult to obtain funding.

Section 2.4 considers the four market failures in more detail. Section 2.3, from an initial analysis, narrows down the relevant dimensions of innovation, by considering some of the market failure concepts discussed above. (These are further developed in section 2.3.) Innovation concepts that do not require further exploration are filtered out.

### 2.3 Relevant dimensions of innovation

The issues at the heart of the theoretical and empirical debates on innovation can be classified into the following four categories:

– **characteristics of the innovation**—including discussion of invention versus innovation, type of innovation (ie, product versus process), and significance of the innovation (ie, degree and scope of innovation, including its radical or incremental nature);

– **activities required for successful innovation**—which potentially encompass investment in R&D, new machinery, design and engineering, services and technology from third-party firms/institutions, and training employees;

– **firm characteristics**—including size, and stage in the firm's life cycle;

– **sector**—in which the firm is active.

On which of these characteristics should indicators of innovation be developed? This section identifies dimensions of innovation that:

– are consistent with the CIS definition;

– can be measured ex ante;

– are likely to be directly associated with innovation market failures.

Having identified the characteristics of innovation that are likely to suffer from innovation-related market failures, an assessment can be made of whether state aid proposals are targeted at innovation associated with market failures, rather than other forms of innovation.

### 2.3.1 Characterisation of market failures

As discussed above, there are four types of innovation-related market failures: spillovers, (lack of) appropriability, coordination/network, and financial market failures.

**Spillovers** are, in general, more likely to occur:

– the more general the knowledge created by the activity or firm—ie, the less product-, process-, firm-, or market-specific that knowledge is;

– the more unlikely it is that the agent or activity generating the knowledge can appropriate all of its effects;

– the easier it is to transfer knowledge between agents—eg, between firms, between universities and firms, and between individuals.

For a firm, it appears to be more difficult to **appropriate** the fruits of an innovation:
– the more problematic it is to 'codify' the knowledge generated;
– the easier it is to transfer such knowledge—eg, intellectual property rights (IPR) do not guarantee appropriability (or at least full appropriability) because knowledge leaks.

**Coordination** failures of the type affecting collaborative R&D projects are more likely to occur:
– the larger the need for firms to interrelate, for the project to succeed—eg, because it requires a wider variety of competencies;
– the greater the sunk costs arising from the project;\(^{20}\)
– the riskier the project is, and the more difficult it is for investors to price such risk.

**Network** failures are more likely to occur the more important it is to access networks for successful innovation to occur. The type of networking required depends on the innovation mode of the sector concerned. Specific forms of network (eg, incubators and clusters) are more suited to some situations than to others.

Finally, **financial** market failures are more likely to occur:
– the riskier the project/activity is from an economic and technical perspective (the higher the overall uncertainty in relation to the success of the project);
– the greater the information asymmetries (ie, the larger the disparity between the degree to which the innovative company and the investor can forecast the probability of project success);
– the more complex the project is, and the earlier the company/project is in the cycle;
– the higher the due-diligence costs;
– the lower the collateral of the firm (eg, high intangible assets);
– the less likely it is that the firm undertaking the innovation has a track record;
– the lower the access of the firm to retained earnings to finance the innovation.

The above all provide important pointers to defining the relevant dimensions of innovation (ie, those which are relevant to innovation market failures).

### 2.3.2 Characteristics of innovation

This section discusses three separate characteristics of an innovation, examining whether these are relevant to developing ex ante descriptors of innovation:

– **invention versus innovation**;
– **type of innovation**—ie, product, technological process and organisational process innovation;
– **significance of innovation**—including the degree of innovation (marginal versus radical innovations), and the geographical scope of the innovation (ie, area of reference for the degree of innovativeness)

\(^{20}\) Sunk costs are fixed (often capital) costs that a firm has to incur and cannot be recouped, even in the event of termination of production (ie, exit).
Innovation versus invention
The CIS definition of innovation implicitly emphasises that innovation requires the successful implementation of a new product or process. Innovation is thus much more than creating technologically new products or processes. Its effects on the economy, in terms of its impact on consumer and producer welfare, via the commercialisation of the inventions, are key. However, both invention and innovation might generate positive externalities (ie, technological spillovers and surplus appropriability), and can be hindered by financial market failures and coordination failures.

The question is whether invention or innovation could suffer from different market failures, and to a different degree. The case in favour of focusing on invention is that, following a linear view of innovation, invention is a pre-condition for innovation—ie, if there is no invention, there cannot be innovation. As examined in more detail below, the innovative activities associated with the process of invention (eg, R&D) are more likely to generate spillovers than the activities associated with introducing the invention into the market (eg, marketing) and therefore successfully innovating.

In addition, invention is more likely to be subject to both technical and economic uncertainty. The further a firm goes into the process of innovating, the fewer these uncertainties are. For instance, at the beginning, a project might run into technical difficulties because the idea or know-how is sold to another firm. In addition, it might be that the product/process cannot be developed and therefore the firm has to go back and undertake basic research. Under any of these scenarios, the invention will not be produced. However, once the invention is in place, the main source of uncertainties will be economic—eg, related to changes in the level and structure of the potential demand for the invention. As a result, it will be more difficult for investors to estimate the risk associated with inventions than with innovations, and hence financial market failures might be more serious for the former than for the latter.

In practice, however, it may be difficult to differentiate ex ante between invention and innovation. The more radical the intended innovation and the more complex the processes required to facilitate it, the more difficulty the entrepreneur (and, moreover, third parties including the Commission) will have in determining whether an ‘innovative investment’ will lead to an invention or an innovation when the project is starting. This is due to the uncertainty associated with these kinds of project (see also the discussion of radical versus incremental innovation, below).

As a result, if may not be possible, even if it were desirable, to target directly one or the other. Therefore, including the ‘invention’ versus ‘innovation’ dimension might not, from a practical perspective, be very useful for assessing state aid proposals. What is likely to be more useful is to identify the activities required to achieve successful invention or innovation, and the degree to which these face different degrees of market failure. These activities, in effect, are the intermediate steps used to transform an idea, via invention, into an innovation. This discussion is developed further in section 2.3.3 below.

Nonetheless, in the context of assessing state aid proposals, a distinction might be drawn between small and large firms. Because aid for larger firms is more likely to involve a specific investment rather than a scheme across many potential qualifying firms, a well-developed business plan should be available for analysis. Within this, the firm should have highlighted how it intends to ensure the highest probability that its project will lead to successful innovation, including the processes in place to deliver this. Many of the issues concerned do not lend themselves to well-defined metrics, and each investment would need to be examined on a case-by-case basis. Firm size is discussed in more detail in section 2.3.4.

The overall conclusion is that the invention versus innovation dimension is not useful for defining ex ante innovation that is likely to suffer from market failures. This dimension is therefore not explored further in this report. However, there should be an onus on large firms to demonstrate that they will deliver innovation (as opposed to only invention).
Type of innovation
Traditionally, the literature has distinguished between two main types of innovation:\(^21\)

– *product innovations*—these comprise the introduction of technologically new or improved products (ie, goods and services) to the market;\(^22\)

– *process innovations*—these consist of the adoption of technologically new or significantly improved production methods, including methods of product delivery. It may involve changes in equipment, use of factors of production, working methods or a combination of these. Process innovations are supply-side-oriented.

It has been argued that the above classification of the types of innovation is technologically oriented, creating a bias against organisational process innovations (ie, improvements in soft technologies). Recognising the importance of the latter, process innovation is sometimes further classified into:

– technological process innovations—these are equivalent to the definition of process innovation given above;

– organisational process innovations—these are related to innovations in the way in which a production process is organised and the management techniques applied in both the industry and service sectors.\(^23\)

In the remainder of this report, process innovation refers to both technological process and organisational process innovation. For the purposes of this analysis, drawing a distinction between product and process innovation would only be relevant if they delivered more, or less, innovation, or if they suffered significantly different types of, or degrees of, market failure.

Therefore, two main questions arise:

– are product innovations more ‘innovative’ than process innovations—in other words, targeting which of these types of innovation might generate more innovation?

– do they face different market failures (including spillover effects and other market failures), and to a different degree?

In relation to the first question, the answer is that both appear to have the same potential to generate innovation and spillovers. The main difference is that product innovations have a direct impact on consumer welfare, while process innovations either occur because an intended product innovation requires process innovation to facilitate it, or a process innovation, in its own right, reduces the unit costs of production of an existing product or intermediate input.

In terms of the market failures faced by each type of innovation, process innovations might be more affected by a lack of appropriability and might therefore generate higher spillovers than product innovations. Process innovations are related to the way the production process is organised, the methods of work employed by the firm, the use of production factors, and changes in equipment, or a combination of these. The knowledge generated by process innovations is therefore embedded in staff, and may be difficult to codify and appropriate, which makes it more likely that spillovers occur. A counterargument, however, is that a product being sold in the marketplace is very visible, whereas a process concealed in a factory has some scope for being kept secret. Appropriability might therefore be less of a concern for process innovations. Indeed, there is some empirical evidence suggesting that

\(^{21}\) See OECD (1997b).

\(^{22}\) An existing product can be significantly improved through the use of higher performance components or materials, such as the substitution of plastic for metal in kitchen equipment or performance components.

\(^{23}\) The 2004 European Innovation Scoreboard has incorporated organisational innovations as an important dimension of innovation. See European Commission (2004h).
the differences between social and private returns to process R&D are higher than those to product R&D, and that spillovers are higher in the former, although this evidence is limited.\textsuperscript{24}

From a theoretical and empirical perspective, it is not clear whether financial market failures are more likely to be hindered by process or product innovations. However, for investors, it might be more difficult to price the risks and to forecast the returns on product innovations, given that the end-result depends on the final demand for the new product concerned. Thus, financial market failures might be higher in the case of product innovations. However, there is little evidence in this regard. In any case, under these circumstances, factors in addition to the type of innovation might be important for determining the degree of innovation-related market failures faced by product and process innovations. These other factors include the size of the firm undertaking the innovation project, its stage in the life cycle, and the sector in which it is active. These are discussed in sections 2.3.4 and 2.3.5 below.

The overall conclusion is that the product versus process dimension is not useful for defining ex ante innovation that is likely to suffer from market failures.

**Significance of innovation**

Significance of innovation refers to:

- the degree of innovativeness—this depends on how new the innovation is compared with the current technology—ie, whether it is a marginal or incremental, radical or technological revolution;
- the geographical scope of the innovation—this refers to the area of reference for the degree of innovativeness—ie, the firm, country, or globally.

Figure 2.2 explains in more detail the dimensions of the concept of significance of innovation, as well as providing examples.

**Figure 2.2  Dimensions of significance of innovation**

<table>
<thead>
<tr>
<th>Degree of innovativeness</th>
<th>Geographical scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginal or incremental innovation: an innovation which is part of a continuum of in and which, when considered on its own, is relatively minor in relation to existing innovations (eg, small engineering changes that reduce the costs of production for car)</td>
<td>Firm: the new innovation is considered to be independent of whether competing firms have already generated the same innovation</td>
</tr>
<tr>
<td>Radical innovation: an innovation that leads to the introduction of a completely new process or product (eg, a car)</td>
<td>Country: the new innovation is considered to an innovation if no other firm in the country where the innovator is located has generated the same innovation</td>
</tr>
<tr>
<td>Technological revolution: clusters of innovations that together may have an impact that is more far-reaching than a radical innovation (eg, the steam engine)</td>
<td>Global: the new innovation is considered to an innovation if no other firm has made the same innovation</td>
</tr>
</tbody>
</table>

Source: Oxera analysis of several sources including Fagerberg (2005) and Kline and Rosenberg (1986).

Kline and Rosenberg (1986) and Lundvall (1992), among others, argue that the cumulative impact of incremental innovations is as great (if not greater) than that of radical innovations.

\textsuperscript{24} See Griliches and Lichtenberg (1984).
or technological revolutions. In particular, radical innovations or technological revolutions require knowledge generated from previous marginal innovations; thus, it is not clear whether which of these generate more ‘innovation’. Furthermore, the distinction of different degrees of innovation does not take into account the fact that innovation is a dynamic process that covers a continuum of innovations of different ‘sizes’—ie, it is not clear whether, without marginal innovations, a radical innovation could become a reality.

However, almost by definition, more radical innovations are more uncertain, more costly, and therefore more likely to suffer from financial market failures. Incremental innovations do not involve significant unknowns, and usually do not incur high costs. Since, on a stand-alone basis, incremental innovations are unlikely to be affected by financial market failures, their accumulation is also unlikely to be hampered.

Furthermore, given the degree to which radical innovations push the boundaries of knowledge and given their scale, it is more likely that they generate, on a stand-alone basis, higher spillovers, in which benefits might extend beyond competing firms to the whole economy. In totality, innovations that are ‘new to the world’ would be more likely to be hindered by spillovers, appropriability problems, financial market failures, and network market failures than innovations that are ‘new to the firm’.

In practical terms, it may be difficult to determine ex ante whether an innovative project is going to lead to a marginal or radical innovation, or whether it would result in an innovation that is new to the firm, to the EU or the world. However, as shown in Box 2.1, these issues have been considered in assessing R&D state aid proposals put forward in relation to larger firms.

**Box 2.1 Radical versus incremental innovation**

In the interviews conducted by Oxera, it emerged that when a project is being put forward with the purpose of achieving a radical result, it is possible to make a judgement on the degree of innovation and its scope. This is especially the case for projects that are notified individually by Member States to the Commission (ie, large-scale projects). Here, the R&D Framework (European Commission 1996) emphasises leaps forward and rules out routine impacts. For example, in the case of Rolls-Royce engines (European Commission 2001d), the novelty of the new engines (that they were significantly different from previous ones) and the number of prototypes that needed to be developed were examined in some detail. External consultants looked at these technical matters. In addition, in the Italian pharmaceuticals case study (European Commission, 2004c), the novelty of the molecules being developed was considered in determining whether the proposals were innovative. The issue of whether the product innovation concerned was not only new to the firm, but also new to the EU, was examined. External experts concluded that the molecules were in fact new at the global level.

Although not a high-tech sector, it is of note that the special provisions in place in shipbuilding—the Shipbuilding Framework—emphasise that aid for R&D and innovation in the sector must relate to the industrial application of a technologically new or substantially improved product or process, compared with the state of the art in the industry in the EU, and which carries a risk of technological or industrial failure (European Commission, 2003b).

---

25 For instance, the first steam engine (ie, the Newcomen engine) was very large and had a limited applicability. It was not until more than 50 years later (in 1769) that an engine with a separate condenser unit was patented by James Watt. This innovation increased the power of the steam engine and led to a chain of innovations that improved its performance, including rotary motion, the governor, the compound engine, and the high-pressure engines. In fact, the first commercial installation of a Watt engine occurred in 1777 and the first steam-powered boat was launched in 1807.
Article 87(3)(b), which is potentially applicable to very large projects, is discussed further in section 2.4.6. Arguably, whether aid classifies for consideration under this Article is a political decision. However, objective criteria relevant to innovation market failures could assist decision-making.

These observations (and the discussion in Box 2.1) all seem to point in the same direction: state aid to large firms is more likely to be for stand-alone projects than that to small firms (which is likely to relate to schemes for which several firms qualify). State aid would not therefore be justified for incremental innovations because, on a stand-alone basis, the project would generate fewer spillovers and would be very unlikely to suffer from financing difficulties. Large firms are probably more likely to undertake R&D with clear market potential in an existing core competency. The onus should therefore be on large firms to demonstrate that their projects are aimed at introducing radical rather than incremental innovation, not because incremental innovations are not desirable, but because radical innovations are more likely to suffer from market failures. Large firms are likely to have the information and resources available to demonstrate this. This is closely related to demonstrating the geographical scope of the innovation (new-to-firm versus, for example, new-to-world).

By contrast, less emphasis should be placed on smaller firms demonstrating the radical (or otherwise) nature of their innovation activity, in respect of it being, for example, new-to-world or new-to-firm. Indeed, one view of small firm innovation is that small firms are more likely to generate radical innovation in the first instance, since it is through this process that they gain entry into incumbents’ markets.26 Good quality information is unlikely to be directly available on this dimension in any case, although sector could be a proxy for significance of innovation. Firm size and sector are discussed further below.

In conclusion, the radical versus incremental dimension is not generally useful for defining ex ante innovation likely to suffer from market failures, but there should be an onus on large firms to demonstrate that they will deliver radical (as opposed to only incremental) innovation, which is also more likely to be new-to-EU or -world rather than just new-to-firm.

2.3.3 Innovation activities
The traditional or linear approach sees innovation as the result of a well-defined set of steps, where companies start by investing in basic research, equipment and instruments, design, engineering, training, and scientific and technical knowledge from other firms to develop an invention. Once the invention is ready, it is manufactured, marketed and distributed to the end-customer. R&D takes place in well-defined stages, and is integral to this process.

More recent non-linear approaches recognise that innovation rarely evolves in well-defined, sequential and exclusive stages; instead, it is the result of a dynamic and multidimensional process that involves different interactions and feedbacks. Firms do not innovate alone—interactions take place within the firm and also with other firms and institutions, and with the end-users of the innovation. Innovation is path-dependent, firms evolve, and the conditions to obtain innovation can change over time. As part of this process, R&D is important, but is only one component of the innovation process.

Indeed, as illustrated in Box 2.2 below, the non-linear nature of innovation emerged strongly in the case studies explored by Oxera.

---

26 This is akin to a Shumpetarian view of the role of small firms in introducing disruptive technologies and gaining entry into markets. However, see below for how Shumpeter’s view evolved over time (section 2.3.4).
Box 2.2 The non-linearity of the innovation process

Oxera spoke to a representative from a French Ministry involved in putting forward a scheme to offer assistance to young innovative SMEs (European Commission 2003a). In the expert's view, innovation is not simply about the early stages of the R&D process, but the process as a whole, including commercialisation. For example, innovation included undertaking an initial run or limited market testing of products. Marketing was also an important part of the innovation process. In the expert's view, the R&D Framework did not adequately account for these various aspects of innovation.

Some analogous issues arose when Oxera talked to a representative from a large microelectronics firm involved in many R&D projects. The view expressed was that new concepts of innovation are very wide in scope, but that allowing state aid for all aspects of innovation was not desirable. The focus should be on technical innovation (ie, R&D), which is measurable, and on aspects of this not too close to the market. However, non-linear theories mean that distinguishing between industrial research and pre-competitive development is not useful since, to be successful, projects must incorporate feedback loops. There should also be recognition that the involvement of a sample of users in early stages, and in prototype design, does not make the project not close to market. In the representative's view, the R&D Framework did not adequately allow for state aid for these various aspects of innovation, and was therefore outdated.

In the Cesare Sorono case study (European Commission, 2004c), one of the main issues was that, in the pharmaceutical industry, developing new molecules does not follow a linear process. Indeed, it was not clear in this case whether pre-clinical testing could be classified as applied research or pre-competitive development, as it involved elements of both. This is due to feedback between these two 'stages'. Furthermore, the concept of prototypes is less applicable to molecules than, for example, aircraft engines.

Oxera spoke to a biotechnology entrepreneur, who highlighted the complexities of innovating in the biotech industry. From start-up to maturity, there is a series of critical development steps, all of which contribute to an organisation's 'innovation': for example, managerial changes, financing arrangements, the need for alliances with the right people and companies, and obtaining the appropriate patents. It is therefore often difficult to identify the exact point at which the innovation occurs in this process.

The implication of the non-linear approaches to innovation is that a single activity performed by a firm does not lead to innovation. Therefore, R&D on its own may not lead to innovation and, instead of being the starting point, R&D plays the role of problem solver (Kline and Rosenberg, 1986). Although empirically it has been established that there is a positive relationship between R&D expenditures and measures of invention (ie, innovative intermediate output) such as patents and patent citations, it is not clear whether it would have been possible for firms to reach this stage without investing in other innovative activities.\(^{27}\)

---

\(^{27}\) It has been established empirically that there is a strong link between R&D expenditure and innovation. Using patent counts, Pakes and Griliches (1980) found that there is a statistically significant relationship between a firm’s R&D expenditure and the number of patents it applied for and received. In particular, the authors found that the cumulative effect of R&D on patenting is around 0.6—ie, if the accumulated R&D expenditures increase by 10%, the number of patents increases 6%. However, the effect of R&D on patenting appears to be decreasing up to the fourth lag, but the fifth lag is large and positive. The authors refer to this as the truncation bias of the shape of the estimated lag distribution. Using more accurate estimation techniques, Hausman, Hall and Griliches (1984) re-examined the relationship between R&D and patenting. The truncation problem disappeared. The estimated lag structure suggests a declining effect of R&D on a firm’s patenting. Blundell, Griffith and Van Reenen (1995) noted that the consistency of the estimators from the models used in Hausman et al (1984) depends on the assumption that R&D is strictly exogenous. However, this is not necessarily the case. The innovation process can follow a non-linear process and be characterised by a number of feedbacks. Then, R&D spending leads to innovation, but innovation might also provide the incentives for future R&D investments. R&D might therefore be determined by the system rather than exogenously.
As a result of the complexity of the innovation process, targeting such processes for the purposes of state aid may not always be possible. However, innovation is indeed a non-linear process, it is also the case that market failures occur, or occur with more severity, in certain parts of this process. If it is not possible to identify ex ante exactly where market failures occur, it might be necessary to target proxies of that process, such as the activities that the firm has to undertake for successful innovation to take place, which are more likely to be hindered because of market failures and are therefore eligible for the aid. The rationale for this approach is that activities that do not suffer from market failures will still take place without aid. Therefore, to the extent that is practicable, aid should be targeted at those activities that suffer from innovation-related market failures, notwithstanding the fact that other activities are a necessary condition for successful innovation.

In relation to the activities that may be necessary to successfully innovate, the following are important:

- basic research;
- applied research;
- development;
- design;
- training of employees;
- machinery and equipment new to the firm—ie, embodied technology;
- acquisition of third-party patented inventions, licences on patents, non-patented knowledge, designs, and other services and technologies—ie, disembodied technology;
- marketing.

Much of the debate and, crucially, empirical evidence on market failures has focused on R&D (see section 2.4.2). The analysis presented below therefore relies on Oxera’s understanding of the interaction of market failures and the above activities. Although R&D (basic research, applied research and development) is not the only important activity in the innovation process, it is often a crucial input, is readily measurable (hence empirical studies focus on it) and, as will be discussed below, is relevant to the analysis of whether market failures would be expected to occur.

The R&D activity that appears to be more likely to be hindered by market failures is basic research, followed by applied R&D. In contrast, the activity that seems less likely to be hindered by market failures is marketing, although there are some exceptions.

As discussed in section 2.4.2, the empirical analysis of the impact of R&D on total factor productivity suggests that there are high public returns (exceeding private returns) from R&D, and that such returns are higher in early-stage R&D (ie, research) than at later stages (ie, development). Therefore, basic research appears to generate more spillovers than development.

From a theoretical perspective, basic research is likely to generate a high level of spillovers as a result of its relative generality, and the lack of appropriability of the knowledge created. By definition, basic research is the research activity undertaken mainly to acquire new scientific and technical knowledge not linked to any particular application or use. Due to this generality, the knowledge generated can potentially have many applications and therefore benefit a wide range of firms undertaking different economic activities.

In addition, precisely as a result of its lack of direct applicability, the economic return of basic research is likely to be relatively low. Indeed, the main way in which basic research is appropriated is via publication in scientific journals or by being circulated in the scientific community (in seminars, conferences, etc)—activities that do not allow the agent undertaking the research to extract rents from it. In contrast, the results of applied research and even more those of development activities, can be appropriated via patents, trademarks, and other forms of IPR.
Regarding activities such as investments in embodied and disembodied technology, and training, it appears that the market failures mainly occur in relation to the knowledge generated while using embodied and disembodied technology, and while receiving the training. In particular, these activities are more likely to generate spillovers the more general and transferable skills the employee acquires, which increases the probability of benefiting other firms through formal and informal exchanges of ideas, or when switching jobs between firms.28

Collaboration failures are likely to occur in any of the activities mentioned previously if several agents need to work jointly for the successful delivery of the innovation. Given the high level of uncertainty in terms of the financial returns of basic research (and therefore the potential for costs to be sunk), collaboration failures might be high for this type of project. In addition, since investments in disembodied technology require that firms interact with other companies and institutions (eg, universities, research centres), coordination failures might also arise.

Finally, in general, the marketing of an innovative product is specific to the innovation in question; thus, other firms are unlikely to be able to benefit from the knowledge generated by the innovator. As a result, spillovers might be relatively low. In addition, at the marketing stage, firms almost have the ‘innovation’. The probability of knowing the result of the innovation from a technical perspective is close to 1 for both the investor and the innovator, and there is less economic uncertainty in terms of the potential market than in earlier stages (although there is a still risk that, for example, the market conditions change and the expected demand drops). At this stage, there is less likelihood that the innovator will not be able to raise external finance than at an earlier invention stage. This view was confirmed in interviews conducted by Oxera with officials in a UK government department (see Box 2.3). This box can be compared with Box 2.2. Essentially, although innovation is non-linear and a wide concept, only certain aspects of innovation suffer from market failures.

Box 2.3 Later- versus early-stage R&D

Oxera discussed the stages of the R&D process with innovation experts in a UK government department. In their view, despite the existence of complex feedback loops in R&D projects, assistance is more important at the earlier stages, since this is where uncertainty is higher. Furthermore, in presenting projects to government, firms are generally able to distinguish between research, on the one hand, and development, on the other. Asked whether support at the commercialisation or marketing stage was justified, the experts highlighted that the company concerned would practically have a product by this stage, and that it was unlikely that the firm would have difficulties in raising finance at this point. The role of government is not to underwrite all commercial risks: thus, government should only intervene where uncertainty is particularly acute—ie, during the earlier stages.

Therefore, while the CIS definition of innovation might encompass marketing, because effective marketing is necessary to get products to the market, this activity appears unlikely to face market failures. Innovation in marketing should occur as a normal part of the competition process. Furthermore, marketing is not necessarily relevant to process innovation if the latter is aimed at reducing the unit cost of an existing product. To the extent that a product innovator has to open a new market and ‘educate’ its potential consumers, firms entering the market after the initial innovator may be able to free-ride on the marketing efforts of the innovator, and marketing might therefore generate spillover effects. However, in general, market failures in marketing are likely to be limited.

28 A detailed discussion of training is beyond the scope of this report.
In conclusion, R&D activity, and the various stages of R&D activity, is measurable and relevant dimensions for defining ex ante whether innovation is likely to suffer from market failures. Other measures, such as embodied technology, may be less relevant, and less readily measurable. Marketing is not necessarily a relevant dimension in the current context.

### 2.3.4 Characteristics of the firm: firm size and stage in the life cycle

The theoretical and empirical debate highlights that both small and large firms have the potential to innovate, and that it is not clear that one or other is more innovative. Several authors have noted that innovation and firm characteristics such as size are related. However, the theoretical and empirical literature is not conclusive as to whether small-sized firms are more innovative (or engage more frequently in innovative activities) than large-sized companies, or vice versa.29 Several justifications for a positive correlation between firm size and innovation have been proposed. In particular, larger firms have greater appropriation possibilities and might face lower economic and technical risk, making them more likely to innovate. In addition, large firms can develop economies of scale and therefore spread the fixed costs of innovating over a larger number of units of output (ie, with a lower unit cost of production). Indeed, R&D activity has economies of scale.

However, large firms might have difficulties in adapting established practices to new economic and technological environments that provide opportunities for innovation. The higher flexibility of smaller firms, as well as better internal communication, and a higher degree of specialisation, might allow them to take advantage of the opportunities offered by the unexpected emergence of new market opportunities and innovations that demand a change in the competencies of the firm.

There is a variety of empirical evidence analysing the relationship between firm size and innovation—good reviews can be found in Acs and Audrestch (1990) and Cohen (1995) (and in earlier studies, such as Mansfield 1963). Two conclusions arise from these studies. First, R&D expenditures and firm size are positively correlated and this relationship appears to be roughly proportional among R&D performers in most industries or when controlling for industry effects. This implies that large-scale firms invest more in R&D than SMEs. Second, the number of innovations (measured by patents) tends to increase less than proportionately with firm size, and R&D productivity (ie, number of patents to R&D expenditure ratio) tends to decrease with firm size. In other words, smaller firms are more productive than large-scale companies.

Moreover, the debate in section 2.3 on market failures shows that small-scale innovative firms are more likely to be affected by market failures than large-scale firms. The problems are likely to be exacerbated for small firms at earlier stages of the life cycle (ie, small-scale seed/start-ups or young innovative SMEs), and in particular in innovative sectors in which the firm is active (eg, high-tech).

In relation to spillovers, as discussed in section 2.4.2, it is not clear whether small- or large-scale firms are more likely to generate them. However, there is evidence suggesting that SMEs generally do not protect their intellectual property (particularly companies outside the high-tech sectors), suggesting that knowledge spillovers are more likely to occur. Smaller firms may be more inclined to undertaking radical innovation, to enter markets, but large firms also undertake projects intended to generate radical innovations. Therefore, it is not clear whether spillovers are higher from smaller or larger firms. Section 2.3.2 considered why there should be a requirement for large firms undertaking innovation, which are seeking state support, to demonstrate that their innovation is radical, and new-to-EU or -world.

Although both large and small firms innovate, large firms often have more resources to innovate, whereas small firms are more likely to face impediments. Two areas in which there

---

29 One of the initiators of the debate was Schumpeter, who was of the view that innovation is driven by small entrepreneurial ventures. This view evolved towards one in which innovation is driven by large, persistent enterprises operating in concentrated markets.
appear to be important differences between SMEs and large-scale firms are financial market failures and coordination/network failures. Regarding the former, SMEs tend to have limited retained profits that can be invested in innovative activities, and do not have the market power that investors value. In addition, firms might not have a track record in terms of successful innovations, which makes it more difficult for investors to price the risk associated with the firms’ new projects. The problem is more serious for start-ups (and, to a lesser extent, for young innovative firms), and for companies in risky sectors such as the high-tech sector. Depending on the sector, SMEs might have insufficient tangible assets (collateral), which appears to be problematic if the firm wants to access external funding. Indeed, financial market failures occur due to the conjoint of a firm being a SME, start-up and in an innovative sector.

It is unclear whether small- or large-scale innovative firms are more likely to face R&D coordination failures. However, with regard to network failures, these are more likely to affect SMEs, since they may lack access to formal and informal networks. In contrast, larger firms usually have established relationships with other agents participating in the innovation system, and have more resources to establish them.

In conclusion, firm size, and firm stage in the life cycle, is highly relevant dimensions for defining ex ante whether innovation is likely to suffer from market failures, as the market failures will vary along these two dimensions.

2.3.5 Sector

As discussed in greater detail in section 2.4 below, market failures are more likely to affect firms in high-tech sectors than in other sectors. Evidence suggests that companies in high-tech sectors tend to protect their intellectual property using patents, publishing findings in academic journals, and other methods (eg, secrecy). However, IPR do not necessarily guarantee full appropriability because knowledge is likely to leak quickly in the high-tech sector through scrutiny of patent applications, formal and informal contacts between individuals, employees switching jobs, and contacts with common input suppliers. Companies benefit from the externalities generated by the innovations of others, although they ‘lose’ with their own innovations—it is difficult to fully internalise the externalities generated by innovation, but a company can take advantage from the spillovers of other firms. As a result, in high-tech sectors, spillovers are likely to be high.

Similarly, financial market failures might be high because of technical and economic uncertainty (unproven technologies and high intangible assets, such as know-how). There is thus a close correspondence between the radical nature of innovations introduced in certain sectors and the financial market failures that might occur. However, after a firm has gone through the early stages of innovation, uncertainty and financial failures reduce (see section 2.4 for further discussion).

Collaborative R&D failures are particularly relevant to the high-tech sector, including companies in which complex systems innovation occurs (eg, aerospace, telecoms, semiconductors), and in scale-intensive sectors using specialised knowledge (eg, machinery and equipment). Network failures are likely to occur in any sector, but specific networks designed to mitigate network failures (eg, clusters, incubators) are more relevant to some sectors than others.

The issue of sector as a measure of innovation can be thought of in terms of the OECD-style classification of sector (high-tech versus low-tech) (OECD, 1997), which are based on historical measured R&D intensity, combined with the distinction between science-based industries, those relying on specialised capabilities, scale-intensive sectors, and users of others’ innovations proposed in Pavitt (1984). This is illustrated in Table 2.1 below.

30 This was confirmed in a discussion with a spin-out in the optical sector. The firm makes intermediate inputs that are used in the telecoms and transport sectors, among others. The firm has used secrecy and its accumulation of tacit uncodifiable knowledge as an alternative way of protecting its intellectual property.
### Table 2.1 Sector classifications

<table>
<thead>
<tr>
<th>High-tech industries</th>
<th>Medium- to high-tech industries</th>
<th>Medium- to low-tech industries</th>
<th>Low-tech industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Includes the following science-based sectors:</td>
<td>Includes the following scale-intensive sectors:</td>
<td>Includes the following scale-intensive sectors:</td>
<td>Includes traditional industries that are mainly users of other sectors' innovations:</td>
</tr>
<tr>
<td>– aircraft and spacecraft</td>
<td>– motor vehicles, trailers and semi-trailers</td>
<td>– building and repairing of ships and boats</td>
<td>– wood, pulp, paper, paper products, printing and publishing</td>
</tr>
<tr>
<td>– pharmaceuticals (including biotech)</td>
<td>– petrochemicals excluding pharmaceuticals</td>
<td>– coke, refined petroleum products and nuclear fuel</td>
<td>– food products, beverages and tobacco</td>
</tr>
<tr>
<td>– radio, TV and communications equipment</td>
<td>– railroad and transport equipment</td>
<td>– other non-metallic mineral products</td>
<td>– textiles, textile products, leather and footwear</td>
</tr>
<tr>
<td>and the following sectors that rely on specialised capabilities (eg, engineering, accounting):</td>
<td></td>
<td>– basic metals and fabricated metal products</td>
<td></td>
</tr>
<tr>
<td>– office, accounting and computing machinery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– medical, precision and optical instruments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– electrical machinery and apparatus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– machinery and equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Those sectors which, according to Pavitt’s classifications, are science-based or rely on specialised capabilities, have been classified as high-tech. Supplier-dominated sectors, which are mainly users of others’ inventions, have been classified as low-tech. Scale-intensive sectors have been divided into medium- to high-tech and medium- to low-tech according to R&D intensity, in line with the OECD methodology. Sources: Oxera analysis of OECD (2003a) and Pavitt (1984).

Alternatively, the sector classification might be conducted with reference to the Martin & Scott (1998) concept of innovation mode. This distinguishes between:

- **Innovating input suppliers**—eg, software, instruments, equipment;
- **Innovating input users**—eg, agriculture, light industry;
- **Complex systems innovation**—eg, aerospace, telecoms, semiconductors;
- **High-science-content technology industries**—eg, biotechnology.

In summary, sector is a relevant dimension for identifying ex ante whether innovation by firms in that sector is likely to suffer from significant market failures.

### 2.3.6 Conclusions

The above analysis suggests that, in developing measures of innovation most likely to be measurable ex ante and which are associated with innovation market failures, the following proxies are the most relevant:

- **Significance of the proposed innovation**—including both degree and scope;
- **Innovative activity that the firm is carrying out**—particularly, R&D, by stage;
- **Size of firm**—small versus large;
- **Stage in the firm’s life cycle**—seed or start-up versus later-stage or mature;
- **Sector**—high-tech versus others.

In relation to the characteristics of the innovation, market failures depend on the significance of innovation, because of the close correspondence with the uncertainty involved. Market failures also differ by the activities necessary to innovate successfully, and according to the firm’s size, its stage in the life cycle and the sector in which it is active.

The analysis suggests that radical (and new-to-EU or -world) innovations and those undertaken by small-scale start-ups (or young firms) in the high-tech sector are more likely to be affected by significant market failures. For such firms, the sector is in itself a proxy for the radical or otherwise nature of innovation, and there may be little merit in seeking to explore in
detail the significance of innovation for these firms, as discussed in section 2.3.2. In addition, basic research is more likely to be affected by market failures than applied R&D.

Table 2.2 sets out the relevant criteria and indicators that should be used ex ante to determine the innovation dimensions.

**Table 2.2 Criteria and indicators for relevant innovation dimensions**

<table>
<thead>
<tr>
<th>Innovation dimension</th>
<th>Criteria</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Significance of innovation</strong></td>
<td>Large firms should be asked whether the project: 1. is intended to generate a marginal, or significant innovation? and, to provide evidence on this, whether 2. the result of the project is new to the firm, to the country, to the EU, or to the world? The more radical and the newer to the world the innovation is, the more likely it is that the project could be hindered by market failures (Large firms should also ensure that processes are in place that maximise the probability of successful innovation)</td>
<td>A large firm is over X employees (e.g., see the SME definition below). This includes small subsidiary firms that are part of a larger group Based on the information provided by the large firm (greater than X employees) in relation to 1) and 2), the opinion of external experts should be sought Because large firms suffer from fewer innovation market failures than small firms, it should be emphasised that state aid should only be provided to large firms if their innovation is likely to be sufficiently radical. Such a requirement should not be placed on smaller firms</td>
</tr>
<tr>
<td><strong>Activity</strong></td>
<td>1. Is the firm proposing to undertake R&amp;D-related activities as part of the project? 2. What is the percentage of total project expenditures represented by R&amp;D?</td>
<td>For SMEs: X% of total project expenses are R&amp;D expenses For large firms: X% of total project expenses are R&amp;D expenses</td>
</tr>
<tr>
<td><strong>Firm size</strong></td>
<td>Is the firm a SME?</td>
<td>The current EU definition of medium-sized firms could be used (e.g., between 50 and 250 employees); small-sized firms (e.g., between 10 and 50 employees); and micro (less than 10 employees), or based on assets or turnover. These firms should be independent (i.e., should not be a subsidiary of a larger group)</td>
</tr>
<tr>
<td><strong>Stage in the life cycle</strong></td>
<td>1. Is the firm a seed or start-up? 2. Is it a young firm?</td>
<td>1. Has the firm been established in the past X years? Is the firm a spin-out? 2. Is the firm less than X years of age</td>
</tr>
<tr>
<td><strong>Sector</strong></td>
<td>Is the firm part of a high-tech sector?</td>
<td>Based on the OECD classification of companies, Pavitt’s classification, or innovation mode. For example, the high-tech sector includes the following science-based complex-systems sectors: aircraft and spacecraft, pharmaceuticals, biotech, and telecoms. It also includes the following sectors relying on specialised capabilities (e.g., engineering, accounting); office, accounting and computing machinery; medical, precision and optical instruments; electrical machinery and apparatus; and machinery and equipment</td>
</tr>
</tbody>
</table>

Note: Benchmark numbers are not provided, as quantitative and comparative analysis would be required to devise these. This is beyond the scope of the current study.

Source: Oxera.
2.4 Developing further criteria for assessing innovation market failures

The discussion of innovation in section 2.3 highlighted that the principal descriptors of (or proxies for) innovation, which are both ex ante measurable and relevant to innovation market failures, are:

- **activity**—specifically R&D, by stage;
- **firm size**—small versus large firms;
- **firm’s stage in the life cycle**—earlier stages versus more mature firms;
- **sector**—eg, high- versus low-tech.

The radical or otherwise nature of the innovation was also cited as being of importance, particularly in assessing proposals involving assistance to larger firms.

Thus, section 2.3 considered measures of innovation relevant to market failures. This section focuses in more detail on measures of market failures relevant to innovation, putting forward criteria, indicators and questions that assist in identifying ex ante whether four basic types of innovation market failure are likely to occur. In many cases, whether these would be expected to occur ex ante can be related directly back to the four innovation descriptors discussed above (indeed, the measures of innovation above are also measures of market failure). Furthermore, information on the above descriptors can be analysed at various levels of aggregation (see section 2.4.1, below).

Given the complexities, however, other measures are more idiosyncratic in nature (particularly in relation to coordination/network and financial market failures). It is of note that there is very little literature looking specifically at market failure indicators, except perhaps in the case of financial market failures.

There is some controversy over whether innovation policy should seek to tackle market failures or system failures. On the one hand, because the innovation process is often complex and non-linear, identifying exactly when market failures occur can be difficult. On the other hand, others point out that the danger of adopting a systems-based approach is that policy may become too broad.31 Despite the complexities, the non-linear school of thought arguably offers two messages in respect of market failures.32

- **Picking winners**—because of the complexities in the innovation process, it can be difficult for government to pick winners in an attempt to resolve market failures. Therefore, support for intermediaries (eg, incubators, financial intermediaries) may often be more effective than support for specific firms.

- **Role of state aid versus other measures**—because firms rarely innovate alone, and innovation often occurs as part of a system, the first-best option to correcting market failures may be to ensure that the underlying components of the system are present and work well (for example, ensuring a robust entrepreneurial base, or a high-quality regulatory framework), rather than necessarily employing a more specific measure that constitutes state aid (ie, one that has the potential to distort competition).

Moreover, it is still possible to identify specific market failures. In what follows, factors that might constitute system failures are identified, but only where these are sufficiently close to, and are of particular relevance to, the issue being considered (see also section 2.2).

---

31 A non-linear view is taken in European Commission (2002), which recommends that government intervention should tackle barriers to innovation rather than market failures. This entails looking at the institutional framework, resources for innovation, and networking/knowledge transfer. However, Abramovsky et al (2004) favour a more linear approach, involving the identification of individual market failures, as the authors noted that anything could be described as a system failure, and such analysis generates poor policy predictions. (The authors divide market failures into spillover, coordination and information effects).

32 See, for example, Navarro (2003) and European Commission (2002).
As discussed in sections 2.2 and 2.3, there are four basic types of innovation market failure that might occur: knowledge (technological) and market spillovers; lack of appropriability; coordination or network failures; and financial market failures resulting from asymmetric or imperfect information. As Figure 2.3 illustrates, these innovation market failures can be classified into those resulting from successful innovation, and those that might hinder the facilitation of innovation.

**Figure 2.3 Market failures and their relationship with innovation**

---

Source: Oxera.

---

In respect of the wider effects of innovation that generate knowledge (technological) and market spillovers, the process of undertaking innovation, or the end-result of the innovation process (eg, a product), often generates wider benefits (ie, positive externalities). Knowledge is thus often complementary and non-rival. This should be seen in the context of a private firm making R&D investment decisions. In ranking R&D projects, individual firms may not price in these wider benefits. Left to the market, projects which, from a private perspective, are unprofitable (private returns to innovation are below the private cost of capital or hurdle rate), but that would otherwise generate large social benefits (total public returns, which include private returns and additional social returns, are significantly above private returns), might not be taken forward.33

In the context of the current report, it is these positive externalities of innovation that provide the ultimate reason for why governments would wish a priori to support innovation. The government support internalises the spillover externality, which should encourage more spillover-generating innovation. As discussed in section 2.4.2, the evidence demonstrates that (technological) spillovers are particularly high between firms within an industry, but that they ultimately contribute positively to productivity and economic growth (surplus appropriability).34 From a purely innovation-focused perspective, governments should be less interested in supporting innovation through state aid where there are only likely to be private benefits generated by the innovation (for example, product innovations which some customers value, but which do not generate large knowledge spillovers).35

The following are factors that may hinder the facilitation (or delivery) of innovation.

---

### Public goods and appropriability

Closely related to the concept of spillovers is the notion that knowledge and ideas are often non-excludable: it can be difficult to exclude others from using the innovation and make them pay individually for the benefit they

---

33 Throughout this report, public returns are deemed to be the sum of private returns and additional social returns.

34 This is consistent with new (or endogenous) growth theory.

35 Nonetheless, governments should still create an economic environment in which such innovations can occur, and where state aid on some other basis (eg, employment objectives, assistance to SMEs in general) might be justified.
receive. Worthy projects may be given up by firms as a result. For example, in the absence of intellectual property protection, firms will be reluctant to invest in innovation if the knowledge spillovers generated are simply used by direct competitors which copy the product, and which have not had to undertake the investment. Put another way, the firm generating the knowledge in the first instance would not be able to appropriate its private investment in the innovation. Patents may serve to restrict such knowledge spillovers in the short term, while revealing the underlying technology, encouraging innovation and generating large eventual spillovers (and thus high public returns) in the longer term.

– **Coordination or network failures**—firms rarely innovate alone. However, there may be problems that impair the ability of actors to coordinate or at least interact, and so deliver innovation. A wide range of problems may arise, including:

  – firms’ difficulties in committing to collaborative R&D (positive externalities);
  – wasteful investment by firms in substitutable R&D (negative externalities);
  – inadequate access by smaller firms to the innovation system (which may be caused by a wide range of factors).

The more established notion of coordination failures is that coordination represents an optimal solution, but that certain factors can hinder coordination. In many situations, coordination failures occur because, while the private returns of all relevant participants coordinating are above their individual private costs of capital, private returns are below the cost of capital if only some of the relevant participants cooperate. This can either appeal to cost considerations (the costs of one agent depend on the presence of others), or more generally critical mass effects (the value of a network to each agent depends on its size and composition). New theories of innovation also emphasise additional motivations for coordination failures. However, recent theories, and evidence on these, also enable the identification of situations in which coordination failures are unlikely to occur.

– **Imperfect and asymmetric information**—this affects financial markets, in particular. Start-ups engaged in high-tech innovative projects may be involved in projects with a highly uncertain future, in which the firm has a clearer idea of the chances of success than the financiers. Against this background of uncertainty and asymmetric information, the due diligence and monitoring required can lead to high transaction costs. Certain firms may therefore find it difficult to obtain funding from external financiers. Worthy projects with a good prospect of earning a private return commensurate with the actual risks of the project may not attract funding. Thus, in a world of perfect information, private returns may be at, or above, the private cost of capital, but such projects may still not go ahead.

There is nonetheless some blurring between what constitutes a wider benefit of innovation and what constitutes a facilitating factor, since most of the above involve externalities of some dimension. For example, the notion of public goods is closely related to knowledge spillovers. Also, coordination between firms often gives rise to knowledge spillovers (thus, coordination failures also arise due to the lack of internalisation of these externalities). Financial market failures do not arise because of externalities, but because of information imperfections. However, the lack of external financing provision to innovative projects would be of concern since such projects are also likely to generate spillovers.

The criteria for identifying ex ante whether the above four types of market failure occur are discussed below. The tables presented in sections 2.4.2 to 2.4.5 are relevant to measures proposed by Member States for supporting schemes or projects relating to small and large innovative firms. They are also relevant to large-scale innovative investments. However, particularly large innovative investments raise some additional issues, and these are discussed separately in section 2.4.5.
Before exploring the criteria for identifying each type of innovation market failure, section 2.4.1 explains the methodology used in constructing the tables containing the criteria, and how the tables might then be used.

### 2.4.1 Methodology in constructing criteria tables

The above highlights the importance of examining, as **descriptors**, activity, firm size, firm stage in the life cycle and sector (and the radical or otherwise nature of the innovation). For **practical purposes**, as will be illustrated in the tables below, when defining criteria to determine how likely it is that a proposal put forward by a Member State will be relevant to tackling innovation-related market failures, such information can be collected at **four information levels**:

- the country in which the investment or scheme will take place;
- the firm undertaking the investment (or qualifying firms, if part of a scheme);
- the sector in which the firm is active; and/or
- more specific information on the project itself (for example, if assistance is proposed in relation to a specific investment undertaken by a firm).

There is an exact correspondence between the firm- and sector-level descriptors already discussed and the firm and sector information levels. However, for illustration, the ‘activity’ undertaken (for example, early-stage R&D) might be explored at various levels:

- **the firm level**—does the firm concerned undertake early-stage R&D?;
- **the country level**—eg, what is the level of R&D intensity in the country concerned?;
- **a more disaggregated level**—eg, does the project concerned involve early-stage R&D?.

In turn, whether more detailed questions are asked at the project level is, in itself, likely to depend on firm size. Furthermore, other questions might be asked at the project level (and indeed the country level), which go beyond the descriptors developed (see below).

From a practical perspective, having information to ascertain the degree of innovation market failures at a country, firm or sector level may enable an assessment of whether a scheme might be affected by innovation market failures, even when there is not enough information at the project level.

The country-level criteria do, however, provide only an **initial idea** on whether innovation market failures are likely in relation to either schemes or specific investments. For example, is there a lack of R&D activity in the country concerned (which may limit the realisation of beneficial spillovers)? How many patents are registered in the country concerned (a lack of patenting activity may raise appropriability concerns)? Do the country’s competition provisions hinder R&D collaboration at the early stages (which may give rise to coordination failures)? Does the country have an equity culture (which may affect the degree to which the economy is geared towards investing in riskier, more innovative ventures)?

Although it is important that these questions are asked, such criteria only ‘set the scene’, providing a high-level overview of the situation. They do not necessarily mean that innovation market failures exist. For example, high patenting activity may be problematic if ‘questionable’ patents abound in the economy concerned. The lack of an equity culture is also not necessarily indicative of financial market failures.

These issues are considered further in the following discussion of the individual market failures, and are reflected in each of the tables.

The question then is how far to drill down into the firm-, sector- and project-level criteria, to obtain a more in-depth understanding of whether a proposal is aimed at tackling innovation...
market failures. Ultimately, a judgement will be required on this balance. However, as discussed in section 2.1:

- a priori innovation market failures are more likely to affect smaller firms than larger firms;
- Member State assistance to smaller firms is more likely to be in the form of schemes covering many qualifying firms (which may not have a track record, or the resources to provide detailed information);
- Member State assistance to larger firms (which have a track record) tends to concern a specific project or investment (around which a detailed business plan will have been developed).

Thus, in the case of SMEs (and schemes to assist SMEs), higher-level metrics should be both necessary and sufficient for this task (e.g., at the firm and sector levels). In the case of large firms or investments, higher-level metrics are necessary, but a greater number of metrics should be used. In such cases, criteria at the project level should be applied, and further questions outside of the framework developed below should be asked, which will vary from case to case and are not considered further here. The tables developed also recognise these considerations.

Figure 2.4 summarises how practitioners might move from more general (country) levels of information to more specific (project) ones, through the one-ended arrows in the figure (on the right-hand side). In addition, information at each of the levels of an innovative scheme or investment might be complementary, providing a better idea of how likely it is that a scheme will address market failures. This is represented in Figure 2.4 by the double-ended arrows.

**Figure 2.4 Criteria for assessing innovation projects: an operationalisation**

![Figure 2.4 Criteria for assessing innovation projects: an operationalisation](source: Oxera)

The above levels of information are, in general, reflected in each of the rows of the tables. For each of the four information levels illustrated in Figure 2.4, criteria, questions and indicators are outlined in the columns of the tables below:

- **Criterion**—against which the market failure is assessed;
- **Context**—the background to why the criterion concerned is relevant;
- **Indicators and questions**—relevant metrics, or questions that could be asked, to gauge the extent of the market failure;
interpretation—what the level of the metrics concerned, or the answers to the questions, means in terms of justifying a priori government intervention (and, potentially, state aid) to resolve a determined market failure.

To summarise, in what follows, the four innovation market failures, and the theory and evidence, are considered in turn. For each innovation market failure, tables are then developed around the relevant descriptors of innovation, beginning with information at the country level and ending with information at the project level (where relevant). At each of these information levels, criteria, questions and indicators are then developed.

As mentioned, due to the complexities, the above generic approach has nonetheless been adapted in the case of coordination/network failures (particularly in relation to incubators, in which the issues are more idiosyncratic) and financial market failures (in which there are particular controversies).37

2.4.2 R&D spillovers

If positive spillovers (of some kind) are not generated by innovation, state aid for innovation purposes is unlikely to be a priori justified. Indeed, Jaffe et al (1996) noted that the market failure created by R&D spillovers is one of the primary justifications for government policy designed to encourage R&D, and that, while there is inherent uncertainty regarding the spillover effects of particular projects (as much as there is regarding the technical potential of a project), it is possible to identify generic features likely to be associated ex ante with greater likelihood of spillovers.

R&D is not the only activity to generate spillovers, but is a measurable and important part of the innovation process and, as noted in section 2.3.3, much of the empirical evidence on spillovers examines the impact of R&D. The empirical evidence suggests that there are high public returns (exceeding private returns) from R&D, providing the ultimate underlying rationale for any government support to be provided for R&D. R&D generates both knowledge/technological spillovers (in which the knowledge generated is used by other firms to develop new technologies, products and processes) and market spillovers/surplus appropriability (benefits that accrue to customers in the market, rather than being captured by the innovating firm). The recent literature and evidence has emphasised, in particular, the role of the former, and, while there are methodological issues concerning the evidence, technological spillovers are particularly significant.38 Spillovers tend to occur across closely related industries (rather than through the general economy), and there are particularly high rates of knowledge diffusion in the high-tech and science sectors.39

Knowledge creation and exchange of ideas, which influence the extent of both knowledge and market spillovers, occur mainly at the early stages of the R&D process.40 In effect, market failures are higher during the earlier stages. The realisation of knowledge spillovers

---

37 Large-scale investments are examined separately, in section 2.4.6.
38 Cameron (1998) highlights that empirical studies have typically found a significant link between R&D and productivity, implying a social return from R&D (including the private return) of between 20% and 50%, and that, where studies have sought to isolate the effect of technological spillovers via proxies (e.g., by examining the effects of R&D on patenting behaviour of other firms), such spillovers are ‘pervasive and significant’, between firms, industries and (to a lesser extent) countries. Griliches (1995) summarises key results from a number of (mainly US) studies on the private and public (social) returns of private sector R&D spend. The estimates of social returns range from 10% to 160%, but are typically around 30–80%. Jones and Williams (1997) considered the various spillover mechanisms from R&D, including the impact on other industries, and arrived at a social return of 100%. Salter and Martin (2001) nonetheless report that the attempts to model the effects of R&D on productivity, and the resulting social returns, have suffered from conceptual problems and measurement difficulties.
39 Martin and Scott (1998) review a number of studies that show this.
40 For example, Griliches (1986) found that returns to early-stage R&D are higher than those to applied R&D. Englander et al (1988) found that returns to R&D are higher in research-intensive sectors than in non-research-intensive sectors. Adams (1990) showed how the science base is a major contributor to productivity growth, albeit with a lag of 20 years. Link (1987) showed that US federal support for basic research had a larger effect on productivity growth (and thus a higher social return) than applied R&D. Salter and Martin (2001) nonetheless identified some problems in the empirical literature on the effects of publicly funded basic (i.e., early-stage) research.
does not necessarily depend on the commercialisation of the product or process, whereas the realisation of market spillovers is more likely to.\textsuperscript{41}

The issue of spillovers should be approached from how a private firm would make its marginal investment decision. As suggested above, in ranking projects, private firms do not price into their cash-flow forecasts the prospective wider benefits, through spillovers, of their innovation. As such, schemes with wider benefits may not pass the company’s hurdle rate. State support serves to raise the private cash flows, thereby enabling the project to pass the hurdle rate, and to go ahead. The challenge for policy then is to identify ex ante projects characterised by:

– **high spillovers**—public returns (including private returns) are significantly higher than prospective private returns;

– **lack of private investment**—private returns, on their own, are below the private cost of capital.

In practice, it may not always be possible ex ante to gauge whether projects would or would not necessarily go ahead, according to the second criterion. Where this is the case, it may be desirable simply to target innovation with high spillovers and thus public returns. What does this mean in terms of distinguishing between large and small firms undertaking R&D? As discussed briefly in section 2.3.4, the evidence shows that both large and small firms are likely to innovate and hence have the potential to generate spillovers. However, distinctions should still be made.

The spillover justification is probably one of the few categories of market failure that applies to large firms undertaking R&D: such firms do not necessarily face problems in finding finance for projects; they are usually aware of IPR opportunities and have the resources to undertake patent litigation activity; and they have an established presence and access to networks (as discussed in sections 2.4.3 to 2.4.5).\textsuperscript{42} Government support, which has the effect of raising prospective private returns, would still a priori be justified, but there should be emphasis on obtaining information on the magnitude of spillovers envisaged. Otherwise, governments may simply be supporting projects that would have gone ahead anyway. If specific problems arise concerning the large firm in question relating to coordination failures and financing, this boosts the case for government intervention. Some of the issues regarding spillovers from large-firm R&D versus other market failures arose in Oxera’s discussions with relevant parties and are discussed further in Box 2.4.

**Box 2.4 Spillovers generated by large-scale firms**

The large- versus small-firm distinction emerged from Oxera’s discussions with various parties. For example, when Oxera spoke to a representative of a large European car manufacturer, it was his view that the situation for a large company is totally different to that for a SME. As a large company, it did not suffer from financial, coordination or network failures to the same extent as a small firm. In terms of trade networks, the company had a presence in over 100 countries. It was also judged to be the case that, in the car sector, there is always a need to innovate in any case since innovation drives the market. Nonetheless, while retained earnings were used to fund early-stage R&D in new technologies, such as fuel cell vehicles, a role for public support was also identified.

Oxera also interviewed a European Commission official who oversaw two large company R&D investment cases, under the R&D framework, concerning Rolls-Royce engines and aid to Cesare Sorono (European Commission, 2001d and 2004c, respectively). What became

\textsuperscript{41} However, even when an innovating firm aborts an R&D project, or is unsuccessful in launching a product to the market, exchange of knowledge means that another firm may develop a similar or substitute product as part of its own R&D process, which itself may generate market spillovers.

\textsuperscript{42} In other words, other ‘facilitating’ types of market failure are less likely to arise.
clear was that the role of spillovers specific to the projects, and other market failures, were not considered in detail in these cases. It was judged that the R&D Framework did not enable sufficient account to be taken of these factors (these issues are discussed further in section 3).

The issue of whether governments might support projects that might have gone ahead anyway relates to a second point: the evidence suggests that government support is often biased towards R&D and larger firms. There is mixed empirical evidence on whether such support adds significantly to the R&D that would otherwise have been undertaken by the private sector in the absence of state support (due to selection bias). These issues were discussed with innovation experts in a UK government department (as explored in Box 2.5).

Box 2.5 Selection bias

Innovation practitioners in a UK government department were asked whether innovation and/or market failures were more likely to occur in smaller or larger firms. The experts highlighted that, if it is believed that R&D generates spillovers, firm size should in theory be irrelevant. However, a large proportion of R&D is undertaken in larger firms, and such firms do not tend to suffer from financial market failures. Thus, the case for support for larger firms is based predominantly on the existence of spillovers. The practitioners also cited a tendency for firms to put forward more commercially lucrative R&D projects for state support and that governments may be more inclined to pick such projects since government support can then be shown to be making a difference.

The evidence also suggests that, for small firms, government support for R&D is complementary, whereas, for larger firms, it is more likely to substitute for (crowd out) private R&D investment. Support for small firms tends to be additional because, as suggested above, such firms are more likely to be affected by appropriability, and coordination/network and financial market failures. These issues are discussed later in this section. Government support to raise private returns has a higher probability ex ante of having a stimulating effect. For small firms, specific evidence on the extent of spillovers might not, therefore, be required.

Before exploring further the criterion regarding spillovers, it is necessary to establish the objective of any potential government support. This is because the selection of the criterion and its interpretation depend on the degree of ‘stringency’ practitioners wish to use when reviewing state aid proposals. Fundamentally, it is necessary to determine the following.

- Incentives—is the purpose of the proposed government support simply to reward firms for having undertaken R&D which has wider benefits (reflecting public benefits in private

43 For example, the 2004 Innobarometer showed that, across the EU, there is a bias towards providing public support for large firms, and for R&D purposes (European Commission 2004i). Mohnen and Garcia (2004) noted that, from the EU CIS innovation survey, those performing R&D are more likely to receive government support than new-to-market innovators. However, Wagner (1994) shows that start-ups are not necessarily deterred from entering capital- or R&D-intensive industries.

44 There is a wealth of evidence showing that public support is not a random experiment, and may result in winners being picked (ie, funding projects or firms that are most likely to succeed even in the absence of government support). Klette et al (2000) discussed five microeconometric studies, which examined whether R&D subsidies reduce market failures, four of which purported to show positive effects on the performance of the targeted firm from the government-supported programmes. The authors found that government support is not a random experiment, and is prone to selection bias.

45 David, Hall and Toole (1999) examined 19 studies that looked at what firms would have invested in, in the absence of government support. In nine of these, substitution effects (partial or complete crowding out) were found, and in the remainder there was a partial or complete complementary effect (increased R&D in the economy), although these types of study have been critiqued by Klette et al (2000). Acs et al (1994), and Lerner (1996) conclude that, for small firms, government support for R&D is complementary, whereas for larger firms government support is a substitute. Examining R&D in Spanish manufacturing, Gonzalez et al (2004) concluded that some firms would stop performing R&D in the absence of subsidies, but most subsidies go to firms that would have undertaken R&D in any case. This occurs due to the selection of candidates, and the risk aversion of agencies. Although there is no crowding out of private funds, assistance to smaller firms has more of an inducement effect than assistance to larger firms.
costs), irrespective of whether the firm would have undertaken the innovation anyway, or, moreover, to incentivise greater provision of R&D and thus facilitate more spillovers (incentive effects)?

– **Degree of additionality**—if the focus is on incentive effects, is the rationale for government support simply to speed up a project (or add to the scope of a project) that would otherwise go ahead, or to facilitate projects that would otherwise not go ahead? In the context of larger firms, the objective should be to produce incentive effects for projects that would not otherwise go ahead. Although governments should not pick projects that would have gone ahead even without state support, there should be an emphasis on making sure that the firm has incentives to ensure that the project is commercially successful, conditional on public support having been granted.

Table 2.3 presents criteria, questions and indicators intended to identify ex ante whether a project or scheme is more likely to be hindered by the presence of spillovers. The methodology used to construct the table, and how the table might be used, was discussed in section 2.4.1. For state aid directed to larger firms, the full set of metrics developed (including country-, firm-, sector- and more importantly, project-level indicators) should be used, to avoid crowding out private investment and to ensure that firms have the right incentives to undertake projects that would not otherwise have taken gone ahead. In addition to spillovers, other aspects of market failures should be explored in more detail (coordination and financial market failures), to determine whether they are relevant. These would boost the case for government intervention.

For smaller firms, project-level indicators might be used where information is likely to be readily available. In the absence of such information, the fact that the innovative firm is small and is in a high-tech sector might be sufficient to justify intervention because, as captured in Table 2.3, a priori, market failures are more likely for this type of firm.

Although not discussed in detail in this report, the discussion in section 2.3.3 suggests that investment in training by innovative firms may have an impact on spillovers similar to that of R&D. Within a sector, the more investment in transferable skills, which become embodied within individuals, the more scope there is for knowledge spillovers, as individuals exchange ideas, or move between companies within the sector. Companies may therefore underinvest in training related to innovation. Spillovers would be expected to be greater for transferable skills, and during earlier stages in the process.

---

46 Indeed, as discussed in section 3, the EU R&D Framework, in so far as it applies to larger firms, emphasises both incentive effects and additionality. Here, aid should change the behaviour of agents (for example, improving R&D) and should not crowd out private expenditure on R&D. A question discussed in section 3 is the degree to which the Framework requires these concepts to be applied in practice.
### Table 2.3 Assessing R&D spillovers

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Context</th>
<th>Indicators and questions</th>
<th>Intervention potentially a priori justified when:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country R&amp;D activity (intensity)</strong></td>
<td>R&amp;D generates spillovers. Countries with higher R&amp;D intensities a priori suffer from fewer market failures in realising R&amp;D (and thus spillovers), although differences in R&amp;D intensities may be for other reasons</td>
<td>R&amp;D:GDP (or R&amp;D:value added of sector) in country concerned (a very initial indicator of optimality of R&amp;D and thus spillovers)</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Firm size effects</strong></td>
<td>Both large and small firms generate R&amp;D spillovers, but for larger firms there should be more focus on the extent of spillovers (support for small-firm R&amp;D is more likely to be additional). Start-ups and small firms are not necessarily deterred from entering high R&amp;D sectors (especially high-tech and biotech). While there is evidence that research programmes embedded in larger organisations can be more productive, public support for R&amp;D and academic R&amp;D is of more benefit to small firms than larger firms (although this is for a variety of reasons, including addressing market failures associated with the facilitation of innovation)</td>
<td>Is the firm a SME or large firm? See Table 2.2 Is the firm a start-up or mature firm? See Table 2.2</td>
<td>SME Start-up</td>
</tr>
<tr>
<td><strong>Firm activity</strong></td>
<td>Firms undertaking higher R&amp;D:total costs are more likely to generate spillovers. However, past R&amp;D may not be the best indicator of future R&amp;D, and start-ups will have no track record</td>
<td>Historical R&amp;D:total costs assessed over a period (but treat figures with caution)</td>
<td>High</td>
</tr>
<tr>
<td><strong>Sector effects</strong></td>
<td>R&amp;D and thus spillovers occur in many sectors, but higher and rapid diffusion of knowledge (and thus spillovers) tend to occur in the high-tech and science sectors, through mobility of labour, publications, awareness and networking (see also coordination/network failures)</td>
<td>Science- versus non-science-based. See Table 2.1 High- versus medium- to low-tech. See Table 2.1</td>
<td>Science-based High-tech</td>
</tr>
<tr>
<td><strong>Project R&amp;D activity</strong></td>
<td>Projects with higher R&amp;D:total project costs are more likely to generate spillovers</td>
<td>R&amp;D:total project costs for project concerned</td>
<td>High</td>
</tr>
<tr>
<td><strong>Project R&amp;D activity (early versus later-stage R&amp;D)</strong></td>
<td>Public returns are higher at the earlier stages of the R&amp;D process (when knowledge is created) than at later stages. This holds for both private and publicly supported R&amp;D. By the same token, spillovers are lower at the later commercialisation stages. (Furthermore, at later stages of the R&amp;D process, financial market failures are reduced; there is more risk of subsidising expenditure that would have occurred anyway; and support for later-stage R&amp;D risks distorting competition.)</td>
<td>Expenditure on each of the following stages:total project costs: fundamental (basic) research; industrial (applied) research; pre-competitive development for project concerned</td>
<td>High early-stage R&amp;D expenditure ratio</td>
</tr>
<tr>
<td><strong>Project degree of innovation</strong></td>
<td>Also (as discussed in section 2.3.2), support for larger firms should only be justified if the innovation is reasonably radical (since the spillover justification will relate to a stand-alone project; is more likely to relate to an existing core competency of the firm; and more radical projects have a higher probability of financing problems)</td>
<td>(For large firms only) Is the project intended to generate a marginal, or significant innovation? Is it new to the firm, EU or world? See Table 2.2</td>
<td>Radical, and new-to-EU/-world</td>
</tr>
<tr>
<td>Criterion</td>
<td>Context</td>
<td>Indicators and questions</td>
<td>Intervention potentially a priori justified when:</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
</tbody>
</table>
| **Project extent of interaction and diffusion envisaged** | Technological spillovers through interactions between firms in an industry are more important than spillovers across the economy. | (For large firms only) Relevant qualitative questions include:  
  – how much interaction will the project entail?  
  – to what extent will there be diffusion across the industry from the innovation envisaged?  
  – what mechanisms exist, as part of the project, to disseminate its results more widely? | High interaction  
High diffusion  
Good mechanisms (eg, larger firm may build a public area) |

Source: Oxera.
2.4.3 Appropriability

Appropriability is closely related to spillovers, although some distinctions can be made. Again, the issue should be approached from the point of view of a private company making a marginal investment decision. Market failure occurs when there is a lack of mechanisms to appropriate private returns on innovative investments. Put another way, the main justification for intellectual property measures (such as patents) to resolve market failures is that, in their absence, firms will be reluctant to invest in innovation if the knowledge spillovers are simply used by direct competitors that copy the product, and which have not had to undertake the investment. As noted by Jaffe et al. (1996), appropriability problems arise through the interaction of knowledge and market spillovers generated through R&D.47 The firm generating the knowledge in the first instance would not be able to amortise its private investment in innovation.48 Such free-riding by others can undermine the incentive to innovate in the first instance. No one firm will be willing to pay towards the costs of the innovation.

The aim of intervention is not, then, as in the spillover case, to provide financial assistance to projects to enable them to go ahead. Rather, the problems stem from imperfections in the intellectual property regime. Here, patents might be the answer. These are traditionally cited as achieving a theoretical trade-off between encouraging innovation at the expense of short-term competition. In respect of innovation, patents also perform a dual role of protecting innovation while diffusing the underlying ideas by revealing the technology in the patent listing. While patenting (or at least requiring royalty payments to be made for the use of the patented ideas) limits the full extent of knowledge spillovers in the short term, it does generate desirable wider spillovers through the diffusion of knowledge via listing, and eventual wider spillovers when the patent expires and all agents may freely use the innovation. Weaknesses in the patent system, or lack of access to it by certain firms, might therefore undermine innovation.

However, recent evidence shows that patents are not always a necessary or sufficient condition for innovation. For example, while patenting serves to embody codifiable knowledge within the firm, in sectors that generate the most knowledge (e.g., science and, more generally, high-tech industries), much knowledge is tacit (non-codifiable) and is not readily patentable. Rather, speeding products to market, secrecy, cost reductions, staff retention and marketing are relied on to protect intellectual property. Companies manage this in their own way. Moreover, the evidence appears consistent with the notion that firms value more the benefits that networking brings, in facilitating innovation, than the potential risks of losing the ability to appropriate the results of their innovation activity.49

Furthermore, there is evidence that larger companies in such sectors may register ‘questionable patents’ (i.e., patents, and patent protection, that are too broad) which can undermine innovation.50 For all these reasons, criteria, questions and indicators based on

---

47 By themselves, market spillovers do not reduce the private return to R&D (customers in the market gain surplus from the knowledge generated), nor do pure knowledge spillovers (for example, firms in other markets benefit from the knowledge generated). However, the private returns to R&D do fall if knowledge is simply used by direct competitors of the knowledge-generating firm, which either copy the product directly, or use the knowledge to develop a closely related product.

48 The problem is not so much that private returns fall below the hurdle rate for the investment, but rather that such returns may not emerge at all.

49 Martin and Scott (1998) note that, even though science and high-tech industries are patent-intensive, high rates of awareness among firms of other firms’ research projects mean that diffusion is high and rapid, and knowledge leaks through publications, personnel shifting between firms and institutions, informal communications networks, input suppliers, and scrutiny of patent applications. Thus, firms in such sectors do not expend much effort on keeping information secret (Mansfield 1995), and patents are in any case a weak guarantee of appropriability (Folster 1995). Granstrand (2005) found that firms in the USA and Sweden view market lead times, superior marketing, and production cost reductions as more important than patents in protecting intellectual property, and that patents are neither a necessary condition for innovation, nor a sufficient condition to appropriate all the benefits. DTI (2003) also discusses the role of patents versus other measures in sciences, given the non-codifiable nature of knowledge.

50 For example, in the USA, the FTC (2003) highlighted that patents with too broad a coverage may lead other firms to forgo R&D in areas that the patent inappropriately covers. In interviews, firms in the US biotech industry reported to the FTC that they
sector alone (eg, biotech, and more generally high-tech), for identifying the existence or otherwise of appropriability market failures, are not developed.

 Nonetheless, patents are particularly important in resolving market failures for start-ups in particular sectors, such as in biotech (and high-tech more generally), in which the patent provides a signal to external financiers of future income prospects and collateral (see also section 2.4.5). These issues were discussed with entrepreneurs (see Box 2.6).

**Box 2.6 When is appropriability a problem?**

According to a spin-out company Oxera spoke to, the licensing of IPR by technology transfer departments within universities can be problematic. Licensing is used to protect the patent in case the firm experiences financial difficulties. However, this also means that capital can only be raised against a licence to use the intellectual property, rather than the intellectual property itself. At the same time, the start-up carries the liability for intellectual property infringement, needs to pay for the patenting costs and royalty fees, and, despite the exclusivity of the arrangement, the licence can be revoked at any point.

Oxera also spoke to a serial entrepreneur in the biotech sector about this issue. In his view (as a serial entrepreneur in the biotech sector), an exclusive licence to use a patent, from an operational viewpoint, was as good as owning the patent. The licensee of a patent may have to pay the licensor, depending on negotiation, a series of success-driven payments, on achieving certain milestones, and royalties on eventual sales. In biotech, his view was that ‘no patents means no value’, because of the uncertainties in the sector. The value of different types of patent in the sector then depends on the stage reached, from academic through to more applied: technology patents cover the underlying technology; target patents concern the human biology aspect; and composition of matter patents (the most valuable patents) relate to how the molecules created interact with biological targets in the human body. In his view, the benefits of forming alliances, and holding intellectual property jointly with another firm, outweigh the risks of intellectual property disputes.

Table 2.4 below provides relevant criteria, indicators and questions that could be asked to gauge whether there are problems for firms in securing appropriability. Project-level indicators are not developed below, since appropriability issues are of most concern to particular types of firm in particular sectors in certain countries. For instance, a country with relatively low levels of patenting might provide an initial indication on the extent to which the IPR regime is not effective in securing appropriability, and hence the degree to which an innovator might face problems in appropriating the benefits of its innovation(s). As discussed in the table, country-level problems are more likely to affect early-stage SMEs in high-tech sectors.

IPR issues relevant to a specific project would need to be examined on a case-by-case basis, as idiosyncratic issues may arise that do not fit easily within a general criterion-based framework.

A cautious approach should be followed since, as discussed above, there is a disjoint between the theoretical role of patents and their actual role. A balanced judgement would sought to avoid infringing what they saw as questionable patents, and therefore refrain from research in areas covered by such patents. Thus such patents may deter entry and follow-on innovation. FTC (2003) reported that use of questionable patents within the computer and hardware sector, when combined with the ‘thicket’ of overlapping patents characterising the sector (firms often require access to many patents to produce only one product), can add to transaction costs.

Problems with the IPR regime at the national level may nonetheless be more important to stand-alone innovators. The degree of collaboration, life-cycle development times, and human capital in a sector might then determine whether patents are essential. Although patent citations might provide an indicator of good quality patents, and the number of patents registered by a firm that are associated with the same underlying product may provide an indicator of questionable patents, these measures may not be useful for ex ante practical policy purposes.
need to be reached in each case. In addition, measures to improve appropriability—for example through enhancing the IPR regime—may be general measures that do not constitute state aid.
### Table 2.4 Assessing appropriability market failures

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Context</th>
<th>Indicators and questions</th>
<th>Intervention potentially a priori justified when:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country and sector patent activity</td>
<td>Indicators of the quality of the IPR regime, by country, may be important. A lack of patent activity in a country might provide an initial view on the extent to which the IPR regime in the country concerned is not effective in securing appropriability. However, a cautious approach should be adopted towards interpreting this initial indicator (for example, due to 'questionable' patents). Patent litigation activity may provide an indication of faith in the patenting system in securing IPR.</td>
<td>Number of patents and trademarks applied for, or registered, by country or sector Patent litigation activity, by country or sector</td>
<td>Low Low</td>
</tr>
</tbody>
</table>
| Country IPR facilitators        | The degree to which small high-tech/biotech firms are competent or capable in using the IPR regime is also determined by the quality and quantity of university technology transfer departments; business angel networks (BANs) and incubation facilities | Questions should be asked about the means through which IPR is facilitated in the country—ie, the number of:  
  - technology transfer departments  
  - patents licensed through technology transfer departments to seed/start-up companies  
  - BANs  
  - incubation facilities | IPR facilitators: Low Low Low Low |
| Firm size (per se) effects      | SMEs do not in general express much interest in applying for IPR for their own innovations, or in obtaining knowledge about existing patents as an information source. Small firms may be less aware of IPR options, and have less resource to work their way through patent thicket issues. These factors suggest a role for governments in encouraging SMEs to be more proactive on IPR, although this is not, in itself, a market failure | SME versus large firm | SME |
| Sector and firm size/ stage effects | For start-ups, patenting is more important as a means of convincing investors in the presence of intangible assets, uncertainty, asymmetric information, and the absence of track record or other collateral. This is particularly relevant to high-tech and biotech firms. Problems with the IPR regime at the national level (see patent activity and IPR facilitators, above) are likely to affect these firms in particular. See also financial market failures | To form a judgement, all the following need to be taken into account together:  
  - firm's size (SME versus large); plus  
  - firm's life cycle (early versus mature stage); plus  
  - sector (high-tech/biotech versus other) | Lack of patent activity and IPR facilitators, plus:  
  - SME; plus  
  - early stage; plus  
  - high-tech/biotech |

Source: Oxera.
Coordination failures

The theory on coordination failures is spread across a diverse body of literature. Market failures can be distinguished between:

- collaborative R&D and standards setting failures (complementary and substitutable R&D);
- network failures (including general networks, clusters and incubators).

The relevance of these might be deemed to vary by ‘innovation mode’, according to Martin and Scott’s (1998) classification (see section 2.3.5). Building on this, factors facilitating collaborative R&D and standards are particularly important to high-tech sectors, while general business-to-business networking is relevant to all innovators. Links with academia are especially important in biotech, and are relevant to other high-tech sectors, as is geographical clustering.

All coordination theories have at their heart an assumption that there are reduced costs or increased value in having a critical mass of relevant participants cooperating or at least interacting. Coordination is, in certain situations, optimal.

More traditional economic theories of coordination failures cite that these generally occur because, even though it is in the common interest of parties to coordinate (the cooperative solution is optimal from a private return perspective), private returns are below the cost of capital if only *some* of the relevant participants cooperate. Networks can therefore lower costs, or raise private returns, in some sense. While new theories of innovation encompass this principle (for example, a lack of links in a network, or a lack of preconditions for clustering, can undermine private returns to individual firms), they also emphasise many additional motivations for coordination failures. However, recent theories, and evidence on these, also enable the identification of situations in which coordination failures are unlikely to occur.

For example, as discussed below, rather than necessarily reducing transaction costs between agents (agglomeration economies), the evidence points towards clusters facilitating tacit knowledge transfer. While critical mass in clusters is an important factor, evolutionary considerations are also important. Thus, while in the case of R&D, there is a clearer role for government support to encourage coordination in certain situations, if is far less clear that clustering is necessarily optimal. These considerations are developed further below.

R&D coordination failures and standards setting

The main criteria, questions and indicators for assessing whether R&D coordination failures and standards setting market failures occur are presented in Table 2.5 below.

A convenient simplification is that firms undertaking R&D face a choice between carrying out the R&D projects by themselves or collaborating, although, in reality, the decision is more complex, and there are many different forms of collaboration, from loose alliances to more formal joint ventures (and the nature of the joint venture can itself vary).

In the case of complementary R&D, in the absence of coordination there may be underinvestment, since positive externalities exist between firms. In the case of substitutable R&D (including standards setting), there may be overinvestment of R&D in the absence of coordination, since negative externalities exist. Sharing of costs, and avoidance of duplication of costs, is particularly important in markets in which the demand for the final

---

52 Following Martin and Scott’s breakdown, depending on the innovation mode, the appropriate solution to a perceived coordination market failure might be to facilitate financial and advice networks, arguably including incubation facilities (innovating input suppliers), low-tech bridging institutions for general business advice and business-to-business networking (innovating input users), assistance for formal R&D collaboration (complex systems innovation), or more specialist bridging institutions linking science and academia to industry, and clustering (high science content). However, the distinctions may not be clear-cut.
product, for example, is characterised by ‘network effects’ (ie, network goods). In such markets, standardisation may be required at an early stage to avoid costly ‘standard races’.

Dependent on its the form and motivations, R&D collaboration can, among other things, reduce costs, facilitate knowledge and risk sharing between firms, increase the quality of output and final diffusion of knowledge, and prevent wasteful duplication of R&D effort. There is, however, some debate as to which motivations dominate in practice. Evidence shows that the sharing of costs and risks is a relatively minor motive, and that collaboration that simply reduces costs may serve to restrict the number of promising technological avenues explored.53

In addition, collaborative R&D generates wider spillovers (see section 2.4.2)—indeed, these would be expected to be higher than for individual firm R&D, since collaborative R&D is more likely to be at the earlier stages of the process. Atkinson (1999) cites that firms may therefore, from a public return perspective, underinvest in collaborative research even more than in individual research.

However, despite the advantages of collaborative R&D, the presence of particular factors may undermine the ability of (or incentives for) firms to collaborate. Such factors include competition rules, intense competition in the ex post product market, high sunk and specific costs, the risk of losing IPR, search costs, transaction costs and asymmetric information (adverse selection in choosing partners and moral hazard in monitoring partner performance), and limited previous interactions.54 The theory is underdeveloped, however, and the evidence is patchy on which effects dominate. Factors that would appear to mitigate a number of these problems would seem to include measures that facilitate trust, monitoring and inter-firm knowledge sharing.55

Oxera discussed issues regarding collaboration with a company involved in R&D projects (see Box 2.7).

53 Hagedoorn and Schapkemraad (1991) observed that achieving complementarity is a major motive, while the sharing of costs and risks is a minor motive, and sharing of technological know-how is of average importance. Reduced duplication of substitutable R&D is controversial. For example, Mowery (1998) cites that the benefits may be overstated, since some duplication occurs even when firms partner up; furthermore, the reduced diversity at an early stage in the R&D process may mean that certain promising technological avenues are not explored. Powell and Brantly (1992) highlighted that, in the biotech sector, a single firm rarely has all the necessary skills and capabilities to succeed, and Powell et al (1996) noted that, since technology in the sector changes rapidly, and knowledge sources are dispersed, there is an incentive for firms to form alliances. This arguably points to the importance of complementary R&D in the sector.

54 For example, Martin and Scott (1998) note that, in standards setting, greater ex post rivalry can undermine ex ante coordination. Abramovsky et al (2004) discussed how parties might find it difficult to commit to collaboration projects involving large fixed and sunk/specific costs, even when all parties expect the project to be profitable. Shapiro and Willig (1990) and Pisano (1997) highlight that, given information asymmetry, a partner might contribute less than otherwise to a collaborative project. Veugelers (1998) notes how repeated interactions between firms in alliances are important to prevent cheating (concealing their own technological expertise from the venture).

55 For example, establishing a cluster of knowledge-exchange activity in a common laboratory may overcome these issues. (This is identified by Martin and Scott (1998) as being critical in certain situations.) Trust might also be secured through having had previous collaborations and partnering with the other parties involved in the project, and reputation can also help in a repeated setting.
Box 2.7 Risks of coordination in R&D projects

A representative from a large electronics company thought that, in general, it was difficult to assess robustly ex ante the additionality of specific R&D projects. However, a good ex ante indicator of additionality would be whether the R&D project required collaboration among many partners and reliance on others. This was because collaborative R&D introduced further risks, such as the potential to lose knowledge and intellectual property to others (as well as to gain it); transaction costs in managing the project; exposure to technical and commercial risks from choosing the wrong partners; and potential uncontrollability issues such as delays stemming from partners, or partners experiencing financial difficulties. In short, the view expressed was that collaborative R&D has positive externalities between parties and risks associated with it, thereby potentially justifying state support.

In Table 2.5, the effects of firm size are not presented because the evidence on whether collaborative R&D failures are higher for smaller firms than larger firms is unclear. The evidence suggests that firm size does not affect the probability of forming a joint venture, and firms prefer to team up with other firms of a similar size.

Nonetheless, arguably, formal R&D coordination failures may be acute for particularly large-scale innovative projects, due to the scale of the projects, reliance on others, and the risks involved. In such projects, because of the complexities and informational problems, adverse selection and moral hazard problems may be particularly acute (choosing the correct partners upfront may be difficult, in particular when the partners have not collaborated before, and monitoring partner behaviour once the project is under way may be difficult). Such projects can involve strong network effects, in which there is particular sensitivity of firms’ profits to the actions of other collaborators. Even though all parties are better off from collaborating due to the aforementioned benefits, and collaborative R&D itself generates wider spillovers, collaboration may fail to materialise. Large-scale projects are discussed further in section 2.4.6 below.

Business-to-business networking may be more important for SMEs in general than formal R&D networking (see below).
Table 2.5  Assessing coordination market failures in R&D and standards setting

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Context</th>
<th>Indicators and questions</th>
<th>Intervention potentially a priori justified when:</th>
</tr>
</thead>
</table>
| **Country competition provisions** | Too stringent restrictions on the formation of joint ventures may undermine R&D collaboration. However, in this regard, the competition rules are common at the EU level (eg, R&D Block Exemption for Joint Ventures, individual exemptions). Furthermore, any intervention at this level is unlikely to be classed as state aid since it will be in the form of regulations that are fairly general or which do not involve a transfer of government resources. As is the case for R&D in general, spillovers are likely to be highest in the early stages. The potential for competition concerns (here, in terms of coordination facilitating collusive behaviour) arises at later (closer-to-market) stages. | Relevant questions include:  
- are there EU or country-level regulatory restrictions that inhibit R&D joint ventures?  
- do these inhibit the early stages of projects? | Strict competition provisions  
Strict competition provisions which undermine early-stage R&D joint ventures |
| **Innovation mode and sector**     | R&D coordination failures are particularly relevant to sectors in which complex systems innovation occurs (eg, aerospace, telecoms, semiconductors), but may also occur in other high-tech sectors, and in engineering sectors in which large innovative projects are being undertaken. | Determine innovation mode (section 2.3.5):  
- innovating input suppliers (eg, software, instruments, equipment);  
- innovating input users (eg, agriculture, light industry);  
- complex systems innovation (eg, aerospace, telecoms, semiconductors); or  
- high-science-content technology industries (eg, biotechnology). | Most relevant to: complex systems, high-tech, high-science content (plus, potentially, large-scale engineering) |
<table>
<thead>
<tr>
<th>Criterion</th>
<th>Context</th>
<th>Indicators and questions</th>
<th>Intervention potentially a priori justified when:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project nature of activity</td>
<td>R&amp;D coordination failures arise where companies need to work jointly on an R&amp;D project to realise innovation, but fail to do so. This may occur even when, collectively, all the firms are better off from coordinating Coordination failures are more likely when R&amp;D is complementary across firms (positive congestion effects) and when a project: - involves large-scale fixed investment costs (which are sunk and specific to the project concerned, meaning that the project has little resale value in the event of failure); - requires a wide variety of firms and competencies; - progresses in stages. Such projects may be too large, or require too diverse a range of skills, for any one firm to take on alone. Network effects, adverse selection and moral hazard may be acute. Firms may not trust others to deliver on their part of the contract, and the collaborative project may not go ahead in the first instance. Such risks are higher where the project is particularly large, particularly innovative, and the results uncertain. Uncertainty is highest at the earliest stages of the project</td>
<td>Number of firms required to undertake project Number of competencies required CAPEX of overall project CAPEX of each firm's contribution to project: current CAPEX of firm Specificity (sunk costs, lack of recoverable value) Number of project stages Historical collaborations between partners (trust) Risk of project failure Coordination for early- versus later-stage R&amp;D projects</td>
<td>High High High High Low recoverable value High number of stages No historical collaborations High risk of failure Early stage R&amp;D</td>
</tr>
<tr>
<td>Project complementary versus substitutable R&amp;D</td>
<td>It is necessary to identify whether the objective of the project is tackle a substitutable or a complementary R&amp;D market failure. Complementary R&amp;D appears to have higher risks, in which the formation of relationships appears to be more difficult The case for state support for substitutable R&amp;D is somewhat less because firms should, in theory, be able to join forces to avoid undertaking wasteful R&amp;D, or to reach common standards (although regulators might set initial higher-level standards). However, firms may not cooperate on substitutable R&amp;D if, in improving access to all collaborating firms to the underlying technology, this increases competition between firms in the market ex post</td>
<td>What is the objective of the project: - to undertake complementary R&amp;D? - to eliminate substitutable R&amp;D? - or to set common standards?</td>
<td>Complementary R&amp;D</td>
</tr>
<tr>
<td>Project nature of spillovers</td>
<td>Questions should be asked about the extent to which, at the early stages of a project, sharing of knowledge and the establishment of common laboratories, for example, is envisaged, since this reveals the spillover benefits from coordination, which would otherwise not occur</td>
<td>Is the purpose of project to bring together existing knowledge or to create new knowledge through the collaboration? To what extent are common laboratories envisaged?</td>
<td>Create new knowledge Share common laboratories</td>
</tr>
</tbody>
</table>
Network failures
Beyond the above traditional notions of coordination failures, new theories of innovation (systems, network and evolutionary approaches) emphasise the roles of cooperation, tacit knowledge sharing, feedback, changing networks over time; that many interdependent factors are required to facilitate innovation; and that firms rarely innovate alone. At the same time, almost anything can be a systems failure. Thus, if policy prescription is to work, evidence is required on the degree to which market failures occur, and the degree to which certain types of network might resolve market failures.

The issues are more idiosyncratic than those described thus far. It is perhaps not surprising, therefore, that more qualitative criteria and questions are required. It is helpful first to obtain a higher-level overview of what the benefits are of general networks versus more specific networks, such as clusters and incubators, in facilitating innovation that would otherwise not take place.

SMEs, in general, may simply lack access to business advice and relationships with a reasonably diverse range of contacts. Innovative SMEs also often do not have such relationships. However, several types of network market failure might occur in science-based sectors. Some initial considerations for assessing whether network market failures occur are presented in Table 2.6.

<table>
<thead>
<tr>
<th>General networks</th>
<th>Specific networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business-to-business networking would appear important in all sectors. Firms that do not cooperate, or do not formally or informally exchange knowledge, limit their knowledge base and reduce their ability to exchange knowledge (and thus innovate). However, it is SMEs, rather than larger firms, that tend to lack access to such networks. (Larger firms tend to have existing relationships in the innovation system, or more resources to form new relationships)</td>
<td></td>
</tr>
<tr>
<td>Here, sector and innovation mode are important (see section 2.3.6)</td>
<td></td>
</tr>
<tr>
<td>In terms of aspects of the relationships that may be missing in firms' networking that are important to innovation, firms may lack diversity in their business relationships and partners, vertical networking with suppliers, access to professional and trade associations, links with science partners and venture capital firms (although the importance of these varies by sector), and firms may rely excessively on relationships with their customers</td>
<td></td>
</tr>
<tr>
<td>In the biotech sector and, perhaps to a lesser extent, the high-tech sector, important network-related factors required to facilitate innovation include the academic base, technology transfer departments within universities, attracting diverse academic and management skills, the availability of business advice and financing networks to start-ups, collaborations with other firms, incubation, and clustering of start-ups and finance networks around universities</td>
<td></td>
</tr>
<tr>
<td>The absence of any one of these factors these may give rise to innovation market failures</td>
<td></td>
</tr>
</tbody>
</table>

Source: Oxera.

There is also less emphasis on R&D in these approaches. There is a need to get right both the components of the system (eg, the science base, capital markets, IPR) and the links between them (eg, BANs, business-to-business contacts, technology transfer between academia and business). Lundvall (1992) proposed that firms should be regarded as operating within a National Innovation System (NIS), in which institutional, regulatory, organisational, social and cultural factors are all important in delivering innovation. Building on this work, Metcalfe (1995) further emphasised the role of knowledge transfer in the innovation process, and downplaying the role of R&D as necessarily leading to innovation.

For example, the Innobarometer 2004 (European Commission 2004i) found that only 13% of EU firms participate in an innovation network of some form, with a bias towards larger firms. Pittaway et al (2004) noted that networking is a prerequisite for innovation across the vast majority of sectors, including services (eg, financial), primary (eg, agriculture), manufacturing (eg, car parts), and high-tech (eg, aerospace, semiconductors).

These considerations have, in particular, been influenced by the systematic review of networking relationships important in spurring innovation, undertaken by Pittaway et al (2004), and by Martin and Scott's (1998) breakdown of important networking relationships by innovation mode.
Where links are missing in networks, innovation may be hindered. However, this does not necessarily justify direct government intervention in the form of state aid. Solutions to encourage business-to-business networking for SMEs (including business advice) are likely to be less interventionist, and may not be classed as state aid. The crucial role of networking in the biotech sector emerged from discussions with an entrepreneur in the sector (see Box 2.8).

Box 2.8 Networking in biotech

Discussions with a biotech entrepreneur revealed the particular importance of networking and forming alliances in the sector. Having diversity at the management level within the company (with both science and business-minded managers), and forming formal alliances with the right people, were viewed as especially important. In respect of more general networking activities, this was not viewed as being too problematic in the sector, as academics tend to share knowledge, and attend conferences. Furthermore, it was identified that venture capital firms are always looking for opportunities.

Clusters and incubators
With regard to more specific networks, both clusters and incubators can play an important role in resolving network failures. However, there is mixed empirical evidence on the benefits of the former, and virtually no empirical evidence on the economic impact of the latter. In the context of state aid, the Commission has been asked in the past to approve support for these types of initiative. Therefore, in context, should a specific scheme be put forward, it is important to ask in what circumstances the lack of clustering or incubators might constitute market failures. The policy instruments that could be used to support clusters or incubators are not discussed here; rather, clustering and incubation, analogous to R&D or venture capital, should be seen as facilitators of innovation, in which market failures can arise.

Oxera has discussed clustering with a number of interested parties (see Box 2.9).

Box 2.9 The role of clusters

In discussions with a venture capitalist, it was highlighted that venture capital tends to gather around existing universities with technology transfer departments. Also, in a conversation with an expert on state aid who had previously worked within an enterprise body in London, it was highlighted that, in the USA, innovative SME growth and venture capital activity have been focused in concentrated geographical pockets (e.g., California and Boston). The same can be said of the UK, where most seed venture capital is focused on SMEs in the south-east of England. This picture also emerges across the EU.

Clustering is predominantly relevant to resolving market failures if knowledge spillovers are geographically bounded. Clusters may not emerge if the agents face difficulties in

59 It is of note that the evidence base reviewed by Pittaway et al (2004) highlights that building networks from scratch is inherently difficult, and governments may not be in the best position to decide which specific networks are the most appropriate.
61 For example, European Commission (2004d) illustrates how support has been sought in relation to science parks and incubators. Oxera’s discussions with interested parties have revealed many issues regarding incubators specifically.
62 Marshall (1920) first emphasised (in a traditional context) that firms cluster to access a pooled skills market, an intermediate goods industry and complementary technologies. These are traditional, and more physical, explanations for clustering. Feldman (1999) divides the newer theories of agglomeration into geography mediated spillovers, and location as an intermediate factor for facilitating growth. Geographic clusters in newer industries may help by facilitating tacit knowledge spillovers through face-to-face contact, reducing inter-firm transaction costs, generating stocks of specialised managers and other human resources, and making business opportunities easier to identify (DTI 2003). Audretsch (2003) notes that the European tradition has focused on
coordinating locally, to facilitate this knowledge transfer. As the private returns received by one firm in the cluster depend on the presence of others in the cluster, establishing the cluster in the first place might be difficult. The establishment of critical mass in a locality, to facilitate tacit knowledge transfer and other links, with the right institutions (including star academics), the right firms, and the right venture capitalists, is key.

Critical mass is, however, a state at a given point in time. In this regard, the evolution of clusters has been overlooked in the literature, in terms of both their formation and their role over time. There are many theories of how and why clusters emerge, and the area is still not well understood. The key message from the available evidence is that the coordinated solution, as envisaged by clustering, is not necessarily optimal (or, put another way, that lack of clustering constitutes a market failure).

The available evidence shows, in particular, that the extent to which clusters assist innovation depends on the sector, firm size, and stage of evolution of the firm or cluster. Even in science-based sectors, clustering alone is insufficient to resolve network market failures (see below). Clusters can also lead to lock-in over time (ie, while they resolve market failures to begin with, their justification disappears over time). Evidence from Canada shows that clustering is more important for smaller firms at an earlier stage in their life cycle, and that firms expand their geographical reach and contacts as they mature. Table 2.7 summarises the important questions, based on the available evidence, for assessing whether clusters resolve market failures (or whether lack of clustering constitutes a market failure). These should be used if a proposal involves support for the establishment of a cluster to establish a critical mass of agents, or support for an existing cluster, in a particular area.

The evidence indicates that clusters fail when they are artificially established without taking into account the types of factor in Table 2.7. In addition, clusters may fail when the underlying system is inadequate (for example, if the science base is inadequate), or when they do not build on existing relationships between agents. Textiles clusters in Italy may now be suffering from lock-in, and there are many examples of failed biotech clusters (eg, Lombardy, Italy) and high-tech clusters (eg, Marseilles, France). Although clusters emerged in the USA accompanied by support to small firms within them (eg, Silicon Valley),

the role of clusters in fostering traditional industries, such as the north Italian textiles industry, whereas the North American context has been the role of high-tech clusters in facilitating knowledge spillovers.

In particular, a review by Feldman (1999) of the empirical evidence on clusters shows that innovative activities cluster where knowledge creation is greatest (eg, existing R&D institutions, universities), and thus, where spillovers are largest; knowledge spillovers (as evidenced from patent citations) are often geographically bounded; the presence of star academics in a location is important in sciences, but mainly for start-ups; localisation economies may be limited to university and science-based clusters; there is mixed evidence on whether urbanisation economies (population or city size scale effects) occur; and clustering is more relevant to start-ups and where knowledge is tacit (and thus, appropriating knowledge is difficult). Evidence from Sweden also indicates that geographic clusters generate more than their proportional share of high-tech start-ups (Braunerhjelm and Carlsson 1999).

See, for example, Niosi and Banik (2005), who argued that conventional theoretical explanations for clusters do not adequately account for change.

In particular, a review by Feldman (1999) of the empirical evidence on clusters shows that innovative activities cluster where knowledge creation is greatest (eg, existing R&D institutions, universities), and thus, where spillovers are largest; knowledge spillovers (as evidenced from patent citations) are often geographically bounded; the presence of star academics in a location is important in sciences, but mainly for start-ups; localisation economies may be limited to university and science-based clusters; there is mixed evidence on whether urbanisation economies (population or city size scale effects) occur; and clustering is more relevant to start-ups and where knowledge is tacit (and thus, appropriating knowledge is difficult). Evidence from Sweden also indicates that geographic clusters generate more than their proportional share of high-tech start-ups (Braunerhjelm and Carlsson 1999).

See, for example, Niosi and Banik (2005), who argued that conventional theoretical explanations for clusters do not adequately account for change.

In particular, a review by Feldman (1999) of the empirical evidence on clusters shows that innovative activities cluster where knowledge creation is greatest (eg, existing R&D institutions, universities), and thus, where spillovers are largest; knowledge spillovers (as evidenced from patent citations) are often geographically bounded; the presence of star academics in a location is important in sciences, but mainly for start-ups; localisation economies may be limited to university and science-based clusters; there is mixed evidence on whether urbanisation economies (population or city size scale effects) occur; and clustering is more relevant to start-ups and where knowledge is tacit (and thus, appropriating knowledge is difficult). Evidence from Sweden also indicates that geographic clusters generate more than their proportional share of high-tech start-ups (Braunerhjelm and Carlsson 1999).

In particular, a review by Feldman (1999) of the empirical evidence on clusters shows that innovative activities cluster where knowledge creation is greatest (eg, existing R&D institutions, universities), and thus, where spillovers are largest; knowledge spillovers (as evidenced from patent citations) are often geographically bounded; the presence of star academics in a location is important in sciences, but mainly for start-ups; localisation economies may be limited to university and science-based clusters; there is mixed evidence on whether urbanisation economies (population or city size scale effects) occur; and clustering is more relevant to start-ups and where knowledge is tacit (and thus, appropriating knowledge is difficult). Evidence from Sweden also indicates that geographic clusters generate more than their proportional share of high-tech start-ups (Braunerhjelm and Carlsson 1999).

In particular, a review by Feldman (1999) of the empirical evidence on clusters shows that innovative activities cluster where knowledge creation is greatest (eg, existing R&D institutions, universities), and thus, where spillovers are largest; knowledge spillovers (as evidenced from patent citations) are often geographically bounded; the presence of star academics in a location is important in sciences, but mainly for start-ups; localisation economies may be limited to university and science-based clusters; there is mixed evidence on whether urbanisation economies (population or city size scale effects) occur; and clustering is more relevant to start-ups and where knowledge is tacit (and thus, appropriating knowledge is difficult). Evidence from Sweden also indicates that geographic clusters generate more than their proportional share of high-tech start-ups (Braunerhjelm and Carlsson 1999).

See, for example, Financial Times (2005), which argues that small companies in Italian textile clusters, which previously competed successfully with large-scale producers by producing differentiated high-quality garments, have become more inward-looking as they have matured; lack the expertise to manage a global supply network; and are rooted in craft industries rather than in value-added services.

In Lombardy, Italy, Orsenigo (2001) examined a failed biotech cluster, and showed that clustering alone is not a sufficient condition for innovation. A sound science base, industry–university relations, access to capital, and IPR were identified as more important. The author found that clusters emerged in Lombardy but did not take off, and that, in Italy more generally, the fundamental reason for slow progress in the take-off of high-tech start-ups was an inadequate science base and inadequate links with this. In Marseilles, France, Rychen and Zimmerman (2002) observed that, if national policy seeks to establish clusters or networks in areas without taking sufficient account of local conditions, these will fail. The authors cite the example of the (in their view) unsuccessful development of a microelectronics cluster in Marseilles.
clusters might also emerge in the absence of state aid—the establishment of good universities and a core science base is often more important.

**Table 2.7 When do clusters resolve market failures?**

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Context</th>
<th>Indicators and questions</th>
<th>Intervention potentially a priori justified when:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activities and knowledge creation</strong></td>
<td>Clustering is of most relevance where, at the core, there are already institutions creating new (eg, basic) knowledge, such as universities, or companies already undertaking high levels of R&amp;D. (Clustering is thus more relevant to sectors with a high science content and high-tech sectors than more traditional industries.</td>
<td>Are there existing knowledge-creating institutions in the locality (eg, universities)?</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Sectors and tacit knowledge</strong></td>
<td>The more tacit (uncodifiable) the knowledge generated, the greater the need for geographical proximity to enable face-to-face interaction, reduce search costs and engender trust. Again, these issues are particularly important in high-tech and high-science-content industries</td>
<td>Is the sector high-tech (including biotech) or another sector?</td>
<td>High-tech (including biotech)</td>
</tr>
<tr>
<td><strong>Firm size and evolution effects</strong></td>
<td>Beyond internalising tacit knowledge spillovers, there is mixed evidence on whether clustering for other reasons necessarily assists innovation, and clustering appears less relevant for traditional industries, more mature industries, or larger firms, in resolving market failures</td>
<td>Is the sector in a traditional industry?</td>
<td>No</td>
</tr>
<tr>
<td><strong>Start-ups (especially those in sciences) benefit from clustering around individuals with key skills (such as 'star players' within universities). However, location is less important for larger, more established firms, and the rationale for clustering during the early stages of a firm's life cycle may disappear over time. Clustering is also of more benefit to smaller firms (eg, start-ups) because they are more receptive than large firms in pursuing radical innovation.</strong></td>
<td>Are the firms targeted by the scheme small and start-up?</td>
<td>SME Start-up</td>
<td></td>
</tr>
</tbody>
</table>

Source: Oxera.

Incubators (or enterprise or technology centres) are intermediaries that rent out space and provide services to start-ups. These are applicable in a wider variety of situations than clusters, but should be focused on innovative start-up SMEs. The available literature indicates that the private sector may underprovide incubators principally due to property market failures and network failures. In respect of the latter, sharing common facilities provides the opportunity to lower the private costs of SMEs—indeed, the evidence suggests that there are economies of scale in incubators. Moreover, incubators assist in facilitating information exchange (both between a critical mass of incubated SMEs, and in terms of providing a single conduit for more formal networking). However, the evidence on their economic impact is sparse (see above). This is a problem since, as argued by Nolan (2003), the visibility of incubator schemes may provide governments with a tendency to oversupply them.

As part of its research, Oxera spoke to a number of contacts about the role of incubators in resolving these perceived market failures. The main implication of these discussions is that

---

69 Nolan (2003) discussed market failures in the provision of technical assistance and real estate.
70 Nolan (2003) noted that, while there is extensive operational literature on how to run an incubator, there is a marked scarcity of methodological studies on the impact of business incubators, although the available material does indicate that incubators have a positive effect on new SME development, leading to improvements in enterprise survival.
incubators can play a key role in assisting innovative SMEs, but that support for incubators should be carefully targeted. These discussions are outlined in Box 2.10 below.

**Box 2.10  The role of incubators**

Oxera spoke to a not-for-profit incubator in the north-east of England, which seeks to create new businesses, higher-quality employment and increased diversity in the local economy. Although many of the companies in the incubator are high-tech, its focus is not solely on high-tech companies: given the historical shortage of entrepreneurial activity in the area, there is a possibility that small businesses that generate innovation more generally will move into the area. All firms within the incubator had grown on site, and 15% of those on site were identified as being at the seed or start-up stage. Although there is no strict exit policy, once firms reach a certain size, they are encouraged to move on, and 'ramped rents' (rents that increase over time) may be used in the future to facilitate this.

Firms choose to move into the incubator in order to gain access to quality workspace on ‘easy-in/-out terms’, given the shortage of space on such terms in the area, and that the incubator would not make the company leave if it got into rent arrears. In its view, the private sector does not tend to provide incubators, since start-ups/innovative SMEs do not have the turnover, or stability of turnover, during the early stages. Firms also:

- benefit from flexibility in increasing or decreasing their size of operation;
- gain access to external finance, IPR, IT and human resources networks;
- have a diverse peer group to talk to on site;
- have access to in-house advice on business planning and mentoring;
- benefit from the fact that the incubator has links with a number of universities.

In addition, Oxera spoke to a start-up firm within a privately run incubator in south-east England, involved in IT. Its view was that it benefited from the publicity offered by the incubator, access to BANs, sharing of experiences with others in the incubator, and (although the rent was not low compared with other commercial premises), the easy-in and easy-out terms.

Oxera also discussed the role of incubators with European Commission officials who examined a national German incubator scheme (European Commission 2004b and 2005b). The German government justified the scheme on the grounds of property market, capital market and network failures (eg, use of common facilities). The final scheme was eventually approved. However, it was initially thought that the scheme lacked transparency since it was not clear where the incubators would be established, what the entry criteria were for firms to qualify for incubation (this appeared to exclude only ‘large firms’), and whether the aid would filter down from the incubators to the SMEs. Moreover, the evidence on property market failures in the different German provinces (Länder) was inconclusive because of the many different enterprises catered for in existing ‘incubators’. Further information was sought on these issues and it is not clear whether they were all resolved prior to approval (see Appendix 1).

As intermediaries, incubators perform functions that can directly assist SMEs (the innovators) in the innovation process. In the context of an incubator scheme being put forward by a Member State to the Commission, it is necessary to consider whether the incubator is aimed at resolving innovation market failures. To do this, specific dimensions of the scheme could be considered, as outlined in Table 2.8.
It is particularly important that the incubator is *genuine*, rather than a more general property developer. Indeed, one reason for the lack of evidence in the literature on the economic impact of incubators is that not all incubators in the EU fulfil the criteria set out in the table.\(^{71}\)

What is also of note is that there appear to be cases of privately run incubators, although these may have been established in the first instance using public support.

Furthermore, there is little debate in the literature on whether property markets really do ‘fail’ in a strict sense. For example, if SMEs represent a risky proposition, the rents charged (or terms offered) by commercial property agents will simply reflect this. It might nonetheless be the case that commercial property agents are particularly risk-averse, preferring *only* stable income streams, and also face information problems in assessing innovative SMEs. These may give rise to property market failures in a stricter sense, akin to a financial market failure. That commercial property agents do not take into account the wider potential spillover benefits of innovating SMEs is not peculiar to property, and is simply akin to the spillover argument discussed in section 2.4.2.

The north-east England incubator interviews, the European Commission officials, and the UK government department all highlighted that gaps exist in the current state aid frameworks regarding the treatment of intermediaries such as incubators (see section 3).

---

\(^{71}\) Indeed, European Commission/Centre for Strategy and Evaluation Studies (2002) notes that greater differentiation is required between technology or knowledge incubators and ‘other’ incubators, rather than drawing the line between public versus private incubators, as is currently often the case.
### Table 2.8 When do incubators resolve market failures?

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Context</th>
<th>Indicators and questions</th>
<th>Intervention potentially a priori justified when:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objectives of the incubator</strong></td>
<td>The main focus should be on tackling innovation market failures. Thus, the objective of an incubator should be to foster long-term entrepreneurship, by addressing factors that prevent innovative SMEs from succeeding, not employment growth</td>
<td>What are the objectives of the incubator?</td>
<td>Foster long-term entrepreneurship</td>
</tr>
<tr>
<td><strong>National versus regional</strong></td>
<td>The degree to which the scheme operates at the national versus regional level should be examined. This will affect the targeting of the scheme, and its transparency, in addressing real market failures</td>
<td>Is the scheme to be operated at the regional level?</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Entry and exit criteria</strong></td>
<td>These should be clear. Incubators should have a policy on what types of firm should be allowed into the facility, and for how long they can stay. Incubators should focus on innovative start-ups, including (but not limited to) high-tech start-ups. As the company grows and begins to earn revenues, the market failure justification for its incubation should weaken</td>
<td>Are the entrance criteria targeted at start-up innovative firms? Are the exit criteria?</td>
<td>Seed/start-up firms, in particular in high-tech, and university spin-outs Exit criteria exist based on firm size (occupation of incubator), tenancy period, ramped rents after a period</td>
</tr>
<tr>
<td><strong>Networking market failure</strong></td>
<td>Genuine incubators might be justified on the grounds of providing low-cost advisory services and access to finance and business networks to start-ups (more formal networking); sharing of common facilities (economies of scope and scale); and facilitating sharing of experiences with similar firms (informal networking) The extent of networking opportunities provided by the incubator should therefore be examined</td>
<td>To what extent are the following provided: finance network access? client network access? mentoring and business planning? use of common facilities? significant number of other firms onsite?</td>
<td>Yes Yes Yes Yes Yes</td>
</tr>
<tr>
<td><strong>Property market failure</strong></td>
<td>Innovative seed or start-up SMEs are more likely to suffer from property market failures than other firms. Commercial property agents (which may be risk-averse) may perceive young innovative start-ups as high-risk tenants from a financial perspective (potentially akin to a financial market failure). Innovative SMEs lack collateral, turnover, and stability of income, and are a more uncertain proposition for commercial property developers Commercial property agents may, in their decision of what to build and who to rent to, not take account of the wider benefits of innovation (but see spillovers) Genuine incubators may resolve property market failures by supplying good quality commercial accommodation to innovative SMEs on favourable terms.</td>
<td>To what extent do commercial incubators or science parks in the locality provide good quality accommodation to seed or start-up SMEs (in particular, in high-tech, including biotech, or university spin-outs)?</td>
<td>Low number of observed commercial incubators fostering high-tech (including biotech) and/or university spin-outs, and seed/start-up companies Quality of accommodation may be inferred from numbers of client meeting rooms, access to computer and other equipment, etc</td>
</tr>
</tbody>
</table>

Source: Oxera.
2.4.5 Financial market failures

The literature on financial market failures in innovation arguably has less to do with the innovation literature and more to do with the financing literature. As discussed by O’Sullivan, however, there is a disjoint between the financing literature and the innovation literature, with the evidence generally lagged behind the somewhat incomplete theories that have been developed.\(^72\) Much of the recent literature on the market failures that affect innovation has focused on the problems that innovative start-ups and high-growth SMEs may face in attracting external finance. These problems can arise owing to many factors—in the very strict sense, a financial market failure (or ‘financing gap’) occurs when projects that have merit do not obtain the desired financing due to market imperfections.\(^73\) Such ‘good’ projects will have a positive net present value, and yet do not attract the necessary funding.

In general terms, financial market failures are widely cited as having an effect on innovative and high-growth SMEs, particularly in the biotech (and, more generally, high-tech) sectors, but also in other sectors. Equity finance is better suited to risky investments than debt.\(^74\) A commonly cited financing gap exists between the lower levels of (informal) equity financing provided at the early seed and start-up stages by business angels (BAs), and at the growth stage, at which point venture capital (formal) financiers become interested.\(^75\) However, other financing gaps can arise, and this should be seen in the context of the financing life cycle of an innovative seed or start-up firm, as illustrated in Figure 2.5 below.

---

\(^72\) O’Sullivan (2005) highlighted that there are ‘serious limits’ to the dominant conceptual approaches that have emerged, and that the evidence is often ambiguous even on some of the basic theoretical propositions. Her review revealed that the evidence is incomplete on the reliance by different types of firm (eg, large versus small, R&D-intensive versus not R&D-intensive, high-tech versus other) on insider versus outsider financing; the existence or otherwise of a pecking order for larger R&D-intensive firms; how innovative firms seek to use different forms of financing over the life cycle; and the exact role of venture capital in resolving information asymmetries.

\(^73\) See OECD/Oxera (2004) and Industry Canada (2001). HMT (2003) defined the problem of identifying the financing gap as assessing ‘which businesses would have attracted investment if there had been no equity gap’. However, because it is difficult to determine the counterfactual, it is difficult to ascertain the size of the gap.

\(^74\) The key distinction between debt and equity is that debt represents a cost to the business, whereas equity is repaid from (eventual) profits. Banks or other debt providers are interested in the steady repayment of interest and principal, rather than whether a business necessarily outperforms against profit expectations. In the event of financial distress, debt will also be repaid before equity, and debt providers want to see collateral or some other form of buffer in case of such distress. By contrast, shareholders providing equity are interested in profit and outperformance. In the event of financial distress, equity may not be repaid. Equity provides proactive incentives for management to perform, and acts as a buffer to the firm in the event of distress. Equity is therefore more risk-taking in nature. HM Treasury (2003) highlighted that bank debt is most suitable when businesses have started to generate sufficient cash flow to service their interest payments. This creates particular problems for innovative start-ups, since they may not have either tangible collateral or a track record. OECD/Oxera (2004) noted that the direct provision of loans by government, in lieu of a perceived financing gap, is not suitable for financing innovative SMEs. The European Commission Risk Capital Action Plan and the 2001 Risk Capital Communication (European Commission 2001c) both emphasise the role of equity (as opposed to debt financing) in facilitating the growth of start-up and early-stage SMEs.

\(^75\) HM Treasury (2003) cited that the equity gap ‘affects businesses seeking a sum beyond the means of most informal investors, but below a level viable for venture capitalists to invest’, and that the evidence for the UK is that an equity gap exists for the £250,000 to £2m band of finance, and is most severe for investments below £1m and for innovative businesses at an early stage in their development.
The use of informal financing (own funds, those of friends and family, and BA finance injections) is important at the very early stages of the financing life cycle. During the start-up to growth stages, however, formal external equity financing is important.

The most stringent definition of financial market failure then relates to a number of specific factors. Conventional wisdom states that high uncertainty, information asymmetry, intangible assets, complexity of the life cycle, transaction costs (due-diligence and monitoring costs) and investor risk aversion often give rise to this perceived equity or financing gap. In light of the factors affecting innovative SMEs, traditional equity will not generally be forthcoming, but even venture capitalists may provide sub-optimal funding at the seed or start-up stages. The above factors are arguably relevant to more radical innovation activity, as there is a close correspondence between what might be radical innovation and uncertainty. In later stages of their life, innovative firms should encounter fewer difficulties in attracting finance, including equity and some form of debt financing. Thus, market failures would be expected to occur less frequently at these later stages. There is thus an analogy between the various stages of an R&D process and the stages of a firm’s life cycle.

76 BAs are, however, a crucial form of informal financing. These are particularly common in the USA and the UK. HM Treasury (2003) highlighted that informal investors (including friends and family, and BAs) have invested substantial amounts of capital in innovative SMEs. OECD/Oxera (2004) noted that BANs in the USA invest ten times more than formal venture capital funds and that, while in the USA, BANs developed spontaneously, and with little government support, in other countries either government or corporate support has generally been required.

77 OECD/Oxera (2004) further highlighted that the uncertainties and informational asymmetries that characterise SMEs are amplified for innovative SMEs, making financing even more difficult for this subset of firms. In theory, venture capitalists resolve such information problems faced by innovative SMEs, by evaluating proposals ex ante and becoming proactively involved in the management of the company (and monitoring performance) ex post. This literature was pioneered by Sahlman (1990), and Gompers and Lerner (1999 and 2001) built on the work. OECD/Oxera (2004) highlighted that venture capitalists minimise informational gaps by evaluating business plans, the technology, management and market size, and become proactively involved in running the firm, using their specialist skills. However, the factors listed may still lead to a shortage of venture capital. In particular, Christofidis and Debande (2001), OECD/Oxera (2004) and others note that, despite the theoretical role of venture capital, the level of early-stage venture capital financing in the EU is much lower than in the USA. HM Treasury (2003) also commented that most venture capital funds in the UK are targeted towards later-stage businesses. The EVCA (2005) report for 2004 shows that, of the €36.9 billion of funds invested by its members across the EU, seed investments accounted for 0.4%, start-up investments 6%, expansion 21%, and buyouts 70% of the total amounts invested. The key controversy is whether this is due to informational/transaction costs problems, risk aversion of venture capital firms (see, for example, HM Treasury 2003), or other factors.

78 Indeed, government support for later-stage financing might simply crowd out finance from the private sector, and distort competition between existing funds.
However, the lack of provision of early-stage finance may not always be due to the above reasons. Demand-side factors relating to entrepreneurs may give rise to a shortage of good projects, and investors may rationally be reluctant to invest in hi-tech sectors that have exhibited high risks but low returns in the past. Lack of financing may not be caused by information problems alone—the evidence shows that financing problems can occur due to institutional factors, such as a lack of exit mechanisms for venture capitalists, financial market regulations, the tax regime, and a lack of an equity market culture. Some of these are arguably system-related. However, they play such a crucial role in determining whether financing problems occur that they are examined here.

Globally, government-backed schemes aimed at improving the provision of finance to innovative SMEs have had mixed success, and the evidence demonstrates that government support for financing innovative SMEs is secondary to ensuring that the above preconditions are in place.

Because of the above controversies, financial market failures require special treatment. This issue is dealt with in the following way: Table 2.9 provides criteria, questions and indicators for assessing whether financing problems for innovative SMEs are due to institutional issues; Table 2.10 focuses on demand-side explanations; while Table 2.11 provides a framework for assessing information and transaction cost explanations for perceived financing problems—the strictest definition of financial market failures.

All three tables should be examined in conjunction. Depending on the answers obtained, it should be possible to determine, on balance, whether the problems are due to financial market failures in the strictest sense, or institutional or demand-side factors. Crucially, the form of intervention required will differ—state aid is not necessarily the answer to addressing

---

79 HM Treasury (2003) noted that estimating the financing gap is problematic, but that the number of firms refused finance would be a poor proxy since ‘some will have been turned down because they are not commercially viable propositions’.

Demand-side issues cited include a lack of willingness of innovative SMEs to cede control or to incur the costs of securing equity finance, lack of knowledge of alternative external sources of finance (Poutziouzis et al 1999), and a lack of ‘investment readiness’, including poorly presented business plans and inadequate business planning. Christofidis and Debande (2001) highlighted how it is often quoted that managers of European firms are less entrepreneurial, and less willing to risk failure, than their counterparts in the USA. In turn, this may affect the demand for venture capital finance. Research centres, science and technology parks and incubators are cited as providing potential links between entrepreneurs and venture capitalists.

OECD/Oxera (2004) emphasised the role of BAs in helping entrepreneurs to become investor-ready. Arguably, BAs also perform a networking function.

80 For example, see Arundale (2004), who notes that, although proven-technology venture capital funds had emerged in Europe, EVCA venture capitalists and their investors still preferred non-high-tech areas due to the perceived risk of technology investments and the lower average performance of technology funds.

81 For investment opportunities to be attractive to venture capitalists in the first instance, and to encourage a large market oriented towards innovative companies, these exit systems must work well. OECD/Oxera (2004) and Christofidis and Debande (2001) highlight how trade sales are more common than initial public offerings (IPOs) in Europe, in contrast to the USA, but that IPOs have a number of advantages. OECD (2003) noted that the mixed success of establishing second-tier markets in Europe, and subsequent fragmentation and illiquidity, has hindered IPOs, and similar concerns are raised in European Commission (2003d).

82 Christofidis and Debande (2001) and O’Sullivan (2005) note that, in the USA, measures introduced in the late 1970s that decreased capital gains tax and made it easier for pension funds to invest in venture capital both served to increase the supply of venture capital.

83 European Commission (2001c) emphasised the role of equity in financing innovative SMEs, and expressed concerns regarding over-reliance on debt financing. OECD/Oxera (2004) highlighted that bank-centred systems are less conducive to entrepreneurial activity than stock markets, due to the inherent conservatism of lending, which ‘limits entrepreneurialism and severely penalises failure’ (Black and Gilson 1998). Arguably, however, bank-centred systems can be an inherent institutional and historical feature of the system of financing. For example, whereas financing in the USA and UK has historically been grounded in an equity-based culture, in Germany the banking system has historically played a greater role in determining whether financing problems occur.

84 For example, as noted by OECD/Oxera (2004), reforms in Denmark to venture capital pension fund ceilings had a disappointing effect on the market, due to confusing rules, a risk-averse investment culture, and a lack of skilled fund managers. In Canada and Mexico, attempts to replicate the US small business investment company (SBIC) equity-leveraging model were not successful. Christofidis and Debande (2001) and O’Sullivan (2005) revealed how the US SBIC model was created against a background of an established equity culture, growth in technology clusters with university links, and changes to the legal and regulatory framework. The recently approved UK Enterprise Capital Fund (ECF) scheme is built on the US SBIC model, but seems to have been designed carefully, taking account of such factors (see HMT 2003), although the model has yet to be tested. The model enables venture capital fund managers to apply for government leverage to back each £1 that they invest in targeted funds covering qualifying innovative SMEs, up to a maximum of twice the private equity capital in the fund. Once the ECFs start to generate income, repayment of public leverage and interest will occur first, followed by remuneration of private principal, and then any remaining profits will be shared between the government and private sector.
the institutional problems identified in Table 2.9, or demand-side/historical issues listed in Table 2.10.

The criteria, questions and indicators have taken into account the types of scheme typically put forward to resolve financial market failures: direct support to certain types of firm, or assistance to certain types of financial intermediary.
### Table 2.9 Assessing innovation financing problems (institutional factors)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Context</th>
<th>Indicators and questions</th>
<th>Potential for intervention (not necessarily state aid) when:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country financial markets background</strong></td>
<td>The degree to which the economy has an equity-based culture will determine whether a perceived financing gap is due to information issues and transaction costs or an underlying absence of equity</td>
<td>Qualitative questions need to be asked about the existence or otherwise of an equity culture</td>
<td>Equity culture absent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>One indicator is the total value of shares traded (main stock market) as a % of GDP</td>
<td></td>
</tr>
<tr>
<td><strong>Country exit mechanisms</strong></td>
<td>Exit mechanisms (whether trade sales, alliances or IPOs) are crucial to venture capital firms. Venture capital firms look to ‘points of inflexion’ in the financing cycle, in which they can realise a return or cut their losses</td>
<td>Exit mechanism quality questions include whether there are:</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>While trade sales are only well suited to situations in which another firm can find a fit within it, and forming alliances can be another way of obtaining a cash injection, eventual exit via IPOs is better suited to a stand-alone start-up. Over-reliance on trade sales exits may be to the detriment of stand-alone companies</td>
<td>– buyers for trade sales?</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>In addition, overly fragmented secondary IPO markets towards the end of the financing life cycle may restrict venture capital activity at the start of the cycle</td>
<td>– second-tier markets for IPOs and admissions requirements?</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Country regulations</strong></td>
<td>Regulations that prevent institutional investors (such as pensions companies) from investing in venture capital funds (including higher-risk, early-stage funds) can restrict venture capital activity</td>
<td>Regulation quality questions are as follows:</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>The treatment of taxation on venture capital funds, capital gains tax, and tax on new firms can also affect the provision of finance</td>
<td>– restrictions on pensions investment in venture capital funds; tax regulations (taxation of venture capital funds, capital gains, tax on new firms)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quantitative indicators are as follows:</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– distribution of venture capital funds raised by source: pensions, fund-of-funds, insurance companies, banks, individuals, corporations, government and academic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low amounts raised through institutional investors</td>
<td></td>
</tr>
</tbody>
</table>

Source: Oxera.
Table 2.10  Assessing innovation financing problems (role of demand-side and historical factors)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Context</th>
<th>Indicators and questions</th>
<th>Potential for intervention (not necessarily state aid) when:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country investor readiness</td>
<td>Rather than a financing gap existing, a shortage of finance may be due to demand-, rather than supply-side, factors. Entrepreneurs may be unwilling to cede control or may not be investor-ready, or there may be a shortage of good projects. Tackling network failures (eg, via incubation), to get entrepreneurs investor-ready, may be more important than financial market failures per se</td>
<td>A qualitative assessment is required of the willingness of entrepreneurs in the country to cede control at the early and later stages. In terms of investor-readiness, the important factors are access to business support, presence/absence of BAs and BANs, quality of technology transfer departments at universities, the number and role of incubators.</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low number (entrepreneurs less likely to be investor-ready)</td>
<td></td>
</tr>
<tr>
<td>Country and sector historical rates of return</td>
<td>Venture capitalists may also, quite rationally, be reluctant to provide finance to sectors exhibiting poor historical performance (as has been the case in the high-tech and biotech sectors)</td>
<td>An assessment is required of the historical rates of return in the country and sector concerned. Rates of return—historical rates of return on venture capital by stage (seed, start-up); cumulative ex ante internal rates of return by stage.</td>
<td>Low</td>
</tr>
</tbody>
</table>

Source: Oxera.
Table 2.11 Assessing innovation financial market failures (information/transaction costs definition)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Context</th>
<th>Indicators and questions</th>
<th>Intervention potentially a priori justified when:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company stage and size</td>
<td>Small early-stage companies (seed and start-up/pre-commercialisation) are likely to be prone to a financing gap. These tend not to be a subsidiary of a larger firm (otherwise they would have retained cash flow), and to have one person with a vision; a lack of diversification opportunities; a lack of revenues (otherwise the firm would be able to obtain finance including, potentially, debt finance), uncertain costs, limited market power or influence over its external environment, a lack of management skills, little track record, and intangible assets (thus little collateral). Invariably, investors require a higher return from early-stage ventures than from later-stage ventures, and funding may not always be made available.</td>
<td>Is the company a SME? Is the company a university spin-out, seed, start-up or other company?</td>
<td>Yes; A spin-out, seed, or start-up SME</td>
</tr>
<tr>
<td>Sector</td>
<td>In combination with the seed/start-up dimension, firms in high innovation and thus high uncertainty sectors face particular problems in attracting external finance. The high-tech and biotech sectors often involve; ventures driven by academics and spin-outs which may have little business expertise, high intangible assets, high R&amp;D (particularly at the early stages), unproven technologies or applications, multiple-stage complex life cycles with multiple inflexion points (financial injection and exit points); situations in which collaboration and alliances tend to be very important (especially in biotech); and a long lead time and investment horizon (for example, in biotech, a drug may take 10 to 15 years to get to market). Firms in such sectors require particularly complex and specialist due diligence (and thus high screening and monitoring costs relative to the deal size), and have high potential growth, but a high endemic outright failure rate (eg, 80% of start-up firms in biotech fail). Patents are particularly important to these firms (see above), in that they provide an important signal to potential investors regarding revenue prospects, reduce intangibility and represent collateral. If aid is provided on the basis of a competitive tender of venture capital firms to participate in a Small Business Investment Companies- or Enterprise Capital Fund-type leveraging scheme, governments have the flexibility to rank these schemes in terms of which sectors are targeted.</td>
<td>Is the company a seed or start-up venture in biotech (or pharmaceuticals), communications, IT (including computer hardware and software), or semiconductors? Does the company fit within the Table 2.1 classification of science-based sectors, the OECD classification of high-tech sectors, or the wider range of high-tech categories presented in Table 2.1? Is the SME in a high-growth sector peculiar to the country concerned?</td>
<td>Yes; Yes; or Yes</td>
</tr>
<tr>
<td>Informal financing and the equity gap</td>
<td>In a country, the lower bound of the equity gap can be informed through an analysis of the amount of informal financing provided by BAs at the early seed and start-up stages. This can be informed by looking at historical BA activity across several dimensions, although there may be measurement issues because of the informal nature of BA financing. The following indicators are relevant: number of BANs, growth of BANs over time, total funds invested by BANs, typical upper threshold of BA financing in country, informal investment as a % of GDP.</td>
<td>The following indicators are relevant: number of BANs, growth of BANs over time, total funds invested by BANs, typical upper threshold of BA financing in country, informal investment as a % of GDP.</td>
<td>Most of these are low</td>
</tr>
<tr>
<td>Criterion</td>
<td>Context</td>
<td>Indicators and questions</td>
<td>Intervention potentially a priori justified when:</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Venture capital industry                      | Venture capital is cited as being a form of equity financing well suited to innovative SMEs. In theory, venture capitalists *minimise informational gaps* by evaluating business plans, the technology, management and market size. They also become *proactively involved* in running the firm, using their specialist skills. Thus, they alleviate the imperfect and asymmetric information associated with young firms, by scrutinising the firms *ex ante*, and monitoring them *ex post* | Questions could be asked on the following:  
- the degree to which venture capital firms *perform* a venture capital role (ie, the degree of specialist skills in the sector; the degree to which venture capital firms *form* alliances; and the level of active involvement on company boards)  
- whether there are barriers to entry in venture capital market and risk aversion: the average age of venture capital firms; and whether there is industry concentration | Venture capitals do not traditionally perform role  
High barriers to entry |
| Venture capital industry and the equity gap    | Finally, questions could be asked about the extent to which venture capitalists have financed innovative SMEs, to obtain an idea of the size of the venture capital boundary of the perceived financing gap. Good quantitative information should be available | Number of venture capital companies and funds—in absolute terms, and in terms of specialising in seed/start-up firms. Venture capital investment in each of the following areas:  
- overall—absolute terms, as % of GDP, and per inhabitant  
- by stage—investment in early stage (seed and start-up) capital versus expansion/buy-out over time; as % of GDP and per inhabitant  
- by average deal size—distribution of venture capital  
- by sector—eg, software and computing (ICT), pharmaceuticals, health, IT, electronic and electric equipment, engineering and machinery  
- by region (€ and % concentration). (Venture capital nearly always clusters around locations) | Low  
Low amount of seed and early-stage investment activity  
High average deal size  
Few investments in high-tech sectors  
Few investments around university clusters |

Source: Oxera.
Oxera spoke to a number of parties with an interest in innovative SME financing, and these discussions have informed the above tables. As illustrated in Box 2.11, the controversial issue of whether lack of financing is due to financial market failures versus other factors came out strongly.

**Box 2.11 Divergent views on the causes of the lack of innovative SME financing**

In the view of a spin-out company in south-east England, which specialises in the development of software, the problem it has faced in raising finance has been that, on the one hand, BAs do not have deep pockets and, on the other, venture capitalists do not tend to provide finance to pre-product, pre-revenue firms. The firm had already used its personal equity and had attracted BA financing for the earlier stages of product development, but was seeking to take its invention, which had already been trialled with customers on a consultancy basis, to the product (user-friendly, off-the-shelf) stage.

In its view, the problem was not that venture capital firms had not expressed an interest in the company, but that they wanted too high a percentage of the firm in order to provide the financing. In part, this was because due-diligence costs were high, but it was also identified that venture capital firms are more risk-averse in Europe than in the USA. Another key problem for the company is that it has needed to spend 90% of its time chasing finance, which meant that only 10% of its time was spent developing the product further. This presented a ‘catch-22’ situation.

Oxera spoke to an expert on state aid who had worked within an enterprise body in London. He noted that state aid interventions should be focused on ‘high-growth’ SMEs, rather than necessarily seeking to identify innovative ones. Such a focus would, in any case, capture innovative SMEs that suffer from market failures.

Oxera also spoke to a member of a French Ministry in respect of a scheme, eventually approved by the Commission, intended to assist young innovative SMEs undertaking R&D. One problem identified was that, in France, the venture capital market is not sufficiently fluid in providing finance to high-risk firms—most capital goes to more mature, less risky companies, indicating an element of conservatism in the market. Lack of exit was also identified as a factor. Although the French government had sought to encourage the provision of venture capital to smaller, high-risk firms, this had made little impact. Thus, the scheme, which provided an exemption to social security contributions and corporation tax for firms less than eight years old undertaking more than 15% of expenditure on R&D, was introduced as a substitute measure.

Other parties that Oxera spoke to painted a different picture of the underlying problems faced by innovative SMEs in attracting finance. Oxera spoke to a venture capital company managing, among other funds, a university spin-out fund, which had received support via the UK Venture Capital Fund scheme. The fund specialised in areas in which universities were commercialising intellectual property, including physical sciences and electronics, but not the biotech sector. The reasons given for avoiding the latter were that it takes up too much cash to reach the clinical trial stage; the timescale of the project from seed to the end-customer is very long; and it requires highly specialised knowledge to assess proposals. Software and hardware products or new materials could, by contrast, be demonstrated to a customer at earlier stages.

The reasons given more generally for why there is a lack of appetite for seed financing/financing of spin-outs in the EU were that:

- risk-adjusted returns were lower (particularly after the dot.com bubble) and those funds specialising in seed financing have underperformed;
- early-stage funds take a long time to provide a payback, and require considerable due diligence and time assisting management during the earlier stages;
start-ups cannot always attract the best management during the very early stages. In addition, although universities have to date managed this process as best they can, education is required in university departments regarding what makes a feasible business proposition. Against this background, the view of the fund manager was that not very many venture capitalists in the UK would undertake seed financing without first receiving government support.

In the view of a serial entrepreneur in the biotech sector, it was emphasised that the biotech sector is characterised by particular uncertainty, namely significant scientific risk, effectively creating a ‘black hole’ in front of the firm, in which income may not emerge from the final product for ten years or more. Failure rates are endemically high, and there is a dependence on organisation, collaboration, development of intellectual property, and success with the various clinical phases. There can be substantial corporate reorganisations throughout the ten-year produce development life cycle (i.e., before a new medicine is even sold), changes in the venture capitalists involved, and increasing conditionality of the funds provided by venture capital firms. The options for both the entrepreneurs and the venture capitalists to realise a return include partnering, trade sales, and an IPO (at the later phases), rather than necessarily following the entire drug development process through to the sales stage.

Despite the complexity of the sector, in the view of the serial entrepreneur, the good projects did generally attract the required finance. He also expressed the view that, despite the high scientific risk, there is a ready supply of capital to develop new biotech companies (although suppliers of that capital are taking a noticeably more selective approach in 2005, trying to spot winning technologies, compared with their somewhat unfocused investment approach some ten years ago). The key to doing so was to pursue shortcuts, to form the right alliances with the right people, and to obtain the right patents. Patents are crucially important to obtain further funding at each of the various stages (see also section 2.4.3 above). Where government support is provided, in his opinion, there is the potential to bring forward bad projects.

In the view of a venture capitalist, many of the problems in seed and start-up financing in Europe have been due to historical and demand-side factors, rather than market failure explanations. The lack of investment in seed finance in the EU is acknowledged as a problem, but this has been a rational reaction to the poor historical performance of certain sectors, such as ICT. Although good seed funds exist in the UK and Germany, these had been faced with immature projects coming out of universities that were not business-oriented. In particular, there is a lack of willingness of EU start-ups to cede control at either the start-up stage, or, looking forward, at exit. Entrepreneurs also tend to demand too high a return and, in contrast to the situation in the USA, do not want to be serial entrepreneurs (they wish instead to hang on to their businesses). In his view, due to problems with secondary market fragmentation and therefore exit in the EU, ICT firms should have in mind exit via IPO on the US NASDAQ, and should adopt governance measures at an early stage consistent with this; however, this does not happen sufficiently frequently. Although trade sales are common in the EU, these were cited as relying on another firm potentially benefiting from a strategic fit within their existing organisation, and are not necessarily appropriate for stand-alone businesses.

In general, within the EU, the view was that start-ups in biotech are more investor-ready than their equivalent in the ICT sector. Financing problems have been resolved where there exists, in certain areas, a combination of good universities and good intermediaries (clusters, academic technology transfer and incubators). Indeed, venture capital clusters have formed around these centres, such as in Cambridge, UK; Leuven, Belgium; and Grenoble, France.
2.4.6 Large-scale investments

The above discussion illustrates that, in general, innovation market failures would be expected to be higher for smaller firms than larger firms. It was also highlighted that, while both small and large firms generate spillovers, there appears to be a bias towards supporting larger R&D-intensive firms, and that support for R&D is more likely to be additional than a substitute for private sector R&D in the case of smaller firms. Prima facie, therefore, a more cautious approach should be adopted towards approving state aid to large firms undertaking innovative projects. The identification of large spillover effects was viewed as particularly important. In respect of state aid, large firm investments are more likely ex ante innovative projects. The identification of large spillover effects was viewed as particularly cautious approach should be adopted towards approving state aid to large firms undertaking substitute for private sector R&D in the case of smaller firms. Prima facie, therefore, a more

Large investment projects—‘mega-projects’ spanning across Member States, and which are of European importance—may, in particular, be affected by additional innovation market failures (although some of these concerns might also be relevant to larger firms undertaking innovative projects). Article 87(3)(b) of the Treaty provides an exemption for state aid to be provided for projects of European importance, although it has been little used to date.

Ultimately, whether a project is of ‘common interest’ is a political decision. In relation to this, not all projects that may be of common interest would necessarily be justified on the basis that they are innovative or that they suffer from innovation market failures. The current report, however, focuses on the innovation market failure agenda. In this regard, objective criteria would be helpful for taking an informed decision on whether a large innovative project might qualify for consideration under Article 87(3)(b). Arguably, a thorough ex ante demonstration of the likely existence of innovation market failures in relation to the specific investment project could be required.

Nonetheless, much of the literature on innovation market failures either examines R&D in a very general sense (see section 2.4.2), or looks at the specific market failures (particularly financial market failures) encountered by smaller firms (see, for example, section 2.4.5); although, as noted above, coordination failures are likely to be higher for larger and more complex projects (section 2.4.4). Because of the paths followed by the literature, it is important that avenues through which innovation market failures might occur in relation to larger firms undertaking innovative projects, or larger-scale investments, do not remain unexplored.

Large investment projects—‘mega-projects’ spanning across Member States, and which are of European importance—may, in particular, be affected by additional innovation market failures (although some of these concerns might also be relevant to larger firms undertaking innovative projects). Article 87(3)(b) of the Treaty provides an exemption for state aid to be provided for projects of European importance, although it has been little used to date.

Ultimately, whether a project is of ‘common interest’ is a political decision. In relation to this, not all projects that may be of common interest would necessarily be justified on the basis that they are innovative or that they suffer from innovation market failures. The current report, however, focuses on the innovation market failure agenda. In this regard, objective criteria would be helpful for taking an informed decision on whether a large innovative project might qualify for consideration under Article 87(3)(b). Arguably, a thorough ex ante demonstration of the likely existence of innovation market failures in relation to the specific investment project could be required.

85 To determine whether additional considerations, beyond the market failures discussed previously in this report, might arise, it is useful to consider a spectrum of examples to illustrate the point. A large car manufacturer undertaking some innovative investments, and some collaborations with other manufacturers to reduce costs, is not in a high-tech sector, and is not as R&D-intensive as other large firms in such sectors. In this example, arguably, few additional considerations arise beyond those already discussed in the report. A large microelectronics manufacturer undertaking many medium-sized R&D projects, some of which involve collaborations, should have the financial resources to support R&D, although public support may still be justified on the basis of spillovers. Again, however, few additional considerations should arise beyond those already discussed. An aircraft engine manufacturer may represent a case of a large firm undertaking large innovative investments. Investment in new engines may be particularly innovative if they involve radical changes, and will be subject to technical uncertainty, multiple stages, and the potential for timetable slippages. This is arguably an in-between case of a large company innovating and a large-scale innovative investment, and additional issues may therefore arise. However, for innovative ‘mega-projects’ spanning across Member States, additional considerations are more likely to arise. For example, the development of new large aircraft falls within the high-tech sector, is R&D-intensive, is subject to many uncertainties, requires high levels of coordination, and has the potential to generate far-reaching spillovers.

86 As will be discussed below, the Airbus A380 project could have been examined under Article 87(3)(b), but this route was not adopted. This Article can be used as a derogation to the 1996 R&D Framework, and to state aid rules in general. The R&D Framework notes that, to invoke the derogation, the project concerned must be of common European interest, which ‘must be demonstrated in practical terms’. For example, the project must represent a ‘major advance over specific Community R&D programmes’, or enable ‘significant progress to be made towards achieving specific Community objectives’. The R&D Framework notes that the derogation may apply to transnational projects of major qualitative and quantitative significance.

87 The analysis of the current section focuses solely on innovation market failures, rather than on EU competitiveness considerations, or other factors. Large-scale investment projects might be granted exemptions from state aid rules, or not be classed as aid at all, for reasons other than that they facilitate innovation. Justifications based on the possibility that state aid is necessary due to subsidies provided in non-EU countries being perceived to be unfair are not discussed. Wider political objectives more generally are not discussed. Market failures are only considered where these relate directly to the size and
The market failures that may arise in relation to mega-projects of European importance are as follows.

- **Spillovers**—relative to SMEs and large companies, spillover effects are more likely to be economy-wide and transcend national boundaries.

- **Coordination failures**—large innovative projects require more coordination across agents, resulting in a scaling-up of the effects of complexity, multiple project stages, and reliance on others. Uncertainty and uncontrollability are likely to be exacerbated at the early stages of such projects (see also section 2.4.4).

**Financial market failures**—much of the financing literature focuses on innovative SMEs, rather than large-scale investments. Financing problems may, however, be encountered in large-scale investments due to a ‘betting-the-company’ effect (analogous to a SME effect), risk aversion of management and investors, illiquidity of markets, and high initial outlays in CAPEX-intensive projects (again, analogous to the SME effect).

However, before exploring in detail the market failures that might arise, in order for the project to qualify for initial consideration under Article 87(3)(b), an initial assessment could be required of the following three dimensions, in economics terms:

- **stand-alone**—the project should be justified on a stand-alone basis;

- **large**—to be of common interest, the project undertaken must involve parties from a significant number of Member States, and the benefits derived from it should also span several Member States;

- **innovation**—since the investment must be justified on a stand-alone basis and, moreover, linking state aid to the size of the project per se is not desirable, the innovation concerned must be radical and, ideally, new-to-world in scope.

Arguably, mega-projects are more likely to pass these criteria than smaller-scale R&D investments. Unless all three of the above three criteria are met, the project should arguably not be considered further for exemption under Article 87(3)(b).

If the criteria are met, the extent to which the project is likely to suffer from spillover, coordination and financial market failures could then be considered in more detail. However, a principal concern in this regard is that the theory and evidence on the innovation market failures that arise in large-scale investments are very much incomplete. The case of the Airbus A380 is useful in eliciting some of the relevant issues. Moving beyond this, there are pointers from the available theory and evidence on large-scale projects, and some lessons from project finance, utility regulation, public–private contracting and recent modelling undertaken by Oxera of nuclear power stations in the UK.

innovativeness of the project concerned. Legal issues regarding the qualification of an investment proposal for treatment under Article 87(3)(b) are not discussed.

88 For example, whether a project, on a stand-alone basis, leads to significant and widespread spillovers might assist in determining, purely from an innovation market failure perspective, whether the project concerned is of European importance. Consideration of all three market failures could assist in assessing whether state intervention is likely to be additional to that which might be provided by the private sector in the absence of intervention. As noted, however, legal issues regarding the qualification of an investment proposal for treatment under Article 87(3)(b) are not discussed in this report.

89 Interestingly, Article 87(3)(b) was not used to approve launch aid to Airbus because, in the Commission’s view, assistance to the consortium did not constitute state aid since it does not affect trade between Member States. However, even if it did constitute state aid, the Commission’s view has been that it would ‘normally qualify’ for an exemption under Article 87(3)(b). See response of Mr Mario Monti on behalf of the Commission to questions on the A380 project (see European Commission 2001e). However, the provision of assistance to Airbus has been controversial, and there was disagreement between the Commission and the USA over the appropriateness of launch aid having been provided to support the A380. The current report does not seek to reach a view on whether Airbus should or should not have received government support for the A380; rather, the project is examined to elicit some of the relevant issues.
The launch and development of the Airbus A380 range of jets has been discussed by Esty (2004b) and Esty and Ghemawat (2002). The studies are useful in highlighting several characteristics of the Super Jumbo project, in terms of its innovativeness and the market failures that might arise in such projects.90 Building upon these studies, a number of characteristics of the Airbus A380 project can be discerned, including that it:

– was a radical innovative investment by a high-tech company with a history of innovation;
– was necessary to use cooperation over four Member States;
– was high-cost, with high upfront cost, and subject to significant cost uncertainty;
– involved high demand (and revenue) uncertainty over a long amortisation timeframe;
– involved significant technical risks that needed to be overcome;
– constituted a bet-the-company investment.

Although not discussed in detail in the studies, the project also had the potential to lead to large spillovers, including:

– potentially reducing aircraft prices for long-haul worldwide by eliminating Boeing’s monopoly in the very large aircraft market;
– using many suppliers over several Member States;
– potentially improving air travel in general.

The Airbus case provides some context to some of the issues that might arise. The key question, however, is whether the size, effects, costs, risks and complexities inherent in large innovative projects, as described above, give rise to what can be classified as innovation market failures. However, turning to each of the three market failures of interest (spillovers, coordination failures, financial market failures), the available literature is very patchy.

The potential for spillovers provides the main justification for intervention to assist large-scale innovative investment projects. If there are no significant wider benefits, in terms of public returns significantly outweighing private returns, there may be little a priori rationale for government intervention (on the grounds of innovation market failure alone). A tough stance should probably be taken towards this for very large projects, since they may involve significant taxpayer resources. Moreover, while spillovers will be greater for pan-European projects than for smaller projects, the potential to distort competition is also generally greater.91 The radical nature of the project should probably be assessed, as it will tend to be justified on a stand-alone basis (rather than being a scheme applying to many potential qualifying firms).

Here, it is the combination of the size and the innovativeness of the project that leads to spillovers. Arguably, for large-scale projects, it is the creation of market spillovers that is the ultimate rationale for providing state support, whereas smaller projects might be justified more on the grounds of technological spillovers. The Airbus project involved many suppliers

90 Since these studies were undertaken, the aircraft has been developed, with the A380-100 making its first test flight in April 2005. Initial deliveries of the new aircraft are due in 2006. Airbus announced its intention to launch the A380 range of Super Jumbos in December 2000, with the first version, the A380-100, seating 555 passengers. Innovations cited by Esty (2004b) included that it would represent the world’s largest passenger aircraft, with more space per seat, wider aisles, the safety of four engines, incorporation of the fly-by-wire technology and flight deck of the Airbus family, and potentially lower costs per passenger than the 747. The list price would, however, be higher than that of the 747. Esty (2004b) highlighted the ex ante demand uncertainty inherent in the project. (Although Airbus had secured initial orders in 2000, for delivery in 2006, there was uncertainty over long-term demand to justify the initial launch, including the long-term nature of the demand forecasts, GDP projections, market shares, fleet retirement, new routes, and flight frequency.) There were also divergences in the view on whether new routes versus larger planes were the appropriate long-term solution to air traffic growth, and the role of the rapidly growing smaller airlines. The Airbus project also involved a long design and development time and large upfront investment, and commentators disagreed on the costs and likely operating margins. The competitive response of Boeing was also uncertain. Esty (2004) described the A380-100 project as a ‘bet-the-company’ type of investment. Indeed, he commented that Boeing’s launch of the 747 in 1965 was viewed as a ‘bet-the-company’ gamble on an untested product and that, despite initial optimism, the project almost caused the company to fail. For example, there were penalties for late deliveries, and no large cash flows until deliveries were made, which left the company short of funds.

91 Within the EU, competition may not be distorted if there is only one manufacturer that can undertake the investment (as is the case for the Airbus A380 project).
across Member States, but its ultimate benefit will be to lower the prices of very large aircraft worldwide. Similarly, the Channel Tunnel project resulted in knowledge exchange between the many firms involved, and itself generated additional knowledge. However, it was the end benefit of the project—in facilitating trans-European transport movements—that provided its ultimate rationale.

Nonetheless, as will be discussed below, there is evidence that, for particularly large-scale investment projects, their wider benefits (in respect of spillovers and, moreover, economic development objectives) can be overestimated. A stringent approach should therefore be adopted to the assessment of potential spillovers.

In respect of coordination failures, the literature in this area, as discussed in section 2.4.4, is patchy, as is the evidence. It is nonetheless likely that factors impeding coordination will be especially acute for particularly innovative and particularly large-scale innovative projects. In turn, these issues may provide a further justification for government support. The mixture of exogeneity of others’ actions to each firm, and the sensitivity of payoffs, may undermine the willingness of firms to sink costs into large-scale collaborations. By their very nature, the projects will tend to have high sunk and specific costs in new technologies, especially at the early stages. Due to the sheer size of such projects, technical uncertainties that arise will have a compounding effect. Selecting the correct partners may be particularly difficult, transaction costs in managing the project are likely to be particularly high, and monitoring ex post compliance of partners more complex (which may give rise to moral hazard).

These factors may not only increase the risks of the project (which would simply be reflected in a higher cost of capital), but may undermine the coordination required to undertake such projects in the first instance. In addition to affecting the willingness of firms to collaborate, these issues may have an impact on the willingness of investors to finance such projects (see below). There is potentially a close correspondence between project network effects and the cost overrun and timetable slippages (see below) that appear inherent in large-scale investments, although this link has not been fully explored in the literature.

In terms of financial market failures, the theory and evidence are again underdeveloped. However, certain characteristics may be present that might affect the financing of such projects. For example, large projects can either put the company concerned on the map, or destroy its competitive advantage. Large-scale and uncertain investments may involve ‘betting the company’. Managers may be especially averse to such investments where they involve particularly large investments relative to current activities. The bet-the-company and asset size effects are in some ways akin to a scaled-up SME effect, in that a problem stems from the new project being inherently uncertain and requiring high cash injections relative to current assets.

---

92 Large-scale projects are more likely to be characterised by network effects, in which, to be profitable, investments must be undertaken sequentially, and to time. They are more likely to involve projects progressing in stages, in which the payoffs are particularly sensitive to all parties cooperating and where, if one firm fails, the whole project fails. The larger the project, the more parties will be required to facilitate it (and the more diverse they will be). Such projects are also potentially more likely to be affected by adverse macroeconomic conditions.

93 Esty (2004a) notes that the financing of innovative SMEs has been explored far more extensively than financing of large projects, both theoretically and empirically, and that even less research has been undertaken on large-scale investments.

94 As noted, Esty (2004b) cited Airbus’s decision to launch the A380 as an example of such an investment, given the history of plane manufacturers going bankrupt after failed launches.

95 According to Esty (2004a), while managers might adopt a risk-taking approach towards small investments, they adopt a risk-averse approach to very large investments. Thus, ‘managers often reject large, risky investment opportunities, especially if they have the potential to inflict sizeable distress or, in the extreme, cause the sponsoring firm to go bankrupt’, even if these projects have a positive net present value.

96 These effects are more about the willingness of management to undertake the investment at all, including through the use of retained earnings, than about financial market failures. The effect can be contrasted with the risk-averse nature of external investors, which is often cited as a potential cause of financing problems for innovative SMEs. Nonetheless, potential external equity investors may also be risk-averse in light of information problems and the historical record of large investment projects.
Large firms will have more scope to use retained earnings than smaller firms to finance investments. However, for particularly large investments, some degree of external financing may be needed. In this regard, external investors may be unwilling to finance large-scale innovative projects. One reason is that they may not be able to understand the risks involved in a project due to its innovativeness, size and the complexity of multiple-firm delivery. This will be compounded if equity is risk-averse.

However, whether problems in obtaining external finance represent financial market failures is highly controversial, since there is much evidence that large projects systematically under-perform against forecast costs, timetabling and revenues, particularly in the case of infrastructure projects. It is not clear that this is always due to deliberate forecasting errors, or because of the network effects inherent in very large-scale projects. Nonetheless, the point to remember is that the reluctance of investors to provide finance to such projects is not necessarily a market failure—this is analogous to investor attitudes towards poor historical performance of seed biotech companies and towards underperformance associated with large-scale projects (see section 2.4.5).

The rationale for state support to be provided on the grounds of financing issues can also be explored, albeit indirectly, by looking at the lessons from project finance, utility regulation and public–private contracting. These indicate further that there may be limits on the degree to which equity investors will invest in particularly risky projects. Lessons may also be learned from recent modelling undertaken by Oxera, which analysed the conditions under which private investors might be prepared to finance the construction of a new fleet of nuclear power stations in the UK. The modelling showed that, due to the financial risks involved private investors were unlikely to fund nuclear investment in the absence of government support.

97 Esty (2004a) summarised a number of studies on large-scale project performance, commenting that it is not totally clear if projects encounter problems simply because they are large, or due to financing, but that what is clear is that smaller projects seem to exhibit better performance than larger projects. For example, Miller and Lessard (2000) studied engineering projects involving, on average, $1 billion over 20 years. The authors found that 40% performed badly, and were abandoned or restructured after a financial crisis. Merrow et al (1988) studied 47 mega-projects, of which only four adhered to the budget, and in which the average cost overrun was 88%. In a separate study, Flyvbjerg et al (2003) examined toll road, bridges and railroad projects. They ascertained that ‘over-optimistic forecasts of viability are the rule for major investments rather than the exception’. Projects analysed included the Channel Tunnel, the Great Belt, the Oresund project and many urban transit projects. Flyvbjerg et al reported that cost overruns of 50–100% and demand forecasts that are wrong by 20–70% are common in mega-projects. They found that the substantial regional, national and international development aspects highlighted in projects typically do not materialise, or are too diffuse to be measurable. In the round, forecasts are often ‘brazenly over-optimistic’. 98 The problems that large-scale projects may experience in attracting finance can be observed by looking at why project financing, rather than corporate financing, is often adopted for large-scale projects. Project financing involves significant amounts of debt financing, and strict controls on what the money provided can be invested in. It is often adopted by default, in light of the problems in attracting equity. However, project financing is not a panacea, since it does not tend to provide finance to earlier, riskier stages of projects. A financing gap may therefore still exist for project launch or construction. Government guarantees may be required to underwrite these more risky stages. Note, however, that the Airbus A380 project, discussed above, did not involve project financing. In addition, the approach followed by utility regulators in privatised utilities illustrates how, in setting price limits, there may be an optimal degree of risk-sharing between monopoly utility firms and their customers. A trade-off is achieved, in the form of the price contract imposed by the regulator. A common practice is to allow for cost pass-through in prices of uncontrollable costs to customers (as occurs, for example, in the UK water, electricity and gas sectors). This implicitly recognises that imparting too much risk on the utility may disproportionately increase the cost of capital of the utility. The use of contracting in the US nuclear decommissioning industry also illustrates that the nature of risk-sharing between the government and private sector depends on the circumstances. Less risk tends to be passed on to the private sector where there are unknown processes, innovative technologies and other significant unknowns. Where an attempt has been made to pass risks on to the private sector through using fixed-price contracts in the wrong situation, the projects have encountered difficulties (see, for example, US Government Audit Office (1998), May. 99 In Oxera (2005), Oxera highlighted that nuclear power plant may be particularly exposed to market price fluctuations and uncertainties of projecting electricity prices over the next 60 years. The underlying economics is likely to be determined by exogenous movements in gas prices (a competing form of power) and potential future government funding. The high upfront development costs of nuclear plant are cited as being of particular importance. Here, nuclear power stations have a particularly high financial risk in their early stages and, in past projects around the world, cost overruns are commonplace, particularly for ‘first-of-kind’ designs. Future decommissioning costs also need to be taken into account. It was noted that the required expected returns on equity for a nuclear generator (linked to the technology, price sensitivity and cost overruns) could be 200–400 basis points above the benchmark. Thus, it is unlikely that private investors would support nuclear investment in the absence of government support to boost private returns.
The indicators developed below are based on the incomplete patchwork of literature discussed above, and thus should be treated as providing an initial assessment of the issues. Because of the lack of theory and evidence, and since, by their nature, large projects may involve significant commitment of taxpayer resources, in examining a project ex ante, there should be stringent information requirements to ensure that it is innovative and that it seeks to address each of these innovation market failures. Not only should the full range of indicators be used, but other detailed questions should be asked around the indicators suggested.

Tables 2.12 to 2.14 provide the relevant criteria, questions and indicators in relation to spillovers and financial market failures. As was undertaken in section 2.4.5 in the context of SMEs, a distinction is drawn in the financial market failures tables between institutional and historical factors, on the one hand, and strict market failures, on the other.\textsuperscript{100} Table 2.5 can be used to assess the coordination failures that may arise (the considerations in the case of large-scale investments are exactly the same, although coordination problems are more likely to arise).

If a mega-project does not generate significant potential innovation spillovers (Table 2.12), there may be insufficient justification to grant the project state aid. However, a judgement would need to be made on the number of criteria that would need to be satisfied across all the tables.

The focus of the tables is on assessing large-scale investment projects which may qualify for exemption under Article 87(3)(b), but, depending on the context, may also be relevant to projects pursued under the EU Fifth Framework Programme, EUREKA and MEDIA+ that may also qualify for treatment under Article 87(3)(b).

\textsuperscript{100} The ‘bet-the-company’ effect of management is treated here as a financial market failure, although it could be argued that this relates to demand- rather than supply-side factors. The reason for the approach taken is that, due to the presence of market imperfections (risk aversion), management is reluctant to use (even) internal equity resources to finance the project concerned, even if the project is worthy (in the sense that it has an internal rate of return greater than the hurdle rate).
Table 2.12 Large-scale investments: assessing spillovers

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Context</th>
<th>Indicators and questions</th>
<th>Intervention potentially justified if:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sector effects</strong></td>
<td>The extent to which the project involves companies in the high-tech (including science) sector should be assessed, since spillovers tend to be higher in these sectors. Projects may involve an engineering focus, which may partly be captured in the above. However, the extent of participation from firms in medium-tech sectors (e.g., transport equipment) should also be assessed.</td>
<td>To what extent are high-tech companies involved in the project? See Table 2.1. To what extent are medium- to high-tech companies involved in the project? See Table 2.1.</td>
<td>High concentration of high-tech companies. Significant concentration of medium- to high-tech companies.</td>
</tr>
<tr>
<td><strong>Project size</strong></td>
<td>Larger projects have more scope to have systemic impacts that transcend national boundaries. However, caution is required. Approving state aid for a project on the basis of project size alone might not be desirable, given the significant taxpayer resources potentially involved.</td>
<td>Projected costs of project (€ billion)</td>
<td>High</td>
</tr>
<tr>
<td><strong>Project degree of innovation</strong></td>
<td>Projects that might qualify for consideration under Article 87(3)(b) must be justified on a stand-alone basis. The innovation envisaged should be radical and preferably new-to-world.</td>
<td>To what extent is the innovation radical and, by way of evidence, new-to-world?</td>
<td>Significant and new-to-world.</td>
</tr>
<tr>
<td><strong>Project R&amp;D activity</strong></td>
<td>Projects with high R&amp;D:total project costs are more likely to generate spillovers.</td>
<td>R&amp;D:total project costs</td>
<td>High</td>
</tr>
<tr>
<td><strong>Project R&amp;D activity (early versus later-stages)</strong></td>
<td>Projects with high early-stage expenditure ratios are more likely to generate spillovers, since this is where knowledge is created (which will affect the extent of both technological and market spillovers), and innovation is more likely to be radical in large projects with more focus on these stages. However, it should also be recognised that the commercialisation of the innovation will be key to the realisation of market spillovers (see below).</td>
<td>Expenditure on early-stage R&amp;D:total project R&amp;D</td>
<td>High</td>
</tr>
<tr>
<td><strong>Project scope and technological spillovers</strong></td>
<td>The degree to which the project involves suppliers across many Member States, of different capabilities, provides a strong indication of technological spillovers. The degree of project coordination required is a proxy to spillover effects, since collaborative R&amp;D tends to take place at earlier stages of projects. (See also Table 2.5)</td>
<td>Number of suppliers and capabilities involved in the project. Number of suppliers and capabilities involved in the project at the early stages</td>
<td>High, High</td>
</tr>
</tbody>
</table>
### Criterion: Project scope and market spillovers

Realisation of market spillovers directly associated with the project (rather than necessarily just technological spillovers) will be a key justification for the approval of large-scale investment projects. Account should be taken of:

- the effects on consumer prices, and the extent to which this affects EU customers, or extends to other countries, including timeframe
- other benefits including timeframe (e.g., improved quality, travel patterns, safety)
- the accuracy in forecasting these potential benefits (including demand and revenue forecasts), given that large innovative projects can suffer from significant forecasting errors

Note that large-scale infrastructure projects may involve wider benefits, and over a longer timescale, than industrial projects (such as in semiconductors).

<table>
<thead>
<tr>
<th>Indicator and questions</th>
<th>Intervention potentially justified if:</th>
</tr>
</thead>
<tbody>
<tr>
<td>What will be the extent of forecast price reductions? What is the geographical scope of these reductions?</td>
<td>Significant price reductions (e.g., a monopoly currently exists in the market concerned); scope of price reductions is worldwide</td>
</tr>
<tr>
<td>What are the other benefits?</td>
<td>Significant other benefits</td>
</tr>
<tr>
<td>How accurate are the demand forecasts? What is the lead firm’s record on demand forecasting?</td>
<td>Detailed demand forecasts with scenario analysis; good historical record of demand forecasting</td>
</tr>
</tbody>
</table>

Source: Oxera.
<table>
<thead>
<tr>
<th>Criterion</th>
<th>Context</th>
<th>Indicators and questions</th>
<th>Intervention potentially justified if:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project size (relative to financial markets)</strong></td>
<td>The degree to which the economies concerned have an equity-based culture will determine whether a perceived financing gap is due strictly to financial market failures as opposed to an underlying absence of equity. The size of the project relative to the capitalisation of the IPO market may also affect the ability of equity investors to finance it at any price. It would be difficult to resolve this issue at the institutional level.</td>
<td>Qualitative questions need to be asked about the existence or otherwise of an equity culture. An indicator is the project size:total value of IPOs over the previous year.</td>
<td>Equity culture absent. High (likely to be state aid).</td>
</tr>
<tr>
<td><strong>Project history (including firm information on similar projects)</strong></td>
<td>It is not always clear that the difficulties faced in financing large-scale investments are strictly market failures. There is an analogy between investor attitudes towards poor historical performance of seed biotech companies, and investor attitudes towards the systematic cost and revenue over-runs (and timetable slippages) often associated with large-scale projects. However, it is not clear if under-performance that seems to typify large projects is due to deliberate forecasting error, or the network effects often inherent in such projects that make forecasting inherently difficult and outturns non-linear. The history of the participating firms’ work on previous projects should be explored, to examine performance against forecasts, and the reasons for divergences between forecasts and outturns.</td>
<td>Are there examples of projects similar to that being planned by the firm concerned that have, in the past, exhibited particularly poor forecasting performance? Has the firm concerned worked on large-scale projects that have exhibited good forecasting performance? Has the firm concerned worked on large-scale projects that have exhibited poor forecasting performance? If so, what were the reasons for this poor performance?</td>
<td>Not clear (but see below). The question must simply be asked to encourage debate in assessing the project. Yes, if the areas in Table 2.14 are relevant. Not clear. However, if yes, and the reason appears to be due to networking effects rather than deliberate forecasting errors, and the areas in Table 2.14 are relevant, there is more reason to expect that lack of financing is because of financial market failures.</td>
</tr>
</tbody>
</table>

Source: Oxera.
### Table 2.14 Large-scale investments: assessing financial market failures

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Context</th>
<th>Indicators and questions</th>
<th>Intervention potentially justified if:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordination failures</td>
<td>See coordination failures (Table 2.5). These factors may also affect the extent to which financial market failures may arise</td>
<td>See Table 2.5.</td>
<td>See Table 2.5.</td>
</tr>
<tr>
<td>Sector effects</td>
<td>The extent to which the project involves companies involved in the high-tech (including science) sector should be assessed, since uncertainties tend to be higher in this sector</td>
<td>To what extent are high-tech companies involved in the project? See Table 2.1</td>
<td>High concentration of high-tech companies</td>
</tr>
<tr>
<td></td>
<td>Projects may involve an engineering focus, which may partly be captured in the above. However, the extent of participation from firms in medium-tech sectors (eg, transport equipment) should also be assessed</td>
<td>To what extent are medium- to high-tech companies involved in the project? See Table 2.1</td>
<td>Significant concentration of medium- to high-tech companies</td>
</tr>
<tr>
<td>Project size and degree of innovation</td>
<td>Project size per se</td>
<td>Projected costs of project (€ billion)</td>
<td>High; and</td>
</tr>
<tr>
<td></td>
<td>Large projects that are radical and new-to-world, using untested processes and technologies, will have higher cost uncertainty, timetable uncertainty and revenue uncertainty. Both managers (who do not wish to ‘bet the company) and investors (who find it difficult to price risk) may be risk-averse to such investments, and may reject positive-NPV investments</td>
<td>To what extent is the innovation radical and, by way of evidence, new-to-world?</td>
<td>Significant and new-to-world; or</td>
</tr>
<tr>
<td></td>
<td>Risk aversion of management due to ‘betting the company’ effects is likely to be higher where the ratio of project CAPEX to the value of existing activities is high. In some ways, the fact that the new project is large relative to existing assets is a scaled-up innovative SME (start-up) effect (start-ups have few existing assets). The causes are, however, different (here, the driver is the preferences of internal equity, rather than external equity)</td>
<td>Project CAPEX:existing assets for companies participating in the project (especially the lead company)</td>
<td>High project CAPEX: existing assets</td>
</tr>
<tr>
<td>Project R&amp;D activity</td>
<td>Projects with high R&amp;D:total project costs are more likely to be riskier from an investor standpoint</td>
<td>R&amp;D:total project costs</td>
<td>High</td>
</tr>
<tr>
<td>Project R&amp;D and CAPEX activity (early versus later stages)</td>
<td>Large projects with high initial CAPEX outlays (including R&amp;D) and long, uncertain, payback periods may not be financed by risk-averse equity investors (uncertainty per se), who may also be reluctant to provide large amounts of initial free cash-flow to such projects (asymmetric information and moral hazard, but see also historical performance, Table 2.13). This high initial negative cash flow (initial operational gearing), risk aversion and moral hazard issue is analogous in some ways to the problems faced by innovative start-ups in attracting venture capital. However, see historical performance, Table 2.13</td>
<td>Early-stage R&amp;D:total project costs</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Early-stage CAPEX:total project costs</td>
<td>Early-stage CAPEX*payback period</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Early-stage CAPEX*payback period</td>
<td>Number of years of forecast negative net cash-flow related specifically to project</td>
<td>High</td>
</tr>
</tbody>
</table>

Source: Oxera.
2.5 Overview tables

The conclusions from the above analysis are that, while the non-linear systems approach indicates that innovation is more broad than previously thought, and is a complex process:

– for ex ante state aid policy purposes, the relevant dimensions of innovation are mainly those which can be measured and which are more likely to suffer from market failures;

– in addition, despite the complexity of the innovation process, and the debate surrounding systems versus market failures, it is possible to identify criteria and questions for assessing ex ante whether market failures are likely to occur.

The systems approach does not prescribe that state aid be provided at all levels of innovation. To the contrary, the approach highlights that, from an economics perspective, focus should be given to the underlying problems causing a lack of innovation rather than necessarily implementing state aid measures. In addition, it means that, where state aid is justified, it can be difficult for governments to pick winners, in respect of the firms benefiting from aid. Focusing on intermediaries, such as venture capital funds or incubators, is potentially more efficient.

In respect of providing direct assistance to firms undertaking R&D, while, in the context of larger firms, the objective should be to target projects that would not otherwise go ahead, this may, in practical terms, mean targeting projects with the highest potential to generate large spillovers. There should, however, be an emphasis on ensuring that the firm is incentivised to make the project commercially successful, conditional on public support having been granted.

Using the four key innovation proxies developed in section 2.3 (activity, firm size, firm stage in life cycle and sector), and the four key types of market failure analysed in section 2.4, it is possible to provide a higher-level cross-tabulation of when market failures might be expected to occur. These can be used as a quick reference point to guide decision-making. Given the situation, practitioners can see, at a glance, which of the four innovation market failures need to be explored further using the detailed tables provided in section 2.4. The tables do not, however, capture some of the more idiosyncratic determinants of innovation market failures discussed in section 2.4. In addition, the tables are most readily applicable to comparing small against large firms undertaking innovation. Particularly large innovative investments raise some additional issues (see the separate discussion in section 2.4.6).

The summary tables are provided in section 2.5.1. In some instances, more comprehensive cross-tabulations have been undertaken. These are given in section 2.5.2. Again, the tables provide an overview of the four innovation market failures that need to be explored further using the detailed tables provided in section 2.4.

2.5.1 Higher-level cross-tabulations

The circumstances in which innovation market failures might be expected to occur are cross-tabulated below. This is undertaken in order of the following innovation proxies:

– activity (R&D by stage);
– firm size (large versus small) and life cycle (start-up versus later-stage);
– sector (high-tech versus low-tech)

In each table, the measure of innovation is presented in the rows. The four main types of market failure that might occur (spillovers, appropriability, coordination/networks, financial) are then presented in columns.

The tables are deliberately very general, and are grouped into pairs. Comparisons within the pairs are more informative than comparisons across pairs. Caution should be adopted in
making comparisons between pairs of tables, since it is not possible for any one table to capture the multiple dimensions of innovation market failures. A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances.

**Innovation market failures by R&D activity**
The tables below distinguish between the innovation market failures likely to be faced by small and large firms.

**Table 2.15  Small firms (innovation by R&D activity)**

<table>
<thead>
<tr>
<th>Market failure</th>
<th>Innovation</th>
<th>Spillovers</th>
<th>Appropriability</th>
<th>Coordination/ network</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic research</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Applied research</td>
<td>✓</td>
<td>(✓)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances. 1 Protecting intellectual property is important in relation to appropriability, but is probably most important at the early stages of the R&D process. Patents are very important for small firms in the biotech (or high-tech more generally) sectors. Source: Oxera.

**Table 2.16  Large firms (innovation by R&D activity)**

<table>
<thead>
<tr>
<th>Market failure</th>
<th>Innovation</th>
<th>Spillovers</th>
<th>Appropriability</th>
<th>Coordination/ network</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic research</td>
<td>✓</td>
<td></td>
<td>(✓)</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Applied research</td>
<td>✓</td>
<td></td>
<td>(✓)</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances. 1 Large firms are more able to use the IPR system effectively. However, patents are neither a necessary nor sufficient condition for innovation. Patents are important in biotech and high-tech more generally, but questionable patents may also be a problem. 2 Coordination failures are not generally problematic unless coordinated R&D is required (large firms tend to have sufficient networking and potential access to the science base). Clusters and incubation appear to be less relevant to larger firms. Source: Oxera.

**Innovation market failures by firm stage in the life cycle**
The tables below distinguish between the innovation market failures likely to be faced by high-tech and low-tech SMEs.

**Table 2.17  High-tech SME (innovation by firm stage in the life cycle)**

<table>
<thead>
<tr>
<th>Market failure</th>
<th>Innovation</th>
<th>Spillovers</th>
<th>Appropriability</th>
<th>Coordination/ network</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed/start-up</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Growth</td>
<td>✓</td>
<td>(✓)</td>
<td>(✓)</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Maturity</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>(✓)</td>
</tr>
</tbody>
</table>

Note: A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances. Source: Oxera.
Table 2.18  Low-tech SME (innovation by firm stage in the life cycle)

<table>
<thead>
<tr>
<th>Market failure</th>
<th>Innovation</th>
<th>Spillovers</th>
<th>Appropriability</th>
<th>Coordination/ network</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed/start-up²</td>
<td>(✓)</td>
<td></td>
<td>(✓)</td>
<td>(✓)</td>
<td></td>
</tr>
<tr>
<td>Growth</td>
<td></td>
<td>(✓)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maturity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances. ² A number of the issues faced by innovative start-ups are not faced by start-ups or SMEs in general. Although financial constraints and inadequate networking (including business-to-business) relationships may lead to problems for the generality of start-ups, these are unlikely to be as severe as for innovative start-ups. Lifestyle SMEs (eg, established small firms not undertaking innovative activity) should not suffer from appropriability concerns, and innovation spillover effects are likely to be limited. Source: Oxera.

Innovation market failures by sector
The tables below distinguish between the innovation market failures likely to be faced by small and large firms.

Table 2.19  Small firms (innovation by sector)¹

<table>
<thead>
<tr>
<th>Market failure</th>
<th>Innovation</th>
<th>Spillovers²</th>
<th>Appropriability³</th>
<th>Coordination/ network⁴</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low tech</td>
<td>(✓)</td>
<td></td>
<td>(✓)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hi tech</td>
<td></td>
<td>✓</td>
<td>(✓)</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Note: ¹ A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances. ² Many different types of firm innovate, but the role of knowledge spillovers is more limited in low-tech or traditional sectors. These tend to use others’ innovation (input users). ³ Patents are crucial to high-tech SMEs (especially start-ups). ⁴ All SMEs may lack access to networks, but lifestyle SMEs in low-tech sectors should not face the same difficulties as innovative SMEs in attracting finance, are less likely to require the same level of financing, and are more likely to have retained earnings. Spillovers are higher in high-tech sectors, appropriability is more important (especially at early stages), networking is crucial, and financial market failures are higher. Source: Oxera.

Table 2.20  Large firms (innovation by sector)¹

<table>
<thead>
<tr>
<th>Market failure²</th>
<th>Innovation</th>
<th>Spillovers</th>
<th>Appropriability</th>
<th>Coordination/ network</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low tech</td>
<td>(✓)</td>
<td></td>
<td></td>
<td>(✓)</td>
<td></td>
</tr>
<tr>
<td>Hi tech</td>
<td>✓</td>
<td></td>
<td>(✓)</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Note: ¹ A tick indicates that innovation market failures are likely to arise, and a tick in parentheses indicates that they might arise depending on the circumstances. ² Large firms face fewer financing problems than smaller firms. Spillovers are higher in high-tech sectors. Appropriability is important in high-tech sectors, but larger firms have a good awareness of the IPR system, and patenting is neither a necessary nor sufficient condition for innovation (eg, networking is more important). Also, in high-tech sectors, questionable patents are more common. Coordination failures are not generally problematic unless coordinated R&D is required—large firms tend to have sufficient networking and potential access to the science base. Clusters and incubation are less relevant to larger firms. For larger firms, financial market failures would not be expected to occur, except where the projects are particularly large and risky. Source: Oxera.
2.5.2 Detailed tables
The tables that follow provide further insights into the above higher-level cross-tabulations. This is again undertaken in order of the innovation proxies:

- activity (R&D by stage);
- firm size (large versus small) and life cycle (start-up versus later-stage);
- sector (high-tech versus low-tech);

Caution should be adopted in making comparisons between tables, since it is not possible for any one table to capture the multiple dimensions of innovation market failures.
### Table 2.21 Innovation market failures by activity

<table>
<thead>
<tr>
<th>Innovation activity</th>
<th>Spillovers</th>
<th>Lack of appropriability</th>
<th>Financial market failures</th>
<th>Coordination failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic research</td>
<td></td>
<td>Likely to face appropriability problems, except when results are published or are kept ‘secret’, but the problem remains that no commercial return results from this type of appropriation of intellectual property, which might generate underinvestment in basic research</td>
<td>Due to the generality of the knowledge generated in basic research activities, technical and economic uncertainty is relatively high. This is also the result of the difficulties in determining the applicability and therefore the probability of commercial success of the knowledge generated. Financial market failures might therefore be high</td>
<td>Collaboration failures might occur if several companies need to work jointly on the basic research activity. Given the high level of uncertainty, and the potential for costs to be sunk, collaboration failures might be high</td>
</tr>
</tbody>
</table>

Basic research is likely to generate a high level of spillovers as a result of its relative generality, the lack of appropriability of the knowledge generated (except in the form of publications), and, precisely because of this lack of appropriability, the relative easiness in transferring the knowledge created. By definition, basic research is the research activity undertaken mainly to acquire new scientific and technical knowledge not linked to any particular application or use. Thanks to this the knowledge generated is relatively general, can have many applications and therefore benefits a wide range of firms.

As a result of its lack of direct applicability, the economic return of basic research is relatively low. Indeed, the main way in which basic research is appropriated is via publication in scientific journals or circulated in the scientific community (in seminars, conferences, etc), activities which do not allow the agent who has undertaken the research to extract rents from it. In addition, given the high level of technical and economic uncertainty at this early stage of the project, it is relatively difficult to price the knowledge at this stage. As a result, even if the agent wanted to sell the knowledge they would probably not be able to do so.
<table>
<thead>
<tr>
<th>Innovation activity</th>
<th>Spillovers</th>
<th>Lack of appropriability</th>
<th>Financial market failures</th>
<th>Coordination failures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Applied research</strong></td>
<td>Likely to generate spillovers but less than in the case of basic research. By definition, applied research is original research to acquire new knowledge with the purpose of developing an innovation—ie, more specific than basic research. Because of its potential applicability, it is more likely that the knowledge created in applied research is appropriated (eg, via patents or other ways of protecting intellectual property), which in the end might allow the investor to extract some rents from the applied research activity</td>
<td>Might be high, depending on the extent to which knowledge can be codified and transferred. To this extent it might be higher for applied research related to types of innovations where appropriability is problematic (eg, process innovations)</td>
<td>Despite the fact that the knowledge generated in applied research is more specific than in basic research, technical and economic uncertainty is still relatively high. For instance, the idea or know-how might be sold to another firm, or employees with the know-how might leave the firm, or the target market can change. Financial market failures might therefore be high</td>
<td>As in the case of basic research, collaboration failures might occur if several companies need to work jointly. Given the high level of uncertainty, and the potential for costs to be sunk (although this is less than in the case of basic research), collaboration failures might be high</td>
</tr>
<tr>
<td><strong>Development (experimental/pre-competitive)</strong></td>
<td>Likely to generate spillovers but might be less than in basic research. At this stage the knowledge created has become more specific to the product/process innovation and therefore to the market in which the firm is active. In addition, given that at this stage the innovation might be relatively closer to the end-customer, the degree of uncertainty might be lower and therefore the prospect of extracting economic rents higher—ie, potential for lower spillovers than in applied research. However, because of such uncertainty, spillovers continue to be important In addition, empirical evidence suggests that basic research generates more spillovers than development</td>
<td>Might be high depending on the extent to which knowledge can be codified and transferred. To this extent it might be higher for development related to types of innovations where appropriability is problematic (eg, process innovations)</td>
<td>Same as in applied research but technical uncertainty might be lower</td>
<td>As in the case of basic research, collaboration failures might occur if several companies need to work jointly. Given the high level of uncertainty, and the potential for costs to be sunk (although this is less than in the case of basic research), collaboration failures might be high</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td>Likely to generate spillovers depending on whether it is related to innovation activities that are likely to generate spillovers themselves (eg, applied research)</td>
<td>Likely to suffer from appropriability problems depending on whether it is related to innovation activities that are likely to generate spillovers themselves (eg, applied research)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Innovation activity</td>
<td>Spillovers</td>
<td>Lack of appropriability</td>
<td>Financial market failures</td>
<td>Coordination failures</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td><strong>Training</strong></td>
<td>Although not discussed in detail, the more investment in <em>transferable</em> skills, which become embodied within individuals, the more scope for knowledge spillovers as individuals exchange ideas (formally or informally), or move between companies. Companies may therefore underinvest in training related to innovation. Spillovers would therefore be expected to be greater for transferable skills (eg, when such skills are related to other activities that generate large spillovers such as basic research)</td>
<td>Relatively high, particularly when training relates to transferable skills</td>
<td>Depends on the degree to which the training is related to innovation activities/types of innovation affected by financial market failures themselves (eg, basic research)</td>
<td>Network failures might be high if the firm needs to access the general education system to find the training it needs (thus, this is potentially more serious the more general or transferable the knowledge is)</td>
</tr>
<tr>
<td><strong>Expenditure in embodied technology</strong></td>
<td>Relatively low given the specificity of the investments in embodied technology, and hence their low transferability. In particular, expenditure in embodied technology is considered to be an innovative activity if including investments in machinery and equipment necessary for manufacturing a product, or implementing a process innovation. However, there might be some spillovers to the extent that the skills acquired by the employees (eg, to operate the embodied technology and integrate it into the production process) are transferred. Employees can transfer such knowledge through formal and informal contacts with others, or when switching jobs between firms</td>
<td>Relatively low but it might be difficult to appropriate the know-how developed by the employees working on the implementation of the embodied technology acquired</td>
<td>Depends on the extent to which the innovation process is uncertain (thus more relevant for radical than for incremental innovation)</td>
<td>Not clear</td>
</tr>
<tr>
<td><strong>Expenditure in disembodied technology</strong></td>
<td>Relatively low, but there might be some knowledge spillovers from the employees working on implementing the services and knowledge acquired from third-party firms</td>
<td>Relatively low, but it might be difficult to appropriate the know-how developed by the employees working on how to implement the disembodied technology acquired</td>
<td>Depends on the extent to which the innovation process is uncertain (thus more relevant for radical than for incremental innovation)</td>
<td>May be relatively high since firms have to interrelate with others (ie, third-party firms, universities, or research centres) to acquire the disembodied technology they need for the innovation</td>
</tr>
</tbody>
</table>
### Marketing

**Spillovers**
Unlikely because marketing innovation is more specific to the type of innovation and the innovator, and therefore the knowledge generated might be less transferable—e.g., a firm responding to a determined market need or educating its potential consumers. However, if a firm opens a new market and has to educate consumers, spillovers are more likely to occur.

**Lack of appropriability**
Might be high if knowledge is mainly tacit—i.e., embodied in staff involved in marketing.

**Financial market failures**
Relatively low. At the marketing stage, firms almost have the ‘innovation’. First, the probability of knowing the result of the innovation from a technical sense is close to 1 for both the investor and the innovator. Second, there is more certainty on the economic front in terms of the potential market (although there is still uncertainty—for example, expected demand falls). Therefore the likelihood of not being able to raise external finance is relatively lower than in the earlier stages of the innovation.

**Coordination failures**
Not clear.

Source: Oxera.
Table 2.22  Innovation market failures by firm size

<table>
<thead>
<tr>
<th>Size of firm</th>
<th>Spillovers</th>
<th>Lack of appropriability</th>
<th>Financial market failures</th>
<th>Coordination failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small-scale firms</td>
<td>Not clear whether large- or small-scale firms generate more spillovers. However, support for small firms is more likely to be additional (see also other market failures)</td>
<td>SMEs generally do not protect their intellectual property by applying for IPR. This is particularly the case for firms outside the high-tech knowledge-based sectors. Key issues arise for high-tech firms because they tend to have intangible assets: patents are therefore crucial.</td>
<td>Depends on whether a lifestyle SME or an innovative SME, and on stage in life cycle. In contrast to large-scale firms, SMEs may: - have limited spare resources for innovating; - not have the market power that might allow them to cover the reduced (and even negative) short-term profit margin through supra-normal profits in the future. However, many SMEs have retained earnings. Problems exacerbated when: - SMEs are innovative (eg, high-tech), with a high share of intangible assets, or insufficient tangible assets (collateral); - firms are at an early stage in their life cycle, and do not have a track record in terms of successful innovations, credit ratings, etc.</td>
<td>Unclear whether small- or large-scale firms face more collaborative R&amp;D failures. Networking failures (eg, business-to-business) may be high for SMEs. They tend to lack access to formal and informal networks. In contrast, larger firms already have relationships in the innovation system, or more resources to form new relationships. Aspects of the relationships that may be missing include diversity in business relationships and partners; a vertical networking with suppliers; access to professional and trade associations; links with science partners and venture capital firms (although the importance of these varies by sector). Moreover, firms may rely excessively on relationships with their customers. Specific networks such as incubators and clusters are more relevant to high-tech SMEs. Lack of incubation and clustering may hinder innovation.</td>
</tr>
<tr>
<td>Large-scale firms</td>
<td>Not clear whether large- or small-scale firms generate more spillovers. However, large firms are more likely to put forward stand-alone projects in a core competency. Other market failures may be low. Thus, establishing large spillovers is key.</td>
<td>Large firms in high-tech knowledge-based sectors use different forms of IPR to protect their intellectual property. However, IPR does not guarantee appropriability because knowledge leaks quickly through scrutiny of patent applications, formal and informal contacts between individuals, input suppliers, etc. Questionable patents may exist in high-tech sectors.</td>
<td>These might be relatively low because large firms can access internally generated funds to finance the innovative project (but might need external funds for ‘substantial’ investments); might have the market power, allowing them to reap the rewards of the commercial exploitation of the innovation; and have a track record. In addition, in terms of economic and technical uncertainty of innovative projects, large firms can spread out the risk of the projects, balance out the successes and failures, and diversify their activities across the life cycles of several overlapping innovations (at least to certain degree).</td>
<td>Unclear whether small- or large-scale firms face more collaborative failures. However, the larger the scale of the project, the higher the probability of collaborative failures to arise (such probability increases with the scale of the fixed costs of the investment, the variety of competencies required by the project, and the number of stages in which the project evolves).</td>
</tr>
</tbody>
</table>

Source: Oxera.
<table>
<thead>
<tr>
<th>Stage in life cycle</th>
<th>Market failure</th>
<th>Spillovers</th>
<th>Lack of appropriability</th>
<th>Financial market failures</th>
<th>Coordination failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed/start-ups</td>
<td>Not clear whether large- or small-scale firms generate more spillovers (but see Table 2.22)</td>
<td>Especially the case in high-tech (intangible assets)</td>
<td>Relatively high if high-tech. Because of their very nature, innovative start-ups do not have a track record of successful innovative investments, credit rating, repayment capability, etc. In addition, a high proportion of their assets are intangible, which makes it difficult for them to offer collateral when applying for a loan</td>
<td>Network failures can be high, since firm is at its early stages, and has not established relationships</td>
<td>Specific networks (incubators and clusters) are important to high-tech firms. Lack of these networks may inhibit innovation</td>
</tr>
<tr>
<td>Mature firms</td>
<td>Not clear whether large- or small-scale firms generate more spillovers (but see Table 2.22)</td>
<td>Lower than for seed/start-ups</td>
<td>Thanks to the availability of a track record and of retained earnings from previous innovative projects, established firms might face relatively low financial market failures. However, this depends on the size of the firm and the sector in which it is active</td>
<td>Relative to start-ups, networking failures are low</td>
<td></td>
</tr>
</tbody>
</table>

Source: Oxera.
Table 2.24 Innovation market failures by sector

<table>
<thead>
<tr>
<th>Innovative sector</th>
<th>Spillovers</th>
<th>Lack of appropriability</th>
<th>Financial market failures</th>
<th>Coordination failures</th>
</tr>
</thead>
</table>
| High-tech         | Spillovers are high, as well as the diffusion of knowledge through mobility of labour, publications, and networking | Relatively low due to the use of patents, the publication of work, and other forms of appropriating intellectual property. Formal IPR does not necessarily guarantee appropriability in high-tech sector because of leaks.
IPR is important to small firms and start-ups in high-tech sectors, due to intangible assets | Might be high because of technical and economic uncertainty (unproven technologies and high intangible assets — eg, know-how), particularly in the earlier stages of the project. However, after firm has gone through early stage, evidence from case studies and interviews shows that uncertainty, and therefore financial failures, are reduced | Collaborative R&D failures are particularly relevant to the high-tech sector, including companies in which complex systems innovation occurs (eg, aerospace, telecoms, semiconductors), and in scale-intensive sectors using specialised knowledge (eg, machinery and equipment).
Clustering and incubation are particularly relevant. Lack of these networks may inhibit innovation.
For small firms, business-to-business networking failures can occur in any sector |
| Medium-tech       | Lower      | Lower                   | Lower                    | For small firms, business-to-business networking failures can occur in any sector |
| Low-tech          | Low        | Low                     | Low                      | For small firms, business-to-business networking failures can occur in any sector |

Source: Oxera.
3 Implications for state aid policy

This section draws out the policy implications of the operational analysis of innovation market failures (section 2) to explore how state aid policy, including the processes followed by both Member State governments and EC officials who handle cases related to state aid, might be developed in order to better assess when innovation market failures are likely to occur. This will assist in the targeting of state aid, and should therefore enhance the prospects for innovation in the EU.

3.1 Approach and key findings

3.1.1 Approach

This section explores how the approach taken towards intermediaries, SMEs and large companies/large investments might be developed. This section is structured as follows.

– **Objectives of an ‘ideal’ state aid policy**—building on the analysis of section 2, section 3.2 proposes the elements of what an ‘ideal’ state aid policy might look like if its sole aim were to address innovation market failures. Here, some overarching objectives of state aid policy in addressing innovation market failures are set out.

– **Identifying the gaps**—the approach to identifying the gaps in the current state aid rules is twofold:

  – section 3.3 provides an initial assessment of the potential gaps in the current state aid rules, based largely on desktop research. Each of the current rules is examined in turn, to gauge the extent to which it meets the above overarching objectives by incorporating the types of criteria, indicators and questions outlined in section 2;

  – section 3.4 then explores in more detail the gaps that may in practice be present in the state aid rules, by drawing on the more specific lessons learned from Oxera’s discussions with relevant parties. These practical issues relate both to the types of market failure that may emerge, and the information requirements placed on Member States.

– **Policy recommendations**—having identified the main gaps, section 3.5 proposes options for improving the use of the current frameworks and moving towards a more ‘ideal’ state aid policy. Key considerations are the current gaps identified above, and the level of information that should be required from Member States in each case, given that a priori market failures would be expected to occur in certain situations more than in others. The recommendations focus on four areas of special interest to the Commission:

  – state aid to intermediaries;
  – state aid to young or start-up innovative SMEs;
  – state aid to large innovative firms;
  – state aid for large innovative investments (or mega-projects).

– **Instruments**—it is for Member States to decide which policy instruments they wish to use. However, section 3.6 discusses briefly how the instruments might be assessed within the state aid rules.

The overall aim of this section is to provide some suggestions on how the existing rules might be complemented by further guidance, or modified, to target state aid more effectively. This could assist both the Commission in assessing state aid proposals put forward by
Member States, and Member States in presenting proposals to the Commission in the first instance. The analysis may be used to complement the guidance on state aid for innovation issued by the Commission, which is currently in the form of a consultation document, and is discussed in the introduction (European Commission 2005c). Within its recent consultation, the Commission considers that a new and separate framework for innovation would not be in line with the objective of simplifying state aid rules. Rather, it focuses on how the current rules might be improved to better enable targeting of state aid at innovation market failures. The current section focuses on the economic arguments regarding the rules for, and practice in, assessing state aid.  

3.1.2 Key findings

In summary, the key insights through following the above approach are as follows.

- **Broad versus narrow frameworks**—some of the state aid frameworks are, by design, more focused on innovation market failures than others. For example, the regional aid and SME aid rules naturally have somewhat broader agendas than the risk capital and R&D aid rules. However, the criteria, questions and indicators developed in section 2 could be used alongside any of the existing rules to assist decision-making. This may also mean that the de minimis regulations, which require very little analysis of innovation market failures, are used less often. The potential problem lies not so much, for example, in the de minimis provision, but in the gaps in the existing frameworks that may lead to recourse to the provision.

- **Risk capital**—the Risk Capital Communication (European Commission 2001c), of all the state aid rules, best captures the innovation market failure agenda. It adopts largely a checklist approach. Through transparent guidance, it adopts a number of the criteria and questions developed in section 2.4.5. The framework also recognises the important role of financial intermediaries. The current framework does not appear to place an undue information burden on Member States, and there may be scope for considering further the factors developed in section 2.4.5 to supplement the analysis, and to use these as a complementary checklist. However, there is the potential for the framework to lead to a high information burden if, given the aid intensity, an opening procedure is triggered. Consideration might be given to adopting a more flexible approach, in which an opening procedure is not triggered as readily, so long as the Member State has provided sufficient evidence upfront against this (in effect) expanded checklist, and the aid is sufficiently targeted.

- **R&D framework and large versus small firms**—the R&D Framework (European Commission 1996), which adopts upfront criteria, takes into account several relevant factors for assessing innovation market failures, developed in section 2, although there are some gaps. In particular, the Framework is not explicit on the types of market failure that arise in different circumstances, and may not require sufficient detailed analysis of innovation market failures in assessing proposals involving support to larger firms. Following section 2, there could be more scope for approving schemes aimed at small firms based on higher-level metrics. Given that smaller firms would a priori be expected to suffer from a wider range of market failures than larger firms, this may ensure a better balance between incurring Type II versus Type I errors in providing state aid. Changes to the R&D Framework are not necessarily required.

- **Incubators**—no specific framework exists that recognises the important role of incubators as intermediaries, or which provides guidance on assessing incubators. As

---

101 This section does not explore the legal issues regarding the current state aid rules, modifications to the rules, or the issuing of further guidance to accompany the existing rules.
such, good quality schemes may not be readily permitted under existing rules (eg, under the R&D or SME aid frameworks), and concerns have also been expressed over the lack of transparency (regarding a scheme that has been put forward). Reliance on the regional aid framework, SME aid and the de minimis provisions is not ideal. Section 2.4.4 identified guidance that could be used to assess and approve incubator schemes. This guidance might be considered in the context of Article 87(3)(c).

– **Large-scale investments**—in appraising very large-scale investments that might qualify for state aid under Article 87(3)(b), a transparent and robust economic framework supporting this decision-making process is probably required. Detailed questions on innovation market failures could be asked, and the criteria developed in section 2.4.6 might be used (although the theory and evidence are limited in this area). Nonetheless, it should also be recognised that whether a particular investment qualifies for treatment under Article 87(3)(b) will often be essentially a political decision.

– **Evidence**—more use of independent experts to assess innovation market failures might be helpful in the context of proposals put forward to assist larger firms.

What does this mean in terms of the broader options for modifying the way in which intermediaries, small firms, large firms, and large-scale investments are currently treated under the various state aid frameworks? The options are as follows.

1. **No change in approach**—the status quo is retained, with no changes to the existing frameworks or guidance around these frameworks.

2. **Strict criteria**—the Commission defines upfront stricter criteria and indicators for making decisions, requires a higher burden of proof, and analyses in detail individual proposals put forward to it against these criteria.

3. **Broad criteria**—this is an in-between case. The Commission might publish upfront guidance on the issues it would examine, which a Member State should bear in mind if claiming that a particular scheme aimed to resolve innovation market failures.

The potential options for modifying the current treatment of intermediaries, small firms, large firms, and large-scale investments are as follows.

– **Intermediaries**—potentially, for incubators, option 3 could be adopted. The guidance would outline what would be expected of any proposals put forward by Member States for assistance to incubators. In respect of financial intermediaries, option 3 could be adopted, with the existing framework complemented by a further checklist. Consideration might be given to adopting a more flexible approach in cases where an opening procedure might otherwise be triggered.

– **Young, innovative or start-up SMEs**—option 3 could be adopted, depending on the sector. Schemes that seek to address market failures in relation to smaller firms might be approved on the basis of higher-level metrics.

– **Larger firms**—stricter criteria (option 2) could be adopted in approving state aid to large firms for undertaking innovative investments. The extent of spillovers, coordination, and financial market failures might be explored in more detail.

– **Large-scale investments**—these raise additional considerations. In appraising large-scale investments that might qualify for state aid under Article 87(3)(b), detailed questions regarding the presence of innovation market failures could be asked, and the criteria developed in section 2.4.6 could be used (option 2).
3.2 Objectives of state aid policy

From an economics perspective, the ideal state aid policy towards innovation would:

- allow Member States to put forward, and the Commission to approve, measures which encourage innovation and which would otherwise not take place because of the existence of identifiable innovation market failures;
- recognise that state aid may be a second-best to other measures that might be employed by Member States;
- ensure that state aid is indispensable for the innovation being supported, including that it is proportionate to the market failure it is intended to correct, and is likely to be additional to, rather than crowd out, private sector investment;
- have a transparent and robust economic framework supporting this decision-making process within the context of the state aid rules;
- have clear information requirements, and a balanced burden of proof;
- not distort competition.

What does this mean in practice?

In line with the objectives of reform of the EU state aid regime, discussed in section 2.1, state aid should be targeted at correcting identified market failures hindering successful innovation. State aid should therefore encourage innovation that would not take place due to the presence of innovation market failures. Market failures mean that the level of innovation in the economy is sub-optimal.

Despite the complexities of the innovation process, as examined in sections 2.2 and 2.4, it is still possible to identify a limited set of market failures that affect the innovation process. To correct or reduce the impact of these market failures, state aid policy should focus on the following (although, as examined below, state aid may not be the only way to tackle these).

- **Spillovers**—through government support, increasing the private returns of innovative R&D projects or schemes, where public returns significantly exceed private returns (and private returns fall short of the cost of capital), to encourage innovation that would otherwise not occur.
- ** Appropriability**—enabling firms that generate knowledge to be able to appropriate the knowledge generated in the process of innovating (and in terms of the end-result), where free-riding effects by firms in the same market as the innovating firm undermine this, to enable private returns to be realised.
- **R&D coordination and network failures**—facilitating coordination to enable agents (as a group) to realise private returns where coordination is required for successful innovation, the coordinated solution is optimal in realising private returns, and where certain factors (eg, network effects) undermine this necessary coordination.
- **Financial market failures**—increasing the private returns to external financiers for investments in innovative firms characterised by high uncertainty, information asymmetries, high due diligence and high monitoring costs, through effectively lowering risks or private costs, thereby leveraging private finance into these firms.

104 See also Kroes, N. (2005b) and European Commission (2005d).
As discussed in section 2, to achieve the above aims, state aid may not be the first-best solution. Because innovation occurs as part of a system, a more effective and efficient approach may be to ensure that the underlying components of the system are present and work well, rather than employing more specific measures that constitute state aid. By definition, state aid has the potential to distort competition since it benefits specific companies within a market. Furthermore, state aid measures may not, in any case, be successful (or may be inefficient in terms of increased innovation per unit of public expenditure) in the absence of the socio-economic, political and cultural systems that support innovation (i.e., system-level features). In all three respects, a number of measures can be undertaken that do not necessarily constitute state aid.

For example, with reference to the four identified market failures, general measures to enhance the IPR regime (e.g., patenting regulations), and rules that allow for early-stage collaborative R&D through exemptions for such R&D within the competition regime, are not state aid. Furthermore, support to universities and the science base (to enhance spillovers, and which may also resolve coordination issues, particularly clustering), and ensuring a good quality entrepreneurial base to encourage the generation of better ideas for consideration by venture capitalists, may not involve state aid measures.

State aid is likely to be more effective if it is reserved for situations in which it is necessary or, indeed, indispensable for innovation, in the sense that, without the aid, it would not be possible, would be too costly, or would take too much time, to correct the innovation market failure using other measures. For example, adjusting institutional features of the economy that potentially act as barriers to innovation may be too costly, over a short timescale, in certain Member States. Countries with bank-centred financing systems may encounter difficulties in addressing financing problems faced by small innovative firms, since debt financing is less conducive to entrepreneurial activity than systems that place more emphasis on stock markets (see section 2.4.5). As the financing system is an inherent institutional feature of the economy, changing this situation rapidly may be unduly costly. Measures involving assistance to firms through government support for debt financing measures might need to be considered, although these are not ideal.

In addition, to be efficient, state aid should be proportionate to, and targeted at, the market failure that it is intended to correct. As suggested above, for example, in relation to coordination between firms, aid aimed at underwriting the risks of coordination would not necessarily be appropriate if other measures (e.g., relaxing the rules regulating joint ventures) could better achieve the aim, or achieve the aim at a lower cost. Furthermore, the impact of any state aid should be additional: providing too much aid, even if correctly targeted at an identified innovation market failure, or providing aid in the wrong circumstance, is unlikely to result in additional innovation. Rather, it may simply crowd out private sector investment. Moreover, it may waste taxpayer resources, and the soft budget constraint presented to firms through over-subsidisation could undermine, rather than encourage, innovation over the longer term. It helps to identify the circumstances in which government support is more likely to be additional. As discussed throughout section 2, this is more likely in the case of small innovative firms than large firms, because the former are more likely to suffer from a wider range of market failures than the latter.

105 The main concern regarding collaboration between firms undertaking R&D would be that this has the potential to extend into the product market, which may, in turn, facilitate collusive behaviour. Competition law generally recognises that R&D collaboration is not problematic if this occurs sufficiently far from the market. See Motta (2005). Moreover, collaboration between small firms might be not be expected to raise competition concerns.106 Furthermore, for those countries with more of an equity culture, a lack of credible exit mechanisms for venture capitalists is likely to hinder the development of risk capital finance to small innovative firms. But the European experience of establishing secondary markets, on which venture capitalists might exit via an IPO, has illustrated that developing critical mass can be difficult. Here, government-supported equity leveraging schemes, in addition to addressing information and transaction cost issues, might compensate, in part, for the lack of IPO exit opportunities (in Europe, most exits take place via trade sales).
Section 2 identified a number of criteria, questions and indicators that provide a robust economic rationale, based on innovation market failures, for evaluating ex ante state aid proposals put forward by Member States. These covered assistance to small firms, intermediaries, larger firms and large-scale investments. Having a defined set of criteria and indicators could make decision-making more objective. The way in which these criteria are used—ie, how they are incorporated into policy and applied in practice—should also be clear, to guarantee the transparency of policy. Clearer policies should lead to faster decision-making and more effective outcomes. In particular, the criteria identified in section 2 clarifies the information requirements that may be needed to evaluate a project or scheme. However, there might be a trade-off between using clear and transparent criteria (eg, companies younger than X years, in the biotech sector, investing more than Y% in R&D) and using broader criteria coupled with more in-depth analysis (to evaluate the scope of market failures and the incentive effect of state aid on a case-by-case basis). Finding the right balance can be difficult.

In relation to these information requirements, state aid policy should seek to achieve an appropriate balance between ‘Type I’ and ‘Type II’ errors.107 Due to information constraints, schemes that are innovative and that suffer from market failures may be missed by the evaluation methodology (ie, ‘Type I’ errors), or a particular scheme might be identified as being innovative and suffering from market failures, whereas, in the event, it may not (ie, ‘Type II’ errors). Section 2.1 identified that these errors are bound to occur but that, a priori, innovation market failures (particularly appropriability, coordination and financial market failures) would be expected to be more serious for smaller firms than for larger firms. Thus policy-makers should be more concerned about the probability of committing a Type II error (ie, allowing state aid even when the project does not suffer from innovation market failures) when state aid is being considered in relation to a larger firm than when it is being considered for smaller firms. Policy-makers should also take into account that, in assessing whether schemes aimed at smaller firms will actually address identifiable market failures, too stringent an approach has a higher probability of leading to Type I errors than if such an approach were applied to proposals larger firms. (Schemes that are innovative and that suffer from market failures may be missed and hence prohibited by the evaluation methodology.) The burden of proof should therefore be lower for schemes to support smaller firms.

Moreover, the indicators and criteria used for ex ante evaluation could actually be constrained by the available information, and an element of judgement outside of the strict application of any evaluation methodology will always be required. In this regard, proposals involving assistance to large firms tend to concern a specific investment, and will involve a detailed business plan developed around the investment; moreover, the company will have a track record and the resources to provide detailed information. In contrast, proposals involving state support to small firms tend to be in the form of schemes across several potential qualifying firms, less detailed information will be available ex ante, and small firms will have limited track record and fewer resources to provide detailed information. Again, this points towards a lower burden of proof for schemes to support smaller firms.

Thus, it is likely to be efficient to use a fuller complement of metrics developed in section 2 when assessing proposals relating to larger firms, and information requirements around these metrics could be greater. For schemes aimed at smaller firms, the higher-level metrics might be sufficient for policy purposes.

Finally, state aid policy should seek to minimise distortion to competition. State aid is more likely to have the potential to distort competition the more specific it is—for example, when aid is targeted to a specific firm (eg, a large firm) or group of firms (eg, a scheme covering a number of SMEs). In particular, such targeting has the potential to distort competition.

107 A Type I error occurs when a null hypothesis that is in fact true is rejected in the analysis. A Type II error occurs when a null hypothesis that is false is accepted in the analysis.
between eligible and non-eligible firms competing in the same product market(s). However, to resolve market failures efficiently, aid often needs to be targeted at such firms. As discussed below, Article 87(3)(c) captures the trade-off that needs to be achieved, in respect of interpreting this part of the Treaty in the context of innovation market failures. Whether distortions occur also depends on the market position of the recipient, the market structure, and the barriers to entry in the relevant market.

Nonetheless, aid provided to intermediaries (such as financial intermediaries or incubators), rather than to specific firms, may distort competition less—in particular if the services supplied by these intermediaries are not currently provided in the private sector to any large extent (e.g., seed funding, incubation). Moreover, the complexities of the innovation process may mean that, in certain situations, state aid for intermediaries is more appropriate than support for specific firms, particularly in the case of small firms, since the private sector (or state-owned intermediaries) is potentially better at picking winners than central government.108

The discussion below looks at the degree to which current state aid policy and practice encompasses the above principles.

### 3.3 Potential gaps in the current state aid rules

The underlying theme developed in section 2 was that innovation market failures are more likely to occur in relation to certain activities, sectors, firms, and stages of the firm's life cycle. Broadly speaking, innovation market failures (including spillovers, appropriability, coordination/network failures, and financial market failures) are more acute for:

- activities such as R&D (especially at the earlier stages);
- sectors such as high-tech (including biotech);
- smaller firms (with the exception of spillovers, which are generated by both large and small firms);
- firms at an earlier stage in their life cycle (seed or start-up).

In addition, spillovers will be relevant to larger firms undertaking R&D if they can demonstrate that their innovation proposals are radical, as their proposals are more likely to be justified on a stand-alone basis. In addition, R&D coordination failures may be pertinent for large firms, particularly in the case of large and complex projects.

A priori, the more that the above circumstances apply, the more likely it is that innovation market failures will arise. This therefore indicates that a tougher stance might be adopted towards state aid targeted at larger innovative firms than smaller innovative firms (or schemes that assist smaller innovative firms).

Sections 2.4.2 to 2.4.5 illustrated that, in assessing whether innovation market failures are likely to arise, other, more idiosyncratic factors should be taken into account, in the form of additional criteria, questions and indicators.

Section 2.4.6 showed that there were additional considerations that might need to be taken into account in appraising large-scale investments or mega projects.

The European Commission uses a number of state aid rules to assess the proposals put forward by Member States for assisting innovation. In what follows, these rules are discussed in turn, and the extent to which they do or do not take account of the concepts discussed in section 2 is considered. This provides an initial assessment of the gaps in the current rules.

---

108 See, for example, Navarro (2003). This emphasises that picking winners should be avoided, and that there should be more focus in the EU on providing public support for intermediaries.
for assessing innovation market failures. Section 3.4 provides more detail on the gaps that occur in practice, as elicited from discussions with relevant parties.

3.3.1 State aid: a three-pronged approach

The way in which state aid policy tends to work is that Member States must notify the Commission before introducing measures that might constitute state aid to enterprises. However, in certain instances, ex ante notification is not required, as is the case of SME aid (see below). Nonetheless, evidence from the five case studies undertaken as part of this analysis suggests that Member States tend to mould their proposals to fit into the existing state aid rules. The existence of any gaps in the current rules and processes, therefore, affects the degree to which the rules are effective in addressing innovation market failures.

As discussed throughout section 2 (see, for example, section 2.1), while proposals to assist larger firms are generally in the form of specific projects, those to assist smaller firms tend to be in the form of schemes across several potential qualifying firms. When putting forward projects or schemes for consideration by the Commission, Member States need to examine the following three basic questions (the Commission also appraises the proposals put forward by Member States along these lines, see, for example, European Commission 2004d):

- **is the measure state aid?** It should first be decided whether the assistance might distort competition or trade, and is therefore state aid (within the meaning of Article 87(1) of the Treaty). Little further analysis is required if the measure is not state aid:

- **can state aid be readily exempted?** If the measure is state aid, is it exempted under the specific Communications and Frameworks published by the Commission? Here, the Commission assesses the extent to which the proposals might distort competition or trade as opposed to addressing certain economic activities that are in the common interest of the Community (within the meaning of Article 87(3)(c) of the Treaty):

- **are there other means for granting exemption?** If the measure is not exempt under the specific rules, can the aid be exempted directly under Article 87(3)(c) of the Treaty, or under other aspects of the Treaty?

Figure 3.1 below provides a simple schematic representation of this framework.
Figure 3.1 Framework for assessing state aid

1. Is the measure state aid?
   - No: Approved
   - Yes: 2. Can the measure be readily exempted under Communications or Frameworks?
     - No: 3. Can the measure be exempted under other rules?
       - No: Not approved
       - Yes: Approved
     - Yes: Approved

Note: This figure is a simplification, and considers whether government assistance is likely to be approved if put forward to the Commission. In practice, Member States may not fully develop proposals for consideration by the Commission that are likely to receive a negative (non-approval) decision.
Source: Oxera.

The process, and how it affects the assessment of innovation market failures, is set out in more detail in the discussion below. As the state aid rules are fairly complex, for ease of exposition Figure 3.1 summarises the discussion, in terms of the process followed in the state aid rules (A) and the applicability of the different rules depending on the potential beneficiary (B). The figure can be used as a reference point for the discussion below.
3.3.2 Is the measure state aid?

Government assistance for innovation is, by default, permissible if it is not likely to be state aid. To be classed as state aid, the assistance must involve all of the following:

- it must constitute a transfer of state resources;
- it must provide a selective advantage to certain enterprises;
- it must have the potential to distort competition within the EU;
- it must have the potential to affect trade between Member States.

Given the above, which measures are unlikely to be state aid? Very general measures that are applied across the economy as a whole, and which are provided to public bodies not involved in ‘economic activities’ (which are therefore not ‘enterprises’ in a strict sense), such as funding for education and universities, do not constitute state aid under Article 87(1). Regulatory measures that do not directly affect the public budget (and thus do not involve a transfer of state resources) are also not state aid. In addition, while general tax breaks available to all businesses might not be classed as state aid, more selective tax breaks (eg, R&D tax credits for certain types of enterprise) might.

Therefore, as a rule of thumb, the less specific the government assistance, the more likely it is that it will not be classed as state aid.

Interestingly, however, in the field of innovation, in theory both significant selective assistance to very large enterprises (albeit in a situation where there are no competitors), or
Innovation market failures and state aid: developing criteria

Small amounts of selective assistance to any type of enterprise, might not be classified as state aid under Article 87(1).

- **Large-scale investments**—at one end of the spectrum, assistance to a large pan-EU monopoly firm might not be classed as state aid, since there is no distortion to competition and no effect on inter-EU trade. This was certainly relevant to the case of the Airbus A380 project. However, as discussed in section 2.4.6, the project might have been granted an exemption under Article 87(3)(b) (see below).

- **Small-scale assistance**—at the other end of the spectrum, a de minimis regulation permits small amounts of selective government assistance to be provided to any given enterprise. Assistance of up to €100,000 over three years does not constitute state aid.

Oxera’s discussions with interested parties revealed that the de minimis regulation is used extensively to approve aid for innovation (see section 3.4.6 below). In part, this is because there are gaps in the existing Communications and Frameworks published by the Commission for assessing innovation market failures (which may result in difficulties in otherwise approving schemes that do address innovation market failures). The de minimis regulation appears to be used as a ‘catch-all’, in the event that certain parts of an aid package cannot be approved under a specific set of rules (although it only covers aid of up to €100,000 over three years). However, under the de minimis regulation, extensive analysis by the Commission of the purpose of the government assistance concerned (eg, in addressing innovation market failures) is not required. Thus, it may allow state aid aimed at achieving other purposes, and so may not be an efficient way of facilitating the targeting of state aid to address innovation market failures. This is discussed further in section 3.4 below.

### 3.3.3 Communications and Frameworks

In the field of innovation, where a measure is classed as state aid, a variety of Communications and Frameworks are published by the Commission seeking to embody the principles of Article 87(3)(c), and thus allowing the aid to be exempted. As noted above, underlying Article 87(3)(c) is the idea that a balance should be struck between the measure concerned leading to this distortion to competition and the necessity and proportionality of the measure in achieving a Community objective (by encouraging ‘certain economic activities’).

This remit can be very broad in practice. Indeed, this is why more specific rules for assessing innovation market failures have been introduced (see below). In the specific context of the innovation market failure agenda, one interpretation is that Article 87(3)(c) requires weighing up the degree to which a measure might distort competition versus the degree to which it addresses innovation market failures. Thus, measures aimed at encouraging additional innovation should both target a real market failure and have desirable ‘incentive effects’ (the measure should generate additional activity, rather than crowd out existing activity).

Each Communication or Framework sets out a series of permissible instruments that can be chosen by Member States, and various permitted aid intensities and thresholds. Crucially, they vary in terms of the degree to which they seek to specifically address the objective of resolving innovation market failures, rather than achieving much broader objectives.

The following categories for exempting state aid have been of most relevance in Oxera’s case studies and discussions. These are presented in order, starting with those that seek to

---

109 In turn, this incentivises Member States to use some instruments over others (eg, tax breaks, grants, loans, guarantees), although the choice of instrument rests with Member States.
deal more specifically with innovation market failures, through to those that are much more broad in nature.\footnote{There are some interactions between each of the rules—eg, aid to SMEs and regional aid.}

- risk capital aid;
- R&D aid;
- SME aid;
- regional aid.

To what extent do these embody the concepts discussed in section 2, including the distinctions between activities, sectors, firms and stages of the firm's life cycle? The discussion below illustrates that, while some of the more specific Frameworks explicitly or implicitly use some of these principles (eg, the Risk Capital Communication), others (eg, the Regional Aid Framework) do not to the same extent. This is not surprising, given the varying underlying objectives of the Communications and Frameworks. However, if state aid is to be more focused on encouraging innovation, the criteria developed in section 2 could be used alongside any of the above existing frameworks to assist decision-making.

**Risk capital aid**

The Risk Capital Aid Communication (European Commission 2001c) is arguably the most comprehensive framework in considering innovation market failures. This predominantly seeks to deal with the financial market failures faced by small innovative firms. It embodies many of the issues outlined in section 2.4.5. The Communication was first adopted in 2001, and represents the most recent framework to date. Given the increased emphasis in policy over time on reserving state aid to tackle identified market failures, it is perhaps not surprising that this Framework captures the innovation market failure agenda more than others.

The Communication proposes a checklist approach to assessing innovation market failures, in which Member States must provide fairly detailed information, which is in turn assessed against various qualitative factors. This is in contrast to the R&D Framework (see below), which provides quantified upfront criteria against which a proposal may or may not qualify for state aid. As developed below, the checklist and upfront criteria approaches have advantages and disadvantages.

The Risk Capital Framework emphasises that the first-best solution is to create an environment for risk capital to be provided; it outlines the market failures that may arise in the provision of risk capital (asymmetric information, due diligence costs) and the types of firm likely to be affected (small high-growth firms, potentially in specific sectors); it sets out the evidence that would be required from Member States on such market failures; and lists a series of qualitative ‘positive and negative factors’ that would be taken into account in balancing whether the chosen instrument would be more or less likely to distort competition and resolve market failures. Tables 2.9, 2.10 and 2.11 might be used to complement these considerations.

The Risk Capital Communication breaks down aid as being provided at three levels: at the level of the investor, the fund manager, and the SME. In particular, the Communication, and its implementation in practice, recognises the benefits of providing support to financial intermediaries (eg, through competitively tendered venture capital leveraging schemes), rather than through direct support to firms.\footnote{Indeed, the recent decision on the UK Enterprise Capital Fund scheme actively played down any distortion to competition occurring at the intermediary level, in part since it would result in new types of fund being established.} This is in contrast to other frameworks, which do not appear to take sufficient account of the potential role for intermediaries in facilitating innovation and thus may be unable to provide a mechanism to enable well-targeted state aid to be granted.
Essentially, the Risk Capital Framework captures the innovation market failure agenda in a number of ways. Moreover, by following a checklist approach, it appears to address this agenda more explicitly and thoroughly than the R&D Framework (see below). Given the controversies surrounding financial market failures discussed in section 2.4.5, the indicators put forward in Tables 2.9, 2.10 and 2.11 might be useful in clarifying further whether financing problems are due to ‘strict’ market failures (information/transaction costs), or institutional/demand-side factors, complementing the considerations already taken into account in the framework. The criteria in these tables have been developed with schemes in mind that cover qualifying firms, and are developed mainly at the level of the country, qualifying sector and qualifying firm (rather than at a more disaggregated level). In themselves, the additional factors should not place too much of an additional burden on Member States.

Nonetheless, lessons can be learned from how the Risk Capital Framework has been applied in the past. Oxera’s discussions with the Commission have confirmed that the majority of measures approved under the Risk Capital Communication are granted approval in a relatively short timespan, following a comparatively simple notification. Thus, as the Framework stands, the use of a checklist approach does not necessarily place an undue information burden on Member States—indeed, the further factors listed in Tables 2.9 to 2.11 might complement the analysis. As will be discussed further in section 3.4.5, however, the Communication has placed a much higher burden on a Member State where the level of aid requested has subsequently triggered an opening procedure (in-depth investigation). In effect, information burden problems may occur due to the interaction of the checklist approach inherent in the Risk Capital Framework, the permitted aid intensities under the framework, and a triggering of a detailed investigation. A more flexible approach could be adopted, as will be discussed below.

R&D aid

The R&D Framework (European Commission 1996) applies to enterprises undertaking R&D. It thus recognises its role as a crucial form of innovation activity, which is both relevant to innovation market failures and is measurable (see section 2.3.3). As noted above, the R&D Framework mainly sets out quantified upfront criteria against which schemes may or may not qualify for state aid. Nonetheless, some further questions are asked as part of the Framework, in particular with regard to proposals put forward to assist large firms.

The Framework sets out different permitted aid intensities for R&D by stage of R&D, depending on whether it constitutes fundamental research (100%), industrial research (50%) or pre-competitive development (25%). In respect of defining R&D costs, these may include staff employed solely in the R&D activity, equipment used solely in undertaking R&D, and overheads. Higher aid intensities are also allowed if the results of the project will be widely disseminated and published.

Areas qualifying for regional aid, and SMEs (under the EC definition) are allowed higher permitted aid intensities. Additional aid is also allowed to support patent applications by SMEs (thus recognising the appropriability issues facing them). SMEs are also exempt from further analysis of the ‘incentive effects’ of R&D aid (ie, the extent to which it addresses market failures and achieves additionality). Analysis of incentive effects is, however, required in the context of larger firms or investments. Here, the R&D concerned must be in addition to the ‘normal day-to-day operations’ of the firm. Considerations taken into account are the degree to which the scheme enables R&D that would otherwise not be pursued, expands its scope or speeds it up, justified with reference to market failures.

In addition, the Framework touches on the role of collaborative R&D. Higher aid intensities are allowed if R&D involves cross-border cooperation, or cooperation between firms and public research bodies (particularly if the project is part of an EU Framework programme), and the analysis of incentive effects may also take account of the additional costs involved in achieving cross-border cooperation. A positive view is taken towards projects involving
cooperation between two partners in at least two Member States, granting of patents, and wide dissemination of the results.

Where, therefore, are the gaps? The R&D Framework captures a number of the issues discussed in section 2 and, in particular, some of the criteria, questions and indicators put forward in Tables 2.3–2.5 (and, implicitly, in Table 2.11). The Framework, adopted in 1996, represented a key step forward in analysing state aid proposals, but it is not always explicit on why the approach adopted has been followed, nor is it explicit about a number of additional considerations that should be taken into account. This may be because the Framework was not developed solely with innovation market failures in mind. In addition, it could be argued that the Framework is an ‘operational translation’ of several of the underlying ideas regarding innovation market failures, which is why the economics underlying it are not spelt out explicitly. Thus, the criteria are not necessarily problematic in themselves, if they are based on sound economics. The additional issues raised in section 2 might assist practitioners in using the R&D Framework.

In terms of the concepts captured within the Framework, the distinction between the allowable intensities for the various stages of R&D, and between large versus small firms, implicitly recognises differences in, and likely magnitude of, market failures that might occur in undertaking R&D across sizes of firm and stage. The Framework recognises that the earlier stages of the R&D process are riskier than later stages. There is, however, no explicit mention of the extent of spillovers at the early stages versus later stages (see Table 2.3). Rather, the main justification for the distinctions drawn is that aid for projects in later stages, which are closer to the market, may distort competition. Nonetheless, the additional spillovers that might emerge through patenting, dissemination and publication are recognised in the Framework.

In respect of SMEs versus large firms, the higher permitted aid intensities in the case of SMEs—and the fact that incentive effects do not need to be explored—implicitly recognises that the generality of market failures would be expected to be higher for SMEs than for large firms, and that state aid to large firms may involve selection bias (see section 2.4.2). In respect of the latter, the fact that, for large firms, R&D should be in addition to normal day-to-day activities shows that the Commission is cautious in approving aid to companies that undertake a proliferation of R&D projects as part of their core business model.

However, little explicit detail overall is provided in the Framework on the market failures that might affect SMEs versus large firms. Furthermore, it does not emphasise particular sectors over others (section 2.4.2 illustrated that spillovers are likely to be higher in high-tech sectors). Activities that might lead to innovation but which are not R&D are not catered for within the Framework, although there is some debate as to whether this is desirable. These issues are discussed further in section 3.4.1 below.

The additional issues that arise in collaborative R&D, in particular, are discussed only very briefly in the Framework. The increased aid intensities for such R&D, and the treatment of collaborative R&D within the incentive effects analysis, implicitly recognises that cooperation may generate larger spillovers, and may be riskier to pursue. However, little additional clarification is provided, particularly on the extent of coordination R&D spillovers and when coordination failures might occur. Table 2.5 highlighted issues that might be considered in these respects (for example, complementary versus substitute R&D, complexity of the project, number of partners and factors facilitating trust). Also, the Framework does not place much emphasis on the role of inter-firm cooperation on R&D, which may be as prone to coordination failures as cooperation between public and private bodies.

In summary, while the R&D Framework captures some important issues, little explicit detail overall is provided on the particular market failures in relation to R&D (for example, spillovers, coordination and financial market failures), and the circumstances in which these are likely to occur. There are, however, several implicit assumptions within the R&D Framework that are consistent with the considerations discussed in sections 2.4.2 to 2.4.5.
As highlighted above, the additional issues raised in section 2 might assist practitioners in using the Framework to target the R&D aid more effectively to innovation market failures.

Furthermore, while the Framework is well suited to some of the direct market failure problems faced by firms undertaking R&D, it does not appear to allow interventions that would be focused directly on the role of intermediaries, such as incubators. As a result, some types of state aid that would target innovation market failures, including those with a direct impact on R&D activity, are not allowable under this Framework. The Framework, and the role of incubators, are both discussed further in section 3.4.

**SME aid**

The SME aid exemption focuses on SMEs per se and covers independent private companies with fewer than 250 employees (or €50m in annual turnover, or €43m in balance-sheet assets) (European Commission 2001b). Here, the investment expenditure that might qualify is quite broad, and is not restricted to innovative activities. Aid is permissible for investment in tangible (e.g., buildings) and intangible assets (e.g., technology transfer). Regarding investment, the rules permit aid intensities of up to 15% for small and micro-sized firms (fewer than 50 and fewer than 10 employees, respectively), or up to 7.5% for medium-sized firms. Higher intensities apply to areas qualifying for regional aid. Qualifying operating expenditure includes consultancy costs, and up to 50% of consultancy costs may be covered by aid. SME aid is exempt from ex ante notification to the Commission, although large projects undertaken by SMEs are not.

The framework is aimed at support for all types of SME, rather than necessarily innovative SMEs, and covers a wide variety of expenditures. By definition, the framework draws a line between large and small companies. As discussed in section 2.4.4, SMEs may lack access to general networking, and, as noted in section 2.4.3, do not proactively seek to protect their intellectual property.

However, the SME framework does not draw any distinctions between activity, sector or stage of development, since it has broader objectives. As discussed throughout section 2, innovative SMEs (for example, R&D-intensive start-ups in high-tech sectors) are more likely to be characterised by innovation market failures. This Framework therefore allows some state aid schemes that would address innovation market failures, but also allows schemes that are likely to have no, or very little, impact on innovation. In addition, as examined in section 3.4.2 below, the SME framework does not adequately account for the role of intermediaries, such as incubators.

**Regional aid**

Regional aid may be provided in qualifying ‘less-favoured’ regions of the EU, in which the aim is to assist the development of these regions (European Commission 1998). Under the guidelines, government support for initial investment and operating costs is permissible. For the most disadvantaged regions,112 aid intensities of between 40% and 65% are permissible. For other qualifying regions,113 aid intensities of up between 10% and 30% are permitted. Aid is conditional on the maintenance of the investment or employment created for at least five years. The aid intensities are reduced for large investment projects (of over €50m).

Since the Regional Aid Framework is aimed at covering wider objectives beyond innovation, such as development, employment and social cohesion in disadvantaged regions, the framework does not include a requirement for Member States to demonstrate the existence of innovation market failures. Recent schemes to roll out broadband in Wales and Spain,

---

112 As per Article 87(3)(a).
113 As per Article 87(3)(c).
have involved an assessment of the distortion to competition, for example requiring open access and competitive procurement, but not necessarily innovation market failures.\textsuperscript{114}

Like the SME Framework, the Regional Framework thus allows schemes that are targeted at innovation market failures, but does not necessarily require schemes to be targeted in this fashion. However, the Regional Aid Framework does allow for aid targeted at intermediaries such as incubators. From this perspective, it is more flexible with respect to innovation market failures. However, because this Framework is limited to specific regions, and innovation market failure occurs in all geographic locations, this may not be the most efficient framework for the general facilitation of innovation-targeted state aid. This is arguably an issue in the UK, since the number of areas qualifying for regional aid is falling over time.

The Regional Aid Framework, and the role of incubators, is discussed further in section 3.4.2.

### 3.3.4 Other rules

Even if aid cannot be exempted under the Communications and Frameworks discussed above, the aid might be exempted through explicit reference to the Treaty and the principles embodied in Article 87(3)(c) itself. For example, the European Commission (2004d) suggests that incubators might be approved under regional aid, SME aid or, failing this, directly under Article 87(3)(c). However, by its very nature, little guidance is available on how any such aid should relate to innovation market failures. The Treaty does, however, provide the flexibility to look at the issues discussed in section 2, in considering aid not captured by other rules.

Other means through which projects might receive state aid for innovation are sector-specific frameworks. However, the only sector qualifying for ‘innovation aid’ is shipbuilding, which has a separate framework, given the size of the industry and its history of overcapacity. Section 2.3.2 highlighted that the demonstration of radical innovation was required, and that this should be linked to the risk of failure of the project.

Crucially, Article 87 3(b) enables projects that are sufficiently large to be of ‘an important project of common European interest’ (and to qualify for an exemption under the Treaty). Although there is some leeway in the Commission’s decision-making, the principles include that the aid must be ‘necessary’ for the promotion of the project; aimed at a well-defined specific project; important in terms of size and qualities; and of common European interest.

However, few projects have actually been considered under Article 87 3(b). Section 2.4.6 highlighted that although the Airbus A380 project could have been considered under this exemption, in practice it was exempted on the grounds that it did not constitute state aid under the definition of Article 87(1) of the Treaty.

Section 2.4.6 noted that additional considerations should be taken into account for large-scale investments or mega-projects. It was judged that an assessment of innovation market failures was probably required to qualify such projects for consideration under Article 87(3)(b). Such projects should be stand-alone and large, and involve radical innovation. Market failures that might arise then include (pan-EU) spillovers, coordination failures and potential financial market failures. However, as discussed, this is a controversial area, with sparse theory and evidence. Furthermore, large-scale projects tend to underperform against forecasts. Care therefore needs to be exercised in assessing whether the spillovers from such projects justify the assistance to be provided, and whether lack of investor interest

\textsuperscript{114} In the UK (specifically Wales) and Spain, these, and many other government schemes, have frequently been examined under the regional aid provisions, which permit state support for productive investment and job creation in less-favoured regions. Here, Article 87 3(c) enables state support to be provided to disadvantaged areas, provided that the aid is given exclusively to those areas. In this context, aid is more likely to be granted if there is open access, there is no favouring of a specific technology, it involves competitive procurement of the services required, and it enables open access to third-party providers, because the potential to distort competition is less. Aid is also more likely to be allowed if it avoids excess profits by providing for progressive reimbursement to the public sector as demand increases. See, for example DTI (2004).
necessarily constitutes a financial market failure, or a more realistic assessment of the likely
economic return on the investment.

3.4 Gaps in current state aid practice

The above discussion provides an initial assessment of the gaps in the current frameworks
for assessing innovation market failures, and the specificity (or otherwise) of the rules to
innovation market failures. In all cases, the issues discussed and criteria put forward in
section 2 could be used to complement the existing rules.

To gain a better understanding of the problems that occur in practice, and the policy issues,
Oxera has spoken to a number of interested parties about the issues that arise in assessing
state aid proposals justified on the grounds of resolving innovation market failures, and
where further guidance to complement the existing rules would be useful. This presents a
key opportunity for the concepts developed in section 2 to be incorporated into policy.

It should nonetheless be emphasised that the gaps identified have been developed, from the
case studies reviewed and the discussions with stakeholders. Although Oxera interviewed a
number of stakeholders, a different picture might emerge from a more comprehensive survey
of state aid cases, and, in particular, further interviews with Commission officials.

The important themes that have emerged from the discussions, can be classified into:

– innovation market failures per se;
– information requirements.

With respect to innovation market failures, the following issues arose:

– **R&D Framework and market failures**—(as suggested in section 3.3.3) the R&D
Framework does not require practitioners to explore in detail the market failures that
may emerge in R&D, in particular in relation to larger firms. From discussions with
practitioners, Oxera understands that the Framework takes as given that R&D is a ‘good
thing’ and, although there is an additionality requirement for larger firms, this may not
facilitate sufficient assessment of market failures faced by large versus small firms. A
priori, section 2 shows that market failures overall for larger firms are likely to be lower
than for smaller firms.

– **Incubators**—(as suggested in section 3.3) the current frameworks do not cater
adequately for helping incubators to resolve potential network and property market
failures. Incubators, if used correctly, can be an efficient form of intermediary designed
to help start-up innovative SMEs. Indirectly, they might resolve problems faced by start-
ups in accessing financial markets. It was identified from discussions with practitioners
that clearer upfront guidance may be of use in facilitating state aid to be provided to
incubators in a way that is both efficient and well targeted. This is developed below.
There is also a need for more transparency from Member States when creating their
proposals for addressing innovation market failures via intermediaries.

– **Large-scale investments and Article 87(3)(b)**—(as discussed in section 3.3.4)
Article 87(3)(b) has been used very little by the Commission since the introduction of the
1996 R&D Framework. Arguably, the use of this exemption could be explored further,
but further guidance would probably be useful.

In relation to information requirements and transparency, the following themes are important.

– **Use of independent experts on market failures**—relating closely to the points above
regarding the R&D Framework, two cases have revealed that, while attention might be
focused on the use of independent external experts to resolve whether proposals aimed
at large firms considered under the R&D Framework are innovative, less use may be made of external experts in assessing whether market failures exist.

- **Comparative information burden**—as noted above, the Risk Capital Framework appears to embody the innovation market failure agenda. Arguably, however, more information relevant to innovation market failures is required under the Risk Capital Communication (checklist) approach than under the R&D (upfront criteria) approach. In turn, this may reveal a potential imbalance between approving assistance to large R&D-orientated companies, on the one hand, and for measures designed to boost SME innovation by resolving financial market failures, on the other. The Risk Capital Framework does not appear problematic in respect of the information required (and there may also be merit in considering the additional factors developed in this report, expanding the checklist). In effect, the imbalance indicates that not enough detailed questions are asked regarding assistance to large firms within the R&D Framework. However, there has been a problem in the past in which a Member State has sought approval for a scheme under the Risk Capital Framework, and a detailed investigation was triggered. It is the interaction of the checklist approach followed and when a detailed opening procedure might be triggered that may cause information burden problems under the Risk Capital Framework. Consideration might be given to adopting a more flexible approach, in which an opening procedure is not triggered as readily, so long as the Member State has provided sufficient evidence upfront and the aid is sufficiently targeted.

- **Use of de minimis provision**—the limitation of measures to the de minimis level (see section 3.3.2) may simply reveal the extent of the gaps in the current frameworks, although, by definition, the measure covers relatively modest amounts of aid. The regulation tends to be used as a default where either the existing frameworks do not adequately deal with innovation market failures (for example, in respect of incubators), or potentially in proposals in which it is questionable that innovation market failures actually occur. In respect of both, particular elements of proposals can be hived off, placed into the de minimis box, and approved without further detailed analysis.

These issues are discussed in further detail below. How the lessons from section 2 might feed into policy is then also considered.

### 3.4.1 R&D Framework and market failures

While incorporating some of the concepts discussed in section 2, the R&D Framework may not explicitly take sufficient account of the market failures faced by large versus small firms in undertaking R&D. The approach of using upfront criteria with some further questions does not require an analysis of all aspects of market failures. As will be argued below, this means that, at present, too little analysis is undertaken of the innovation market failures that arise regarding proposals to assist larger firms.

As discussed in section 2.4.2, while the evidence indicates that R&D generates spillovers, it also suggests that government support is biased towards R&D and towards larger firms, and that support may not add significantly to the R&D that would otherwise have been undertaken by the private sector (due to selection bias). The challenge for policy is to identify projects that, at the margin, would not otherwise go ahead, particularly for larger companies. Part of this involves gaining a better understanding of the size of the spillovers concerned.

In this regard, the evidence reveals that there is a higher probability of achieving additionality in supporting smaller firms than in supporting larger firms. This suggests that the current provisions of the R&D Framework—that small firms do not need to demonstrate incentives effects whereas large firms do—is appropriate. The fundamental problem with the R&D Framework, however, is that it potentially does not go far enough in requiring case handlers to explore in detail the market failures that arise in the context of larger firms. Although spillovers occur from R&D undertaken by both large and small firms, problems regarding
appropriability, coordination and financing market failures would a priori be expected to affect innovative SMEs more than larger firms.

What this all points to is that, while state aid for R&D schemes aimed at innovative SMEs might be approved on the basis that they are targeted, for example, at young firms undertaking R&D in particular sectors, a more thorough analysis of the likely spillover effects (and other market failures) is potentially required in the case of state aid targeted at larger firms.

In addition, section 3.3.3 reveals that the guidance in the Framework is somewhat incomplete on other aspects, such as the role of the sector concerned, and when R&D coordination failures might be expected to occur.

Oxera examined three cases that had been appraised by the Commission under the R&D Framework. The first two considered R&D undertaken by firms in high-tech sectors: aircraft engines and pharmaceuticals, respectively. As highlighted in section 2.4.2, a priori, it would be expected that spillovers might be higher in these sectors than in other sectors. However, several lessons can be learned from these cases. The last case related to a scheme aimed at assisting young innovative firms undertaking R&D.¹¹⁵

Box 3.1 considers some of the issues arising in the Rolls-Royce engines case.

**Box 3.1 Rolls-Royce engines**

Oxera spoke to a case handler involved in the Rolls-Royce engines case (European Commission 2001d). The company needed to show that its new engines were sufficiently different from previous ones (the radical nature of the innovation), and various aspects of this were examined (see Box 2.1). Such factors, regarding innovation, were analysed as the result of challenges made by a complainant, and it was felt that the factors would not have been examined in the absence of a complainant. Although external consultants were employed to look at the above technical matters regarding the innovativeness of the proposals (see Box 2.4), there was less analysis of what this meant for market failures, or the size of the market failures, under the analysis of incentive effects.

For example, the size of the potential spillovers from the project was not looked at in detail. Also, because the R&D Framework treats R&D investments as stand-alone investments, the nature and size of the investment activity was not related back to the nature and size of the firm concerned, in terms of its ability to finance the investment. Although the long payback period and revenue risk associated with the investment were considered, the issue of whether the high technical and commercial risk implied that the project would not have been undertaken without state support was not considered in detail.

The discussion in Box 3.1 does not mean that market failures do not occur in relation to large company innovative projects, or that the wrong decision was taken in the Rolls-Royce case. Market failures can and do occur, and various issues may arise in the aircraft sector. However, in the above case, following the R&D Framework, such issues did not need to be considered in much detail. Hypothetically, the aid might have been permitted in the absence of any significant spillover effects. The radical and launch-stage nature of the innovation could have been more explicitly linked both to the spillover effects and financing problems that may arise, although, as discussed in section 2.4.6, financial market failures are more acute for mega-projects than for large firms undertaking innovative investment projects. The spillover factors considered in Table 2.3, and the coordination issues identified in Table 2.5

¹¹⁵ Elements of these cases were discussed in Boxes 2.1, 2.2, 2.4 and 2.11.
Oxera also interviewed a case handler involved in the case of R&D aid being provided to an Italian pharmaceutical company (see Box 3.2). This was in the form of an upfront grant, in contrast to the risk-sharing measures typically seen in the aircraft engine sector (including in the case of Rolls-Royce).

Box 3.2  Italian pharmaceuticals

In this case (European Commission 2004c), the novelty of the molecules being developed was considered in determining whether the proposals were innovative. Science experts were involved in examining this question (see Box 2.1); however, as with the Rolls-Royce case, other experts were not drafted in to analyse whether market failures existed.

In this case, there were some problems in appraising the various stages of innovation, and fitting these into the R&D Framework. It was felt that the 1996 Framework had well-defined physical stages in mind (such as in the aircraft engine sector), rather than the more continuous stages in pharmaceuticals (see Box 2.2). In respect of market failures, it was felt that the emphasis of the Framework is that R&D is generally a 'good thing' to be encouraged: the rules are not aimed at assessing whether a very specific proposal has an impact in resolving market failures. Technical risks were considered in the analysis of incentive effects, given that there were inherent risks in a new field (large molecules). However, the question of whether the company would be able to finance the R&D in the absence of state aid was not analysed in detail. Rather, the additionality criterion simply required that the investment be improved in some way through government support.

An interesting issue regarding the Italian case study was that the beneficiary was a subsidiary of a larger group and that R&D tends to be an integral part of what pharmaceutical companies do to survive in the market. The risks of undertaking several overlapping R&D projects would be expected to be reflected in the parent’s cost of equity. Furthermore, the subsidiary might, in theory, have access to the retained earnings of the parent. Section 2 suggests that financing market failures would not be expected to arise, as the investment should not, in theory, suffer from either very small innovative company effects, or very large-scale investment effects (see sections 2.4.5 and 2.4.6). The R&D Framework, in contrast to the risk capital framework, arguably did not prescribe that these issues should be explored. This is not to say that the project would not generate spillovers or suffer from other market failures, or that the wrong decision was taken in this case: rather, the issues did not need to be considered in detail. Hypothetically, the aid might have been granted in the absence of significant spillover effects (although the radical nature of the innovation was considered).

Box 3.3 sets out the policy issues discussed with a representative from a French Ministry concerning a scheme, eventually approved by the Commission, designed to assist young SMEs undertaking R&D.

Box 3.3  Young innovative SMEs

Oxera discussed with a member of a French Ministry about a specific case (European Commission 2003a), and whether the R&D Framework was adequate in granting aid to young small innovative companies undertaking R&D (see also Boxes 2.2 and 2.11). An initial package of measures was developed in light of the perceived financial market failures affecting innovative SMEs in France. The scheme applied to small firms less than eight years old, undertaking at least 15% of their expenditure on R&D. Thus, it took account of
the size and age of the firm, and its investment activity.

However, aspects that were included in the initial proposals had to be excluded in the final proposals. In the end, the stages of allowed R&D excluded selling of initial runs; aid was to be restricted to funding projects of firms rather than firms per se; and the measure itself under the R&D Framework was restricted to a social security exoneration (to enable young firms to recruit and get up to speed). A corporation tax reduction (covering later stages) was permitted only under the de minimis rules. SMEs must also regularly monitor and report on their R&D expenditure.

The Ministry took the view that the Framework was therefore too limited in its focus on innovation. In the Ministry’s view, innovation is not about only the early stages, but considers the process as a whole; the stages of the R&D Framework take too narrow a view of the technological aspects of innovation (it is not possible to obtain aid on an initial run or limited market testing of products), and the Framework also takes a narrow view on the non-technological aspects of innovation (it is not possible to obtain aid for non-R&D expenses such as marketing).

Nonetheless, while it is correct that innovation is a fairly broad concept, section 2 shows that innovation market failures tend only to occur for a subset of innovative activities—for example, later-stage activities, undertaken even by smaller firms, would not be expected to suffer from severe market failures (see also Box 2.3 and the discussion pertaining to this).

However, there might be some scope for allowing more support for innovative SMEs where this does not distort competition. For example, aid might be permitted for an initial small-scale run or market test, if there is sufficient evidence that significant uncertainty still exists at this stage. In addition, although SMEs should also be held accountable for the progress of their R&D projects if public support is provided, a balance needs to be struck between the resulting administration costs and ensuring accountability. Because the social security exoneration aspect of the proposals lowers the costs to small firms at the point of undertaking R&D (rather than raising post-R&D profits), this would be expected to have an effect in incentivising R&D activity that would otherwise not be facilitated.

Box 2.7 highlighted that, if projects require coordination between firms (even larger firms), this may be a good signal of additionality. As discussed in section 3.3.3, the R&D Framework does not provide detailed guidance on these issues.

The main conclusions from the above discussion are given below.

– **Small firms**—because, a priori, small firms undertaking R&D activity would be more likely to suffer from market failures than larger firms, there could be more scope for allowing, across the EU, the types of scheme put forward by the French government for assisting SMEs. Schemes might be justified on the basis of higher-level metrics, since aid would a priori be expected to be more additional for small, young, innovative firms undertaking R&D activity. Schemes might also focus on particular sectors. Nonetheless, if schemes are justified with reference to financial market failures, they should not necessarily be considered in isolation from existing initiatives that might seek to resolve such failures more directly (see section 3.6.5 below).

– **Large firms**—too little analysis of the market failures that arise in relation to larger firms is currently undertaken, in part because the R&D Framework is not explicit on the types of market failure that might arise at various stages of the R&D process. More might be required in terms of the evidence on spillovers, coordination failures, and financial market failures, especially if the firm is a subsidiary of a larger group. As identified in section 2, financial market failures would not a priori be expected to occur, although the radical nature of the innovation will affect the risks involved. Many of the criteria,
indicators and questions developed in section 2 could be applied to R&D investments undertaken by larger firms.

3.4.2 Incubators
Section 2.4.4 explored the potential role of incubators. There are, at present, considerable difficulties for genuine incubators—intermediaries renting out space and providing services to start-ups—in obtaining government assistance that might be deemed to be state aid. The underlying problem is that aid to incubation intermediaries is not explicitly catered for in any of the state aid frameworks. Aid is only granted if it meets some other criteria that, on the whole, are not necessarily related to innovation market failures (eg, the region the incubator is in, or the limited size of the aid). Incubators therefore fall between the gaps.

As discussed in section 3.3.3, the R&D Framework applies only to firms undertaking R&D, and the thresholds in the SME rules cover the end-aid provided to privately owned SMEs, rather than higher thresholds which might apply to intermediaries. In contrast, the Risk Capital Framework explicitly recognises the role of financial intermediaries (through venture capital fund vehicles) in providing assistance to SMEs.

State aid for incubators therefore tends to be approved under the regional aid rules, which are less demanding provided that the area concerned qualifies for regional aid, or are split between approvals under the SME guidelines and the de minimis regulations. The last two areas are also less demanding in respect of evidence. Potentially, approval directly under Article 87(3)(c) might also be possible. However, approval via these routes, as they stand, is not optimal—potentially, they also provide a loophole for poorly targeted incubators to be approved for state aid.

Therefore, it is not surprising that, as noted in section 2.4.4, there is little evidence on the economic impact of incubators. Fundamentally, it is not clear that the underlying objective of all incubators across the EU is to foster start-up SME innovation and entrepreneurship, and to resolve market failures.

There is a need to resolve this gap, because:

- providing support to good quality intermediaries, rather than to individual firms, is less likely to distort competition. In addition, it avoids central government picking winners;

- incubators have the potential to resolve networking and property market failures faced by SMEs (particularly start-ups), which are the end-beneficiaries of such aid;

- incubators are a useful tool in enabling innovative SMEs to become ‘investor-ready’, thereby potentially resolving problems faced by start-ups in accessing finance.

The difficulties faced by incubators in attracting government funding were highlighted when Oxera spoke to an incubator in north-east England. The policy issues are further discussed in Box 3.4.
Box 3.4 EU state aid policy towards incubators

Oxera’s discussions with an incubator in north-east England revealed how, in its view, real incubators do not distort competition with existing property developers, since the private sector does not undertake genuine incubation functions (see also Box 2.10).

The incubator had, in its view, stuck to a genuine incubator remit. At the same time, to become more professional and efficient, it had commercialised, adopting a company-limited-by-guarantee structure, and operating on a public–private partnership (PPP) basis. However, to expand its facilities, it required some form of government assistance. The incubator highlighted that an incubation fund for England had failed to be established, and subsequently national funding for the development of incubators was withdrawn.

The above concerns access to funds provided by a Member State. However, the incubator also raised the issue of how, due to its status, it faced difficulties in gaining access to European-level funding (rather than, say, through national regional aid). Such funding had been made available in eligible areas, but state aid rules applied for grant application purposes. In the case of the commercially operated incubator, it was treated as an SME under the rules (having previously been treated as a public body), which limited the available funding. In the opinion of the incubator, the funding allowed was inadequate to support the financial viability of further incubator development in the area, since the incubator’s rental income was insufficient to support the levels of commercial borrowing necessary to fund further capital development. In the incubator’s view, the capital development of an incubator is treated as a commercial property development, and fails to recognise the public objectives of incubation.

These types of concern were also raised in discussions between Oxera and innovation experts in a UK government department on this issue. The representatives questioned the notion that commercial incubators distort competition whereas public sector bodies compete with no one. It highlighted that there was a need for more commercially focused incubators, rather than just university-orientated incubators. The experts felt that granting aid to SMEs was more straightforward under existing state aid rules than providing aid to incubators.

Concerns have also been raised in certain published documents. For example, the UK DTI has argued the following regarding national regional aid:

> The Commission takes a very limited view of the funding of incubation activities, equating this with other, standard property development activities. This is reflected in its insistence that investment aid in incubators is approved through instruments dependant on the Regional Aid Guidelines and the aid intensities therein (DTI 2004). ¹¹⁶

The DTI also voiced concerns, regarding state aid rules, about the difficulties it has faced in implementing the Small Business Service Incubation Scheme, which involves delivery through arm’s-length, independent, incorporated, not-for-profit bodies, rather than through direct provision by government (DTI 2004).

The problems of lack of transparency regarding a scheme put forward in Germany, to create a series of incubators, were also discussed with Commission officials. The lack of clear guidelines for the consideration of incubators was very much apparent in this case (see Box 3.5).

¹¹⁶ The DTI does not recommend that incubator schemes should not be examined under the Regional Aid guidelines, but that sole reliance on the Regional Aid Framework may mean that the mentoring, assistance, sharing of areas and networking roles of incubators are not adequately recognised. It recommends expanding the SME rules to cater for all these factors.
Box 3.5 Incubator scheme in Germany

A fairly complex case involved the consideration of a scheme for state aid to be provided to create a series of incubators in Germany (see also Box 2.10, and European Commission 2004b). In this case, there was a need to consider aid at both the intermediary and SME level. A key concern, however, was the degree to which aid to the (public sector) incubators translated into the desired assistance to the SMEs.

As discussed in section 2.4.4, the justification for the scheme was based on financial market failures, property market failures and networking failures. It involved a grant being provided to local communes to build the facilities, with the result that the rents charged would be subsidised. Initially, an aid intensity of 90% was sought, with 95% of the schemes being in assisted areas qualifying for regional aid. This was very high aid intensity, and the Commission could only approve this would be under Article 87(3)(c) rather than under any specific framework. The final scheme was eventually approved. However, from discussions with the case handlers, the federal level of the aid made it difficult to assess which areas would receive the aid, and initially it was thought that the scheme lacked transparency. It was not clear where the incubators would be established; which firms (large versus small) could enter them; whether the aid would filter down to the incubated firms; and the evidence on property market failures was inconclusive (see Box 2.10 for more detail).

After the Commission sought assurances that the aid would trickle down to the level of the SMEs, the aid was eventually passed via the de minimis rules regarding the expenditure for construction of the incubators, and under SME aid rules for the consultancy services offered to SMEs thereafter. Hence this reveals a gap in the consideration of incubators. The case handlers thought that, although incubators should be encouraged and the Commission viewed the proposals in a positive light, the analysis at the time did not focus sufficiently on innovation or market failures in any detail, since it was not required at the time once these rules had been invoked. It was also thought that clearer rules might have helped the Member State to better formulate its proposals in the first instance. These would also be useful for the Commission in assessing the proposals.

The lack of guidance on intermediaries is arguably akin to the situation that existed prior to the publication of risk capital guidelines (regarding the treatment of financial intermediaries), discussed in section 3.3.3. Because incubators have the potential to resolve market failures for SMEs in a non-distortionary way, this seems to represent a key gap in existing practice.

What may be required, therefore, is good quality guidance which both Member States and the Commission can take into account when putting forward and reviewing proposals for incubators (in the context of the current report, mainly regarding funding provided by individual Member States). In particular, there is a lack of evidence on the impact of incubators on innovation outcomes. Part of this may stem from the fact that there are incubators that are not necessarily targeted at achieving such outcomes. There is thus a need to distinguish those incubators that are aimed at fostering entrepreneurship and correcting market failures from those aimed at achieving other objectives, or, moreover, ‘property developers’. This guidance might be incorporated into the SME framework, or be used in combination with the principles of Article 87(3)(c).

Member States should be transparent in putting forward their proposals for state aid to incubators, and private and public sector incubators should, in theory, be treated equally. The criteria, questions and indicators set out in Table 2.8 could be used to assess whether a particular incubator scheme put forward by a Member State addresses market failures. The table showed how particular firms at a specific stage in their life cycle (seed and start-ups) are likely to benefit from incubation. The underlying principles set out in the table were that:

<table>
<thead>
<tr>
<th>Box 3.5 Incubator scheme in Germany</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A fairly complex case involved the consideration of a scheme for state aid to be provided to create a series of incubators in Germany (see also Box 2.10, and European Commission 2004b). In this case, there was a need to consider aid at both the intermediary and SME level. A key concern, however, was the degree to which aid to the (public sector) incubators translated into the desired assistance to the SMEs.</td>
<td></td>
</tr>
<tr>
<td>As discussed in section 2.4.4, the justification for the scheme was based on financial market failures, property market failures and networking failures. It involved a grant being provided to local communes to build the facilities, with the result that the rents charged would be subsidised. Initially, an aid intensity of 90% was sought, with 95% of the schemes being in assisted areas qualifying for regional aid. This was very high aid intensity, and the Commission could only approve this would be under Article 87(3)(c) rather than under any specific framework. The final scheme was eventually approved. However, from discussions with the case handlers, the federal level of the aid made it difficult to assess which areas would receive the aid, and initially it was thought that the scheme lacked transparency. It was not clear where the incubators would be established; which firms (large versus small) could enter them; whether the aid would filter down to the incubated firms; and the evidence on property market failures was inconclusive (see Box 2.10 for more detail).</td>
<td></td>
</tr>
<tr>
<td>After the Commission sought assurances that the aid would trickle down to the level of the SMEs, the aid was eventually passed via the de minimis rules regarding the expenditure for construction of the incubators, and under SME aid rules for the consultancy services offered to SMEs thereafter. Hence this reveals a gap in the consideration of incubators. The case handlers thought that, although incubators should be encouraged and the Commission viewed the proposals in a positive light, the analysis at the time did not focus sufficiently on innovation or market failures in any detail, since it was not required at the time once these rules had been invoked. It was also thought that clearer rules might have helped the Member State to better formulate its proposals in the first instance. These would also be useful for the Commission in assessing the proposals.</td>
<td></td>
</tr>
<tr>
<td>The lack of guidance on intermediaries is arguably akin to the situation that existed prior to the publication of risk capital guidelines (regarding the treatment of financial intermediaries), discussed in section 3.3.3. Because incubators have the potential to resolve market failures for SMEs in a non-distortionary way, this seems to represent a key gap in existing practice.</td>
<td></td>
</tr>
<tr>
<td>What may be required, therefore, is good quality guidance which both Member States and the Commission can take into account when putting forward and reviewing proposals for incubators (in the context of the current report, mainly regarding funding provided by individual Member States). In particular, there is a lack of evidence on the impact of incubators on innovation outcomes. Part of this may stem from the fact that there are incubators that are not necessarily targeted at achieving such outcomes. There is thus a need to distinguish those incubators that are aimed at fostering entrepreneurship and correcting market failures from those aimed at achieving other objectives, or, moreover, ‘property developers’. This guidance might be incorporated into the SME framework, or be used in combination with the principles of Article 87(3)(c).</td>
<td></td>
</tr>
<tr>
<td>Member States should be transparent in putting forward their proposals for state aid to incubators, and private and public sector incubators should, in theory, be treated equally. The criteria, questions and indicators set out in Table 2.8 could be used to assess whether a particular incubator scheme put forward by a Member State addresses market failures. The table showed how particular firms at a specific stage in their life cycle (seed and start-ups) are likely to benefit from incubation. The underlying principles set out in the table were that:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2.8</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
<td>Questions and Indicators</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Innovation market failures and state aid: developing criteria</td>
<td></td>
</tr>
</tbody>
</table>
– regional initiatives should probably be preferred over national ones, for targeting and transparency reasons;
– the objectives of an incubator should be to foster long-term entrepreneurship, not employment growth;
– proposals for incubators should be targeted at seed and start-up innovative firms, but not necessarily confined to high-tech sectors, and entry and exit criteria should be clear, to determine which firms can enter the incubator and when they must leave;
– evidence should be presented upfront on the degree to which the scheme addresses networking and property market failures.

Incubators are a specific form of network, as are clusters. As was also discussed in section 2.4.4, the role of clusters in resolving network market failures is controversial and more guidance might be required. Incubators are applicable to a wider range of circumstances than clusters. Clusters have the potential to internalise tacit knowledge spillovers, but the evidence on their benefits is mixed. In addition, they are more relevant to areas where institutions creating knowledge, such as universities, already exist at the core of the locality, in sectors in which tacit knowledge is high (such as high-tech and biotech), and for small firms at an early stage in their life cycle. Clustering is less likely to resolve perceived market failures in more traditional industries, more mature industries, or for larger firms. The criteria developed in Table 2.7 could be used to identify cases in which clusters are more likely to reduce the degree of innovation market failures.

3.4.3 Large-scale investments and Article 87(3)(b)
Section 2.4.6 illustrated that Article 87(3)(b) remains little used to date (this was also reflected in section 3.3.4 above). The Article potentially applies to important projects of European interest, including very large investments. Oxera spoke to a representative from a large microelectronics firm about this Article. In the representative’s view, it was not necessary to assess directly whether the project suffered from innovation market failures in order to examine whether it should qualify for consideration under Article 87(3)(b).

However, in the context of the focus of the current report on the innovation market failure agenda, guidance regarding the circumstances, from an economics perspective, under which a mega-project should be considered for exemption under Article 87(3)(b) might be useful for decision-making purposes. Section 2.4.6 highlighted that market failures that might affect these types of project include (pan-EU) spillovers, coordination failures and potentially financial market failures. Tables 2.12–2.14 (and Table 2.5) could be used to assess whether any of these do in fact affect the project concerned, and their degree. Depending on the extent to which market failures are likely to hinder innovation, state aid might be used as the way to reduce these. However, this is a controversial area, since, as discussed in section 2.4.6, the theory and evidence are underdeveloped, and large-scale projects tend to underperform against forecasts.

3.4.4 Use of independent experts
The UK Rolls-Royce and Italian pharmaceuticals cases indicate that technical or engineering consultants might be used more in order to consider the innovative dimensions of R&D proposals under the R&D Framework, relative to the use of experts to consider the market failures that occur. Whether this applies to the generality of cases is not clear.

Nonetheless, the Commission could explore whether there is merit in making more use of external experts to gauge innovation market failures in relation to R&D proposals from larger firms. This could specifically help in gauging whether the proposed state aid will lead to additional innovation, rather than providing a subsidy to innovation that might take place anyway.
3.4.5 Comparative information burden

The information requirements of the Risk Capital Framework and the R&D Framework are somewhat different.

As noted above, the R&D Framework is often used to approve R&D aid to larger firms. It has been shown that the degree of analysis of market failures currently required by the Commission, in relation to these proposals, can be limited. This is because the approach adopts mainly upfront criteria, with some additional questions asked (for example, in relation to proposals to assist larger firms). In contrast, the Risk Capital Framework is far more comprehensive in its requirements for Member States to demonstrate that their proposals sufficiently address market failures (see section 3.3.3). The burden of proof may therefore be higher in the case of proposals considered under the Risk Capital Framework than under the R&D Framework. Paradoxically, however, risk capital aid is often targeted at seed and start-up firms, which are more likely to suffer from market failures than larger firms.

This may reveal a potential imbalance between approving assistance to large R&D-oriented companies, on the one hand, and for measures designed to boost SME innovation by resolving financial market failures, on the other. This does not mean that the Risk Capital Framework places too high an information burden on Member States; rather, the imbalance indicates that not enough detailed questions are asked regarding assistance to large firms within the R&D Framework.

Indeed, the approach of the Risk Capital Framework is broadly welcome, since it captures the market failure agenda and covers a number of the issues discussed in section 2.4.5. Also, the checklist approach adopted under this Risk Capital Framework has not necessarily impaired the ability of Member States to receive approval on schemes in most cases (see section 3.3.3). Furthermore, the additional factors identified in Tables 2.9–2.11 might be used to complement the existing framework. These may be used to clarify further the causes of problems faced by SMEs in obtaining finance, and whether these are financial market failures in a strict sense (information/transaction costs), or due more to institutional or demand-side factors.

However, there is a case that highlights that there may be information burden problems arising from the interaction of the comprehensive checklist approach adopted as part of the Risk Capital Framework and the legal requirements of the Framework regarding permitted aid intensities, the latter of which has led to the Commission seeking further information under the Article 88(2) procedure. Although the Article 88(2) opening procedure is an important safeguard, there may be problems if recourse to this occurs too readily.

The Risk Capital Framework and a UK scheme recently approved by the Commission were discussed in section 2.4.5. Box 3.6 provides further discussion from a policy perspective. This highlights, albeit through one case, how recourse to the opening procedure can delay the approval of schemes aimed at assisting financial intermediaries.
Box 3.6  The UK Enterprise Capital Fund scheme

The aim of this scheme is to assist in closing a perceived financing gap (over the £250,000 to £2m finance band) for UK businesses in their early stages of development, and high-potential-growth SMEs with a high risk of failure. Based on the US small business investment company (SBIC) model, the ECF scheme is aimed at stimulating intermediaries, who will then invest in small firms, and will involve the provision of government leverage to qualifying venture capital firms, which are able to raise investment from the private sector. This finance must then be invested in eligible SMEs. The venture capital companies must compete for these ECF funds.117

The Commission approached these proposals positively, noting that it fulfilled several of the conditions laid down in the Risk Capital Communication. However, the Commission was initially sceptical of the size of the equity gap suggested by the UK government. Because the scheme would operate across the UK, it went beyond regional aid rules, and considerably exceeded the thresholds for assistance envisaged in the current Risk Capital Framework.

As such, the Commission sought a more thorough analysis of the extent of market failures by collecting more evidence, under its information-seeking powers within Article 88(2) of the Treaty, from the UK and other Member States (especially from venture capital companies in the UK). Following a two-year process, the scheme was approved in May 2005. In its decision, the Commission noted that the equity gap is a pan-European phenomenon (European Commission 2005a).

The process of approving the scheme was discussed with members of a UK government department. They highlighted that there were delays in implementing the ECF scheme, due to the additional information gathering that took place under the Article 88(2) requirements. It considered that recourse to this stage had perhaps taken place too readily. Given the evidence available, and that the investment was commercially driven, it was thought that a more simplified process could have been followed.

As noted in Box 3.6, the Commission now recognises that the equity gap problem is a pan-EU problem, which may affect its thinking on the matter going forward, in particular the degree to which recourse to the Article 88(2) opening procedure is necessary when proposals are put forward aimed at leveraging venture capital funds to innovative SMEs.118 Consideration might be given to adopting a more flexible approach, in which an opening procedure is not triggered as readily, provided that the Member State has supplied sufficient evidence upfront and the aid is sufficiently targeted.

In conclusion, therefore, the Risk Capital Framework captures many of the concepts, criteria and questions put forward in Tables 2.9–2.11. The additional factors highlighted in these tables might complement the existing Framework, and might enable the causes of financing problems for SMEs to be better identified, while not significantly increasing the information burden on Member States. The Commission might use the tables as a checklist in assessing further the extent to which financial market failures occur in Member States (and Member States could also be encouraged to look at these factors before putting forward schemes). However, where a Member State provides good evidence, a more flexible approach might then be adopted towards triggering an opening procedure, in cases where this might otherwise apply.119

117 Details of the scheme, and much of the evidence appraised by the UK to support it, are set out in HM Treasury (2003).
118 Nonetheless, this is also a legal matter. This report does not discuss the legal issues involved.
119 This report does not seek to explore the legal issues in further detail.
An important consideration in adopting a more flexible approach, however, would be whether the aid put forward is sufficiently targeted. For example, a priori, it would be expected that early-stage innovative (especially high-tech and biotech) SMEs would be more prone to financial market failures (see section 2). Aid aimed at leveraging finance from intermediaries is also less likely to distort competition, and less likely to pick winners, than that provided directly to firms. Therefore, aid provided to financial intermediaries via competitive tender, where government support is carefully structured as part of a risk-sharing arrangement, and for which the end-beneficiaries are early-stage innovative SMEs, would a priori be expected to be aimed at tackling market failures and not to distort competition too much (particularly if seed funds do not exist, or do not exist without government support).

### 3.4.6 De minimis provisions

The de minimis provisions (European Commission 2001a) are used extensively in resolving problems regarding state aid proposals. They apply irrespective of the form of government assistance or its intention. Nonetheless, it is important to emphasise that aid does not ‘automatically’ qualify for the de minimis rule, as this is based on an objective test (the grant equivalent must be no more than €100,000 over three years). Also, by definition, the measure covers relatively modest amounts of aid. Thus, the de minimis rule is not problematic in itself, but gaps in other frameworks may lead to recourse to the provision.

The regulation tends to be used by Member States where the existing frameworks do not adequately deal with innovation market failures, or in proposals where it is questionable that innovation market failures actually occur.

The use of this provision to approve state aid that might address innovation market failures may simply reveal the extent of the gaps in the current frameworks. Particular elements of proposals that cannot be approved under other rules can be hived off, placed into the de minimis box, and approved without further analysis. The provisions were eventually used in the German incubator scheme (see Box 3.5) and the France young innovative firms scheme (see Box 3.3). Case handlers at the Commission revealed that use of the de minimis provisions was not ideal.

One way to avoid over-extensive use of the provisions is to have better procedures for dealing with incubators and innovative start-ups (as discussed in section 3.3). Such guidelines might be incorporated into the SME regulations, or be used directly in the context of Article 87(3)(c).

However, it is likely that aspects of many proposals will continue to be approved under the de minimis rules. If aspects of Member States’ proposals are small enough so as not to distort competition, it is within the rights of each Member State to exempt government assistance under these provisions.

### 3.4.7 Summary

Before moving to the policy options, it is useful to summarise the main points that can be elicited from the above. As already noted, the gaps identified are conditional on the insights obtained from the case studies reviewed and the discussions with stakeholders. Although Oxera interviewed a number of stakeholders, a different picture might emerge from a more comprehensive survey of state aid cases and, in particular, further interviews with Commission officials.

The discussion has nonetheless highlighted the following potential key gaps in the current state aid rules.

- **Broad versus narrow frameworks**—some of the state aid frameworks are, by design, more focused on innovation market failures than others. The aim of this report is not to put forward a new innovation framework. Most of the existing rules, including those more
specific to innovation (risk capital, R&D) and those less specific (SME, regional aid, other rules) could be complemented by considering further the criteria, questions and indicators in section 2 (where relevant) as part of the analysis.

- **Better aid**—proposals that are either not state aid (eg, very large pan-EU investments that do not have the potential to distort competition), or small amounts of aid exempt under the de minimis criterion do not require analysis of innovation market failures. Thus, the issues discussed in section 2 do not need to be applied. However, improving the way in which the state aid rules work in practice, in those areas in which more analysis of innovation market failures is required, could reduce the need to rely on the 'no state aid' category. This could lead to aid that is targeted more effectively.

- **Risk capital**—of all the Frameworks, the Risk Capital Communication best takes into account innovation market failures. Through transparent guidance, it adopts a number of the criteria and questions developed in section 2.4.5. In addition, it recognises that creating a climate conducive to venture capital is a first-best, and small innovative firms are more likely to face financing problems than larger firms. Moreover, it acknowledges the very important role of financial intermediaries. The current Framework does not appear to place an undue information burden on Member States, and there may be scope for considering further the factors developed in Tables 2.9–2.11 to supplement the analysis, and indeed to use these as a complementary checklist. However, information burden problems may occur due to the interaction of the checklist approach inherent in the Risk Capital Framework, the permitted aid intensities under the Framework, and a triggering of a detailed investigation. Consideration might be given to adopting a more flexible approach, in which an opening procedure is not triggered as readily, so long as the Member State has provided sufficient evidence upfront against an (in effect) expanded checklist and the aid is sufficiently targeted.

- **R&D Framework and large versus small firms**—the R&D Framework, which adopts upfront criteria, takes into account several relevant factors, although additional criteria discussed in section 2 could be used alongside it. Small firms would a priori be expected to suffer from market failures more than large firms, and this is recognised in the Framework. However, the current requirements of the Framework mean that, when state aid proposals are assessed in practice, there is potentially not enough detailed analysis of (or detailed evidence sought on) the market failures that arise in relation to assistance provided to large firms, including insufficient analysis of additionality. In contrast, there could be more scope for approving schemes aimed at small firms based on higher-level metrics, such as that put forward in France to assist young innovative SMEs. This may help ensure that state aid is proportionate to the market failure it is intended to correct, and is likely to be additional to, rather than crowd out, private sector investment. It may ensure a better balance between incurring Type II versus Type I errors.

- **Incubators**—the current Frameworks may not deal sufficiently with approving programmes aimed at incubators. Incubators are not captured adequately by the R&D and SME Aid Frameworks. Reliance on the Regional Aid Framework and de minimis provisions may be imperfect. Good quality schemes may not be readily permitted under existing rules. The problem is that there is at present no specific framework that recognises the important role of intermediaries such as incubators, or that provides guidance on assessing incubators. This is in contrast to the Risk Capital Framework (which recognises the role of financial intermediaries). To move forward, it has been identified that there may be a need for more guidance. Section 3.4.2 and Table 2.8 have put forward some suggested guidance: to operationalise this, either the SME framework could be amended, or, as is preferable, the guidance could be considered directly in the context of Article 87(3)(c). Furthermore, proposals to form clusters could be considered with direct reference to Article 87(3)(c), employing the criteria developed in Table 2.7.
Innovation market failures and state aid: developing criteria

Large-scale investments—in appraising large-scale investments that might qualify for state aid under Article 87(3)(b), a transparent and robust economic framework supporting this decision-making process is probably required. Whether a particular investment qualifies for treatment under Article 87(3)(b) will essentially be a political decision, but objective criteria should assist in decision-making regarding innovative projects that may suffer from market failures. Detailed questions regarding the presence of innovation market failures should be asked, and the criteria developed in section 2.4.6 could be used. However, the theory and evidence in this area are very much incomplete.

Evidence—more use of independent experts to assess the incidence of innovation market failures might be preferable in the context of proposals to assist larger firms.

De minimis—in addition, there may be too much reliance on the de minimis regulation, although this may be because of gaps in the existing frameworks and how they are used. The above measures may help to resolve this. Nonetheless, it is within the rights of each Member State to use the de minimis regulation where aspects of their proposals are sufficiently small so as not to distort competition. By definition, the measure covers relatively modest amounts of aid. Moreover, whether the measure can be invoked is based on an objective test (the grant equivalent must be no more than €100,000 over three years). This arguably serves to limit the Commission’s discretion. Thus, the de minimis rule is not problematic in itself, but gaps in other frameworks may lead to recourse to the provision.

3.5 Policy options and recommendations

Section 3.2 explained that the ‘ideal’ state aid policy towards innovation would:

- allow the Commission to encourage innovation that would otherwise not take place because of the existence of identifiable innovation market failures;
- recognise that state aid may be a second-best to other measures that might be employed by Member States;
- ensure that state aid is necessary for innovation, including that it is proportionate to the market failure it is intended to correct, and is likely to be additional to, rather than crowd out, private sector investment;
- have a transparent and robust economic framework supporting this decision-making process within the context of the state aid rules;
- have clear information requirements, and a balanced burden of proof; and not distort competition

Taking into account the discussion in sections 3.3–3.4, how can state aid practice and policy be improved, to meet these objectives?

3.5.1 The options

First, what are the broader policy implications for moving forward? How might the criteria developed in section 2 be applied in the following situations:

- intermediaries—incubators and financial intermediaries?
- young, innovative or start-up SMEs—undertaking R&D?
- larger firms—undertaking R&D?
- large-scale investments—in which additional issues may arise?

The three relevant options for change are as follows:
1) *no change in approach*—the status quo is retained, with no changes to the existing frameworks or guidance around these frameworks;

2) *strict criteria*—the Commission defines upfront stricter criteria and indicators for making decisions, requires a higher burden of proof, and assesses in detail individual proposals against these criteria; and

3) *broad criteria*—this is an in-between case. The Commission might publish upfront guidance on the issues it would examine, which a Member State should bear in mind if claiming that a particular scheme aimed to resolve innovation market failures.

What the above discussion shows is that ‘no change’ is unlikely to be an attractive option. Broadly speaking, in relation to intermediaries (aimed at assisting small innovative firms) and small innovative firms, there is a priori more likely to be innovation market failures, less information available, and greater potential for additionality via government support. By contrast, for larger firms and large-scale investments, there are likely to be fewer market failures, more information available, and less potential for additionality.

The following takes the types of enterprise and investment in turn, focusing on firm-, sector- and project-level information (see section 2.4.1). In all cases, country-level indicators could also be explored as an initial part of the analysis.

- **Intermediaries**
  - *Incubators*—potentially, for incubators, option 3 could be adopted. The guidance would outline what would be expected of any proposals from Member States for assistance to incubators. The criteria could be those discussed in relation to incubators in Table 2.8 (and discussed in section 3.4.2, above). The SME Framework might be amended or, as is preferable, the guidance could be considered directly in the context of Article 87(3)(c). The guidance should not be unduly prescriptive, but allow genuine incubators to be distinguished from commercial property developers.

- **Financial intermediaries**—option 3 could be adopted. Broadly speaking, the Risk Capital Framework, which adopts a checklist approach, already incorporates a number of the concepts discussed in Tables 2.9 to 2.11, although Member States might be encouraged to differentiate further between demand-side, institutional and informational/transaction cost factors. This should not increase significantly the information burden. A more flexible approach might be adopted whereby an opening procedure is not triggered as readily, so long as the Member State has provided sufficient evidence upfront against an expanded checklist, taking account of the tables, and the scheme is sufficiently targeted. (The UK ECF scheme, aimed at leveraging venture capital funds for early-stage innovative firms, appears to be an example of a scheme taking account of such factors.)

- **Young, innovative or start-up SMEs**—option 3 could be adopted, depending on the sector. Schemes seeking to address market failures in relation to smaller firms might be approved on the basis of higher-level metrics, such as firm activity, size, sector, and stage of development, since a priori there is more reason to expect that such schemes would address a number of market failures, as demonstrated in Tables 2.3 to 2.11. Thus, a selection of the higher-level metrics from each of these tables might be used. (The French scheme aimed at young SMEs undertaking R&D is an example of a scheme based on higher-level metrics.) Detailed historical information is, in any case, unlikely to be available in the case of start-ups.

- **Larger firms**—large established firms should have the historical and forward-looking information for the Commission to make a more detailed assessment of a specific investment being put forward by a larger company, which a Member State regards as
qualifying for state aid. The above discussion highlights that the current R&D Framework appears to ask too few questions of larger firms. Stricter criteria (option 2) could be adopted in approving state aid to large firms for undertaking innovative investments. The extent of likely spillovers, coordination failures, and financial market failures should probably be explored in more detail. Section 2 outlines the criteria, questions and indicators that might be used. The criteria (including those at the project level) developed in Tables 2.3 and 2.5 are particularly relevant, which provide an indication of the extent to which an investment by a large innovative firm is likely to be affected by spillovers and coordination failures, respectively.

- **Large-scale investments**—these raise additional considerations, but the theory and evidence are less well developed. As noted above, in appraising large-scale investments that might qualify for state aid under Article 87(3)(b), detailed questions regarding the presence of innovation market failures should be asked (Option 3), and the criteria developed in Tables 2.12 to 2.14 (and Table 2.5) could be used.

Table 3.1 thus summarises the options for each type of agent, including the innovation market failure criteria discussed in section 2, which could be used to implement the proposed policy option. The potential operationalisation of these options is discussed further in section 3.5.2.
### Table 3.1 Potential policy options

<table>
<thead>
<tr>
<th>Type of agent</th>
<th>Policy option</th>
<th>Why?</th>
<th>Innovation market failures criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediaries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incubators</td>
<td>3. Broad criteria</td>
<td>A priori more likely to suffer from innovation market failures. A need for more guidance has been identified, but this should not be unduly prescriptive</td>
<td>See Table 2.8. New guidance could be considered directly in the context of Article 87(3)(c)</td>
</tr>
<tr>
<td>Financial intermediaries</td>
<td>3. Broad criteria</td>
<td>A priori more likely to suffer from innovation market failures. Checklist approach already used (incorporating many of the broad criteria developed in section 2) under the Risk Capital Framework. Could be complemented. More comprehensive checklist may enable more flexible use of opening provision (which has high information burden)</td>
<td>See Table 2.9–2.11. The Risk Capital Framework already embodies many of these concepts, but the tables provide more information. Better differentiation of causes of financing problems may be desirable</td>
</tr>
<tr>
<td>Young, innovative or start-up SMEs</td>
<td>3. Broad criteria</td>
<td>More likely a priori to suffer from innovation market failures. Less likely to have information at the project level</td>
<td>Higher-level criteria discussed in section 2 related to the country where the firm is active, sector, and stage of development (less project-specific). Higher-level metrics from Tables 2.3 to 2.11 could be used</td>
</tr>
<tr>
<td>Larger firms</td>
<td>2. Stricter criteria</td>
<td>Less likely a priori to suffer from innovation market failures. Likely to have forward-looking information. Current frameworks (eg, R&amp;D) may ask too few questions</td>
<td>Section 2 in general, and in particular Tables 2.3 and 2.5 (spillovers and coordination failures). Detailed questions could be asked, including at the project level</td>
</tr>
<tr>
<td>Large-scale investments</td>
<td>2. Stricter criteria</td>
<td>Theory and evidence undeveloped. May suffer from innovation market failures, but a thorough analysis could be required</td>
<td>Tables 2.12–2.14 (and 2.5). Detailed questions could be asked, especially at the project level</td>
</tr>
</tbody>
</table>

Note: Financial market failures that may occur in relation to larger firms are not discussed in the table, although those relevant to large-scale investments could be examined. In general, for large companies undertaking several manageable and diversified projects, financial market failures would not be expected to occur. The risks inherent in the project may, however, affect whether it is taken forward on spillover grounds. Source: Oxera.

### 3.5.2 Operational proposals

It is for the Commission and Member States to decide how they would wish to operationalise the above proposals. Some suggestions are given below.  

### 3.5.3 Intermediaries

With respect to incubators, a short checklist approach could be used, in which incubator schemes meeting a higher proportion of the following positive criteria might be considered for state aid approval directly under Article 87(3)(c). Positive criteria include incubator schemes:

---

120 Quantified benchmarks are not put forward in this report, as this is beyond the scope of the study.
– with the objective of fostering entrepreneurship (and with systems in place to measure this);
– operated at the local or regional (rather than national) level;
– with well-defined entry and exit criteria, focused on (but not necessarily limited to) high-tech start-ups;
– aimed at resolving finance, client access, mentoring, and facilities network failures, and which house a sufficient number of other firms; and
– where sufficient evidence has been put forward on the existence of property market failures.

Table 2.8 provides indicators and questions that might enable determination of whether an incubator meets the above criteria.

In relation to financial intermediaries, given the wide potential coverage of risk capital schemes, a checklist approach could also be adopted, as in the Risk Capital Framework. Also, Member States could be encouraged to provide any further evidence set out in Tables 2.9 to 2.11, so that the degree to which problems arise from strict financing market failures versus demand-side or institutional factors can be taken into account. This should not significantly increase the information burden since the criteria developed in these tables have in mind schemes covering qualifying firms, and are developed mainly at the level of the country, qualifying sector and qualifying firm (rather than at a more disaggregated level).

However, as discussed in detail in section 3.4.5, there may have been a high information burden in the approval process for the UK ECF scheme, due to the aid intensity of the scheme (and thus the triggering of an opening procedure). A more flexible approach might be adopted towards whether an opening procedure is triggered for future schemes, such that aid could be approved more readily. This would depend on whether the Member State concerned has, upfront, put forward sufficient evidence that financing problems for SMEs are closely related to information/transaction costs (and potentially institutional) factors, and the aid is sufficiently targeted. Tables 2.9 to 2.11 cover whether the aid appears to address financial market failures in a strict sense, or if financing problems may be due to other factors. In respect of targeting the aid, a more flexible approach might be adopted where the aid meets all of the following upfront criteria:

– it is no greater than the plausible upper bound of the financing gap;
– it is aimed at providing finance to early-stage innovative (especially high-tech and biotech) SMEs;
– it is provided via intermediaries via competitive tender; and
– government support is structured as part of a risk-sharing arrangement.

3.5.4 SMEs

Higher-level metrics could be used when evaluating schemes intended to benefit young innovative or start-up SMEs, since these are a priori more likely to suffer from innovation market failures. Furthermore, little information may be available, and thus determining whether a particular project of a young innovative SME might suffer from market failures may be difficult. In addition, seeking the necessary information would increase the administrative burden on the SME.

The relevant higher-level metrics could be identified from Tables 2.3 to 2.11. Operationally, one option is that there could be greater scope for approving schemes meeting all three of the following upfront criteria:

– schemes aimed at young SMEs or start-ups below a certain age;
– where such SMEs are undertaking a given percentage of R&D; and
– where the SME operates in a high-tech (or science-based) sector.
3.5.5 Larger firms
In the case of larger firms, a checklist of the questions to ask could be adopted where the extent of likely spillovers, coordination failures (and, potentially, financial market failures) could be explored using the criteria, questions and indicators developed in section 2. Particular attention could be paid to the issues set out in Tables 2.3 and 2.5. Questions beyond these assessment frameworks could also be asked, and will vary from case to case.

3.5.6 Large-scale investments
As in the case of larger firms, a checklist approach could be adopted to appraise whether innovative large-scale investments might qualify for state aid, on the basis of innovation market failures, under Article 87(3)(b). All of the detailed questions set out in section 2.4.6 (Tables 2.12–2.14, and Table 2.5) are of relevance. Detailed questions beyond these assessment frameworks could also be put forward, which will vary from case to case. Ultimately, however, it should be recognised that whether an investment qualifies for treatment under Article 87(3)(b) is a political decision. Furthermore, compatibility with the Treaty would not necessarily be judged against innovation market failure criteria factors alone, and might take account of wider economic and social criteria.

3.6 Policy instruments
This report has not considered in detail the instruments available to Member States to tackle perceived innovation market failures. In this regard, it is for Member States to choose the appropriate instrument, although the rules should incentivise the choice of more appropriate instruments. For instance, the Risk Capital Framework states that a positive view would be taken towards measures that are: targeted at SMEs; support equity rather than debt financing; and share risk between the private and public sector, as opposed to those that directly subsidise the private sector.

This section discusses some of the important lessons that can be learned from the preceding analysis regarding the specific forms of intervention, and more specifically in relation to the following debates:

– is state aid the best instrument to increase the levels of innovation?
– should state aid be granted directly to firms or to intermediaries?
– are grants or risk-sharing arrangements a more efficient way to channel state aid?
– how might assistance to small firms be structured?
– can measures be taken forward in isolation, or do the interactions between measures need to be considered?

3.6.1 State aid versus not state aid
To increase innovation in the EU, it is preferable for Member States to tackle underlying system factors that undermine innovation in the first instance rather than providing state aid.

This is very much apparent from the discussion of venture capital and clusters in sections 2.4.5 and 2.4.4, respectively. For example, the lack of an underlying equity culture may mean that state aid measures to increase venture capital will simply be ineffective (for example, introducing venture capital leveraging schemes in countries with debt-based economies). Creating the preconditions for venture capital to be forthcoming may be better than state aid, and, as noted in section 2.4.5, the evidence shows that government support is secondary to such factors.

In respect of clusters, the presence of a science base and good universities is a prerequisite for an effective cluster that facilitates innovation. Coordination through clustering is not necessarily optimal in every circumstance, and it is not clear that state aid is required to induce clustering. Account should therefore be taken of the networks and interactions that already exist, and state aid should be aimed at improving links between what already exists...
(eg, support aimed at technology transfer, creation of incubators and BANs). Measures that seek to artificially establish clusters from scratch should be resisted since the likelihood is that they will fail (see section 2.4.4).

3.6.2 Firms versus intermediaries
Instruments that are aimed at assisting intermediaries rather than specific firms have a number of advantages over providing direct funding to firms, particularly in the case of SMEs.

First, the private sector, or commercial operators of public intermediaries (eg, incubators), tend to have better information than the government, and are charged with the task of picking winners. In search of market opportunities, and from dealing with companies on a day-to-day basis, a venture capitalist may be in a better position than government to assess the latest potentially commercialisable developments in biotechnology. It is of note that the risk capital rules recognise that, to address perceived financing gaps for SMEs, support to financial intermediaries is preferable to direct assistance to firms.

Second, support to intermediaries should not necessarily distort competition any more than providing direct assistance to SMEs. For instance, the decision on the UK ECF scheme recognised that the funds being created were new, and that the main concerns regarding any distortion to competition were at the level of the SME rather than the vehicle (intermediary) used to support the SME.

Third, the use of competitive tendering (inviting bids by intermediaries) could ensure efficient use of public funds, and more effective targeting of innovation market failures.

Similar considerations also apply to incubators: with clear guidelines on entry and exit criteria, incubators are tasked with selecting qualifying firms. An incubator manager will have a hands-on view of firms that might benefit from its incubation facilities. If the private sector does not provide incubators, the scope for distortion to competition at the level of the intermediary should be limited (although there may still be a distortion at the level of the SME). Competitive tendering can be used by government, where prospective incubator managers need to bid to attract government support.

3.6.3 Grants versus risk-sharing arrangements
From a competition perspective, one of the advantages of upfront fixed funding, such as through grants, is that, since the amount of the funding is fixed and not related to the recipient firm’s level of production, the aid is less likely to affect future short-term production decisions. As a result, the aid has less scope to distort competition in the market. This is in contrast to variable funding, which is likely to affect short-term production decisions in the market, and may distort competition more by reducing the marginal costs of production for the assisted firm.121

However, from a public policy perspective, grants may not in all circumstances lead to a desirable allocation of risk between the government and the private sector. While grants play an important role for smaller firms, which face the greatest uncertainties, for larger firms, the use of risk-sharing agreements enable governments to share in the benefits of the project if it is successful, rather than simply subsidising the project’s risks.122

Therefore, there could be more use of risk-sharing measures, particularly when assistance is provided to large firms, provided that the distortion to competition is limited (as the projects

---

121 By its very nature, upfront funding does, however, influence decisions regarding whether to take a project forward.
122 Risk-sharing agreements are common in the aircraft sector (including launch aid for engine production, such as in the Rolls-Royce case in Box 3.1, and for aircraft build, such as in the case of Airbus, discussed in section 2.4.6). The UK ECF scheme, to attract venture capital (as discussed in Box 3.6) adopts similar principles. In these two cases, repayments to government do not need to be made if these types of project fail, but, to incentivise firm performance, government capital is repayable before private capital.
would not otherwise be taken forward by any company in the market, due to the extent of market failures).

### 3.6.4 Assistance to small firms

As has been discussed, a priori, small firms are more likely to suffer from innovation market failures than larger firms. State aid rules should seek to encourage innovation by small firms, rather than hinder it through the administrative requirements placed on Member States.

The chosen instrument also needs to reflect the information that is likely to be available in administering the scheme. For instance, the French R&D scheme (European Commission 2003a)—which applies to firms devoting at least 15% of their expenditure to R&D, that are small, and that are less than eight years old—focuses on higher-level metrics. It supports R&D at the very early stages since it subsidises a firm’s costs (through the exemption from social security contributions). It also reduces the burden on firms’ profits later on through a corporation tax reduction, which can be seen as a reward to firms that have undertaken R&D. In addition, the UK R&D tax credit scheme also applies a (partial) exemption to corporation tax for small firms.\(^\text{123}\) It is not entirely clear how the tax credit scheme assists firms since it simply rewards R&D that has already been undertaken. Subsidising early-stage costs may be preferable in stimulating R&D than subsidising later-stage profits emerging from successfully completing the R&D process.

### 3.6.5 Potential substitutability of measures

It is important to assess the extent to which schemes might substitute each other; otherwise, there is the potential for over-subsidisation of firms, and inefficient use of government funds. Indeed, Amramovskvsky et al (2004) noted that, in the UK, there is a large number of schemes relative to the number of rationales.

Member States might consider the number of schemes in use relative to the number of rationales (on market failure grounds) put forward. For example, measures that subsidise small-firm R&D (such as tax credits or social security exonerations) arguably seek, as their rationale, to correct for both spillover effects and financial market failures. Such measures assume that financial market failures continue to exist. Government measures to leverage the supply of venture capital, by contrast, seek to correct at source financial market failures affecting small firms. Although it is likely that there is a rationale for both sets of measures to be adopted, the important point is that the schemes put forward should not be considered in isolation. The extent to which schemes might substitute each other should be further assessed.

### 3.7 Conclusions

Although successful innovation can in itself be complex, and can fail for a large variety of reasons, the analysis undertaken in this report indicates that it is possible to target state aid more effectively so that innovation market failures are addressed. The application of the criteria set out in this report provides a mechanism for the Commission to target state aid more effectively to complement existing Frameworks and Communications, or to modify them.

The choice of the optimal policy instrument is outside the scope of this report, but there are a number of considerations that should be applied. In particular, the operation of any specific policy instrument may vary with the underlying economic characteristics of the country (or region) concerned, which should be taken into account.

\(^{123}\) See http://www.hmrc.gov.uk/randd/. In the case of the French scheme, the corporation tax element was approved under the de minimis regulations. In the UK scheme, the partial exemption granted meant that the aid was captured within the aid intensities permitted by the R&D framework.
In addition, differences in innovation in the economy cannot all be attributed to market failures. Underlying system-level characteristics may be more significant. For example, the existence of an equity culture and good exit mechanisms for venture capitalists may be more important than providing government support through state aid in addressing the perceived financing problems faced by small innovative firms. Also, where government assistance is provided, general measures to enhance the IPR regime, support to universities and the science base, and ensuring a good quality entrepreneurial base, may not actually involve state aid measures. Thus, policy-makers should not overlook the issue that state aid may not be the most efficient way of tackling any perceived lack of innovation in an economy.

The analysis presented in this report may be used to complement the guidance on state aid for innovation issued by the Commission, which is currently in the form of a consultation document (European Commission 2005c). In this, the Commission considers that a new and separate framework for innovation would not be in line with the objective of simplifying state aid rules. Rather, the Commission focuses on how the current rules might be improved to better enable targeting of state aid at innovation market failures. In the introduction (see section 1), it has been highlighted that there are similar themes developed within the independent analysis undertaken by Oxera in this report and in the Commission’s recent consultation (which was published after the main analysis undertaken by Oxera for this report). However, there are also differences in the approach undertaken, and in the options for change developed.
Appendix 1 Case studies

As part of the study, Oxera examined in some detail five case studies regarding state aid, innovation and innovation market failures. The aim of these case studies was to understand what interested parties understood by innovation, innovation market failures, the rationale for government support and whether the current state aid rules work well in targeting and resolving innovation market failures.

The main issues covered as part of these cases, including issues that emerged in interviews, are summarised in the boxes throughout this report. This appendix provides some additional background on each case study, which are as follows:

- an incubator in north-east England;
- state aid to Rolls-Royce in the UK regarding aircraft engines;
- assistance to an Italian pharmaceutical company;
- an incubator scheme in Germany;
- a scheme to assist young innovative SMEs in France.

The first of the above involved an interview with the management of the incubator concerned, and did not relate to a specific state aid scheme approved by the Commission. The remaining four case studies concerned specific schemes approved by the Commission. The UK Rolls-Royce, Italy and Germany case studies involved interviews with European Commission officials who handled the cases. The France scheme entailed an interview with a representative of a French Ministry involved in the case.

A1.1 UK north-east England incubator

As discussed in Boxes 2.10 and 3.4 of the report, Oxera spoke to the manager of an incubator in north-east England.

The incubator was set up in the 1980s on a not-for-profit basis, although it has operated on a more commercial (company limited by guarantee) basis since the mid-1990s, and had originally secured European Commission funding. Its original objectives, to which the organisation running the incubator believed it still adhered, were to create new businesses and higher-quality employment opportunities in the area, and to encourage diversity in the local economy. There had historically been a shortage of entrepreneurial activity in the area. The incubator focuses on assisting innovative firms (although it maintains some flexibility in its admissions criteria, and not all firms need to be high-tech), and thus entrepreneurship. In particular, the centre focuses on innovative, technology-oriented firms, and those with prospects for high growth.

As discussed in Box 2.10, the organisation operating the incubator cited various issues that the facility resolves, including both property market failures and network failures. As discussed in Box 3.4, concerns were expressed regarding state aid policy towards privately versus publicly owned incubators, in respect of financing expansion.

A1.2 UK Rolls-Royce engines

Oxera spoke to a European Commission official who acted as case handler in the case of state aid provided to Rolls-Royce Engines (European Commission 2001d). As discussed in Boxes 2.1, 2.4 and 3.1, a number of issues emerged in the discussion.
The decision on the case was published in 2001 and involved aid requested by Rolls-Royce from the UK government to help finance the development of two new engines—the TRENT 600 and 900—both of which have a higher thrust capacity than existing engines. The form of aid was to be an advance of £250m to the company from the UK government, to be repaid if the project was successful. An assumption was made on the required return to government, and on the costs covered by a private risk-sharing partnership, which would involve other firms in the industry. The project involved new technologies, and four main development phases: research, simulation, and new technology experimental testing; development of prototypes, certification, flight tests and rectification (little resale value); further prototyping with reliability and durability as the focus (commercial resale value); and certification/integration to the aircraft.

Since Rolls-Royce competed with other engine manufacturers, the assistance was judged by the Commission to be state aid under Article 87(1). The aid was assessed under the R&D Framework, and included both an analysis of the novelty of the prototypes (the innovation) and the incentive effects of the aid (which touched on some areas of potential market failures). In respect of the latter, the technological leaps required in each of the development phases, the technical and commercial risks involved, and the length of payback period were considered to some extent. The aid was judged to be compatible with Article 873(c), and was thus approved by the Commission.

A1.3 Italy pharmaceuticals

Oxera spoke to a European Commission official who acted as case handler in the case of state aid provided to Industria Farmaceutica Cesare Serono SpA (IFS). The case, and the various issues that emerged during the interviews, is discussed in Boxes 2.1, 2.2, 2.4 and 3.2. The decision on this was published in 2004 (European Commission 2004c). The aid was put forward to assist the company in the development of new chemical synthesis processes for oral pharmaceutical forms of polypeptides. The project also included the production of active ingredients and pharmaceutical products in view of pre-clinical and clinical testing (ie, aid for process and product innovation). IFS is part of a large multinational group (Serono SA).

The project included the expansion of the R&D laboratory and the development of R&D activities. This fell under the R&D Aid Framework, but the project also included training aid. In relation to R&D, the scheme included industrial research and pre-competitive development, while training aid was for general training aid. The Italian authorities requested the maximum allowable intensity for industrial and pre-competitive R&D as defined in Annex I of the Community Framework for R&D Aid (European Commission 1996), and for training aid as defined in Article 2 of Commission Regulation N 68/2001 (European Commission 2001f).

In this case, the focus of the discussion was on the level of aid in one area—ie, pre-clinical testing. Interestingly, the discussion in the decision highlights the debate surrounding whether the innovation process is always linear (in which research comes first, followed by development).

Initially, the Commission doubted that pre-clinical testing could be classified as industrial research. The Commission was unable to rule out that some of the pre-clinical test could be classified as pre-competitive development. The implication was that if aid was for pre-competitive development, rather than for industrial development, it would go from covering 50% of the costs of pre-clinical tests to covering 25%. Pre-clinical tests consist of testing principles on animals while clinical tests comprise tests on healthy patients. In the Commission’s opinion, the results of pre-clinical tests are collected and critically analysed to

check whether clinical tests (on healthy patients) can be launched. This could be viewed as planned research and critical investigation, which would then qualify as industrial research.

However, pre-clinical tests, like clinical tests, are based on ‘prototype’ versions of the product. In this respect, they could, like clinical tests, be regarded as pre-competitive development activities but, since they precede clinical tests and are conducted with less mature products, they are clearly not closer to the market than clinical tests are. IFS provided evidence indicating that only 10% of the molecules reach the next step (ie, the clinical test). In the Commission’s opinion, this is evidence that the results obtained in this drug development phase are still a long way from both the production of a particular drug and its marketing. The Commission therefore approved pre-clinical tests as part of industrial research, and took into account the high costs of these tests.

A1.4 Germany incubators

As discussed in Boxes 2.10 and 3.5, Oxera spoke to European Commission officials who handled the case of a scheme put forward by the German government to assist the construction of enterprise and technology centres in various German provinces (Länder).

The decision on the case was published in early 2005. The scheme, proposed by the German government, involved subsidisation of the construction (or extension) of industrial centres and technology centres, and the renting out of the facilities (and shared equipment) concerned to qualifying firms (start-up SMEs, or medium-sized innovative companies in the high-tech sector). The assistance was to be in the form of grants for the construction stage, up to 90% of project costs. The grants would be paid to ‘responsible bodies’ within Länder — mainly (public sector) local communes—which would then select private construction firms to undertake the work via a public tender. 95% of the aid was to be to Assisted Areas. The aid would, in effect, mean cheaper rents for qualifying firms, and facilities that took into account their specific requirements. The assistance was judged by the Commission to be state aid.

At first, the Commission was not convinced that the scheme was compatible with state aid rules. In particular, its view was that the German government had not provided sufficient information on the selection of the responsible bodies (there was no evidence of a tender process for awarding the aid to such bodies), or on the degree to which the high level of (maximum) aid sought (90%) would filter down to the SMEs. The Commission was also not convinced of the degree of market failure. The Commission acknowledged that risky SMEs can face problems in renting facilities and that incubators can help both to provide rents to SMEs at below market prices and facilitate synergy effects (eg, sharing of equipment, clustering). However, the Commission also highlighted that a market normally exists for renting rooms to SMEs (through real estate firms, which the new facilities would be in competition with), but that these rents might simply be regarded as too high. Furthermore, the Commission wanted more detail on the criteria for determining which firms might qualify for entry into the centres, to be confident that these served an incubator function.

Hence the Commission had doubts that the aid was compatible with the Common Market, and initiated a further information procedure under Article 88(2). During the course of this, the German government amended its original notification, to ensure that all aid would be passed through to enterprises using the centres. Little further detail was published in the decision on how some of the other issues discussed above were dealt with. The aid was approved under the de minimis rules and the SME aid framework. The Commission reiterated the important role of incubators/technology centres in helping young entrepreneurs to develop their ideas and survive their first critical years, and how the German scheme provides office rental, consultancy services, research accommodation, networking with other companies, and opportunities to collaborate with universities and research institutes.

As discussed in Boxes 2.2, 2.11 and 3.3, Oxera interviewed a representative from a French Ministry involved in a scheme to assist young innovative SMEs. The decision on the case was published in 2003 (European Commission 2003a). The proposal initially put forward by the French government had, as its main measure, a reduction in the social security contributions to qualifying firms during the phase of launching a R&D project and the creation of an innovative company, with the objective to lower the costs associated with recruitment. As an additional measure, to minimise the impact of the economic environment on such projects and increase the capacity of the firm to become self-financed, the scheme proposed a total or partial reduction on taxes on non-wage employee benefits. Oxera understands that the original scheme also included a corporation tax exemption (which would reduce taxes on any eventual profits).

To qualify for the scheme, a SME needed to prove that it was less than eight years of age, that it was undertaking or planned to undertake one or more R&D projects qualifying as fundamental, industrial or pre-competitive development, and that it was making an intense and continual effort to spend on R&D more than 15% of its total expenditure. As discussed in Box 3.3, the measures were developed in the light of perceived financial market failures affecting innovative SMEs in France.

Although the scheme was eventually approved, as also discussed in Box 3.3, certain elements included in the initial proposals were excluded from the final proposals, to meet the requirements of the R&D framework. Aid was not to be provided for the undertaking of initial market testing through the selling of initial production runs, and the aid was to be restricted to funding projects of firms rather than firms per se. The measure itself, under the R&D Framework, was restricted to a social security exoneration (the employer contribution to which is 30% of a worker’s salary, plus 2% maximum for workplace accident insurance cover and sickness cover). There would be a complete exemption for staff working full-time on qualifying projects, and a pro-rata exemption for staff spending part of their time on such projects. Under the scheme, SMEs must also regularly monitor and report on their R&D expenditure. A corporation tax reduction was only permitted under the de minimis rules.
References


Cameron, G. (1998), 'Innovation and Growth: a survey of the empirical evidence', Nuffield College, Oxford, July. This paper is based on chapter 2 of DPhil thesis at the University of Oxford. JEL Classifications: O30, O47.


DTI (2005), 'Non-Paper from UK on the Proposed Review of State Aid for Innovation and the Existing R&D Framework', February.


Innovation market failures and state aid: developing criteria


European Commission (2001d), 'State Aid N 120/01 UK—Aid to Rolls Royce for the Development of the TRENT 600 and TRENT 900 Engines', 3266 FIN, October 30th.

European Commission (2001e), 'Answer given by Mr Monti on behalf of the Commission, to Written Question E-2718/00', in OJC C113E/157, 18.4.2001.


European Commission (2003c), 'Aid to 'Cesare Serono SpA' for the development of new chemical synthesis processes for oral pharmaceutical forms of polypeptides, Invitation to submit comments pursuant to Article 88(2) of the EC Treaty', OJC 110/2.


European Commission (2004b), 'Aid C 3/04 (ex N 644/g/02)—Development of the Communal Infrastructure with Economic Character within the Scope of the Joint Task Scheme "Improvement of the Regional Economic Structure" (in original language Gemeinschaftsaufgabe "Verbesserung der regionalen Wirtschaftsstruktur") according to part II point 7 of the outline plan. Part g: Aid to the Construction and extension of industrial centres/technology centres ("Gewerbezentren"/"Technologiezentren") that provide accommodation and common services for newly created SEs and newly created innovative and technology-oriented SMEs. Invitation to submit comments pursuant to Article 88(2) of the EC Treaty (2004/C 84/02)', OJC 84, April 3rd.


European Commission (2004g), 'Aid C 17/04 (ex N 566/03)—Enterprise Capital Funds. Invitation to Submit Comments Pursuant to Article 88(2) of the EC Treaty', 2004/C 255/02.

Innovation market failures and state aid: developing criteria

European Commission (2005b), 'State Aid: Commission Endorses German Aid Scheme for Tenants of Technology Centres and Incubators', press release, IP/05/536, May 3rd.
Financial Times (2005), 'Italy must look beyond little companies', John Gapper, May 26th.
FTC (2003), 'To promote innovation: The proper balance of competition and patent law and policy', A report by the Federal Trade Commission, October.
Hagedoorn, J. and Schadkemraad, J. (1991), 'The role of interfirm cooperation agreements in the globalisation of economy and technology', Merit, Maastricht.
HM Treasury (2003), 'Bridging the finance gap: next steps in improving access to growth capital for small business', December.


Mohnen, P. and Garcia, A. (2004), ‘Impact of government funding on R&D and innovation’, mimeo. This study was financed by the European Commission in preparation for the Competitiveness Report.


Oxera (2005), ‘Financing the nuclear option: modeling the costs of new build’, Agenda, June.


Schumpeter, J. (1911), Theory of Economic Development.

Schumpeter, J. (1942), Capitalism, Socialism and Democracy.


