State aid to R&D and Competition:
An Economic Assessment Methodology

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A.1 Introduction

The fundamental principle behind the European Commission's state aid (or, subsidy) policy can be thought of as been the following: aid can be authorised only if it contributes to the achievement of a Community objective in such a way that the distortion of competition and trade is justifiable **(principle of compensatory justification)** and is thus "compatible with the common market ex Article 87(3) EC". As noted in a recent OECD (2001) report, in practice, the principle of compensatory justification implies that:

(a) The aid should serve a purpose of general Community interest. It is accepted that R&D satisfies this criterion.

(b) Its objective is to correct a market failure. R&D aid again satisfies this criterion.

(c) The intended result is balanced against the distortion of competition.

One should add here that:

(d) The intended result is balanced against a potential distortion to trade.

Points (c) and (d) are of course related: a distortion to trade will imply a distortion to competition though the reverse may not hold[1]. As it is rightly noted in a recent Commission Communication[2]: "When the effects of a measure are limited and mostly confined within national or regional borders, the choice of national authorities concerning State intervention is more likely to be consistent with the principles of compatibility with the common market. Indeed, an aid with limited effect on other Member States is more likely to fulfil the requirement for compatibility of Articles 87(3)(c) and (d) of the EC Treaty of *"not adversely affect[ing] trading conditions to an extent contrary to the common interest"*. Conversely, measures with important cross-border effects are much more likely to cause significant distortions of competition between Member States, and therefore require a more careful assessment of their positive contribution to Community interests".

The main objective of these notes is to describe a methodology for the economic assessment of subsidies (state-aid) to R&D. In principle this methodology can be thought of as building on the foundations already established by the Commission in the recent Communication on "A new framework for the assessment of State aid of lesser concern" (2004), in which, in what may be considered as its most novel part, the Commission espouses the premise that in the area of state aid policy an economic assessment procedure could be applied.

Specifically, in the final section of this document the Commission set outs in general terms "the approach it will follow in order to identify State aid measures, which are not covered by existing State aid regulations, frameworks or guidelines, or by the new (LASA) framework and which, because of certain conditions, can be expected to produce only limited effects on intra-Community trade and which therefore should more likely meet the requirement of Article 87(3)(c) and (d) of not affecting trading conditions to an extent contrary to the common interest. This approach will be used as an integral part of the Commission's efforts to modernise and simplify the State aid rules, allowing Member States greater flexibility to design aid measures while maintaining the principle of a strict State aid control, as required by the Treaty".

Continuing in this vein, the document points out that "The Commission considers that there is scope for a simplified assessment of measures providing sufficient guarantees of a limited effect on trade…….. (and that) the following factors appear to be particularly relevant in assessing the impact on trade of different aid measures:

a) the amount of aid;
b) the tradable/non-tradable nature of the aided activity;
c) the competitive structure of the markets concerned;

[1] One has to be careful: taking trade to include all flows of resources, goods and services across Member States implies that, for example, state aids in a MS in a sector producing non-tradable goods may distort competition AND trade if the participation of firms from other MSs are excluded – since this restricts the flow of capital and possibly other resources from other MSs in the specific sector of the MS providing the aid. Under this interpretation state aids will produce distortions to trade whenever they result in the restriction of potential entry in a MS' market or activity by foreign firms.

[2] "A new framework for the assessment of State aid of lesser concern", 2004.

d) the possible market power of the beneficiaries;
e) the availability of the aid to different operators in the market".

Specific conditions limiting potential negative effects must also apply, in particular:

(i) aid is linked to eligible expenses directly incurred in carrying out the activities concerned and the amount of aid granted in connection with the project is limited to the minimum necessary;
(ii) there is a reasonable limit to the amount of aid that can be granted to a single beneficiary. This limit is to be assessed case by case;
(iii) aid is granted in a way that does not create impediments to the development of the internal market and does not alter significantly the competitive position of the beneficiary vis-à-vis other firms carrying out the same activity. When applicable, in relation to this last point, the following principles are followed:

- Individual aid is awarded through a tender or equivalent procedure[3].
- Aid to infrastructure projects is subject to open access requirements;
- An aid scheme is open to all companies willing to carry out the identified activities within the jurisdiction of the granting authority, according to objective criteria and does not allow for a single beneficiary to get a significant proportion of the total budget of the scheme actually spent".

The document finally emphasises "that the (above) approach only covers the assessment of the effects of a measure on trade and competition. The Member State concerned must also demonstrate that the measure promotes the development of certain economic activities or of certain economic areas, or promotes culture and heritage conservation in such a manner as to qualify for the exemptions listed in Article 87(3)(c) and (d) of the EC Treaty".

Building on the above, below we propose a general framework in which we attempt to take into account all the factors that could potentially affect the economic assessment of a measure of state aid to R&D[4]. In particular, we consider that such a state aid measure (1) will have an impact on the market failures associated with R&D activities, (2) will have other efficiency effects (3) will have distortionary effects on competition and trade and (4) will have other distortionary effects (related to the opportunity cost of government revenue used to finance state aids).

The assumption made, in relation to the **objective of a policy measure**, is particularly important in delineating the factors that will be considered in the assessment. In this section we will make the assumption that the objective of a state aid to R&D measure in a MS is fundamentally to increase social welfare in that MS. In turn, our assumption as to the criterion to be used by a supra national authority such as the Commission in assessing such a measure will be that the criterion is that of the **total**

[3] This might not be the case when, for example, there is evidence of only one or very few subjects possessing the necessary requirements for performing the aided activity. Any such exception should, however, be duly motivated.

[4] We should however stress here that below we do NOT provide a step by step algorithm based on quantitative or qualitative rules and criteria that could be used by policy makers to assess the competition and market failure effects of state aids to R&D. This could be developed, along the lines used in the anti-trust and merger cases (where one has to assess competition effects taking into account, for example, efficiency defences) but it is outside the scope of the current project.

welfare of all MSs that could be affected by the measure. A measure will improve total welfare if the total benefits created – by correcting market failures in research and generating other efficiencies – outweigh possible costs from distortions. An obvious shortcoming of this criterion is that it does not attach any importance to the **distribution of welfare** among MSs. Thus, according to this criterion, the Commission should find that a measure is benign if it increases total social welfare even if that happens because social welfare is increased in the MS implementing the measure more than social welfare is reduced in the other MSs affected by the measure. Further the criterion puts equal weights on effects on consumers as it does on effects on firms and their profits. This is again a simplification – indeed a simplification that runs counter to standard practice in CEU (and other countries such as USA) where in assessing the impact on competition of firms' actions in antitrust and merger cases, greater weight is given to consumer welfare.

Nevertheless, we believe that the criterion of the total welfare of all MSs affected by a measure is the most appropriate one to use in the context of formulating a general framework for the economic assessment of state aid to R&D measures. One of the main advantages of using this criterion is that it provides the most general benchmark, thus directing one to take into account **the greatest possible set of relevant factors**. A policy maker, in practically implementing the methodology, can then put his/her own specific set of weights in the various elements of the methodology taking into account other (distributional or political) considerations. In each case, the consequences of the choices in weights for the final assessment will be rather obvious. For example, a quite substantial trade distortion may be given greater weight than the gain in welfare in the MS implementing the measure, or, this may be thought of as appropriate at least when the substantial trade distortion is associated with no or negligible benefits for the consumers of other MSs. Also, the policy maker could make a partial utilisation of the various elements in the methodology to make sequential decisions on the basis of any given prioritisation of objectives. For example, a state aid could be in the first place considered compatible with the common market if it increases the SW of the MS in which it is introduced: only if it found that this is the case do we go on to consider the implications for other MSs, etc.

A.2 Main Aspects of the Economic Assessment Methodology

The main aspects of our methodology are illustrated in Figure 1 below (see end of document). Note that in the discussion below we will **concentrate on the effects of state aid on private R&D** which we will associate, in particular, with Applied Research and/or Development undertaken by private firms for the purpose of producing innovations to be exploited or commercialised so as to gain a competitive advantage in their product markets. However, to a very large extent exactly the same methodology could be used to provide also an economic assessment of the effects of state aid to Applied Research and/or Development, irrespective of whether the recipients are private firms or Public Research Organisations (PROs) that produce patentable discoveries commercialized by other (private) establishments.

The model implicit in the methodology described in Figure 1 assumes a 4-stage decision process - the following:

a) In stage 1 a MS government (say Member State A) decides and announces a specific state aid scheme to R&D for private firms.
b) In stage 2 firms in the directly affected market(s) (d.a.m.) make their entry and/or exit decisions
c) In stage 3 firms make their R&D decisions which (if successful) result in process or product innovations
d) Finally in stage 4 firms compete in the product market and make pricing / output decisions

Decisions are interrelated: each decision is made taking into account decisions in previous stages and anticipating decisions that will be taken in the subsequent stages. Also, decisions and final outcomes are affected by other changes induced by the aid scheme in the form of **other efficiency gains** – e.g. in the form of locational externalities, or other industry **sector effects**[5] – e.g. in the form of an expansion of demand for an input produced upstream (these are indicated as effects (2) in Figure 1): these changes affect (and are affected by) R&D, innovation and pricing/output decisions in the d.a.m. (effects (6), (7), (6'), (7'), (14) and (15)) and have a direct effect on SW if they induce changes in output/prices and profits in other product markets (effects (17) and (17'). Finally, the SW outcome in MS A is affected by **other distortions** – in the form of the opportunity cost of state aid funds (effects (18), (19)).

Of course, the **overall Social Welfare (SW)** (that is, the sum of consumer welfare and profits) of **all** the MSs affected by the scheme is determined by the SW of MS A (effect (21)) and by the SW of all other affected MSs (effect (20)).

More specifically, the impact on SW in MS A is determined by four factors:

(i) The impact of the state aid scheme in generating **innovations** in the directly affected markets (d.a.m.) – effect (10). Note that process innovations by reducing costs lead to a gain in welfare via effect (9) on the prices and output of the d.a.m. Product innovations or improvements in quality on the other hand have a direct impact on SW (for given prices) – this is effect (10). The effect on Innovations is determined by changes in R&D (effect (8)) and by changes in the productivity of R&D induced through the "other effects" - (7) and (7').

(ii) The impact of the state aid scheme on **prices/outputs** in the d.a.m. – effect (16). Prices and outputs in the d.a.m. will be affected by process innovations (effect (9)), as just mentioned, by the impact on competition – effect (11) – and by other efficiency and other sector effects – effect (15).

(iii) The direct effect of other changes induced by the aid scheme in the form of **other efficiency gains** or other industry **sector effects** (effects (2)): these changes have a direct effect on SW (effects (17) and (17'))

[5] For a careful analysis of state aid policy using the distinction between a market (e.g. an airline route), an industry (the airlines) and the industry sector (aircraft manufacturing), see Fingleton et.al. (198).

if they induce changes in output/prices and profits in other product markets.

(iv) Finally, the SW outcome in MS A is affected by **other distortions** – in the form of the opportunity cost of state aid funds (effects (18), (19)).

Effects (10), (16) and (17) together determine the final effects on prices, product qualities / new product innovations and other industry sector (upstream and downstream) effects. These in turn together with effect (19) determine the final impact on consumer welfare and profits in MS A and hence on the total SW of MS A.

Concerning the effect of the state aid scheme introduced in MS A on the SW of other MSs and **trade distortions** and their effect we note the following:

When the affected markets concern tradables all effects on the SW of other MSs can be captured by effects (10'), (16') and (17') which (as for MS A) together determine the final effects on prices, product qualities / new product innovations and other industry sector (upstream and downstream) effects. These together determine the final impact on the other MSs' consumer welfare and profits and hence on their SW. Thus in this case trade distortions in Figure 1 represent changes in trade flows arising from competition distortions (effect (12)) the implications of which, for SW, have already been captured in the effects above. This means that, in this case, the category "Trade Distortions" appears in the Figure only in case the assessor wishes to assign a weight to this for other reasons, i.e. irrespective of how SW is affected (for example, the disappearance of a firm from another MS as a result of the aid scheme may create a serious competition and trade distortion against this MS but SW in this MS may be increased by the scheme because, for example, it makes possible the introduction of higher quality products at lower prices by firms in MS A that are consumed in the other MS).

When the affected markets concern non-tradables on the other hand then the effect of the state aid scheme on other MSs will depend on whether their firms are allowed on equal terms to participate in the scheme. If they are not (effect (12') then this creates a trade distortion – in the wider sense mentioned in the previous section – which has a distinct (negative) effect on the SW of other MSs (effect (13)).

Finally note that **competition** is affected in a direct way (effect (3')) through the effect of the state aid scheme on entry and exit decisions (effect (3)) and indirectly through changes in the R&D performance of firms due to the aid in the d.a.m. (effect (4). It is useful to decompose competition effects in (a) effects - competition distortions – associated with an alteration of the **Competitive Positions** of firms and (b) effects on the **Intensity of Competition** – see below for precise definitions. These effects on competition in turn affect R&D decisions (effect (5)) as well as pricing / output decisions (effect (11)).

We will now consider each of the above effects in detail in turn below.

A.3 Determining the long-run net impact of state aid on private R&D and innovativeness

Several factors need to be taken into account for determining the long-run net impact of State aid on R&D and innovativeness – effects (1) and (8) in Figure 1 – that is, the impact after accounting for the effect on future incentives to undertake R&D of changes in competition induced by the aid and for the impact of "other effects" induced by the aid. First, there will be a **direct impact on the R&D of the recipient firms** and on their rivals (effect (1)) and thus on their innovative performance – effect (8) in Figure. Then there will be an effect on R&D via the competition effects of the state aid – effect (5) in the Figure. To determine the **competition effect** we must take into account the direct effect on competition from the state aid by, for example, changing entry and exit conditions – effect (3), and also the indirect effect via the impact on the competitive positions of firms of changes in the relative size of R&D investment performed by firms – effect (4). Finally, the "other effects" induced directly by the state aid (effects (2)), and indirectly as a result of changes in the R&D and innovation of firms in the d.a.m. – effects (6) and (6') – induce in turn changes in the size of R&D investment performed by firms – effect (7) and in R&D productivity for generating innovations – effect (7').

Below we examine in turn each of these effects.

A.3.1 The Direct Impact of State aid on R&D and Innovativeness

The direct impact of state aid on the private R&D of the recipient firms and on their rivals and thus on their innovative performance is shown as effects (1) and (8) in Figure 1. Firms, when deciding whether to undertake an R&D investment project, compare the (often very) uncertain anticipated future revenues with the future cost of the investment – thus determining the expected rate of return of the project. Assuming that it is possible to rank all potential projects in a continuous decreasing order in terms of their anticipated marginal rate of return (which presupposes that R&D projects can be considered as been finely divisible) and also that the marginal opportunity cost of capital (MCC) for undertaking them can be identified, then, all other things equal, state aids that increase the marginal rate of return or decrease the MCC of R&D projects (e.g., by reducing fixed or variable R&D investment costs), or reduce the risk associated with the R&D investment, will result in an increase in the level of investment undertaken by recipient firms.

However, in assessing the direct impact of state aid on R&D and innovation the following should be taken into account. To start with note that to assess the impact we must distinguish between (i) effects on the recipient firms (ii) effects on rival firms and (iii) aggregate effects.

- *Effects on the recipients of the state aid*

Consider first the immediate direct effects on **recipient firms' R&D** investment:

a) One consideration is that R&D projects cannot in practice be considered as been finely divisible. This implies that an aid scheme

(whether a non-specific aid scheme, e.g a generic tax reduction scheme aimed at R&D activity, or a specific grant scheme aimed at discrete projects) may increase the anticipated rate of return of R&D projects but not by enough so as to induce firms to undertake new projects. In this case firms will be interested to become aid recipients but they will use the aid to reduce their own involvement in R&D projects that they would have undertaken anyway[6].

b) There is often a selection bias in public funding in the sense that it is targeted to specific projects with already high anticipated rates of return[7]. These are projects that the firms are likely to have decided to undertake anyway. Even though the public funding increases the rates of return of other projects, with lower rates of return, those firms would not have undertaken, the latter may not be eligible for public funding.

c) In the case that the aid is in the form of contract – specified procurement then it may simply substitute for some of the investment that the performing firms otherwise would have been prepared to undertake in order to be in a position to bid successfully for related government procurement contracts[8].

All the above suggest that the **magnitude of the state aid** in relation to the costs of the subsidized activity will be very important in inducing firms to undertake R&D projects in addition to those they would have undertaken any way. On the other hand, the higher the magnitude of the aid the greater the likelihood of a substantial competion distortion – see below.

However, many factors suggest that, **even if** the short-run direct additionality effects are small, state aids may, *ceteris paribus*, create substantial positive effects in the medium and long-run in terms of R&D and innovativeness for the recipient firms[9]. Specifically:

d) State aids to R&D can yield learning and training effects that acquaint the firms with the latest advances in scientific and engineering knowledge, as well as "absorptive capacity" enhancing effects, thus increasing the firm's efficiency in undertaking R&D programmes in the future.

e) State-aids in the form of payments spread out over many periods (e.g. via publicly funded procurement contracts) can signal strong future demand that may induce substantial increases in investment in the

[6] We may also get the opposite effect: if the aid size is bigger than what is required for a firm to undertake an additional project then part of the aid is not needed.
[7] As noted by David et.al. (1999) this is a result of "pressures within public agencies for high "success rates" in contract awards.
[8] See also David et. al. (1999), p. 17.
[9] The *ceteris paribus* condition is important: the reverse may also arise. State aids may increase R&D undertaken by firms in the short-run but may reduce incentives to undertake R&D in the longer term, e.g. by affecting the intensity of competition and/or the degree of technological symmetry between firms – see also below.

medium to long-run. On the other hand spread out grant payments may have serious disadvantages - see below.

f) State aids that reduce the firms' fixed R&D start up costs – e.g by funding the construction of test facilities or the acquisition of durable research equipment or the fixed cost of assembling specialized research teams – will allow firms to conduct their own future R&D projects at lower incremental cost thus inducing them to undertake more such projects.

A number of additional remarks are worth making at this point:

g) State aids can also affect the **focus of investment** undertaken by firms if they are directed towards certain types of investment e.g. investments directed to product innovation or quality improvements. The potential impact of the state aid on competition will depend, as we will see, on the type of the investment affected.

h) The direct effect of a state aid may also depend on the **structure of the state aid payments**[10]. If there are no credit constraints and perfect information, a state aid paid in full to a firm in the first period of its R&D investment is no more likely to make the firm carry out the R&D than the equivalent aid paid to the firm over several periods. However, if there are credit constraints and/or information is imperfect, then a front loaded payment to a firm can make the decision to carry out R&D more likely, relative to an aid where payments are spread over several periods. This is because a state aid that is spread over several periods and tied to remaining in that market is more risky for a firm than a front loaded aid, as *ex ante* it knows it might have to stay in a potentially unprofitable industry for a longer period of time. Also a financially constrained firm is more likely to find that it can cover its upfront R&D costs with a frontloaded state aid than an equivalent aid spread out over many periods.

❖ *Effects on rivals*

Let us consider next the effect of the aid on the rivals of the recipients – when the scheme is not a generic one applying to all firms in the sector. State aid will affect **rivals' incentives to undertake R&D** because if the subsidized firms generate successful innovations this will alter the competitive positions in the market and hence rivals' incentives to invest in R&D.

a) All other things equal the impact of the aid on rivals R&D activity will be smaller when there are substantial spillovers generated by the research induced by the aid and it is relatively easy to imitate the recipient firms' successful innovations. It is worth noting here that selection bias in public funding – see also above – may imply that public funding is directed to

[10] See Report to OFT by Frontier Economics, 2004.

projects not with high social rates of return – projects generating high spillovers – but to projects with high private rates of return.

b) Rivals' incentives will depend on the magnitude of the aid and the extent to which it improves the position of recipients – if the innovation produced by the aid has a "drastic effect" this means that non-innovating rivals will not be able to compete effectively and will therefore exit the market unless they are able to replicate the innovation in a reasonable time scale.

c) Given the above, rivals' incentives will be affected by the intensity of product market competition and on changes in this induced by the aid.

d) Further, rivals' incentives will depend on the extent of the initial technological asymmetry – whether there is a "technology gap" and how large this is. In the case where there is a technology gap incentives will be affected by whether the technology leaders or the laggards get subsidised.

Factors (c) and (d) are analysed in detail in Section A.4.4 below.

Finally, we note that the effect of the state aid scheme on welfare, via its effect on the R&D of rivals, will also depend on the extent to which the aid eliminates **duplicative R&D projects** of rivals. To the extent that this occurs welfare will be increased since less R&D will be invested to generate a given amount of innovations.

❖ *Aggregate effects*

Even if state aids would not substitute for private R&D funding at the firm or industry level in the absence of macro level effects, this may occur when the latter effects are taken into account. Macro level considerations relate to the likely upward pressure on the prices of R&D inputs when the provision of funding to a particular firm or group of firms occurs in the context of an expanded government R&D programme that absorbs substantial scientific and engineering personnel, along with other specialised materials and facilities. This seems a particularly significant consideration in the context of a large scale effort in each EU member state to increase R&D investment via public support to the private sector in view of meeting the Barcelona target. If this effort is not combined with an equally large scale effort to increase the supply of skilled, engineering and scientific personnel, a potentially substantial micro impact will be in danger of been annulled by macro effects of the type just mentioned.

The study of David and Hall (2000) points to four factors as important in determining the nature of the macro level relation between private and public R&D. Complementarity rather than substitution effects are likely to dominate – leading to a net expansion in private R&D funding - where:

(i) The elasticity of labour supply of qualified R&D personnel is higher
(ii) The relative size of the public sector in total R&D input use is smaller
(iii) The grant-contract mix of public outlays is skewed more towards the former

(iv) The rate at which the private marginal yield of R&D decreases more gradually with increased R&D expenditure

A.3.2 Effects of state aid on R&D/Innovation via the Competition effects of the aid

These are the effects indicated as effect (5) in Figure 1. To determine the competition effects we must take into account the direct effect on competition from the state aid by, for example, changing entry and exit conditions – effect (3), and the indirect effect via the impact on the competitive positions of firms of changes in the relative size of R&D investment performed by firms – effect (4). Effects (3), (4) and (5) are discussed in Section A.4 below.

A.3.3 Effects of state aid on R&D/Innovation via other changes produced by the aid

These are the effects (2), (6) and (7) in Figure 1 and are discussed in Section A.6 below.

A.4 Effects on Competition and Trade

A.4.1 Introduction

It is very important at the outset of this discussion to understand that while state aids to R&D could potentially have effects that create **competition distortions,** when such effects are present, this does not imply that there will necessarily be also a **reduction in competition intensity** (see for definition below) nor does it imply that, as a result of competition distortions, **Social Welfare will be reduced**. To determine the final – net – effect of the state aids on social welfare **via their effects on competition** we need to account for:

(i) The size and nature of the competition distortion created by the aid. Competition distortions imply an alteration in the relative competitive position of firms and this may occur - either through effect (3) or (4) - in different ways each with different effects (e.g. a laggard firm may catch-up with the leader or a leader may further enhance the size of the technology gap between itself and its rivals).

(ii) The effect of the aid scheme and the competition distortions it generates - either through effect (3) or (4) - on the intensity of competition. Intensity of competition may increase or decrease as result of the aid.

(iii) The effects of (i) and (ii) above on R&D performance – effect (5) in Figure 1, *and* on allocative (static) efficiency through the impact on pricing/output - effect (11) in Figure 1.

A.4.2 Main Factors Determining Competition (and Trade) Distortions

Competition distortions may be produced by R&D state aids when these, by making recipient firms undertake additional R&D leading to additional successful innovations, **alter the competitive position of the recipient firms** relative to non-recipients – either they alter the cost distribution between firms or the distribution of product/quality characteristics. Distortions will also emerge as a result of the effect of the aid scheme on the entry and exit decisions of firms – for example, aid may deter entry of potential new entrants that do not qualify for the aid as a result of not having been in the industry already, whilst it may induce new entry if it is available to potential entrants too and reduces their fixed R&D costs. So distortions on competition will arise as part of effects (3) – capturing direct effects on entry and exit - and (4) – capturing effects via the change in the relative R&D performance of firms. Considering aid that is directed to industries producing tradables the competition distortions generated by the aid will go hand in hand with trade distortions. The size / significance of these distortions will depend on a number of factors. We summarise the main ones below:

(i) Size of aid: note that if the state aid is directed to specific discrete R&D projects, the magnitude of the aid matters for competition to the extent that it makes a firm undertake an investment it would not otherwise undertake. Further increases in size would not be expected to affect the assessment competition. This would not be the case if the aid is directed to R&D activity itself rather than discrete projects. Needless to say the state aid must be kept to the minimum required to achieve its objective in order to minimise distortions, this being already a key principle in the design of state aids.

(ii) Degree of specificity of aid scheme. A state aid is only likely to give rise to competition concerns if it results in a change in competitive positions of one firm vis a vis its rivals (existing and potential). This is most likely to be the case if the state aid favours one firm over another through either selectivity in eligibility criteria or asymmetry of effect. Besley and Seabright (2000) make the point for generic (as against ad hoc or selective aid schemes) most succinctly. As they write “generic aids are most likely to be targeted at genuine market failures” rather than to be motivated purely by the desire to shift competitive positions strategically between countries. “A generic scheme that enables all firms to access a given level of subsidy according to pre-set conditions will be both a relatively ineffective and a relatively expensive way to engage in rent shifting (through changing competitive positions in imperfectly competitive markets). It is relatively ineffective because it sets common subsidy levels whether these are the appropriate ones or not. It is relatively expensive because it grants subsidies to many firms that do not thereby gain increased rents, in order to shift rents to the few that do”.

(iii) Mechanism used to allocate the state aid – when its objective requires selectivity in the award criteria. In many circumstances (when the number of bidders is not very small) competitive processes (auctions) will be best

for ensuring that the aid is allocated efficiently – to those that value it most[11].

(iv) Extent to which there is discrimination on the basis of ownership is ver important when firms are mobile. Firm mobility in terms of geographical location, product space and barriers to entry influences the distribution of the effects of aid[12]. When firms are mobile then aid is much more likely to be targeted to alleviating market failures rather than by the desire to shift monopolistic rents to the subsidizing jurisdiction provided that aid is available to all firms (whatever the location or identity of their owners) on a non-discriminatory basis[13].

(v) Whether state aid is directed to process or product innovation. When targeted at R&D directed to process innovation effect of state aid will as when aimed directly at cost reduction. When on the other hand it is targeted at product innovation there will be a competition effect if this concerns a new version of an existing product (business stealing) but there will be no competition effect when it concerns a new product (market creating effect).

(vi) Presence of significant economies of scale or network externalities in the markets affected – in this case even a small R&D subsidy in the early stages of product development may have substantial long-term consequences on competition (and, of course, trade)[14].

(vii) The market power of the recipient(s) – if this is small then aid is unlikely to generate large competition concerns and large negative externalities across countries - that is, it is unlikely that there will be a substantial trade distortion[1516]. Further, in the presence of market power, competition concerns will depend on whether there is an initial technology gap between firms and on the identity of the recipients – whether they are the leaders or the laggards (on these see also below). In considering market power we must investigate both output and input markets: for example, state aid to a firm with little market power in output markets but with substantial power in markets for specialised inputs (say, skilled labour) could create trade distortions (by poaching research scientists from other countries). However given the similarity of technological processes across firms market power in input markets will usually be exercised by firms

[11] For discussion specifically on this see the Frontier Economics Report to OFT (2004) and for a more general discussion on the use of auction theory in state aid policy modelling see Besley and Seabright (2000).

[12] The "firm mobility" factor has been stressed in all economic analyses of state aid quoted in this section. Fingleton et.al. (1998) provide a very succinct account – p. 28. As they note, a firm is mobile in geographic space if it does not have location-specific sunk costs. It is mobile in producto space if it can easily switch from one product to another (high cross elasticity of substitution).

[13] Fortunately, a survey by OECD found that a large proportion of state aid programmes (about 80%) do not discriminate on the basis of ownership. See OECD Report, 2001, p. 39.

[14]See also OECD Report 2001, p.37.

[15] Quite extensive discussions on this point – though mostly in the context of examining the competition effects of state aids in general not specifically state aids to R&D - exist in Besley and Seabright (2001, p.36-39), in the Forntier Economics Report to OFT (2004) and in Fingleton et.al. (1998).

[16] We are assuming away terms of trade effects that would arise if the country implementing the aid scheme is a large consumer of the output of the directly affected markets – on this see discussion by P. Sorensen in Besley and Seabright (2000).

also enjoying market power in output markets[17]. We return to these issues below.

A.4.3 Effects on Intensity of Competition

There is a rich variety of interpretations that economists give to the notion of "intensity of competition" (or competitive pressure) depending on the situation analysed[18]. It is often assumed that whatever parameter is used to measure competitive pressure, a rise in this should reduce firms' profits, increase industry output and increase consumers' welfare. For a market in which there are no differences between firms (firms are symmetric) this idea is indeed quite appropriate and the following possible **measures of competitive pressure** can be used. We can say that competitive pressure on the existing (or active) set of competitors in a market[19] would be enhanced if:

(ii) there was an increase in the number of competitors
(iii) there was an increase in product substitutability[20]
(iv) firms made competitive moves through price choices rather than production level choices (Bertrand rather than Cournot competition)[21]

Also, if it is possible for new firms to enter the market, then competitive pressure would be enhanced if:

(v) there was an increase in the total size of the market.

However, in many cases it is more appropriate to assume that firms in a market are not symmetric. It is quite usual that they may, for example, differ in efficiency. In this case it is more interesting, especially when we are investigating the effects of competition on incentives to invest in R&D, to focus on the effect of competitive pressure on specific firms of differing efficiency. As stressed by Boone (2000 and 2001), **with asymmetric firms** a rise in competitive pressure should:

a) reduce the profit of the least efficient firms, though it may lead to an increase in the profit of the most efficient firms, in particular,

b) increase the profit of the most efficient firm if this is far enough ahead in terms of efficiency from its rivals.

[17] As stressed in Fingleton et.al. (1998) and Belsey and Seabright (2000).
[18] For very good recent discussions that are also related to our concern of how competition affects incentives to invest in R&D, see Boone, 2000 and 2001, as well as Vives, 2004.
[19] Or, if there were *barriers to entry* in the market.
[20] Product substitutability can be used as a catch-all expression to measure the extent of aggressiveness in the interaction between firms.
[21] Though, as noted by Vives (2004), a change from Cournot (production setting) to Bertrand (price setting) behaviour is often interpreted as an increase in competitive pressure, since Bertrand equilibria tend to be associated with lower profits and higher output, "this interpretation need not make sense within a given industry. Indeed the mode of competition is typically dictated by the structural conditions in the industry" – see also Vives (1999, Ch. 7).

Note that with asymmetric firms apart from the number of competitors and product substitutability or, more generally, the extent of aggressiveness in the interaction between firms, there is another source of competitive pressure:

(vi) the higher the efficiency of rival firms the greater the competitive pressure on a firm.

Below we summarize the main effects that aid to R&D is expected to have on the **intensity of competition**:

I. Direct effects of the state aid scheme on competition intensity – shown by effect (3) in Figure 1:

These are effects related to the entry and exit decisions of firms that could result from the scheme even before the scheme has an impact on the R&D of the recipients (effect (1) in Figure 1). For example, the scheme may induce some new firms to enter specific R&D activities with a view to enter relevant markets if it reduces fixed R&D costs especially if the payment is frontloaded in the presence of finance constraints and uncertainty. This effect will strengthen intensity of competition. On the other hand, an aid scheme directed to specific existing firms may have the opposite effect: it may dissuade new firms to enter and may induce firms that are currently laggards and are not going to be subsidized to exit the product market, and this will lessen competition intensity.

II. Indirect effects of the state aid scheme on competition intensity – shown by effect (4) in Figure 1:

Indirect effects on competition intensity are effects produced through the effect of the scheme on the R&D performance of the recipients and the other firms in the industry sector – effect (4) in Figure 1 – and the consequent effect of this on the behaviour of firms. Changes in the R&D performance will affect competition intensity as a result of the following factors:

a) Changes in R&D performance may create additional exit effects (on top of those referred to above). Thus if the aid results in successful innovation and this increases the technology gap between the recipient firm(s) and other firms this may then induce exit by the latter. Additional exit (or reduction in entry) will also be induced if successful innovation raises the market power of the recipients making their behaviour towards actual rivals and potential entrants more aggressive – see below.

b) The change in competitive positions resulting from the changed R&D performance (and successful innovations) may well make predation more likely – reducing future intensity of competition[22]: predatory behaviour can simultaneously reduce the number of current competitors and raise barriers to entry. For example, predatory pricing raises barriers to entry by allowing an incumbent firm to develop a reputation for acting aggressively

[22] See also OECD Report, 2001, p.37.

in the face of new entry. (For a model and examples of aid with predatory effects see Mollgaard, 2004).

c) The change in competitive positions may affect behaviour relative to product market competition, in particular it may increase the likelihood of "tacit cooperative" behaviour or collective dominance leading to price increases and a reduction in consumers' welfare. This for example could occur if successful innovations by laggard firms that are the aid recipients create a more "level" industry in which it is easier to sustain tacit collusion.

d) There may be effects on product substitutability (product differentiation), as noted above, a very important parameter affecting intensity of competition. Successful product innovations may reduce significantly the degree to which rivals' products can substitute the products of recipients thus reducing the degree of aggressiveness in firms' interaction – thus, the intensity of competition – culminating in an increase in prices.

A.4.4 Effects on R&D performance via the effects of state aid on competition

By producing competition distortions, for example, by changing the cost distribution – an effect which will depend on the technology gap and its size and on who gets the subsidy – and by changing competition intensity, state aids to R&D will affect the **future incentives** of firms to spend on R&D and their innovative performance – effect (5) in Figure 1. That is, if originally firms would be investing a certain amount on R&D, the state aid will have a direct effect on the amounts invested and also, by changing their competitive situation, the aid will induce a change in the amounts invested in the future.

The **effect of distortions of competition and of changes in competition intensity on R&D** is a very complicated issue that has attracted a lot of attention by economists. Early seminal work by Arrow (1962), Lee and Wilde (1980) and Dasgupta and Stiglitz (1980) looked at how changes in the number of participants in a patent-race affected the rate of innovation. On the basis of their findings others have claimed that more intense rivalry always increases incentives to invest in R&D (or, the "incentive to innovate" which is the terminology that is usually used). This is not quite true however. The problem is that this claim does not explicitly distinguish between the number of participants in an innovation (patent) race and competition *in* a product market. An increase in the number of racers always increases R&D effort. The more relevant question from a public policy point of view is how competition in the product market affects the rate of innovation[23].

Some of the theoretical models[24] have tended to conclude that competition *reduces* R&D effort. On the other hand, one could at least tentatively conclude that available **empirical evidence** (Porter (1990), Geroski (1990, 1994), Bailey and Gersbach (1995), Nickell (1996), Blundell, Griffith and van Reenen (1999), Symeonidis (2002a,b) and Galdon-Sanchez and Schmitz (2002) is favourable to the *positive effect*

[23] See also discussion in "Competition Policy and Innovation" by D. Encaoua and A. Hollander, 2002.
[24] For example, Dasgupta and Stiglitz (1980) or Spence (1984).

of competition on R&D effort and innovation[25]. Some of the more recent game-theoretical work, however, tends to produce results which are robust and more in line with the empirical evidence.

Consider first a situation in which firms are not involved in a "winner-takes-all" patent race but in competition for incremental cost-reducing innovations (non-tournament R&D competition) that do not generate any substantial spillovers, and that all firms are in a symmetric position. Then the firms' incentive to invest in R&D will depend on their output since the value of a reduction in unit costs will increase with the output produced. Output per firm depends in turn on demand and price-pressure effects. For a given total market size, competition affects the effective market of a firm, its residual demand (a level or size effect), and the elasticity of the residual demand faced by the firm (an elasticity effect). Typically, an increase in competition with more competitors for a given total market size will decrease the residual demand for the firm and will increase the demand elasticity. The first effect will tend to decrease R&D effort because a unit cost reduction will benefit a diminished output, whereas the second will tend to increase R&D effort, because a unit reduction in costs will allow the firm to decrease price with a higher output impact.

For this case Vives (2004) shows that:

(i) In most cases increasing competitive pressure by increasing the number of firms keeping market size constant will tend to *reduce* R&D effort, because the residual demand (size) effect dominates the price pressure (elasticity) effect.

(ii) Increasing competitive pressure by increasing the degree of substitutability will usually *increase* R&D effort. In this case the size and the elasticity effects both work in the same direction.

(iii) When entry into the market is relatively free, increasing competitive pressure by increasing market size will *increase* R&D effort. This will be true irrespective of the competitive behaviour of firms (Cournot or Bertrand) and of whether or not products are differentiated. This provides a strong incentive for policies that promote market integration and a reduction in barriers to trade.

Of at least equal interest to the above are situations in which firms are asymmetric and engage in patent races – note that, given that now a technology gap is created as soon as a firm wins a race, when R&D competition takes the form of patent races (or tournaments), the natural state for firms to be is one of asymmetric market positions. The papers by Vickers (1986), Beath et.al. (1995), Aghion et.al. (1997, 2001), Aghion and Howitt (1992), Caballero and Jaffe (1993), Encaoua and Ulph (2000) and Boone

[25] This did not hold for early empirical work that used market concentration as the measure of intensity of competition. Concerning this literature Cohen and Levin (1989) write that it leads to "little support for the view that industrial concentration is an independent significant determinant of innovative behaviour". However, as stressed by Boone (2001) even the most recent econometric studies have not been able to capture completely satisfactorily the notion of intensity of competition and they ignore the cost history of an industry because it is hard to measure: however as we see below, for given level of intensity of competition, changing the cost history will change the relation between competition and R&D activity.

(2000 and 2001), provide very interesting results concerning firms incentives to invest in R&D in such situations.

Now firms, in undertaking R&D, are influenced not just by the standard "profit incentive" (or "stand-alone" incentive) associated with undertaking any profitable investment[26], but also by a desire to gain a strategic advantage. If a firm knows that its rivals are engaging in R&D in a "winner takes all" patent race, then it will see its own competitive position as being threatened. This fear of losing out to a rival is something that will help to explain the amount of resources that a firm allocates to R&D itself. This component of the overall incentive to do R&D is usually referred to as the "competitive threat" (or "replacement effect"): the size of this incentive depends on the difference between the profit if the firm wins the patent race and the profit if it loses[27]. So how does the intensity of competition affect these incentives?

(i) To start with, in case the firms engaged in the patent race are initially symmetric – there is no technology gap between them – then their incentives to invest in R&D will be higher when intensity of competition is high as, with strong competition, firms will have a strong incentive to "escape competition" by innovating.

(ii) Boone (2001), generalising previous results of Beath et.al (1995) and Vickers (1986) with asymmetric firms, shows how firms' incentive to innovate depends on the intensity of competition *and* their relative position in the market. When competition intensity is high it is a leader (or a more efficient firm) that will have the greatest incentive to acquire a patent for a cost-reducing innovation, whilst a laggard will have the greatest incentive when intensity of competition is low. The intuition is clear: the sacrifice in profit by the leader who fails to innovate increases with the intensity of product market competition. The implication for competition policy is important: increased dominance by a single firm should not be interpreted as a lack of competition. Rather it may signal that the technological leader has the most incentive to innovate *because* of intense product market competition.

(iii) Given that R&D investment depends on the firms' valuation of the innovation and that (a) this valuation increases with intensity of competition for a leader and decreases with intensity of competition for a laggard, and (b) as competition intensity changes this causes a change in the identity of the winner of the patent race, it follows that there is a non-monotone relation between intensity of competition and R&D activity (and thus the speed of technological progress). In general, an increase in intensity of competition can increase or decrease R&D activity depending on the industry' cost history and the initial value of competition intensity[28].

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[26] This can be measured by the difference in profit with the innovation and the profit the firm earns now.

[27] That is, it is the loss that the firm suffers from failing to maintain its current position and being replaced by a rival. Note that the profit of the firm if it loses will normally be less than the profit it currently earns. For details on all these issues see Beath, Katsoulacos and Ulph (1995) "Game theoretic approaches to the modelling of technological change", in Stoneman P. (Ed). "Handbook of the Economics of Innovation and Technological Change", Basil Blackwell.

[28] Note that one weakness of empirical studies measuring the effect of competition intensity on R&D incentives is the use of concentration as a measure of competition intensity which is misleading if firms differ considerably in efficiency levels.

(iv) Consider then a non-generic (or *ad hoc*) state aid in an industry in which firms are involved in R&D tournament competition and assume that while the aid affects the competitive positions of existing firms it does not affect the intensity of competition by inducing new entrants into the market or changing the degree of aggressiveness with which firms compete. Given that there is a technology gap between firms to start with, the effect of the aid on future incentives depends on which firm gets it and what would have happened without the aid. What would have happened without the aid depends on original cost history and intensity of competition. Assume that this is such – competition intensity is very weak- that the laggard would be the winner of the race in the absence of aid. If the laggard receives the aid then the market will move to the same competitive situation as without the aid. If on the other hand the leader receives the aid and this is sufficiently high as to make him the winner of the race then there will be an increase in the gap between leader and laggard which may induce the exit of the laggard and a relative lowering of the future incentives to innovate (relative to future incentives without the aid when the laggard would be the winner). If now competition intensity is sufficiently strong so a more efficient firm (leader) is the likely winner, then an aid to the leader will not affect the competitive situation that would emerge without the aid, whilst an aid to the laggard could remove the technology gap and increase future incentives to innovate relative to the non-aid situation. To summarise, in markets with intense product market competition (e.g. because of high product substitutability) aid to R&D is unlikely to affect adversely future R&D activity – relative to the situation without the aid – because of the competition distortions generated by the aid.

(v) A clear lesson emerging from the literature on patent races concerns the interpretation of concentration as a measure of competition intensity. Usually a high level of concentration is interpreted as weak competition, while an industry with a lot of firms and similar market shares is seen as highly competitive[29] (neglecting the potential effect of symmetry on collective dominance). This is clearly a wrong way to think of competition intensity in the context of industries in which firms differing in efficiency engage in tournament R&D competition. In this case high intensity of competition (measured by for example the degree of aggressiveness in firms' interaction – see above - that can be captured by product substitutability) implies that only a small number of highly efficient firms will be active in the market and consequently concentration will be high. With low intensity of competition, the less efficient firms can produce as well and one finds a large number of firms active in the market. Hence for a given cost history, low concentration is associated with low intensity of competition and not with a highly competitive market.

(vi) Another result[30] is directly relevant to the analysis of state aid to R&D when the aid can affect the intensity of competition. If aid is directed to industries with low competition intensity (e.g. because product substitutability is low – which implies that the laggard values the innovation most) *and* in which

[29] This view emerges from the standard Cournot model of oligopoly with symmetric firms. See also Boone (2001).
[30] See also Encaoua and Hollander (2002).

innovation leads to small improvements then we need not be concerned about the potentially negative competition intensity effects of aid to laggard firms, at least in terms of how these effects impact on R&D activity. Indeed in such situations it is better to aim for low intensity of competition as this would give the followers incentives to leapfrog the leader – in these industries turnover among the leading firms is expected to be high. In industries, on the other hand, in which innovation leads to major cost reductions *and* competition is intense (which implies that the leader values the innovation most), we should be very concerned about the potentially negative competition intensity effects of state aid to R&D. Here reducing competitive pressure through state aid is likely to reduce R&D activity.

(vii) In the above it has been assumed that there are no spillovers from the R&D activities of firms – and hence no knowledge diffusion. Models that allow for the possibility of knowledge diffusion indicate that they are important to obtain a positive impact of product market competition on R&D activity. In particular when knowledge diffusion is sufficiently high then competition pressure will always increase R&D activity[31].

A.4.5 Effects on allocative efficiency via the effects of state aid on competition

Of course competition distortions and the changes in the intensity of competition will have also effects on the **pricing/ output decisions of firms and thus on static allocative efficiency** in the markets concerned, *given* the R&D and innovation effects of the state aid – effect (11) in Figure 1.

Not taking into account effects on the *future* incentives of firms to innovate (described in A.4.4 above) and how these will affect prices in the future, state aid to R&D, could well increase overall static welfare. This will occur when, for example, state aid by reducing the fixed costs of R&D allows the currently less efficient (high-cost) firms to innovate and close the gap with the leaders. Reducing cost differences between firms will reduce prices and this will increase consumers' welfare. The gain in consumers' surplus may outweigh the cost of the subsidy so there is a net welfare gain. It is important to note that even if aid in country A that has the above effect creates a substantial trade distortion by shifting output from country B to country A, the effect of the aid will be to increase consumer welfare in country B too.

On the other hand, if the state aid diminishes intensity of competition by inducing exit or making the interaction and/or the strategies of firms less aggressive as noted above then this will, *ceteris paribus*, that is *given* the effect of these changes of competition on R&D and innovation, tend to increase prices and reduce consumers' welfare.

Clearly the final net effect of the state aid's impact on competition, on prices/output will depend on:

[31] See Encaoua and Ulph (2000) and Encaoua and Hollander (2002).

(I) the extent to which the competition effects via (5) tend to increase R&D and create additional innovations tending to reduce prices – the size and direction of effect (9);

(II) the extent to which the competition effects increase (decrease) competitive pressure tending to reduce (increase) prices for given R&D and innovation.

Of course in order to be able to effectively identify, with any degree of accuracy, the effects of state aid on competition, prices, trade and social welfare within the EU it is necessary to identify the **relevant markets** affected by the aid. We finally turn to this important issue in the next section.

A.5 Assessing the Competition Impact of State aid Schemes – the role of Antitrust and Merger Procedures

In some ways State aid control could be thought of as fundamentally different from the analysis of antitrust and merger issues. For example, in assessing a state aid the Commission concentrates on the justification for that aid in terms of serving a purpose of general Community interest and correcting well identified market failures[32]. However, as we have seen, the Commission's assessment also requires that it measures the competition and trade impact of the measure. It is then necessary, for tracing the impact to employ a methodology / procedure that at least in many important aspects is identical to that used in antitrust and merger issues. For example, especially when the aid is thought that it might create significant trade effects, it is very important and necessary to determine the **relevant markets** affected and to establish the **market power** of the firms directly and indirectly affected (as already noted, in both output and input markets).

Another difference between state aid control and antitrust and merger issues is that in the latter it is the actions of firms that are the subject of control, in order to avoid significant negative effects on competition that would be likely to reduce consumer welfare in the long term. In the former, on the other hand, it is the actions of governments that are the subject of control. However, notwithstanding other types of difficulties in controlling the actions of national governments, this difference should not have any effect in the way government actions are assessed **in terms of their consequences for competition and trade.** As recognised already in some countries (e.g. Denmark and some of the newly acceded MSs[33]) the principle must be that the business activities related actions of all economic units, including national governments, local authorities as well as private firms, take place on equal competition terms and this is assessed using procedures based on the same fundamental principles.

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[32] It should be noted that there is a counterpart of this in merger cases, in which one has to make the assessment taking into account not only the potentially harmful effects of the merger on competition but also the "efficiency benefits" that might be generated by the merger. These "efficiency defences", taken seriously into account in USA and Canada for many years, have also been given much greater weight in the Commission in its recent amendment of the merger regulation (2004).

[33] See OECD Report, 2001. Denmark amended its Competition Act in October 2000 to incorporate a new provision according to which the competition effects of state aids become the subject of control by the Danish Competition Authority. See also the case of the Czech Republic etc.

In at least three recent studies dealing with state aid policy the relevance and importance of antitrust and merger procedures for assessing competition effects of state aid cases has been stressed – Besley and Seabright (2000), Fingleton et.al. (1998), and Frontier Economics Report to OFT (2004).

Fingleton et.al. (1998) in particular examine carefully the role of antitrust policy definition of relevant markets in state aid cases in which it is important to identify competition effects and market power of recipients. As they write "the approach to market definition used in antitrust cases is, generally relevant and useful for state aid cases…". While a major difference between the use of market definition for antitrust policy and state aid control is that in the former the market is delineated to see whether the market mechanism will ensure competition and thus assess market power, whilst in the latter, apart from the need to assess market power, it is required that we trace the effects of aid across markets, this does not mean that making the appropriate market definition is not of equal importance in the latter as in the former case. Indeed, "the procedures used are likely to be similar…..(though) there are some important divergences with respect to method". The authors point out a number of such divergences[34]:

- In state aid cases a divergence from the integration of supply and demand aspects employed in antitrust policy procedures would be appropriate. In particular, supply substitutability would only become relevant to the measurement of the effects of the aid, once the markets have been identified from a demand perspective.

- All the input and output markets must be defined where the recipient has or might have a high market share. In antitrust policy cases, the input markets would only be defined where there is a possibility of monopsony power.

- The definition of the geographic market is central to the question of product/firm mobility and trans-frontier effects and might be expected to assume a greater importance in state aid cases than in antitrust cases, because the impact of the state aid may be to alter the recipient's geographic market strategy.

- Although the techniques for identifying the relevant geographic market would be the same for both antitrust policy and state aid cases, greater emphasis may need to be placed on the question of *potential competition* at the market definition stage[35].

A.6 Other Effects of State aids to R&D

These are the effects (2), (6), (6') and (14) in Figure 1.

We can point to at least three important potential effects of state aid to R&D, other than its direct impact on R&D incentives and on competition (effects (1) and (3) respectively), which we indicate as effects (2) in Figure 1.

[34] They also discuss a number of examples.

[35] It is standard in competition cases to bring in potential competition after the market has been defined, at the stage where the extent of market power is been assessed. In state aid cases, the effect of the aid may be to prevent such competition from materialising and this may be of particular importance in the context of market integration.

1. First, there may exist significant **locational or agglomeration externalities** associated with the R&D activities of firms. This provides an additional incentive for governments to subsidize R&D, so as to induce new firms to undertake research and production activities in specific locations. Further the expansion of R&D and innovation by existing firms due to the aid in specific locations tends to internalise these externalities – effects (6) and (6') in Figure 1. These efficiency effects may in turn generate further beneficial R&D effects – effect (7) in Figure 1 – as well as raising directly social welfare – effect (17) in Figure 1, as, for example, when they are associated with Marshallian labour market externalities.

2. The effect of the aid scheme on the **R&D of firms in complementary or supplier relationship** with the recipients is likely to be positive. As the recent literature suggests[36] subsidized firms have incentives to voluntary share any new knowledge gained from the new projects/ R&D investment undertaken as a result of been subsidized with their suppliers and firms in complementary product markets and this information sharing is likely to enhance the incentives of these firms to increase their R&D spending. This will in turn further enhance incentives for R&D in the affected markets (effect (7) and the productivity of R&D in these markets and thus innovativeness (effect (7').

3. To the extent that the aid scheme increases output in the directly affected markets this will tend to increase the demand of firms in complementary markets or in markets upstream or downstream with the d.a.m. For example, an increase in output and reduction in price in the d.a.m will reduce cost and lead to an increase in output in downstream markets thus enhancing social welfare (effect (17)). Also increased demand for an input used in the affected markets will benefit upstream firms and may if there are economies of scale in its production reduce the price of this input, thus further reducing prices in the affected markets (effect (15)). These effects will be greatest the more competitive are the related markets concerned.

Besley and Seabright (B&S, 2000) have placed particular emphasis on how subsidy competition between governments could play a significant role in efficiently internalising locational externalities[37], thus providing an important justification for such subsidy competition.

B&S start by considering the literature on intergovernmental competition when there are substantial externalities between governments. They note that much of this literature reaches pessimistic conclusions on the efficiency of intergovernmental competition. They cite as examples, excessive taxation of non-mobile factors as a result of intergovernmental tax competition, and the excessive use of subsidies to shift rents of imperfectly competitive markets in the strategic trade literature.

However, they stress the many questionable aspects of this literature, as that governments are assumed to compete only once and that firms are assumed to be able to negotiate only with their governments – an unrealistic assumption in a world of

[36] See for example Katsoulacos and Ulph (2002).

[37] Though their presentation is in the context of a general examination of state aid policy, their arguments on how intergovernmental competition can internalise location externalities applies equally well when the focus is the research and not only the production decisions of firms.

multinational corporations. They propose a framework which, when expanded to include the research decisions of firms, has the following characteristics:

- Firms make decisions about where to locate and on research and output. Thus firms do not belong intrinsically to one country rather than another, though they may undertake research and/or produce in one country rather than another.
- The location and research and output decisions of firms create external costs and benefits for the economy of the country in which they take place. Benefits to governments include tax revenue, reduction of unemployment, knowledge spillovers, labour market externalities etc while costs may include pollution, congestion etc. Costs and benefits differ across locations and firms' private decisions do not reflect these.
- Since firms do not appropriate all the benefits of their location and research and production decisions, governments have an incentive to compete to attract them. Governments can offer subsidies to firms contingent on these decisions.
- As well as creating externalities for the economy in which research and production takes place, firms' decisions create externalities for other countries. These may be geographical (as when the expansion in production in country X increases demand for certain inputs from country Y), or they may consist in an impact on the profits of rival firms, about which governments are assumed to care, either directly or because of their implications for tax revenue (as when a decision to locate in country X affects the profitability of a rival firm in country Y).

The authors then describe the process of intergovernmental competition as an auction in which governments are bidders who wish to have firms locate within their jurisdiction. They develop a model in **which intergovernmental competition in the presence of externalities is efficient**. On the basis of this they argue forcefully that the sources of failure in intergovernmental competition are not a direct consequence of externalities – as has been implicit in much mainstream policy analysis that is opposed to state aids – but from particular failures in the policy process, due to limited commitment, restrictions on bidding and government failure.

A.7 Other Distortionary Effects of State aids to R&D

Apart form correcting market failures – raising efficiency – and generating competition and trade distortions, the subsidization of R&D activities will also entail the usual distortionary affects produced by public subsidies of any form - effect (18). Generally speaking, the welfare impact of any subsidy can be measured by the change in the welfare of consumers' that it generates (via reduced prices, improved product quality etc), *plus* the change in the profits accruing to the firms affected – directly or indirectly – by the subsidy, *minus* the opportunity cost of the government revenue used to pay the subsidy. In the previous sections we have examined in some detail the various factors that affect the first two of the above categories of the change in welfare. The last factor, the opportunity cost of the government revenue, will be just equal to the cost of the subsidy if the required funds can be raised by lump-sum (non-distortionary) taxation. However, since the government revenue to pay the subsidy will usually be raised by some form of distortionary (welfare reducing) taxation, the

opportunity cost of the government revenue will exceed the cost of the subsidy, as considered in Neary (1994) and Collie (2000b). That is the cost of the subsidy must include the deadweight social welfare loss imposed by the distortionary taxation used to finance the subsidy – effect (19) in Figure 1.

Collie (2000b)[38] in particular examines the welfare effects of prohibiting state aids in an integrated market, such as that of the European Union under the assumptions that the aids are financed by distortionary taxation and that (oligopolistic) firms produce nationally differentiated products. He examines the case of production subsidies, which comes to the same thing in the context of this analysis as examining subsidies to process innovation directed R&D. He finds that if products are close substitutes then there exist reasonable values for the opportunity cost of subsidies for which the prohibition of all subsidies would raise aggregate welfare (the total welfare of all member states[39]). However when products are sufficiently differentiated the prohibition of state aid is likely to reduce aggregate welfare. The reason is that the reduction in the prices of imported differentiated products due to the subsidy produces a positive externality on other countries that outweighs the negative externality from rent-shifting[40].

However the author's conclusions that the above results imply that proposals to have a block exemption arrangement for "seemingly benevolent forms of state aid (such as aid to R&D) may be misguided…. when account is taken of the opportunity cost of government revenue" cannot be sustained given that his analysis does not take at all into account the market failure correcting effects of these types of state aid.

To limit these other distortionary effects it may be appropriate to establish an upper **threshold on the total amount of aid which may be granted in each MS in each calendar year[41].**

[38] This extends and generalizes his analysis in Collie (2000a).
[39] As he shows in Collie (2000a) this will always be true in the case of homogeneous products.
[40] So the joint welfare maximizing subsidies are higher than the market equilibrium subsidies that would arise in the absence of any coordination.
[41] This echoes a similar concern in the Commission Communication on state aid of lesser amounts (2004).

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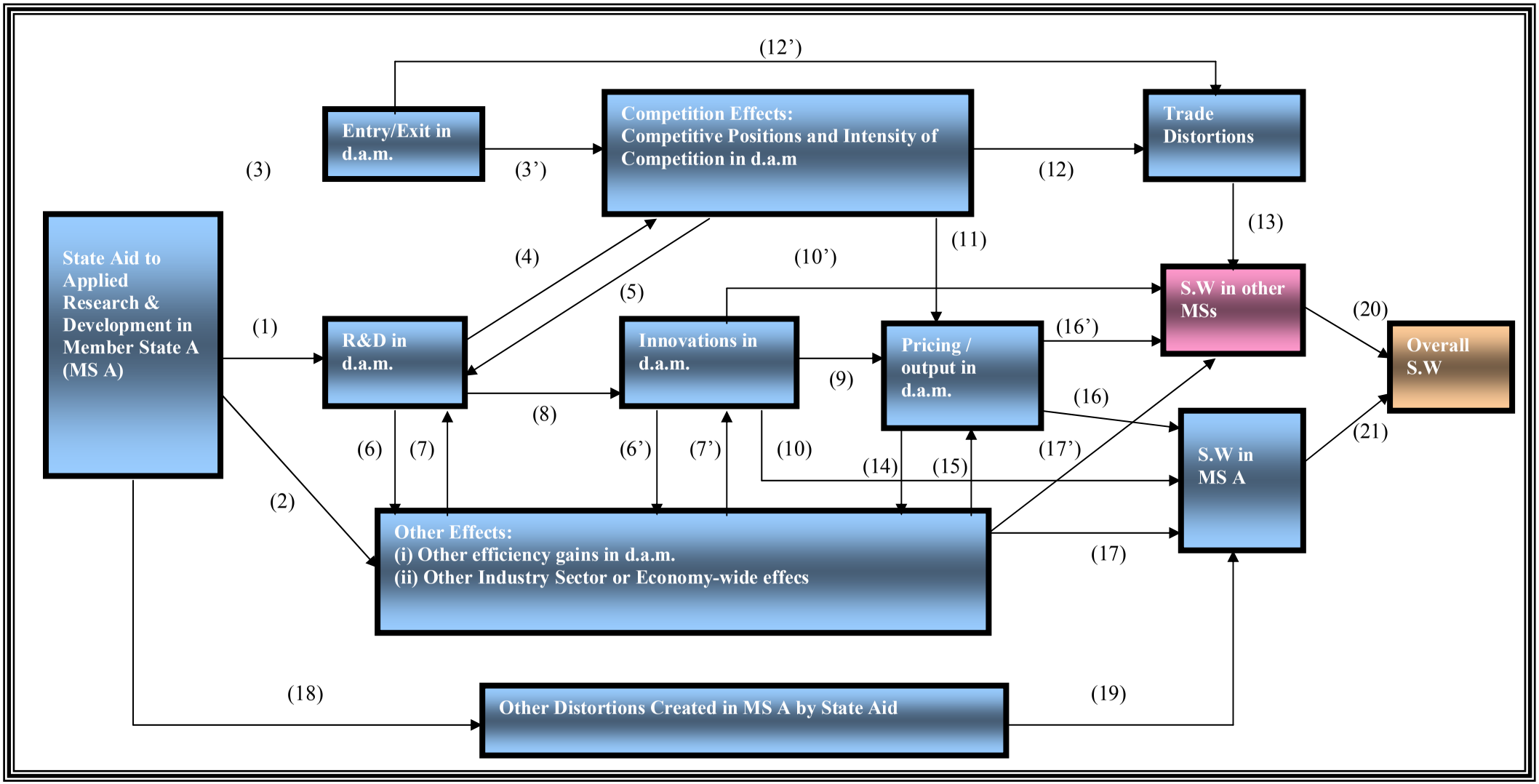
Figure 1: METHODOLOGY FOR THE ECONOMIC ASSESSMENT OF STATE AID TO R&D



Note: d.a.m. = directly affected markets
S.W = Social Welfare