OECD Economics Department Working Papers No. 458

From Innovation Development to Implementation: Evidence from the Community Innovation Survey

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https://dx.doi.org/10.1787/701385123017

OECD

Unclassified **ECO/WKP(2005)45**

Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

02-Dec-2005

English text only

ECONOMICS DEPARTMENT

ECO/WKP(2005)45
Unclassified

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JT00195404

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ABSTRACT/RÉSUMÉ

FROM INNOVATION DEVELOPMENT TO IMPLEMENTATION: EVIDENCE FROM THE COMMUNITY INNOVATION SURVEY

Innovation surveys provide a broad measure of the successful commercial introduction of new product and process innovations. The dual purposes of this paper are to establish whether survey-based measures of innovation are related to more widely used intermediate measures, such as R&D and patents, and to identify the principal factors that affect the probability of successful innovation. Cross-country panel data is used from the third European Community Innovation Survey (CIS3), with allowance made for possible differences by firm size and by sector of activity. The survey measures of innovative activity and success are found to be positively correlated with past R&D and patenting, suggesting that factors affecting the development of innovations also affect their subsequent implementation. The availability of qualified personnel and private financing, less rigid product and labour market regulations, greater co-operation in the innovation process and public financial support are all found to be positively associated with the proportion of successful innovators for at least some sectors and firm sizes. Innovation in small firms is found to be more dependent on co-operation and the availability of finance than in larger firms.

JEL Classification: O31, O38, D21
Keywords: Product and process innovations, firm size and industry differences, Community Innovation Survey data

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DU DEVELOPPEMENT A LA MISE EN OEUVRE DE L'INNOVATION : OBSERVATIONS A PARTIR DE L'ENQUETE COMMUNAUTAIRE SUR L'INNOVATION

Les enquêtes sur l'innovation fournissent une large mesure de l'introduction commerciale réussie de nouvelles innovations produits et procédés. Les objectifs de ce papier sont d'une part d'établir si les mesures de l'innovation basées sur ces enquêtes sont corrélées aux mesures intermédiaires de l'innovation plus couramment utilisées, telles que la R-D et les brevets ; et d'autre part d'identifier les principaux facteurs qui déterminent la probabilité d'innover avec succès. Les données de panel pays utilisées proviennent de la troisième Enquête Communautaire sur l'Innovation (CIS3), et permettent de différencier les résultats par taille d'entreprise et secteur d'activité. Les mesures d'enquête de l'activité et des succès d'innovation sont positivement corrélées avec la R-D et les brevets observés sur les années précédentes, suggérant que les facteurs qui affectent le développement des innovations déterminent également leur mise en oeuvre ultérieure. D'autre part, la disponibilité de personnel qualifié et de financement privé, une réglementation des marchés de produits et du travail peu restrictive, une plus grande coopération dans le processus d'innovation et l'aide publique financière sont toutes positivement associées à la proportion de firmes ayant innové avec succès, du moins pour certains secteurs et tailles d'entreprise. Enfin, l'innovation dans les petites entreprises est plus dépendante de la coopération et de la disponibilité de financement que dans les grandes entreprises.

JEL Classification: O31, O38, D21
Mots-clef : Innovations produits et procédés, différences par taille d'entreprise et secteur d'activité, données de l'Enquête Communautaire sur l'Innovation

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FROM INNOVATION DEVELOPMENT TO IMPLEMENTATION: EVIDENCE FROM THE COMMUNITY INNOVATION SURVEY

by

Florence Jaumotte and Nigel Pain[1,2]

1. Introduction

1. Applied studies of the determinants of innovation typically use patents and R&D as indicators of innovation output. However, neither of these necessarily provides a fully satisfactory measure of innovation output. Formally, innovation is considered to be the successful development and application of new knowledge.[3] As such, it is distinct from invention. In practice, it is convenient to view innovation as a process ranging from initial research (R&D) through to the development of prototypes and the registration of inventions (patents) and eventual commercial applications. This strict definition emphasises that innovation requires much more than greater R&D inputs into the research process. Fixed capital investments are often necessary to be able to produce and utilise new products and processes, as are workforce training and organisational restructuring. Moreover, many ideas may not come to fruition. Commercial innovations can also include other measures, such as designs and trademarks, that are not recorded in patents and R&D statistics.

2. Other measures of innovation that focus more closely on the actual implementation of innovations have recently become available, following the introduction of innovation surveys in various countries. The research in this paper explores whether these broader measures of innovative activity and innovative success are also influenced by factors similar to those found to influence business R&D intensity and patents in Jaumotte and Pain (2005b).

3. Using panel regressions on macroeconomic data, Jaumotte and Pain (2005b) investigate the effect of a broad range of specific science policies and framework factors on business R&D intensity and patenting. Both framework factors and specific science policies are found to matter and can have a direct

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1. The authors are members of the Switzerland/Spain Desk, Country Studies Division I and the Macroeconomic Analysis and Systems Management Division, respectively, of the Economics Department of the OECD. The authors are grateful to Mike Feiner, Jorgen Elmeskov, Pete Richardson and other colleagues in the Economics Department and the Science, Technology and Industry Directorate for helpful comments and advice, and to Caroline Guerra and Diane Scott for statistical support and assistance in preparing the document.

2. This study was carried out as part of the ongoing work in the Economics Department on structural adjustment, economic growth and innovation, and was previously presented as part of a wider research report to Working Party 1 of the OECD Economic Policy Committee and to the OECD Committee for Science and Technology Policy. Other parts of that report are also available in the Economics Department Working Paper series, see Jaumotte and Pain (2005a, b and c).

3. A more detailed definition of innovation and research activities can be found in OECD (1997). Innovations can be organisational as well as technological; only the latter is considered in this paper.

and indirect effect on these measures of innovative activities. The specific science policies which contribute the most to explain the evolution in business R&D intensity and patenting include the availability of scientists and engineers, research conducted in the public sector (including universities) and business-academic links. The effect of public financial support for business R&D is generally positive but modest and may increase for cash-constrained firms. Intellectual property rights are found to increase significantly patenting, but much less so R&D spending. Framework policies and conditions also play a crucial role in determining the innovativeness of economies. The latter is found to be enhanced by low product market regulation, high level of financial development and strong diffusion from foreign inventions.

4. In order to help assess the robustness of these results to alternative measures of innovative activity, an alternative dataset is used in this paper, drawn from the third European Union Community Innovation Survey (CIS3). This survey gathers comparable innovation data for 16 European countries[4] from a representative sample of firms in each country. Recorded innovations include the introduction to the market of new or significantly improved products and the introduction within enterprises of new or significantly improved processes. Data are available on the number of firms who are innovators and also on the proportion that are successful. The latter is just a count measure of the proportion of firms that have introduced at least one innovation. But the CIS also provides information about the market value of innovations by including data for the proportion of turnover accounted for by sales of new products.

5. The CIS contains several other useful data series. In particular, it has data on the shares of “pure” innovations and imitations in the total number of reported product innovations. A pure innovation is a product that is new for the surveyed enterprise and also for its product market; an imitation is the introduction of a product that is new for the enterprise but not for its product market. The survey also extends the coverage beyond traditional indicators of *innovative activity* (R&D spending and patents) by including other types of spending necessary for innovation to be implemented (such as investment in machinery and training) and other forms of protection. All the information is available by sector of activity and size class of firms, allowing tests to be undertaken for differences between them.

6. A number of studies have already used firm-level data from the CIS to examine the determinants of innovative success. These studies suggest that a wide range of different factors can affect the chances of successful innovation. For example, using data for France, Mairesse and Mohnen (2004) find that R&D spending per employee has a significant positive impact on measures of innovative success, although the actual contribution of R&D is found to be much smaller than the unexplained difference in innovativeness across sectors.[5] R&D intensity is found to be a good predictor only for the proportion of successful innovators in the high-tech sector. In earlier work (Mairesse and Mohnen, 2001), they also found that R&D can explain only a relatively small part of differences in innovation performance across seven European countries, particularly in low-tech sectors. Faber and Hesen (2004), using data aggregated at the national level for 14 EU nations in 1992 and 1996, conclude that the share of innovative products in sales increases with innovation expenditures and the proportion of innovators, as well as with public expenditures on

4. The countries are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, and the United Kingdom.

5. Mairesse and Mohnen (2004) also find that R&D spending per employee generally increases with foreign exposure, demand pull and cost push factors. They also identify positive effects on R&D from the use of information from basic research institutions (for high-tech sectors only), and from co-operation, information from clients, and market share (in low-tech sectors only).

R&D, the use of external sources of information, the size of the economy, entrepreneurship, the presence of small and medium-sized firms, and the technology distribution of firms.[6]

7. The present analysis takes another look at the determinants of innovative activity and innovative success using the cross-country data available in CIS3 for different sectors and firm sizes.[7] It does so in three separate steps. First, it examines whether the survey measures of innovative activity are correlated with economy-wide business R&D intensity and triadic patent applications. Significant correlations would suggest that the determinants of R&D and patents identified in Jaumotte and Pain (2005b) also influence broader measures of innovative activity. A second step is to explore the linkages between survey measures of innovative activity and measures of innovative success, such as the proportion of successful innovators and the share of new products in turnover. This enables an assessment to be made of whether output measures of innovation are significantly related to input measures. Finally, use is made of the information available in CIS3 on a broad range of potential determinants of innovation to examine directly the determinants of innovative success. Potential determinants include the proportion of firms having received public funding, co-operation between firms and with government research organisations, and the obstacles encountered by firms in their innovation efforts (such as rigid regulations and financing difficulties). The analysis is also refined by distinguishing between true innovators and imitators, as well as by sector of activity and size class.

8. The paper is organised as follows. Section 2 first describes the survey data set and uses it to compare countries' innovative performances by various measures of innovation, and to examine characteristics of innovation by sector and firm size. Section 3 examines the linkages between the survey and macroeconomic innovation data. Section 4 explores the linkages between innovation inputs and outputs based on the survey data. Section 5 examines the determinants of innovation success based on the survey data. Finally, Section 6 draws some summary conclusions.

2. Descriptive data

9. This section describes the CIS data set and the associated measures of innovative success and innovative activity. On this basis it then highlights differences across countries, sectors of activity and firm sizes with respect to innovation performance, the composition of innovation spending, the choice of protection methods, the frequency of co-operation arrangements, public funding and reported obstacles to innovation. These data are used in the subsequent empirical analysis.

2.1 The dataset

10. The Community Innovation Survey provides comparable innovation data for 16 European countries, though country coverage varies depending on the indicator considered. The third, and most recently released survey (CIS3) covers innovation over the period 1998-2000. The two previous surveys covered the periods 1994-96 and 1996-98 respectively. Changes in survey methodology and sampling procedures mean that the three surveys are not fully comparable, making it difficult to link them for empirical work. For this reason, the focus in this paper is solely on the information in CIS3.

11. The data are collected at the firm level and provide measures of innovative activity and innovative success that vary by sector of activity and firm size. The industrial sectors of activity include

6. They also find a negative effect from co-operation between firms for R&D, and a negative effect of privately financed R&D (once innovation expenditure is controlled for).

7. Other countries, such as Canada and New Zealand, have also undertaken innovation surveys occasionally. Any extension of the approach in this paper to include these countries would need to consider carefully the cross-country comparability of the survey questions in the different countries.

mining and quarrying, manufacturing, electricity, gas and water supply; service sectors include wholesale and commission trade, transport and communication, financial intermediation, and business services. Three size classes are distinguished: small (less than 50 employees), medium-sized (between 50-249 employees) and large (250 or more employees).

12. All countries carried out CIS3 using a stratified sample of companies with the exception of Iceland, which used a census. Although sampling rates differ across countries, the stratification of the sample (by size-class and sector of activity) should ensure that the samples are representative. When the non-response rate of sampled firms was too high, it was recommended that a non-response analysis be carried out in order to correct for possible biases that could arise from having an unrepresentative sample. Several countries carried out such a non-response analysis.[8] The differences in sampling and response rates nevertheless suggest that care has to be taken when interpreting cross-country comparisons made with the aggregated CIS data. This caveat also applies, though to a lesser extent, to the econometric analysis which uses the within-country variation between sectors of activity and size classes.

13. The survey provides information about the number of successful innovators and also the number of innovations per successful innovator and their market value. The first measure includes product and process innovations, whereas the measure of turnover share includes only product innovations. Each of the indicators of product innovations may be further split into those new to the firm and the market, and those new only to the firm. Differences in the share of turnover may reflect not only differences in innovative success but also differences in market structure, competition, and the diffusion of innovation. The survey measures of innovation are subjective, with judgements about the innovative character of particular changes being partially dependent on the views of the performer. Even so, as shown by Mairesse and Mohnen (2004), the subjective measures appear to be consistent with more objective measures of innovation, such as the probability of holding a patent and the share in sales of products protected by patents.

14. The CIS also provides a number of different measures of innovative activity -- the proportion of firms who are innovation active, the proportions of firms undertaking different types of innovation spending, and the proportions of firms making use of different types of protection for their inventions. Innovation active firms include successful innovators, firms that have ongoing, but not yet completed, innovation activities and firms that have temporarily abandoned their innovation projects. The categories of innovation spending include intramural R&D, extramural R&D (R&D financed by one company and performed by other companies or by public research organisations), other acquisitions of external knowledge,[9] investment in capital goods and training required to implement an innovation, and spending necessary for the innovation to be placed on the market (marketing, design).[10] The forms of protection can be split into two groups, covering formal and strategic methods. The former includes patents, trademarks, registration of design patterns, and copyrights. Strategic methods include secrecy, design complexity and lead-time advantage on competitors. One means of summarising this range of information is to construct aggregate indicators by taking the average of the proportions of firms undertaking each type of innovation

8. The CIS3 survey in Germany has a particularly low sampling rate (12%) and response rate (21%). The subsequent non-response analysis suggested that there was a difference between the proportions of enterprises with innovation activity in the main and non-response surveys. However, further analysis (using data from the annual national innovation survey in 2000) suggested that this did not bias the CIS3 response pattern and that the aggregates did not need to be corrected.

9. For example, rights to use patents and non-patented inventions, licenses, know-how, trademarks, and software.

10. Data on the actual levels of spending are also available, though coverage is less complete; the quality of the data is also thought to be less reliable. For these reasons, these data were not used in this paper and the proportion of firms engaging in innovation spending was preferred.

spending (except spending on marketing and design) and the average of the proportions of firms using each mode of protection.[11]

15. Finally, an important assumption made here is that the true value of missing information on innovation-related indicators is zero for non-innovative firms. For example, it is assumed that non-innovative firms do not engage in innovation spending, do not receive public funding for innovation and do not have co-operation arrangements for innovation.[12]

2.2 Cross-country differences

16. The CIS broadens the evaluation of the innovation performance of countries by providing an indicator of the implementation of innovations (successful innovators), as well as more encompassing measures of innovation spending and protection. Figure 1 compares the proportion of successful innovators, and the aggregate indicator of innovation spending with the more traditional measure of the proportion of firms engaging in intramural R&D. In the EU as a whole, 41% of firms were found to be successful innovators in CIS3. Germany, Iceland, and Belgium are reported as the three countries with the highest proportions of firms that are successful innovators, with proportions above 50%. Greece, the United Kingdom, Spain, and Norway are the countries with the lowest proportions. There is no clear cross-country correlation with the proportion of firms having engaged in intramural R&D. For example, Finland, Denmark, the Netherlands, and France are cited as having high proportions of firms engaging in R&D (in excess of 20%) but relatively low proportions of successful innovators. On the other hand, abstracting from Iceland, the aggregate indicator of innovation spending appears to be more closely correlated with the proportion of successful innovators.

17. The composition of innovation spending is shown in Figure 2. Acquisition of machinery and expenditure on training appear to be the other main forms of innovation spending, and sometimes appear even more important than R&D. Machinery acquisition is a more frequent category of spending than intramural R&D in Spain, Italy, Greece, Portugal, Germany and Luxembourg. Spending on training is also more frequent than on intramural R&D in Germany and Luxembourg. It can also be seen that many of the countries with the highest proportion of successful innovators also have the highest propensity to engage in non-R&D innovation spending.

18. Another indicator of innovation performance is the use made of different protection methods (Figure 3).[13] The aggregate indicator of protection appears to be strongest in the United Kingdom, Sweden, Finland, and Austria. The frequency of protection is lowest in Greece, Iceland, Spain, Portugal, and Italy. In most countries, strategic protection is more frequently used than formal protection, and within this category lead time and secrecy are most common. The exceptions are France, Denmark, Sweden, and Greece, where formal protection appears to be relatively more frequent. Among formal protection methods, trademarks are used more frequently than patents in most countries. This evidence appears consistent with that from other company surveys, in that it suggests that patents account for only a relatively small component of total protection (at least in frequency terms), and also that broader indicators

11. Use of an average implies that equal weight is given to the proportion of firms using each mode of protection. This may not be optimal, but receives some statistical support from the empirical estimates shown in Section 4 of this paper.

12. See Mairesse and Mohnen (2004) for evidence supporting this assumption. Using the French annual R&D survey for 2000 they find that only 2% of R&D performing firms declared that they were non-innovators in CIS3.

13. The number of firms using protection is shown as a proportion of all firms rather than as a proportion of innovative firms as it includes firms who are not presently innovation active but who are still protecting innovations made in previous years (pre-1998).

of protection may provide a more accurate picture of innovation activity. However, measures of the extent of protection (no matter how broad they are) require careful interpretation as, beyond differences in innovative activity, they may reflect a different composition of innovation (true innovation versus imitation) and different degrees of product market competition.

19. Successful product innovators can be split into true innovators and imitators (Figure 4).[14] Interestingly, some countries with a high proportion of successful product innovators (Iceland, Germany, and Belgium) are reported as having a comparatively low proportion of true innovators. To some extent, this may explain why the frequency of protection in these three countries is not as high as would be expected based on the proportion of successful innovators. On average, 45% of successful product innovators are imitators.

20. Innovation performance can also be measured by the share of new products in turnover (Figure 5). This indicator embodies information not only about the proportion of successful innovators but also about the number of innovations per successful innovator and the market value of the innovations. The highest shares of new products in total turnover are observed in Germany (23%) and Finland (17%); Iceland has the lowest value (3%).

21. The drawback of this indicator is that it may reflect differences in many factors other than the level of innovation, such as the length of the product cycle, market structure, the degree of competition and the diffusion of innovation. For example, Spain, Italy and Portugal appear to have high shares of new products in turnover despite having a relatively small fraction of companies that are successful product innovators. In these countries it is possible that the share of new products in turnover may be partially inflated due to short product cycles and/or a comparatively high degree of anti-competitive product market regulation, helping innovators to have strong market power (consistent with the evidence of the low diffusion of innovations). The opposite is the case for Iceland, which is reported as having the smallest share of new products in turnover and the largest fraction of successful product innovators. The decomposition of the share of new products in turnover into true innovations and imitations shows a similar pattern to that observed for the proportions of firms that are true innovators and imitators.

22. An important caveat to these cross-country comparisons is that the innovative performance of different countries depends to some extent on their industrial structure and also on the size distribution of their firms. Opportunities for technological progress are unequally spread across sectors, and some countries may specialise in sectors in which comparatively little innovation takes place. The capacity to perform leading research may also vary with the size of the firm. Such differences in innovation patterns across sectors and size classes of firms are examined in the following sections.

2.3 Differences between manufacturing and services[15]

23. Cross-country differences in innovation in manufacturing and services are shown in Figure 6. Greece, Portugal, Iceland and Sweden are the only countries in which the reported proportion of successful innovators in services is either as large as, or greater than that in manufacturing. For the sample as a whole,

14. The country shares differ from Figure A4.1 as the former shows the share of successful process and product innovators in the total number of firms. The data in Figure A4.4 cover only successful product innovators.

15. In order to study differences in innovation across sectors of activity, sector- specific aggregates are constructed based on the sector- specific information of all countries. For example, an aggregate proportion of successful innovators is constructed for each sector by taking a weighted average of the individual countries' fractions of successful innovators for the sector and using as weights the countries' shares in the total population of enterprises working in the sector in all included countries.

44% of firms in the manufacturing sector are reported as successful innovators, compared with 36% of firms in service sectors (Figure 7).[16] This gap appears wider for innovation success than for other measures based on innovation spending. There also appear to be considerable differences between service sectors. Within CIS3 it is possible to decompose the service sector into trade, transport, finance and business services.[17] Finance and business services appear much more innovative than manufacturing, but innovation in trade and transport appears to be modest. Successful innovation in manufacturing is less likely to involve diffusion/imitation than successful innovation in each service sector (Figure 8).

24. There are some differences in the composition of innovation spending and the modes of protection across sectors (Figures 9 and 10). In the manufacturing, trade and transport sectors the most frequent form of spending is reported to be investment in machinery. However, in the finance sector it is spending on training, and in business services there is little observable difference in the frequency of expenditure on investment, training and intramural R&D. Overall, intramural R&D appears to be relatively more important in manufacturing than in services, while training and external knowledge are relatively more important in services. Lead time and secrecy are the two most frequently cited modes of protection in all sectors and sub-sectors (with the exception of trade where trademarks are also important), as shown in Figure 10. Of the formal modes of protection, patents and design registration appear to be relatively more important in manufacturing while the use of copyright is relatively more common in services. This evidence about the composition of innovation spending and protection seems to suggest that the traditional indicators of innovation, namely intramural R&D spending and patent applications, can potentially bias the measure of innovation in favour of the manufacturing sector and against the service sector.

25. Innovative firms in services are reported as being more likely to co-operate with some other entity (private or public) for their innovation activity than are innovative firms in manufacturing (Figure 11). This seems especially true of innovative firms in the financial and business services sectors. It is possible that this may be one factor behind the higher share of imitators in service sector innovators shown in Figure 8. Co-operation arrangements with government and universities appear to be more frequent in all sectors than the use of government and universities as a highly important source of information. Co-operation arrangements are of particular interest because the fundamental research performed in the non-business sector may stimulate private research by opening up new opportunities for applied innovations. This appears to be more frequent in the business services sector than in any of the others.

26. In the survey, the proportion of innovative firms that received public funding for innovation (either from central, local or supra-national government) was about twice as large in the manufacturing sector (at about 35%) as in the service sector (Figure 12). Amongst the service sub-sectors, business services has the highest frequency of public funding (at 24%), possibly reflecting the comparatively high rate of co-operation with government in this sector. At the other extreme, the frequency of public funding for successful innovators in the finance sub-sector is only 3%.

27. Finally, obstacles to innovation are cited less frequently in service sectors than in manufacturing (Figure 13). This may appear puzzling, since manufacturing firms turn out to be more innovative. A similar "puzzle" can be observed for the business services sector, which has the highest propensity to report obstacles and the highest proportion of successful innovators. One explanation is that the obstacles to innovation are more likely to be cited when firms are actually undertaking innovation. An alternative

16. For the European Union as a whole it is estimated that 44% of firms in manufacturing and 36% of firms in services are successful innovators (Eurostat, 2004, Tables 3.1.1 and 3.1.2).

17. More specifically, the sub-sectors are wholesale trade and commission trade, transport and communication, financial intermediation and business services (computer activities, R&D, engineering activities and consultancy, technical testing and analysis).

explanation is that the differences in perceived obstacles to innovation may reflect differences in the nature of innovations across sectors. For example, innovations in the services sector may require fewer resources and be easier to implement.

28. The high cost of innovation is the most frequently quoted obstacle to innovation by firms in manufacturing (about 25%) and services (20%) sectors. The other major obstacles, in decreasing order of importance, are economic risk, lack of financing, and a lack of qualified personnel. Rigid regulations and standards are the only obstacle more frequently quoted by firms in services (in particular in the transport sector) than by those in manufacturing. This lends some support to the hypothesis that the nature of innovations may differ across sectors, though it could also reflect a higher degree of product market regulation in the services sector.

2.4 Differences across size classes of firms[18]

29. The degree of innovativeness increases with firm size, irrespective of the criteria used to measure innovation performance (Figure 14). The proportion of successful innovators appears to be twice as large in large firms as it is in small firms. Such differences appear particularly marked when measured by innovation spending or aggregate protection; on both measures large firms appear to be more innovative than small firms by a factor of 3 to 4. Successful innovation in large firms also seems less likely to involve diffusion/imitation than in other size classes (Figure 15), although the differences between size classes are not particularly large.

30. Investment in machinery is cited as the most frequent type of innovation spending in small and medium-sized firms, whereas in large firms it is intramural R&D (Figure 16). Training also appears to be relatively more important in small and medium-sized firms. In all size classes lead time, secrecy and trademarks are cited as the most frequent modes of protection (Figure 17). Small and medium-sized firms appear to use strategic protection methods more often than formal protection methods, while large firms use both with equal frequency. The differences in the use of formal protection methods stem largely from the greater use made of patents and design registrations by large firms. In contrast, lead time and trademarks are relatively more important for small firms than for large firms.

31. The survey data suggest that the frequency of co-operation arrangements increases with the size of the firm, ranging from 13% of small innovative firms to 42% of large innovative firms (Figure 18). Large firms appear more likely to co-operate with both government and universities than do smaller firms. Thirty-five per cent of large innovative firms are reported as having had a co-operation agreement with a university, compared with only 4% of small innovative firms. Public funding of innovation spending also seems to be more common in large firms (about 35% of innovative firms) (Figure 19). Finally, a smaller proportion of large firms report facing significant obstacles to innovation, which is consistent with their stronger innovation performance (Figure 20). The high cost of innovation is the most frequently cited obstacle to innovation in all size classes, with a lack of financing relatively important for small firms and a lack of personnel relatively important for medium-sized and large firms.

18. In order to study differences in innovation across size classes, size-specific aggregates are constructed based on the size-specific information of all countries. For example, an aggregate proportion of successful innovators is constructed for each size class by taking a weighted average of the individual countries' fraction of successful innovators for that size class. The weights are the share of firms from each country in the total population of enterprises in that size class in all included countries.

3. Linkages between macroeconomic and survey measures of innovation

32. The work reported in this section examines empirically whether survey-based measures of innovative activity are significantly correlated with economy-wide measures such as business R&D intensity and triadic patents. If so, it would suggest that the determinants of business R&D intensity and patenting identified in Jaumotte and Pain (2005b) might also help to determine broader measures of innovative activity, including other types of innovation spending and protection methods.

33. In order to investigate these correlations, the various measures of innovative activity from CIS3 are regressed separately on economy-wide business R&D intensity and triadic patents per 1 000 working-age population. Innovative activity is measured alternatively by the proportion of firms that are innovative, the proportion of firms engaging in various types of innovation spending, and the proportion of firms using various modes of protection. The CIS3 data consist of observations by country, sector of activity and firm size for the period 1998-2000. The two sectors of activity considered are industry and services (a finer disaggregation is not available jointly by sector and size). Economy-wide business R&D intensity is measured as the country average over the period 1998-2000, while triadic patents are measured by the country average over the period 1995-97, due to a lack of data after 1998.

34. A special estimation procedure is required to take proper account of the fact that the dependent variables (proportions of the total firm population) are bounded between 0 and 1. A generalised linear model is used; this is equivalent to applying a logit transformation to the left-hand side variable and estimating the model by weighted least squares. All regressions include dummy variables to control for differences across sectors of activity and size classes, as well as the 1998 average employment per firm in a sector-size group.[19] The sample size ranges from 68 to 84 observations, depending on the measure of innovative activity considered.

35. In this basic model business sector R&D intensity and the number of triadic patents per capita are both found to be correlated significantly with the survey measures of innovative activity (Table 1). A 1 percentage point increase in business R&D intensity (from the sample mean) is associated with a rise of 5 percentage points in the proportion of innovative firms, a rise of 4 percentage points in the indicator of aggregate innovation spending, and a rise of 9 percentage points in the aggregate protection indicator. Economy-wide business R&D intensity and patents per capita are both strongly correlated with the proportion of firms engaging in intra- and extramural R&D but not significantly correlated with the proportions of firms undertaking other types of innovation spending. The aggregate indicators are also positively correlated with the proportion of firms using each mode of protection.

36. This initial analysis suggests that there are close linkages between economy-wide indicators of R&D and patenting and particular measures of innovative activity shown in the CIS3. An implication of this is that the factors found to determine cross-country differences in the aggregate indicators may also be associated with cross-country differences in the survey indicators.

4. Linkages between inputs and outputs of the innovative process

37. An important feature of the CIS is that it contains information about the implementation of innovations. The analysis in this section investigates whether two of these "output" measures -- the proportion of successful innovators and the share of new products in turnover, are significantly correlated with more upstream measures of innovation, such as the proportions of firms undertaking particular types

19. Country fixed effects could not be included because they would be perfectly correlated with business R&D intensity and the patent share, both of which are country-specific measures.

of innovation spending and using particular protection methods. This helps to reveal the relative contributions of each component of innovation spending and protection to the success of innovation.

38. The relationship between the proportion of firms that are successful innovators and the proportions of firms undertaking different types of innovation spending and using the various modes of protection is shown in the regressions reported in Table 2. All regressions include controls for country, sector, and size class fixed effects. The regression shown in column [1] includes each form of spending and protection method separately. Many of the coefficients are not estimated precisely, but it is clear that the proportions of firms with spending on extramural R&D, training and investment in machinery are all significantly correlated with the proportion of successful innovators. The coefficients on the protection method variables are all individually insignificant, and also jointly insignificant. This suggests that once the type of innovation expenditure is controlled for, there is little relationship between the fraction of firms who are successful innovators and the proportions using each mode of protection.

39. This is also shown in the regression in column [2] of Table 2. This regression contains the two aggregated measures of innovation spending and protection, created as an (equal) weighted average of the individual components.[20] The coefficient on the innovation expenditure measure is significant, but the coefficient on the protection measure is not. The coefficients imply that a 1 percentage point increase in aggregate innovation spending (in effect a 1 percentage point increase in the probability of undertaking each type of innovation spending) is associated with an increase of 0.85 percentage points in the probability of being a successful innovator (at the sample mean).

40. The regression in column [3] of Table 2 shows that the aggregate innovation spending measure remains significant even if the variable for the use of innovation protection is omitted. The regression in column [4] shows that the probability of being a successful innovator is significantly correlated with the aggregate protection index only when the aggregate innovation spending measure is excluded. The final column in Table 2 uses an alternative measure, based on the proportion of firms that are innovation active. As might be expected, there is a clear positive correlation between this and the proportion of firms that are successful innovators.

41. The relationship between the share of turnover accounted for by new products and the proportions of firms undertaking different types of innovation spending and using the various modes of protection is examined in the regressions shown in columns [1] to [4] of Table 3. The results in column [1] show that very few of the individual measures have a significant coefficient, with the exception of spending on acquiring external knowledge and the use of lead-time as a method of protection. However, the coefficients are jointly significant, suggesting that it is difficult to separate out their individual effects. This remains the case even when using the (equal) weighted spending and protection variables, as shown in the regression reported in column [2]. The remaining regressions in Table 3 show that there are significant positive bivariate correlations between the proportion of turnover accounted by new products and the aggregated variables for innovation spending and the use of different modes of protection, as well as with the proportion of firms who are innovation active and the proportion of firms who are successful innovators. The coefficients imply that, all else being equal, a 1 percentage point increase in aggregate innovation spending is associated with a rise of 0.7 percentage points in the share of new products in

20. It is not possible to reject the set of coefficient restrictions required to move from the specification in column [1] to that in column [2]. However, this does not mean that equal weights are the optimal set of weights, as it would also be possible to impose a number of other sets of weights as well.

turnover, and a 1 percentage point increase in aggregate protection is associated with a rise of 0.8 percentage points in the share of new products in turnover (at the sample mean).[21]

42. These correlations between inputs and outputs of the innovation process provide additional evidence that the determinants of business R&D intensity and patenting are also likely to be correlated with the implementation of innovations, albeit indirectly.[22] They also show that successful innovation can depend on other types of expenditure in addition to intramural R&D.

5. Determinants of successful innovation: a second look based on survey data

43. This section makes use of the information in the CIS about the potential obstacles to innovation in order to investigate whether the measures of innovative success are related to factors similar to those found to matter for the more upstream measures of innovation, such as business R&D intensity and triadic patents. Some indirect evidence of this was obtained in the previous section. This section provides a more refined analysis of the determinants of innovation, distinguishing between true innovations and imitations, as well as between size of firms and sectors of activity.

44. Innovative success continues to be measured by the proportion of successful innovators and by the share of new products in turnover. The CIS contains information on a number of the determinants of innovation used in Jaumotte and Pain (2005b), including public financing, private financing, human capital, regulation, technology diffusion, and the links between the business and non-business sectors. These factors are measured respectively by the fraction of firms that have received public funding for innovation, the fractions of firms citing a lack of financing, a lack of qualified personnel and rigid regulations and standards as highly impeding factors for innovation, the fraction of firms having a co-operation arrangement for innovation activities (a potential indicator of technology diffusion), and the fraction of firms citing government and/or universities as highly important sources of information for innovation.[23,24]

45. In order to test for differences between true innovation and imitation, separate regressions involving the same potential determinants are run for the proportion of true innovators, the proportion of imitators, the turnover share of truly new products and the turnover share of imitations.[25] Tests are then undertaken for the equality of coefficients in the separate regressions with true innovation and imitation. The proportion of successful innovators and the share of new products in turnover are also regressed on the potential determinants of innovation interacted with three size dummies (small, medium, and large), in

21. The coefficients in columns [5] and [6] imply that increases of 1 percentage point in the proportion of innovative firms and the proportion of successful innovators are associated with increases of 0.4 percentage points in the share of new products in turnover.

22. The direct correlation between the proportion of successful innovators and economy-wide measures of innovation is only weakly significant, while it is totally insignificant for the share of new products in turnover.

23. This is calculated as the average of the proportions of firms citing government and universities as a highly important source of information for innovation. This is used instead of an alternative measure based on the proportion of firms co-operating with government and/or universities as the latter is closely correlated with the indicator of the proportion of firms with a co-operation arrangement.

24. An additional measure, the fraction of firms citing high costs as an impediment to innovation, is not used in the regressions because costs are likely to be strongly correlated with the extent of public funding, the availability of private finance and the use of co-operation arrangements. The fraction of firms citing economic risks as a highly impeding factor for innovation was used, but turned out to be insignificant.

25. Truly new products are new to the firm and to the market; imitations are new only to the firm.

order to allow for differences in the estimated effects of the determinants across size classes. Finally, differences across sectors of activity are tested for by regressing the proportion of successful innovators and the share of new products in turnover on the potential determinants of innovation interacted with the two sector dummies (industry and services). All regressions include country, size and sector fixed effects, as well as the 1998 average employment per firm to control for firm size.

46. The results of the regressions are reported in Table 4 (general results), Table 5 (true innovators and imitators), Table 6 (size differences), and Table 7 (sector differences). The results are broadly in line with those for R&D and patents in Jaumotte and Pain (2005b), but they also yield a number of new insights. Each potential determinant is discussed in turn.[26] In Tables 6 and 7, differences between size classes and sectors are tested by running a single combined regression with different coefficients being estimated for each size/sector on each explanatory variable of interest.

5.1 Public funding

47. An increase in public funding is found to have a significant positive association with the fraction of successful innovators and the share of new products in turnover, as shown by the regressions in columns [1] and [2] of Table 4. The estimated coefficients imply that an increase of 1 percentage point in the proportion of firms receiving public funding for innovation corresponds with a rise of 0.4 percentage points in the probability of being a successful innovator and a rise of 0.7 percentage points in the share of new products in turnover. There is a legitimate concern that the public financing variable may be endogenous, and so, as a robustness test, the regressions are repeated using the 1995-97 proportion of firms receiving public funding. The data from the previous wave of the CIS are not perfectly comparable[27] but nevertheless the significant positive effect of public funding on innovative success is confirmed, as can be seen in the results in columns [3] and [4] of Table 4.

48. Turning to the distinction between true innovators and imitators, public funding appears to have a significant positive association with true innovators (Table 5, columns [2] and [6]), but does not have a significant relationship with either the fraction of imitators or the share of imitations in turnover (Table 5, columns [3] and [7]). The different effects on true innovators and imitators are statistically significant. Public funding has a significant positive association with innovative success for both medium-sized and large firms (Table 6), but has a less significant bearing on success for small firms.[28] The regressions for different industries reported in Table 7 show that public funding has a significant positive relationship with the proportion of successful innovators and the share of new products in turnover in industry, but not on the corresponding measures for services.

5.2 Private financing

49. A lack of private financing has no significant association with the probability of being a successful innovator, but it does have a significant negative relationship with the share of new products in turnover, both for true innovators and for imitators (Table 5, columns [1]-[3] and [5]-[7]). This suggests

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26. The main points of interest in the tables lie in the relative magnitude of the individual coefficients and their significance. The implied partial effects from the main results are discussed in the text.

27. Public funding in industry was proxied by public funding in manufacturing; public funding for the service sector was based on a subset of the service sector (storage and communication, R&D, technical testing and analysis were excluded in CIS2); small firms in manufacturing were defined as 20-49 employees in CIS2 as opposed to 10-49 employees in CIS3.

28. It is of interest to note that the imposition of a common coefficient across size classes is not rejected by the data, although this partly reflects the relative lack of precision in the point estimate in the small firms regression.

that the financing variable is more likely to be reflecting a lack of finance for commercial development than for basic research. Taking all innovators together, an increase of 1 percentage point in the proportion of firms citing the lack of financing as a highly impeding factor reduces the share of new products in turnover by 1.6 percentage points.

50. The lack of financing appears to affect equally true innovators and imitators. However, there is some evidence that the impeding effect of a lack of financing decreases with firm size (at least for medium and large firms). The effects of the lack of financing on the proportion of successful innovators are significantly different across size classes at the 1% level, while the differences based on the share of new products in turnover are only significant at the 10% level. There are no significant differences across sectors of activity.

5.3 Venture capital

51. A widely held view is that the availability of venture capital is especially important to stimulate private innovation activity. The economy-wide availability of venture capital is not entered separately in the regressions reported in Tables 4 to 7 because it would be perfectly correlated with the country dummies. However, indirect evidence about the possible relevance of venture capital can be obtained by regressing the fraction of firms citing the lack of financing as a highly impeding factor on the economy-wide share of venture capital in GDP (measured at its average value over 1998-2000), including controls for sector and firm size. The results are reported in Table 8.

52. A number of different venture capital measures are used, including total venture capital and the components of this covering early stages finance and capital to finance high-tech investments. The results in column [1] show that availability of venture capital is significantly negatively correlated with the fraction of firms citing the lack of financing as a highly impeding factor for innovation. A 1% increase in the share of venture capital in GDP (from its sample mean) corresponds to a reduction of 0.2 percentage points in the proportion of firms citing the lack of financing as a highly impeding factor for innovation. This result is robust to the inclusion of other sources of private financing to the equation, namely bank credit, equity financing, and lagged profits (all three as a share of GDP). Of these other sources of private financing, the lagged profit share reduces significantly the perception of a lack of financing by firms. Equity financing also has a significant negative impact when considered on its own, but not when other financing variables are included.[29] Perhaps surprisingly, higher bank credit is found to be positively correlated with the share of firms citing financial constraints on innovation.

53. A more refined measure of the venture capital available for innovative activities can be obtained by taking only venture capital for early stages or for the high tech sector. Total venture capital remains significant when venture capital for early stages is introduced in the regression, and the latter is also very significant. However when venture capital for high-tech activities is added, only the high-tech variable has a significant negative coefficient (column [4]).[30] The sector and size class dummies shown at the foot of Table 8 suggest that financial constraints are relatively more likely to occur in small firms and in industry sector firms than in other firms.

29. This is consistent with what might be expected if equity financing is acting as a proxy for venture capital (see Jaumotte and Pain, 2005). However, it does not provide a formal test of this hypothesis.

30. Regressions including all the separate measures of venture capital do not add anything to these findings. In general the respective coefficients on the venture capital terms tend to be jointly significant, but individually insignificant.

5.4 Human capital

54. A lack of qualified personnel seems to be associated with a reduction in both the fraction of successful innovators and the share of new products in turnover, though the latter effect is not significant (Table 4, columns [1] and [2]). The coefficient in the regression in column [1] implies that a 1 percentage point increase in the fraction of firms citing the lack of qualified personnel as a highly impeding factor corresponds to a reduction of 0.5 percentage points in the fraction of successful innovators.[31]

55. The subsequent regressions in Tables 5 to 7 suggest that the lack of qualified personnel affects the probability of innovation success for true innovations only, not for imitations. It is also found to be significantly negatively correlated with innovation success in both industry and in services (Table 7, columns [2]-[3]). Although the point estimates suggest that the impact in industry is greater than in services, the imposition of common coefficients cannot be rejected.

5.5 Rigid regulations and standards

56. Rigid regulations and standards appear to have opposite effects on the proportion of successful innovators and the share of new products in turnover (Table 4, column [1] and [2]). A 1 percentage point increase in the fraction of firms citing rigid regulations and standards as a highly impeding factor is associated with a reduction of 0.6 percentage points in the fraction of successful innovators, but an increase of 1.7 percentage points in the share of new products in turnover.

57. A number of tests are undertaken to assess the robustness of these findings. First, the proportion of firms reporting rigid regulations and standards is regressed on the economy-wide OECD indicator of product market regulation, including controls for size and sector (Table 9). The correlation between them is positive and significant at the 10% level, suggesting that firms' perceptions bear some relationship to the actual degree of product market regulation and do not just reflect differences in cultural aversion to regulations.[32] Second, the proportion of firms reporting rigid regulations and standards was interacted with a dummy variable for a number of Southern European countries (Italy, Spain, and Portugal) characterized by high regulation (Table 4, columns [5] and [6]).[33] However, the coefficients on the interaction terms are not significant, and the coefficients on the proportions of firms reporting rigid regulations and standards remain significant. A final step was to discard a country at a time from the regressions; the results appear to be robust to this extension (Table 4, columns [7] and [8]).

58. There are several reasons why rigid regulations could reduce the fraction of successful innovators. For instance, they may restrict the set of opportunities for innovation. Strict employment protection legislation can reduce the benefits of innovation by making any adjustments of the labour force arising from new technology more costly. Rigid regulations may also reduce the incentives to innovate by reducing competition (particularly if they restrict market entry of would-be competitors). Given that the proportion of innovators is smaller, the increase in the turnover share of new products observed in the estimated coefficients must reflect either a larger number of innovations per innovator and/or a higher market value of each innovation. Stricter regulations typically give incumbents more market power and

31. Care is required before drawing policy conclusions from this result, as not having a lack of qualified personnel does not automatically mean that there is sufficient skilled personnel, especially trained scientists and engineers. Some national innovation surveys, such as that for the United Kingdom ask additional questions related to skills.

32. This could be explored further by using sector-specific indicators of regulations.

33. These countries were shown in Section 2 to have a low proportion of successful innovators and a high share of new products in turnover.

enable them to apply larger profit margins on new products. If so, it is possible that the net effect of fewer innovators and larger profit margins would be to increase the share of new products in turnover.[34]

59. Rigid regulations and standards are found to have significantly stronger effects on true innovators than on imitators (Table 5). More rigid regulations significantly decrease the proportion of true innovators, but do not have any significant impact on the proportion of imitators. They have a significant positive impact on the shares of turnover for both types of innovation, but the impact on the turnover share of new products is twice as large as on the turnover share of imitators. The results shown in Tables 6 and 7 show that this latter finding is especially apparent for small and large firms, and for all firms in the service sector. There are no statistically significant differences across size classes and sectors in the extent to which rigid regulation affects the probability of being a successful innovator.

5.6 Co-operation and technology diffusion

60. Co-operation on innovation appears to increase significantly the probability of being a successful innovator but has a non-significant effect on the share of new products in turnover (Table 4, columns [1] and [2]). A 1 percentage point increase in the proportion of firms having a co-operation arrangement for innovation raises the fraction of successful innovators by 0.5 percentage point. The intensity of co-operation is used in this paper as an indicator of the extent of technology diffusion.[35] A higher intensity of technology diffusion thus appears to be associated with a higher proportion of successful innovators.

61. The estimated effects of co-operation on true innovators and imitators are not significantly different from each other, but neither coefficient is statistically significant. However, as shown in Table 6, there is significant evidence that the importance of co-operation for innovative success and for the share of new products in turnover decreases with firm size. The effect on the proportion of successful innovators is about four times larger for small firms than for large firms, and the increase in the turnover share of new products associated with enhanced co-operation is significant only for small firms. Co-operation on innovation also appears to have a larger positive effect on the proportion of successful innovators in the services sector than in industry. However, there is no significant difference across sectors with respect to the turnover share of new products.

5.7 Links between the business and non-business sectors

62. An increase in the proportion of firms citing government and/or universities as a highly important source of information for innovation has a significant positive association with the share of new products in turnover, but has no significant impact on the aggregate fraction of successful innovators (Table 4).[36] The estimated coefficient implies that a 1 percentage point increase in the fraction of firms using information from the non-business sector raises the share of new products in turnover by 3 percentage points. This effect appears to stem from the impact on the turnover shares of true innovators, rather than from the turnover shares of imitators (Table 5), and from industry rather than services (Table 7). The results for size classes in Table 6 are difficult to interpret; the turnover of large firms is significantly raised by enhanced inter-sector linkages, but the turnover share of small firms is significantly lowered.

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34. An alternative interpretation could be that rigid regulations lead to a higher concentration of the market and since larger-sized firms are more likely to innovate, the number of innovations per innovator may be larger when regulations are more rigid. However, the fact that rigid regulations stimulate the share of new products in turnover for both small and large firms does not seem to support this interpretation (see below).

35. The link between these is discussed in Section 2.

36. It is possible that the role of universities as an information source could be understated as it may be reflected in other indicators as well. For example, firms can also access knowledge by hiring graduates and PhD holders instead of co-operating directly with universities.

5.8 Adding the propensity to engage in intramural R&D or aggregate innovation spending

63. When the propensity to engage in intramural R&D is added to the equation for the proportion of successful innovators, it is significantly positive and makes all other determinants apart from firm size and co-operation insignificant. Adding the aggregate index for innovation spending has similar effects, and also makes firm size and co-operation insignificant. Thus, the propensity to engage in intramural R&D or innovation spending appears to capture most of the information that was conveyed by the other determinants of the propensity to be a successful innovator. In contrast, the propensities to engage in intramural R&D and innovation spending are not significant in the equation for the share of new products in sales, and leave the other determinants unchanged. This is in line with the findings of Mairesse and Mohnen (2004, 2001), who show that intramural R&D is a better predictor of the proportion of successful innovators than of the intensity of innovation.

5.9 Employment protection legislation, process innovation, and patenting

64. The analysis in Jaumotte and Pain (2005b) suggests that stricter employment protection legislation (EPL) reduces significantly the propensity to patent for a given amount of R&D. The interpretation of this effect rests on two propositions -- that stricter EPL leads firms to do more process innovations relative to product innovations[37] and that process innovations are less likely to be patented. The CIS data allow these propositions to be tested. The regressions reported in Table 10 suggest that stricter EPL reduces significantly the share of product innovators among successful innovators and increases significantly the share of process innovators, controlling for firm size and sector of activity. The results reported in Table 11 show patents are less likely to be used as a mode of protection when the share of process innovators in all successful innovators is high, controlling for the proportion of successful innovators, firm size, sector of activity, and country fixed effects. This finding, together with those from Table 10, suggests that stricter EPL is likely to be associated with a lower level of patenting, all else being equal.

6. Conclusions

65. Several conclusions emerge from this paper. It is clear that successful innovation is not simply a matter of R&D and patenting. Investment in machinery and training also matter. Among the countries with a high propensity to undertake R&D spending, those with a high proportion of firms engaging in non-R&D innovation spending have the largest proportions of successful innovators. The protection of inventions also takes multiple forms; strategic forms of protection such as lead time and secrecy appear to be common. Focusing only on traditional indicators of innovation, such as R&D and patenting, may tend to over-emphasise the importance of manufacturing and large firms for innovation. It is clear from the CIS that smaller firms and firms in the service sector also account for a considerable share of total innovative activities. Investment in machinery and training, and the use of informal protection methods are more important (relative to their total innovation spending and protection) for smaller firms and services firms.

66. The survey-based evidence on the determinants of innovative success (measured by the implementation of innovations) appears consistent with the results found in Jaumotte and Pain (2005b) for cross-country R&D and patenting. The survey measures of innovative activity and success are generally positively correlated with the economy-wide business R&D intensity and the number of triadic patents per 1 000 working-age population. This suggests that the determinants of the latter may also help to determine the successful implementation of innovations at the end of the innovation process.

37. Reflecting the costs of making significant workplace reorganisations and the accumulation of firm- and occupation-specific knowledge by the workforce.

67. Using survey measures of the potential determinants of innovation, the analysis in this paper provides evidence that the proportion of successful innovators is positively associated with public financing, the availability of private financing, the availability of qualified personnel, less rigid product and labour market regulations, greater co-operation in innovation, and stronger links between the business and non-business sectors. All of these were found to be important determinants of activities at the start of the innovation process, notably R&D, and all are found also to be important at the end of the process if the translation of ideas through development and into the market is to be successful.

68. Looking at the share of new products in turnover, the results are broadly similar except for rigid regulations and co-operation during innovation. There is strong evidence that, at least for the countries for which data exist, a higher degree of product market regulation (and thus possibly lower competition) increases the share of new products in turnover. On the other hand, a higher intensity of co-operation (and hence greater technology diffusion) tends to depress the share of new products in turnover, especially for industry. It is possible that these findings reflect the impact of these factors on market power and profit margins, which may in turn affect turnover shares.

69. Most factors affect true innovators and imitators in similar ways. However, there are some exceptions. Public financing appears to stimulate true innovation but not imitation. This may not come as a surprise since one condition for obtaining public financing for innovation is likely to be the perceived originality of the research being undertaken. A lack of qualified personnel also seems to affect true innovation more than imitation, possibly because the former requires higher skills than the latter. Finally, true innovation is more sensitive than imitation to rigid regulations.

70. Use of the CIS data also enables distinctions to be made by firm size (Table 6). In many cases there do not appear to be significant differences by size class. However, the probability of innovative success for small firms appears to be more dependent on co-operation than for larger firms, and medium-sized firms are found to be more affected by a lack of financing and by the availability of information from the non-business sector. The share of new products in the turnover of small firms is however significantly negatively related to a lack of financing, suggesting that funding for full commercial development may be of benefit to them. Public funding of innovation appears to be significant only for medium and large sized firms.

Table 1. **Linkages between survey and macroeconomic measures of innovation, 1998-2000**

Generalized linear model estimation method[1,2]

Dependent variables	**Model I** BERD/Y (1998-2000) as a regressor	**Model II** TRIAPAT per 1000 population between 15 and 64 (1995-97) as a regressor
Ln (odds ratio[3] of being innovation active) (84 obs.)		
	0.199	3.77
	(2.55)*	(2.80)**
Ln (odds ratio of engaging in type of spending) (68 obs.)		
Aggregate innovation spending[4]	0.18	4.17
	(2.07)*	(2.77)**
Intramural R&D	0.46	8.62
	(4.67)**	(5.27)**
Extramural R&D	0.34	5.98
	(2.62)**	(2.75)**
Machinery	0.03	2.59
	(0.28)	(1.24)
Training	0.10	2.99
	(0.92)	(1.54)
External knowledge	0.01	0.84
	(0.11)	(0.42)
Ln (odds ratio of using a mode of protection) (84 obs.)		
Aggregate protection[5]	0.41	7.27
	(8.37)**	(8.54)**
Patent	0.55	9.64
	(6.78)**	(7.00)**
Trademark	0.38	6.16
	(5.88)**	(5.18)**
Design registration	0.33	5.98
	(3.59)**	(3.64)**
Copyright	0.66	11.42
	(7.62)**	(7.44)**
Secrecy	0.36	6.13
	(4.27)**	(4.19)**
Complexity	0.31	5.96
	(4.71)**	(4.97)**
Lead-time	0.45	8.79
	(5.07)**	(5.67)**

1. The regressions include controls for size (dummy variables for small, medium, and large firms, as well as the 1998 level of employment per firm) and controls for sector of activity (dummy variables for industry and services).
2. The t-statistics are in parentheses. ** denotes significance at the 1% level and * significance at the 5% level.
3. The odds ratio of an event is the ratio of the probability of the event occuring to the probability of the event not occuring.
4. The probability of aggregate innovation spending is calculated as the average of the individual probabilities to engage in the various types of innovation spending.
5. The probability of aggregate protection is calculated as the average of the individual probabilities to use the various modes of protection.

Source: OECD estimates.

Table 2. **Linkages between the proportion of successful innovators and innovation inputs, 1998-2000**

Generalized linear model estimation method[1]

Dependent variable: Ln (odds ratio of being a successful innovator)

	Unrestricted innovation spending and protection	Aggregate innovation spending and protection	Aggregate innovation spending	Aggregate protection	Innovation activity
Aggregate probabilities	[1]	[2]	[3]	[4]	[5]
Innovation spending[2]		4.998	5.115		
		(7.61)**	(10.45)**		
Protection[3]		0.217		4.792	
		(0.32)		(7.00)**	
Innovation active					4.527
					(21.26)**
Probability of engaging in type of spending					
Intramural R&D	-0.106				
	(0.16)				
Extramural R&D	1.741				
	(2.66)**				
Machinery	1.649				
	(2.86)**				
Training	1.393				
	(3.50)**				
External knowledge	0.095				
	(0.18)				
Probability of using mode of protection					
Patent	0.26				
	(0.38)				
Trademark	0.369				
	(0.54)				
Design registration	-0.215				
	(0.29)				
Copyright	-1.022				
	(1.43)				
Secrecy	-0.887				
	(1.54)				
Complexity	0.914				
	(0.84)				
Lead-time	0.871				
	(1.10)				
Size and sector controls					
Services	-0.14	-0.165	-0.169	-0.126	0.016
	(1.89)	(3.60)**	(3.59)**	(1.93)	(0.66)
Small firms	-0.196	-0.169	-0.174	-0.614	0.065
	(1.96)*	(1.39)	(1.44)	(5.35)**	(1.16)
Medium firms	-0.026	0.031	0.029	-0.235	-0.004
	(0.42)	(0.36)	(0.34)	(2.74)**	(0.13)
Observations	68	68	68	96	96

1. The t-statistics are in parentheses. ** denotes significance at the 1% level and * significance at the 5%level.
2. The probability of aggregate innovation spending is calculated as the average of the individual probabilities to engage in the various types of innovation spending.
3. The probability of aggregate protection is calculated as the average of the individual probabilities to use the various modes of protection.

Source: OECD estimates.

Table 3. **Linkages between the share of new products in turnover and innovation inputs, 1998-2000**

Generalized linear model estimation method[1]

Dependent variable: Ln (share of new products in turnover/share of old products in turnover)

	Unrestricted innovation spending and protection	Aggregate innovation spending and protection	Aggregate innovation spending	Aggregate protection	Innovation activity	Successful innovation
Aggregate probabilities	[1]	[2]	[3]	[4]	[5]	[6]
Innovation spending[2]		2.386	3.438			
		(1.32)	(2.66)**			
Protection[3]		1.887		3.498		
		(0.92)		(3.11)**		
Innovation activity					2.456	
					(3.63)**	
Successful innovation						2.289
						(3.39)**
Probability of engaging in type of spending						
Intramural R&D	0.352					
	(0.20)					
Extramural R&D	0.928					
	(0.61)					
Machinery	-2.07					
	(1.17)					
Training	-1.914					
	(1.16)					
External knowledge	4.186					
	(2.43)*					
Probability of using mode of protection						
Patent	0.83					
	(0.50)					
Trademark	2.119					
	(1.73)					
Design registration	2.857					
	(1.30)					
Copyright	0.015					
	(0.01)					
Secrecy	0.55					
	(0.28)					
Complexity	2.897					
	(0.94)					
Lead-time	-4.907					
	(1.97)*					
Size and sector controls						
Services	-0.24	0.03	-0.03	-0.04	-0.03	-0.04
	(1.13)	(0.17)	(0.20)	(0.32)	(0.21)	(0.31)
Small firms	-0.24	0.20	0.16	-0.08	0.16	0.09
	(0.70)	(0.60)	(0.47)	(0.31)	(0.51)	(0.29)
Medium firms	-0.11	-0.08	-0.11	-0.22	-0.18	-0.21
	(0.53)	(0.37)	(0.48)	(1.34)	(1.07)	(1.29)
Observations	68	68	68	84	84	84

1. The t-statistics are in parentheses. ** denotes significance at the 1%level and * significance at the 5% level.
2. The probability of aggregate innovation spending is calculated as the average of the individual probabilities to engage in the various types of innovation spending.
3. The probability of aggregate protection is calculated as the average of the individual probabilities to use the various modes of protection.

Source: OECD estimates.

Table 4. **Determinants of innovative success, 1998-2000**

Generalised linear model estimation method[1]

	Basic models		Robustness test for public financing		Robustness test for rigid regulations and standards		Max and min coefficient values by dropping one country at a time	
Dependent variables	Ln (odds ratio of being a successful innovator)	Ln (share of new products in turnover/share of old products in turnover)	Ln (odds ratio of being a successful innovator)	Ln (share of new products in turnover/share of old products in turnover)	Ln (odds ratio of being a successful innovator)	Ln (share of new products in turnover/share of old products in turnover)	Ln (odds ratio of being a successful innovator)	Ln (share of new products in turnover/share of old products in turnover)
Probability of	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Public funding	1.747	3.115			1.822	3.101	[1.22, 2.13]	[2.20, 3.98]
	(3.99)**	(3.02)**			(4.11)**	(3.06)**		
Lagged public funding			2.002	2.033				
			(5.54)**	(2.70)**				
Lack of financing	-1.121	-7.704	-1.323	-7.988	-1.204	-7.68	[-1.71, 0.25]	[-9.22, -5.97]
	(0.96)	(3.74)**	(1.58)	(3.37)**	(1.01)	(3.73)**		
Lack of qualified personnel	-2.198	-2.28	-2.044	-1.198	-2.223	-2.317	[-2.57, -1.72]	[-4.02, -1.60]
	(3.08)**	(1.57)	(3.17)**	(0.91)	(3.00)**	(1.59)		
Rigid regulations and standards	-2.276	7.183	-2.602	5.451	-2.446	7.197	[-3.13, -1.12]	[6.19, 7.80]
	(2.38)*	(4.72)**	(2.92)**	(3.55)**	(2.69)**	(4.65)**		
Rigid regulations and standards x Medit dummy					3.979	-1.187		
					(1.23)	(0.27)		
Information from the non-business sector	0.081	12.288	-0.791	9.158	0.336	11.944	[-1.24, 1.13]	[7.51, 13.90]
	(0.06)	(3.29)**	(0.72)	(2.23)*	(0.26)	(2.77)**		
Cooperation arrangement on innovation	2.118	-1.308	1.958	0.431	2.094	-1.271	[1.72, 2.64]	[-1.74, -0.43]
	(4.29)**	(1.23)	(4.44)**	(0.45)	(4.25)**	(1.21)		
Size and sector controls								
Services	-0.175	-0.004	-0.122	-0.165	-0.164	-0.01		
	(2.37)*	(0.02)	(1.97)*	(1.05)	(2.22)*	(0.06)		
Small firms	0.183	0.566	-0.147	0.257	0.192	0.567		
	(0.69)	(1.41)	(0.61)	(0.65)	(0.72)	(1.41)		
Medium firms	0.463	0.235	0.195	-0.116	0.476	0.234		
	(2.19)*	(0.90)	(1.04)	(0.40)	(2.26)*	(0.90)		
Average employment per firm	0.001	0.0004	0.0003	-0.0003	0.001	0.0004		
	(3.03)**	(1.40)	(1.83)	(0.78)	(3.18)**	(1.41)		
Observations	73	67	59	53	73	67		

1. The t-statistics are in parentheses. ** denotes significance at the 1% level and * significance at the 5% level.

Source: OECD estimates.

Table 5. **Determinants of innovative success: distinction between true innovation and imitation, 1998-2000**

Generalised linear model estimation method[1]

Dependent variables	Ln (odds ratio of being a successful innovator)				Ln (share of new products in turnover/share of old products in turnover)			
	All innovators	True innovator	Imitator	P-value of test of hypothesis true innovator=imitator[2]	All innovators	True innovator	Imitator	P-value of test of hypothesis true innovator=imitator[2]
Probability of	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Public funding	1.747	2.517	-0.856	[0.00, 0.00]	3.115	5.082	0.997	[0.00, 0.00]
	(3.99)**	(4.52)**	(1.27)		(3.02)**	(4.96)**	(0.74)	
Lack of financing	-1.121	-0.55	-0.15	[0.62, 0.78]	-7.704	-5.97	-7.55	[0.44, 0.59]
	(0.96)	(0.67)	(0.10)		(3.74)**	(2.96)**	(2.55)*	
Lack of qualified personnel	-2.198	-4.00	-0.18	[0.00, 0.02]	-2.28	-2.00	-4.85	[0.17, 0.33]
	(3.08)**	(2.99)**	(0.11)		(1.57)	(0.96)	(1.67)	
Rigid regulations and standards	-2.276	-2.13	0.96	[0.00, 0.04]	7.183	9.84	4.81	[0.00, 0.02]
	(2.38)*	(2.00)*	(0.62)		(4.72)**	(5.54)**	(2.24)*	
Information from the non-business sector	0.081	-1.153	1.616	[0.38, 0.31]	12.288	14.681	7.82	[0.25, 0.23]
	(0.06)	(0.43)	(0.60)		(3.29)**	(2.46)*	(1.36)	
Cooperation arrangement on innovation	2.118	0.906	0.526	[0.55, 0.53]	-1.308	-2.283	-0.609	[0.18, 0.24]
	(4.29)**	(1.43)	(0.87)		(1.23)	(1.84)	(0.43)	
Size and sector controls								
Services	-0.175	-0.052	-0.129		-0.004	0.354	-0.233	
	(2.37)*	(0.61)	(1.25)		(0.02)	(1.56)	(1.08)	
Small firms	0.183	0.1	-0.55		0.566	0.737	-0.006	
	(0.69)	(0.30)	(1.58)		(1.41)	(1.37)	(0.01)	
Medium firms	0.463	0.341	-0.142		0.235	0.59	-0.394	
	(2.19)*	(1.29)	(0.50)		(0.90)	(1.23)	(0.77)	
Average employment per firm	0.001	0.001	0.0001		0.0004	0.001	-0.0003	
	(3.03)**	(1.95)	(0.35)		(1.40)	(1.67)	(0.66)	
Observations	73	73	73		67	61	61	

1. The t-statistics are in parentheses. ** denotes significance at the 1% level and * significance at the 5% level.
2. The first p-value refers to the test of the hypothesis that the estimated coefficient for true innovators is equal to the value of the estimated coefficient for imitators, while the second p-value tests the reverse equality.

Source: OECD estimates.

Table 6. **Determinants of innovative success: distinction by firm size, 1998-2000**

Generalised linear model estimation method[1]

Dependent variables	Ln (odds ratio of being a successful innovator)					Ln (share of new products in turnover/share of old products in turnover)				
	Unrestricted regression					Unrestricted regression				
	Common coeff across sizes	Small firms	Medium firms	Large firms	P-value of test of hypothesis small=medium =large	Common coeff across sizes	Small firms	Medium firms	Large firms	P-value of test of hypothesis small=medium =large
Probability of	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Public funding	1.747	2.339	2.141	1.805	0.70	3.115	5.461	4.715	3.671	0.57
	(3.99)**	(1.64)	(5.04)**	(3.91)**		(3.02)**	(1.88)	(4.46)**	(4.47)**	
Lack of financing	-1.121	-0.664	-3.842	-1.694	0.00	-7.704	-10.857	-7.286	-4.499	0.09
	(0.96)	(0.49)	(2.38)*	(1.08)		(3.74)**	(4.09)**	(3.10)**	(1.65)	
Lack of qualified personnel	-2.198	-0.946	-0.213	-1.933	0.39	-2.28	4.993	2.229	0.52	0.48
	(3.08)**	(0.72)	(0.21)	(1.79)		(1.57)	(1.51)	(1.01)	(0.15)	
Rigid regulations and standards	-2.276	-2.441	0.51	-2.942	0.08	7.183	17.278	4.28	10.49	0.00
	(2.38)*	(1.88)	(0.46)	(1.67)		(4.72)**	(6.51)**	(2.78)**	(3.28)**	
Information from the non-business sector	0.081	-9.16	4.46	-3.11	0.04	12.288	-78.81	8.49	23.24	0.00
	(0.06)	(1.09)	(3.47)**	(0.99)		(3.29)**	(3.84)**	(1.09)	(3.95)**	
Cooperation arrangement on innovation	2.118	8.91	4.24	2.23	0.00	-1.308	8.29	0.82	-1.51	0.01
	(4.29)**	(4.21)**	(5.93)**	(4.83)**		(1.23)	(2.02)*	(0.69)	(1.31)	
Size and sector controls										
Services	-0.175		-0.22			-0.004		0.26		
	(2.37)*		(3.00)**			(0.02)		(1.19)		
Small firms	0.183		-0.622			0.566		1.45		
	(0.69)		(2.50)*			(1.41)		(2.06)*		
Medium firms	0.463		-0.322			0.235		1.129		
	(2.19)*		(1.32)			(0.90)		(1.58)		
Average employment per firm	0.001		0.001			0.0004		0.001		
	(3.03)**		(2.29)*			(1.40)		(3.34)**		
Observations	73		73			67		67		

1. The t-statistics are in parentheses. ** denotes significance at the 1% level and * significance at the 5% level.

Source: OECD estimates.

Table 7. **Determinants of innovative success: distinction by sector of activity, 1998-2000**
Generalised linear model estimation method[1]

Dependent variables	Ln (odds ratio of being a successful innovator)				Ln (share of new products in turnover/share of old products in turnover)			
	Unrestricted regression				Unrestricted regression			
	Common coeff across sizes	Firms in industry	Firms in services	P-value of test of hypothesis industry = service	Common coeff across sizes	Firms in industry	Firms in services	P-value of test of hypothesis industry = service
Probability of	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Public funding	1.747	2.013	-0.565	0.03	3.115	2.738	4.258	0.54
	(3.99)**	(5.63)**	(0.44)		(3.02)**	(2.22)*	(1.32)	
Lack of financing	-1.121	0.215	1.423	0.23	-7.704	-8.692	-7.723	0.72
	(0.96)	(0.15)	(0.97)		(3.74)**	(4.79)**	(2.95)**	
Lack of qualified personnel	-2.198	-4.015	-3.259	0.56	-2.28	2.78	-2.843	0.01
	(3.08)**	(3.36)**	(2.40)*		(1.57)	(1.23)	(1.58)	
Rigid regulations and standards	-2.276	-3.966	-4.44	0.78	7.183	4.126	12.142	0.02
	(2.38)*	(3.20)**	(3.78)**		(4.72)**	(1.68)	(4.14)**	
Information from the non-business sector	0.081	-1.924	-1.555	0.93	12.288	19.554	9.019	0.40
	(0.06)	(0.53)	(1.07)		(3.29)**	(3.17)**	(1.06)	
Cooperation arrangement on innovation	2.118	1.926	4.755	0.00	-1.308	-2.166	-2.246	0.96
	(4.29)**	(2.95)**	(5.89)**		(1.23)	(2.00)*	(1.17)	
Size and sector controls								
Services	-0.175		-0.478		-0.004		-0.054	
	(2.37)*		(3.31)**		(0.02)		(0.13)	
Small firms	0.183		-0.011		0.566		0.574	
	(0.69)		(0.05)		(1.41)		(0.98)	
Medium firms	0.463		0.292		0.235		0.253	
	(2.19)*		(1.59)		(0.90)		(0.61)	
Average employment per firm	0.001		0.0003		0.0004		0.0005	
	(3.03)**		(1.53)		(1.40)		(1.59)	
Observations	73		73		67		67	

1. The t-statistics are in parentheses. ** denotes significance at the 1% level and * significance at the 5% level.
Source: OECD estimates.

Table 8. **Effect of venture capital, 1998-2000**

Generalised linear model estimation method[1,2]

Dependent variable: Ln (odds ratio of citing lack of financing as a highly impeding factor for innovation)

	Models with various measures of venture capital				Models with other sources of private financing			All-inclusive model
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Share of venture capital in GDP								
Total VC	-284.9	-114.9	-138.5	-79.7				-214.4
	(7.71)**	(2.09)*	(2.92)**	(1.05)				(5.34)**
Early stages VC		-767.7						
		(2.81)**						
Early stages and expansion VC			-279.8					
			(2.73)**					
High-tech VC				-539.8				
				(2.87)**				
Other sources of private financing as a share of GDP								
Lagged profits (1995-1997)					-6.314			-4.337
					(4.34)**			(3.37)**
Credit						1.278		0.58
						(4.00)**		(2.17)*
Equity financing							-0.919	-0.216
							(5.46)**	(1.12)
Size and sector controls								
Services	-0.288	-0.277	-0.274	-0.269	-0.36	-0.315	-0.326	-0.336
	(2.03)*	(2.01)*	(1.96)*	(1.95)	(2.25)*	(1.99)*	(2.04)*	(2.90)**
Small firms	0.951	0.788	0.784	0.794	1.211	1.169	1.267	1.105
	(2.26)*	(1.99)*	(1.85)	(1.94)	(1.87)	(2.08)*	(2.19)*	(2.44)*
Medium firms	0.592	0.442	0.439	0.447	0.834	0.794	0.883	0.731
	(1.52)	(1.22)	(1.13)	(1.19)	(1.37)	(1.52)	(1.63)	(1.72)
Average employment per firm	0.0004	0.0002	0.0002	0.0002	0.001	0.001	0.001	0.001
	(0.91)	(0.53)	(0.48)	(0.52)	(1.10)	(1.19)	(1.35)	(1.25)
Observations	69	69	69	69	69	69	69	69

1. The t-statistics are in parentheses. ** denotes significance at the 1% level and * significance at the 5% level.
2. The regressions include a constant term.

Table 9. **Effect of product market regulation, 1998-2000**

Generalised linear model estimation method[1,2]

Dependent variable:	Ln (odds ratio of citing rigid standards and regulations as a highly impeding factor for innovation)
PMR	0.239
	(1.72)
Services	0.075
	(0.34)
Small firms	0.66
	(1.33)
Medium firms	0.371
	(0.89)
Average employment per firm	0.0002
	(0.42)
Observations	63

1. The t-statistics are in parentheses.
2. The regressions include a constant term.
Source: OECD estimates.

Table 10. **Employment protection legislation and type of innovation, 1998-2000**

Generalised linear model estimation method[1,2]

Dependent variables:	Ln (odds ratio of being a product innovator conditional on being a successful innovator)[3]	Ln (odds ratio of being a process innovator conditional on being a successful innovator)[3]	Ln (odds ratio of being a successful innovator)
EPL	-0.66	0.246	0.099
	(5.53)	(3.08)	(0.97)
Services	0.003	-0.199	-0.459
	(0.02)	(1.91)	(4.23)
Small firms	-0.551	-0.421	-1.435
	(1.62)	(1.57)	(3.83)
Medium firms	-0.439	-0.157	-0.712
	(1.40)	(0.67)	(2.04)
Average employment per firm	0.00005	0.0005	-0.00006
	(0.15)	(1.81)	(0.16)
Observations	72	72	72

1. The t-statistics are in parentheses.
2. The regressions include a constant term.
3. Successful innovators are split in three categories: product-only innovators, process-only innovators, product and process innovators. Product innovators here refers to product-only innovators but the results are the same if product and process innovators are included among the product innovators.
Source: OECD estimates.

Table 11. **Propensity to patent and type of innovation, 1998-2000**

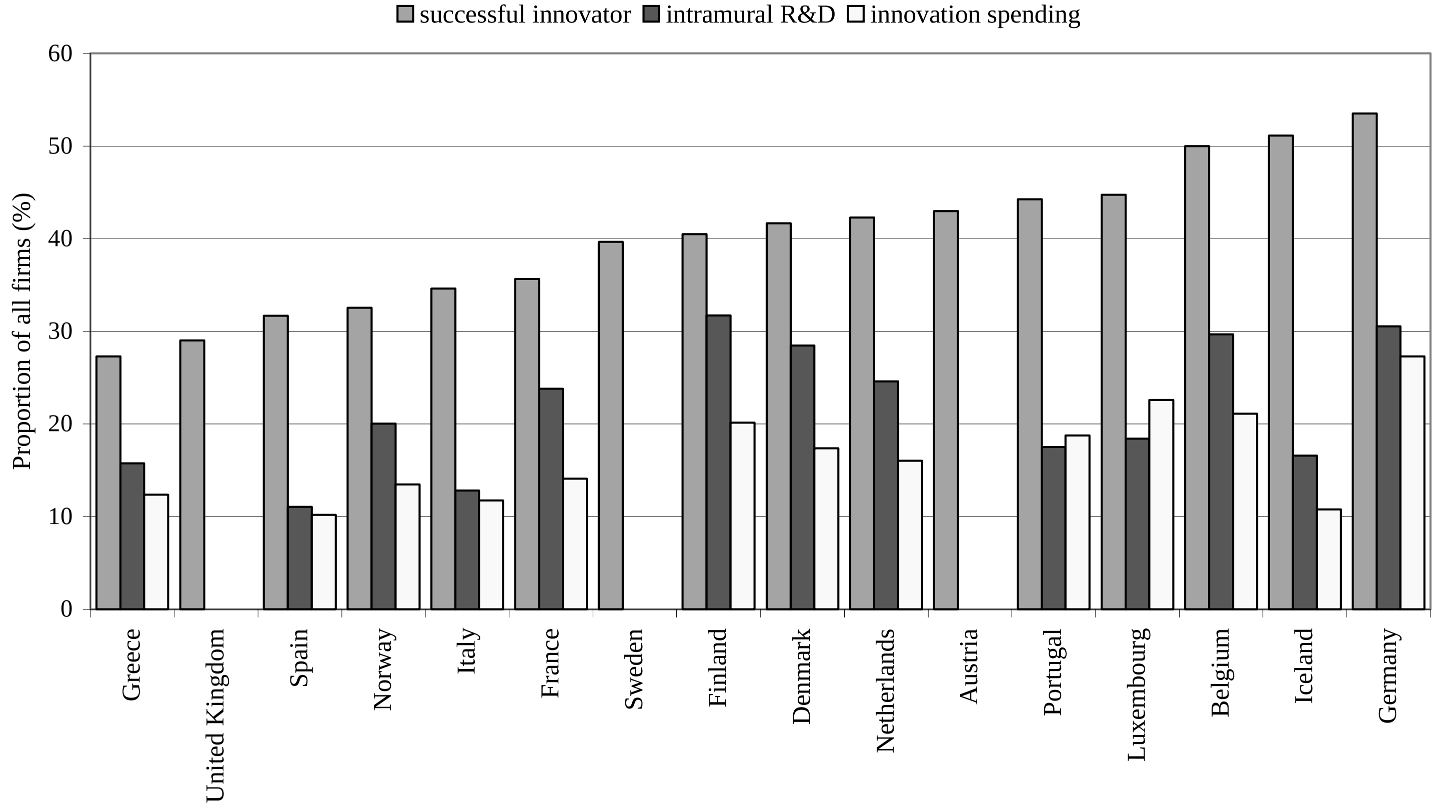
Generalised linear model estimation method[1,2]

Dependent variable	Ln (odds ratio of using patent application conditional on using a mode of protection)
Proportion of successful innovator	0.902 (1.93)
Share of process innovators among successful innovators[3]	-0.954 (2.35)
Services	-0.313 (3.93)
Small firms	-0.303 (1.20)
Medium firms	-0.240 (1.23)
Average employment per firm	-0.00005 (0.26)
Observations	72

1. The t-statistics are in parentheses.
2. The regressions include country fixed effects.
3. Successful innovators are split in three categories: product-only innovators, process-only innovators, product and process innovators.
Product innovator here refers to product-only innovators but the results are the same if product and process innovators are included among the product innovators.

Source: OECD estimates.

Figure 1. **Comparison of countries' innovative performance by various measures**[1]

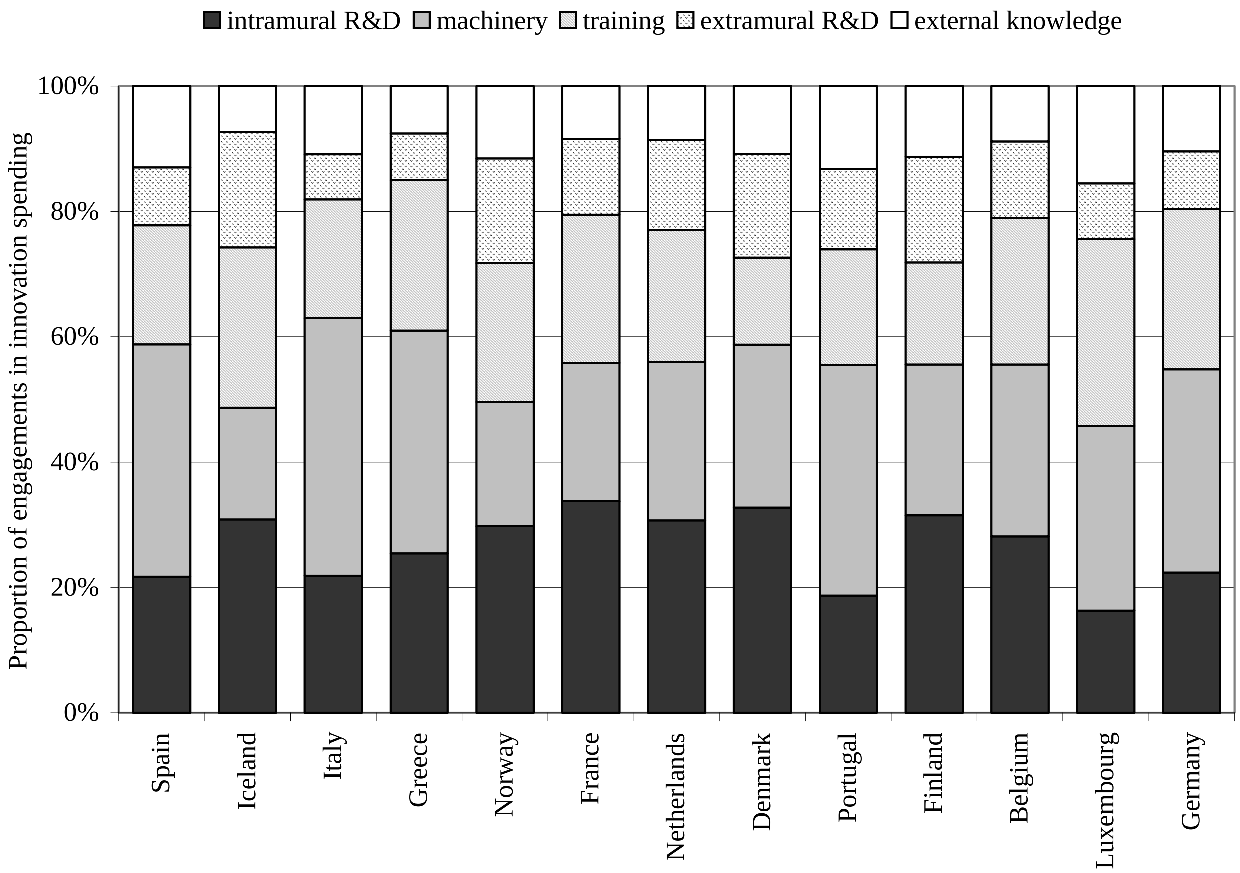


Notes

1. The proportion of firms engaging in innovation spending is calculated as the average of the proportions of firms engaging in the various types of innovation spending. For Austria, Sweden, and the United Kingdom, no data are available on the proportion of firms which engage in innovation spending.

Source: Community Innovation Survey 3 (European Commission).

Figure 2. **Composition of innovation spending by country**[1]



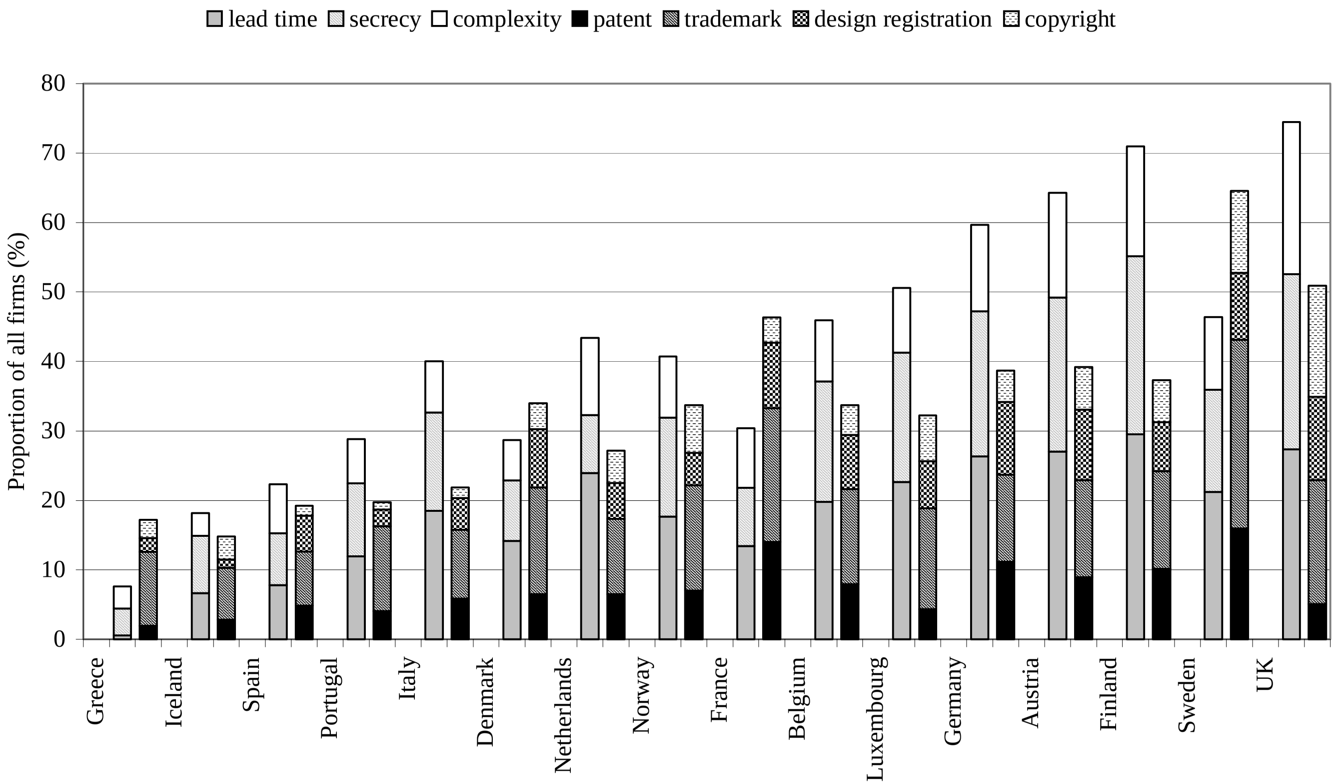
Notes

1. The proportion of engagements in innovation spending is calculated as the ratio of the proportion of firms engaging in a specific type of innovation spending to the sum of the proportions of firms engaging in the various types of innovation spending.

For Austria, Sweden, and the United Kingdom, no data are available on the proportion of fims which are engaging in innovation spending.

Source: Community Innovation Survey 3 (European Commission).

Figure 3. **Choice of protection method by country**[1]

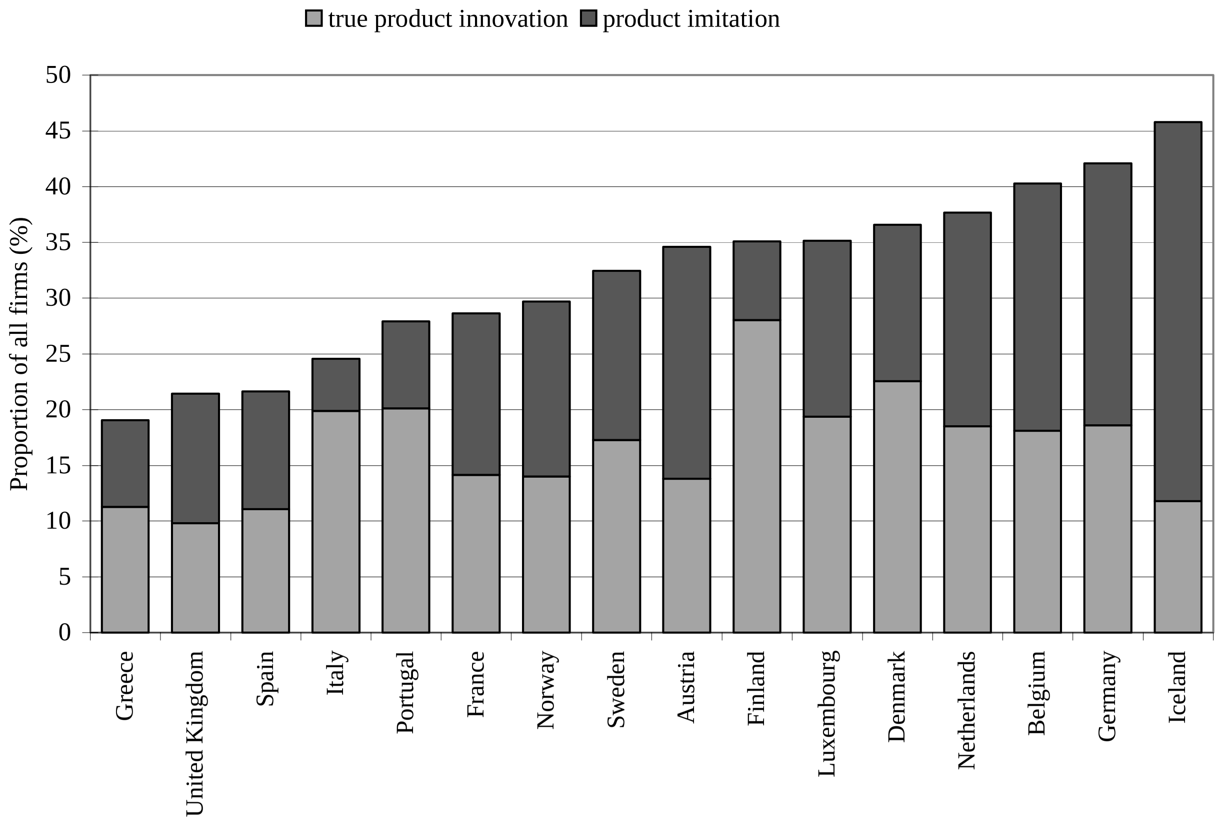


Notes

1. The countries are ordered by increasing level of aggregate protection. The latter (not reported here) is the average of the proportions of firms using the various means of protection of innovations. For each country, the first column represents the proportion of firms which use strategic protection methods (lead time, secrecy and complexity). The second column represents the proportions of firms which use formal methods (trademark, patent, design registration and copyright). A firm can use different protection methods and therefore the proportions do not add up to 1. Note that firms which are not innovative during the 1998-2000 period may nevertheless resort to a protection method, for example to protection innovations developed prior to 1998.

Source: Community Innovation Survey 3 (European Commission).

Figure 4. **Pure innovation and imitation by country**[1]

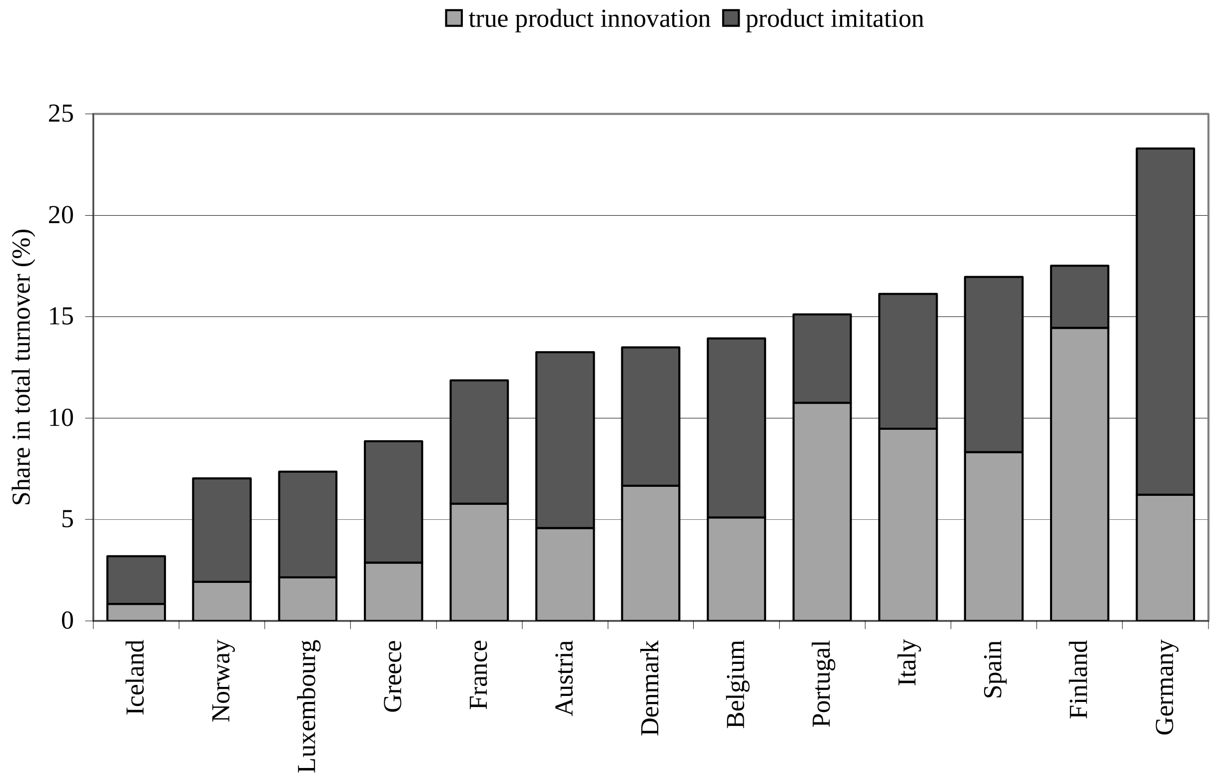


Note

1. The countries are ordered by increasing level of the proportion of successful product innovators (whether the innovation is a true innovation or an imitation). Pure innovation refers to the proportion of firms which have introduced a product new to the market.
Imitation refers to the proportion of firms which have introduced a product new to the enterprise but not new to the market.
Data on the distinction between pure innovation and imitation are available only for product innovations, and not for process innovations.

Source: Community Innovation Survey 3 (European Commission).

Figure 5. **Turnover shares of true innovations and imitations by country**[1]

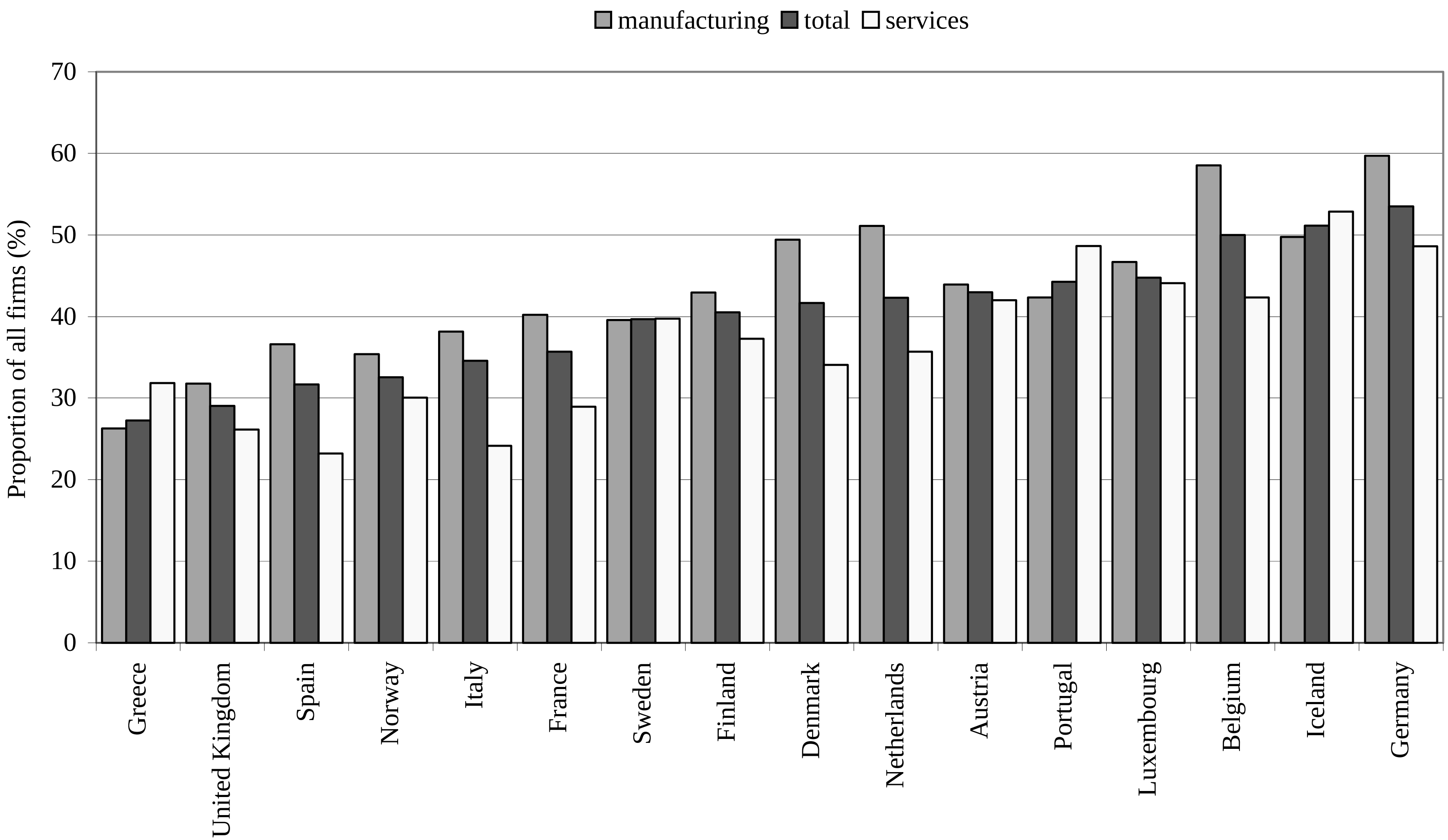


Note

1. The countries are ordered by increasing level of the share of new products in total turnover (whether the new products are true innovations or imitations). Pure innovation refers to the introduction of a product new to the market. Imitation refers to the introduction of a product new to the enterprise but not new to the market. Data on the distinction between pure innovation and imitation are available only for product innovations, and not for process innovations.

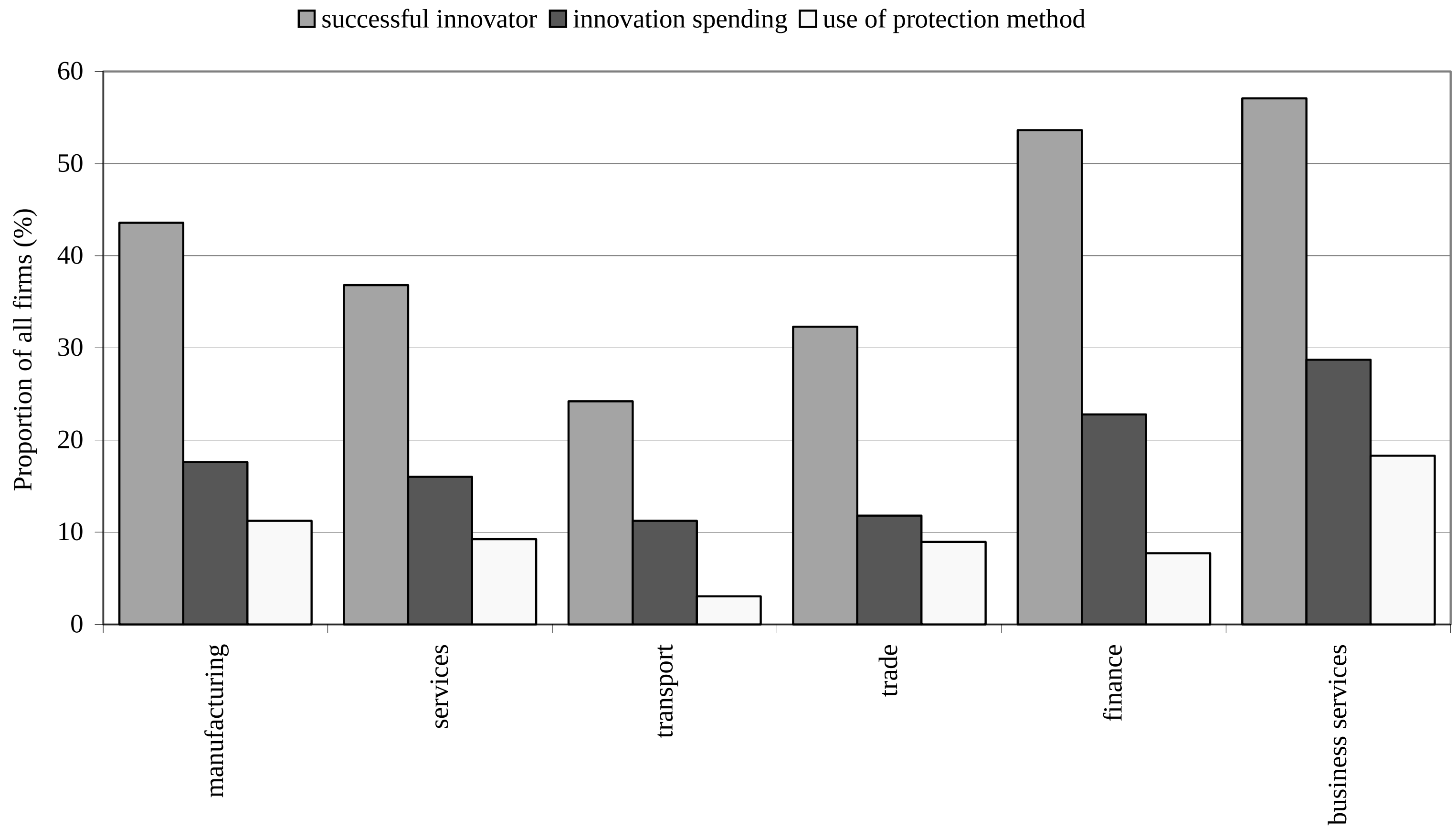
Source: Community Innovation Survey 3 (European Commission).

Figure 6. **Successful innovators in manufacturing and services by country**



Source: Community Innovation Survey 3 (European Commission).

Figure 7. **Comparison of innovation performance by sector based on various measures**[1]



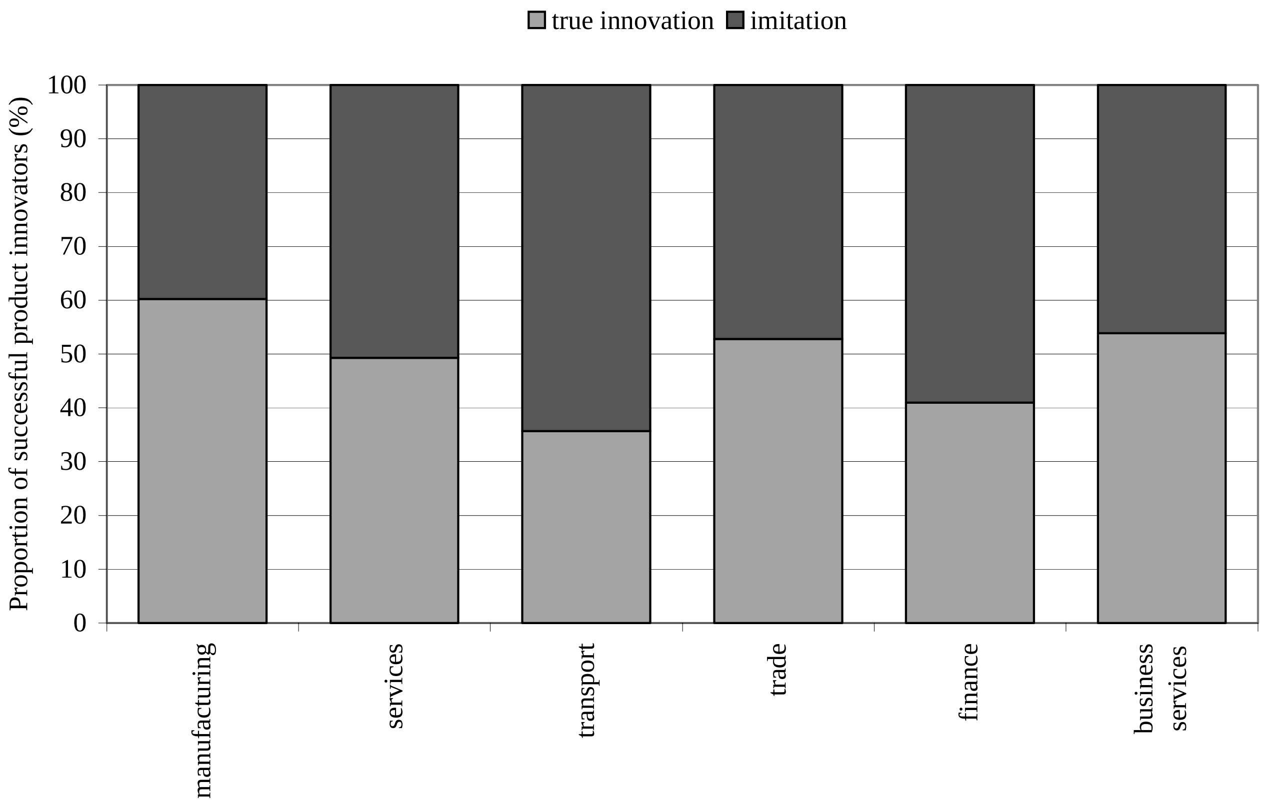
Notes

1. The sectoral aggregates are calculated by taking a weighted average of the individual countries' observations for the sector and using as country weight the country's share in the total population of firms working in the sector in all included countries. The proportion of firms engaging in innovation spending is calculated as the average of the proportions of firms engaging in the various types of innovation spending.

The proportion of firms using a protection method is calculated as the average of the proportions of firms using the various protection methods.

Source: Community Innovation Survey 3 (European Commission).

Figure 8. **Shares of true innovators and imitators in successful product innovators by sector[1]**



Note

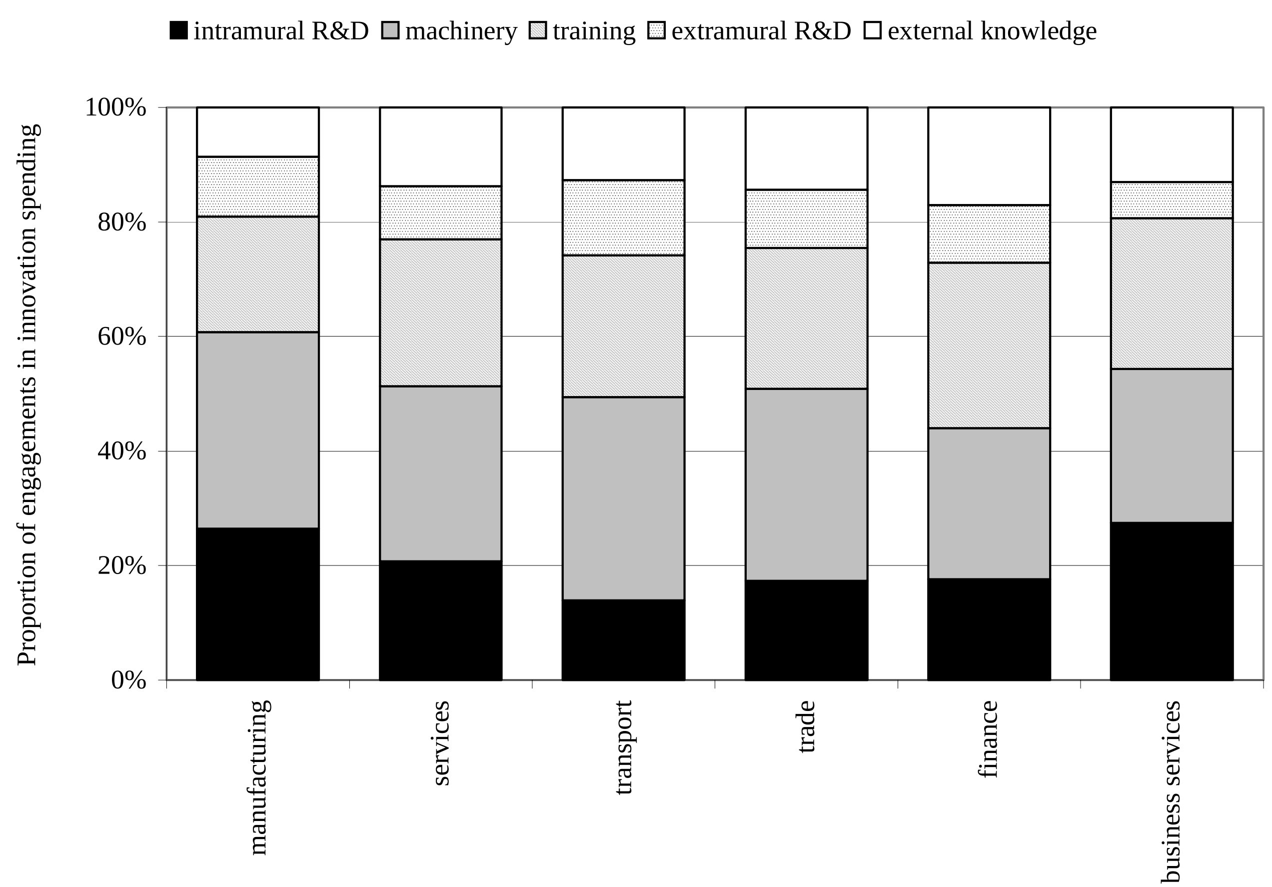
1. The sectoral aggregates are calculated by taking a weighted average of the individual countries' observations for the sector and using as country weight the country's share in the total population of firms working in the sector in all included countries.

Pure innovation refers to the proportion of firms which have introduced a product new to the market.

Imitation refers to the proportion of firms which have introduced a product new to the enterprise but not new to the market.

Source: Community Innovation Survey 3 (European Commission).

Figure 9. **Composition of innovation spending by sector**[1]

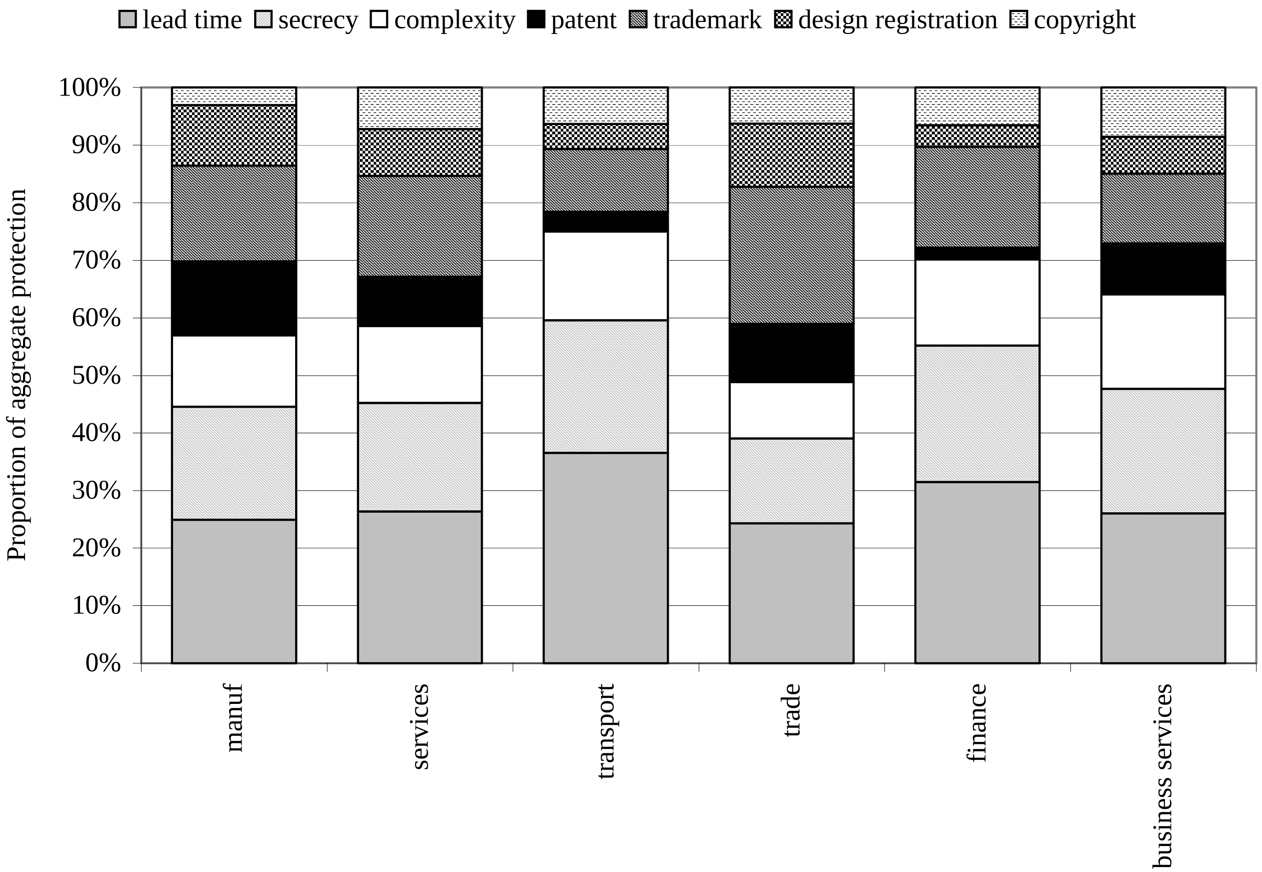


Notes

1. The sectoral aggregates are calculated by taking a weighted average of the individual countries' observations for the sector and using as country weight the country's share in the total population of firms working in the sector in all included countries. The proportion of engagements in innovation spending is calculated as the ratio of the proportion of firms engaging in a specific type of innovation spending to the sum of the proportions of firms engaging in the various types of innovation spending.

Source: Community Innovation Survey 3 (European Commission).

Figure 10. **Choice of protection method by sector**[1]



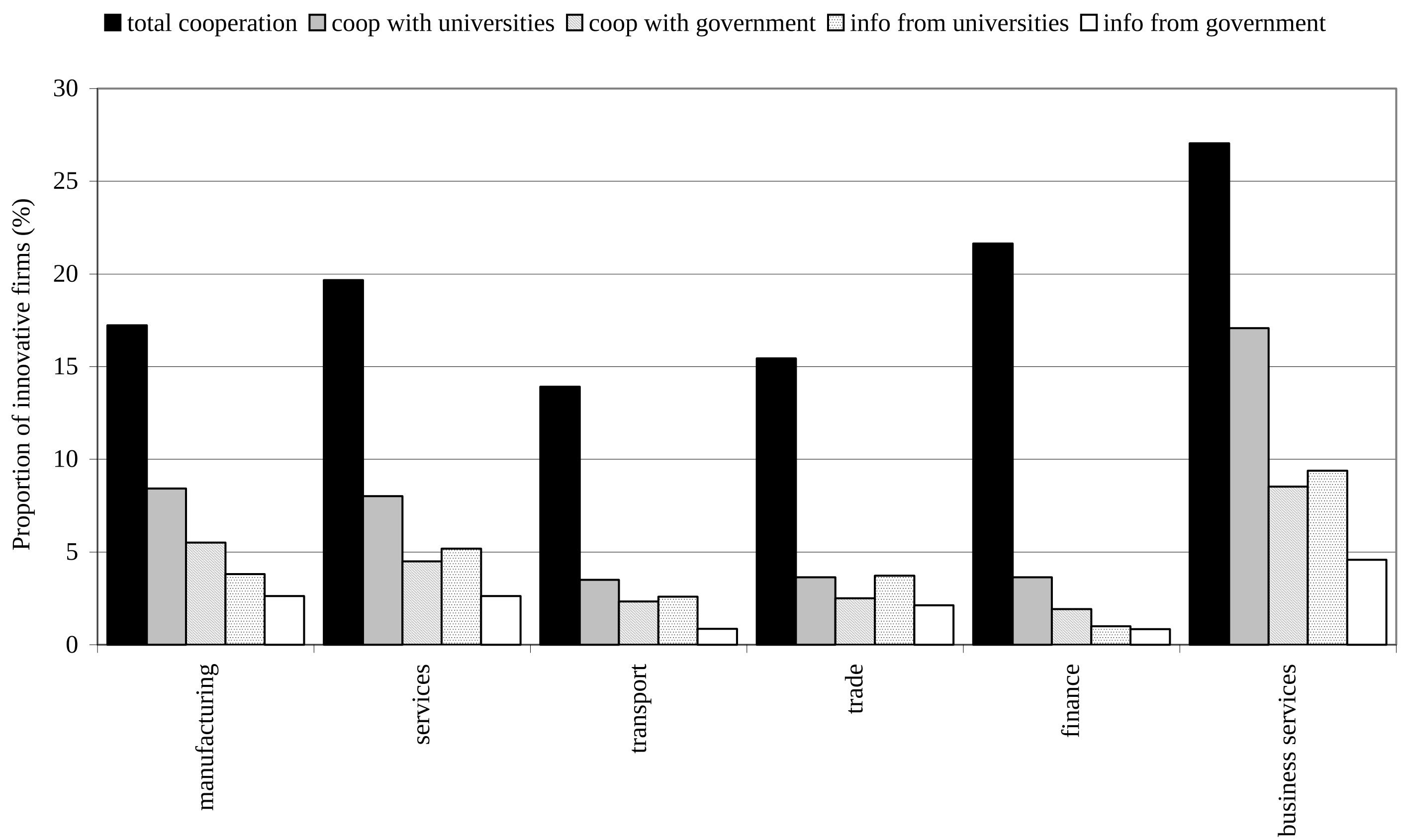
Notes

1. The sectoral aggregates are calculated by taking a weighted average of the individual countries' observations for the sector and using as country weight the country's share in the total population of firms working in the sector in all included countries.

The proportion of a specific type of protection in aggregate protection is calculated as the ratio of the proportion of firms using this specific type of protection to the sum of the proportions of firms using the various types of protection.

Source: Community Innovation Survey 3 (European Commission).

Figure 11. **Co-operation by sector**[1]



Notes

1. The sectoral aggregates are calculated by taking a weighted average of the individual countries' observations for the sector and using as country weight the country's share in the total population of firms working in the sector in all included countries.

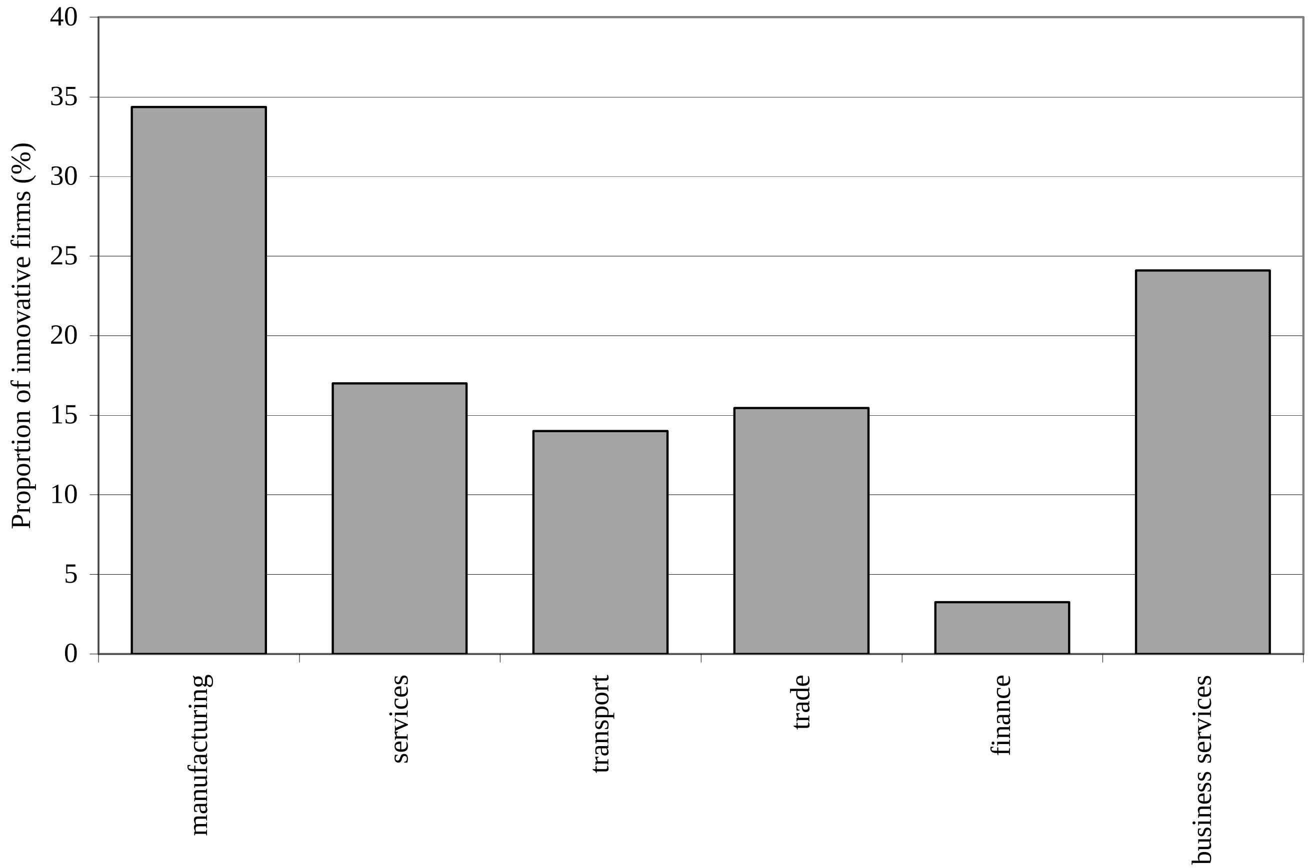
Total co-operation refers to the proportion of innovative firms which had a co-operation arrangement , irrespective of the co-operation partner.

"Co-op with universities (government) refers to the proportion of innovative firms which had a co-operation arrangement with universities (government)

"Info from universities (government)" refers to the proportion of firms which cite universities (government) as a highly important source of information for innovation.

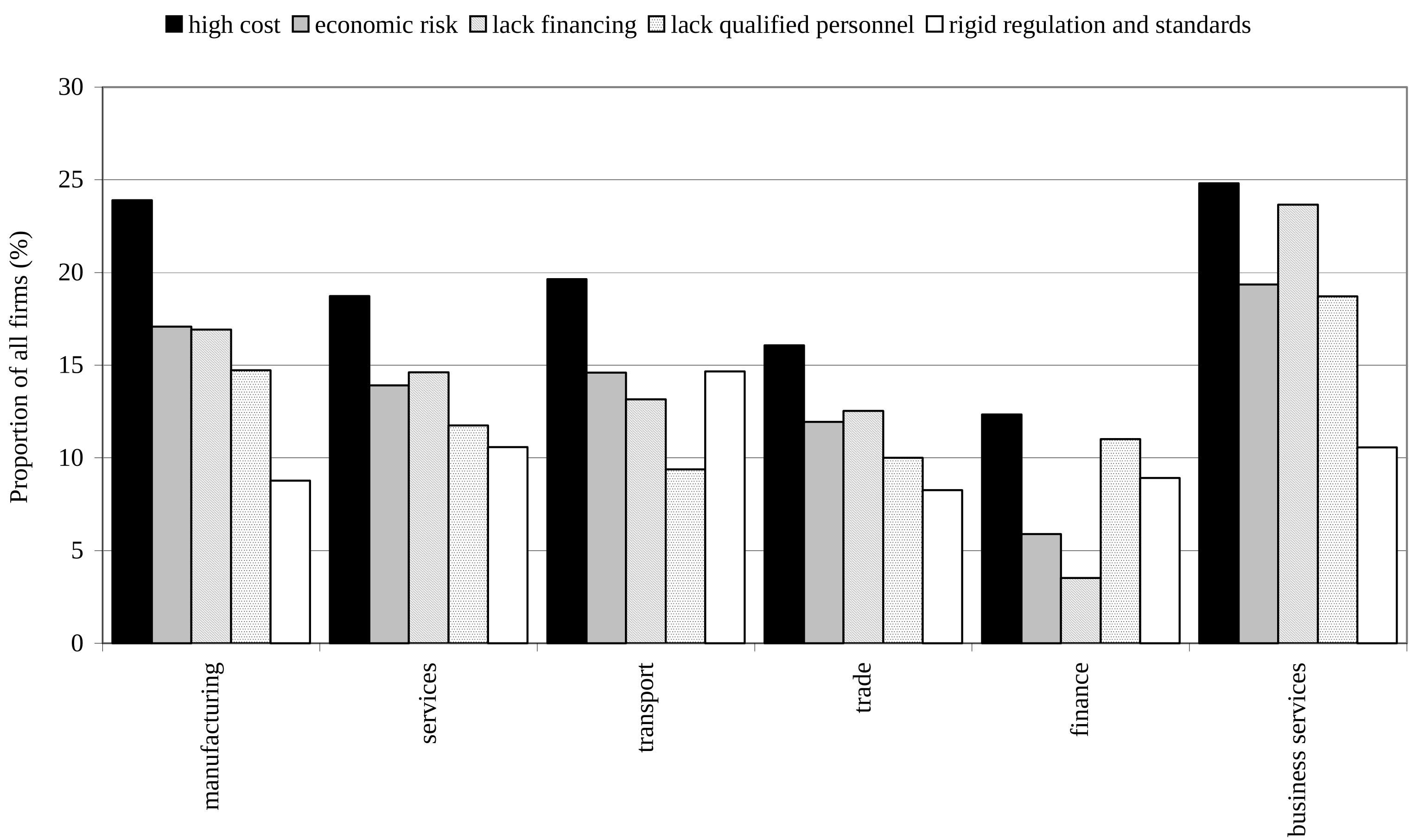
Source: Community Innovation Survey 3 (European Commission).

Figure 12. **Public funding for innovation by sector**[1]



Notes
1. The sectoral aggregates are calculated by taking a weighted average of the individual countries' observations for the sector and using as country weight the country's share in the total population of firms working in the sector in all included countries.
Public funding refers to the proportion of innovative firms which received public funding for innovation.
Source: Community Innovation Survey 3 (European Commission).

Figure 13. **Highly impeding obstacles for innovation by sector**[1]

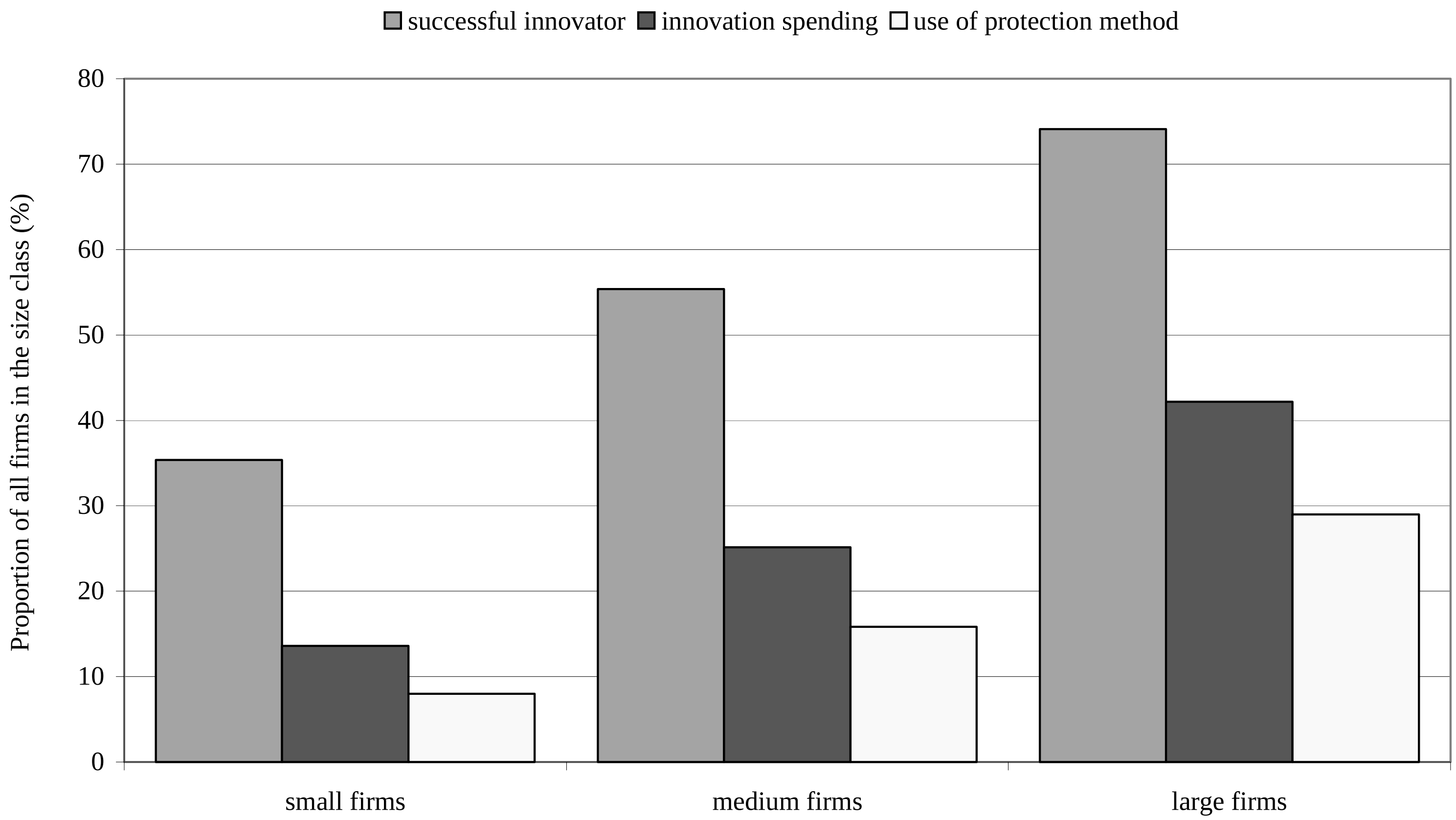


Notes

1. The sectoral aggregates are calculated by taking a weighted average of the individual countries' observations for the sector and using as country weight the country's share in the total population of firms working in the sector in all included countries. The data refer to the proportions of firms citing a given obstacle as highly impeding for innovation. Firms were allowed to choose multiple obstacles and therefore the proportions do not add up to 1.

Source: Community Innovation Survey 3 (European Commission).

Figure 14. **Comparison of innovation performance by firm size based on various measures**[1]

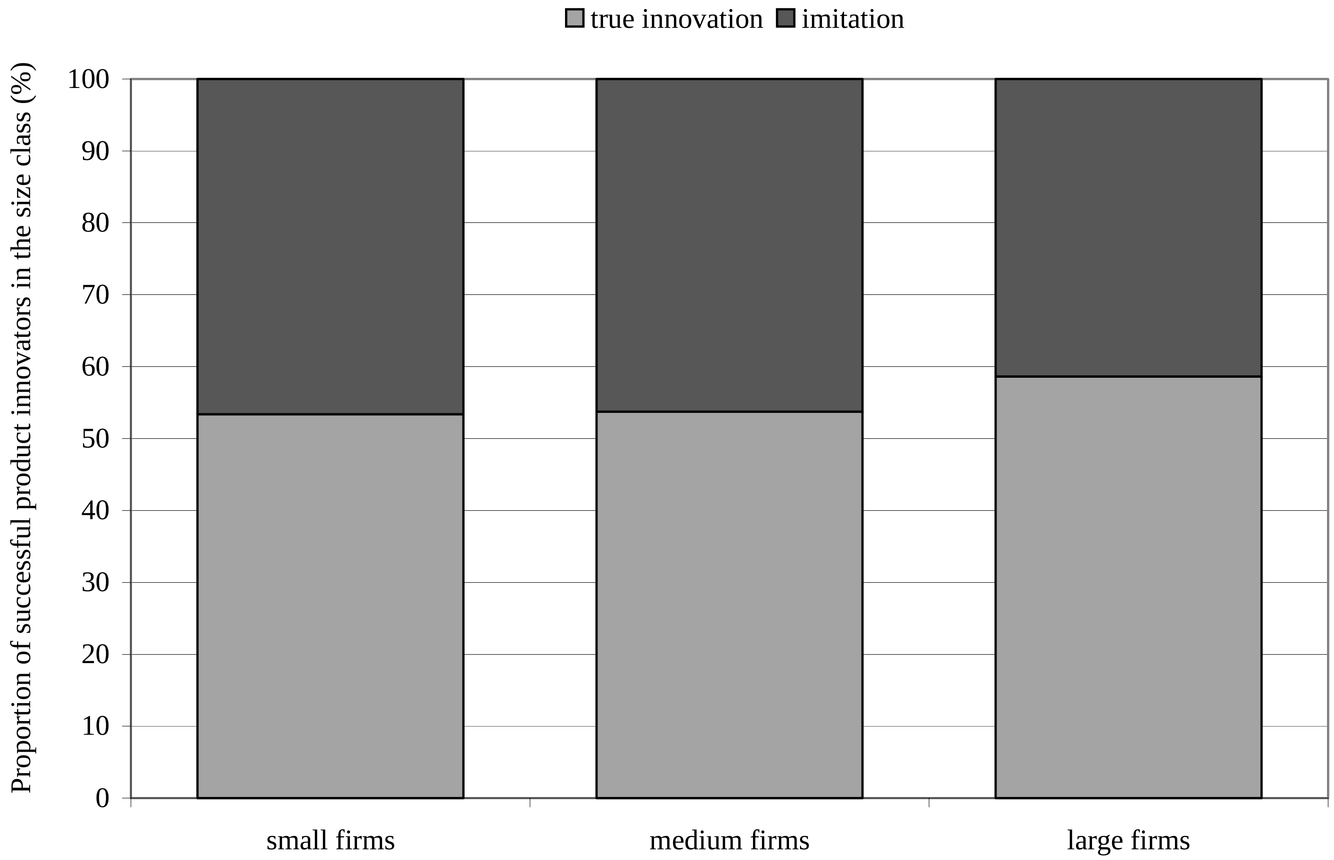


Notes

1. The size class aggregates are calculated by taking a weighted average of the individual countries' observations for the size class and using as country weight the country's share in the total population of firms working in the size class in all included countries. The proportion of firms engaging in innovation spending is calculated as the average of the proportions of firms engaging in the various types of innovation spending. The proportion of firms using a protection method is calculated as the average of the proportions of firms using the various protection methods.

Source: Community Innovation Survey 3 (European Commission).

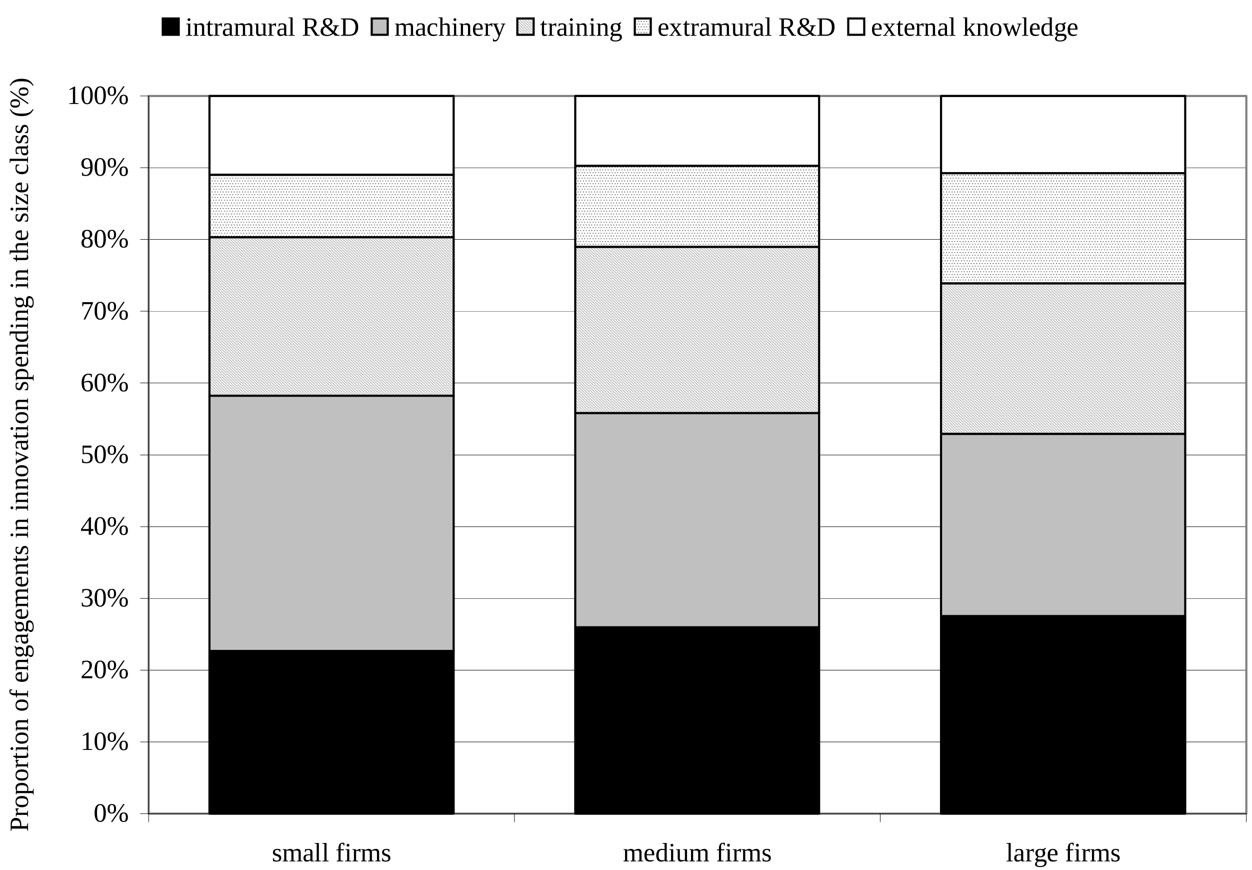
Figure 15. **Shares of true innovators and imitators in successful product innovators by firm size**[1]



Note
1. The size class aggregates are calculated by taking a weighted average of the individual countries' observations for the size class and using as country weight the country's share in the total population of firms working in the size class in all included countries.

Source: Community Innovation Survey 3 (European Commission).

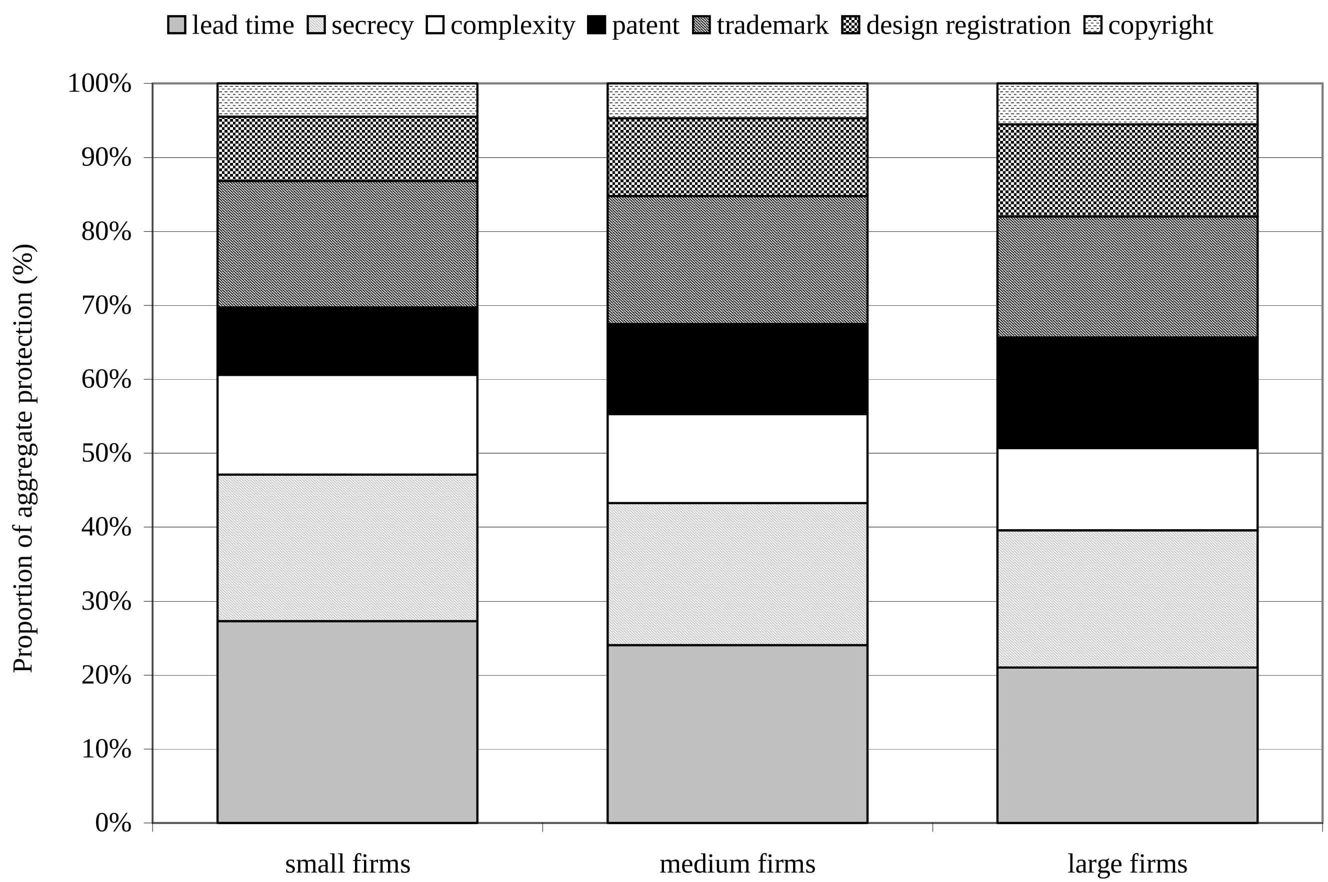
Figure 16. **Composition of innovation spending by firm size**[1]



Notes
1. The size class aggregates are calculated by taking a weighted average of the individual countries' observations for the size class and using as country weight the country's share in the total population of firms working in the size class in all included countries. The proportion of engagements in innovation spending is calculated as the ratio of the proportion of firms engaging in a specific type of innovation spending to the sum of the proportions of firms engaging in the various types of innovation spending.

Source: Community Innovation Survey 3 (European Commission).

Figure 17. **Choice of protection method by firm size**[1]

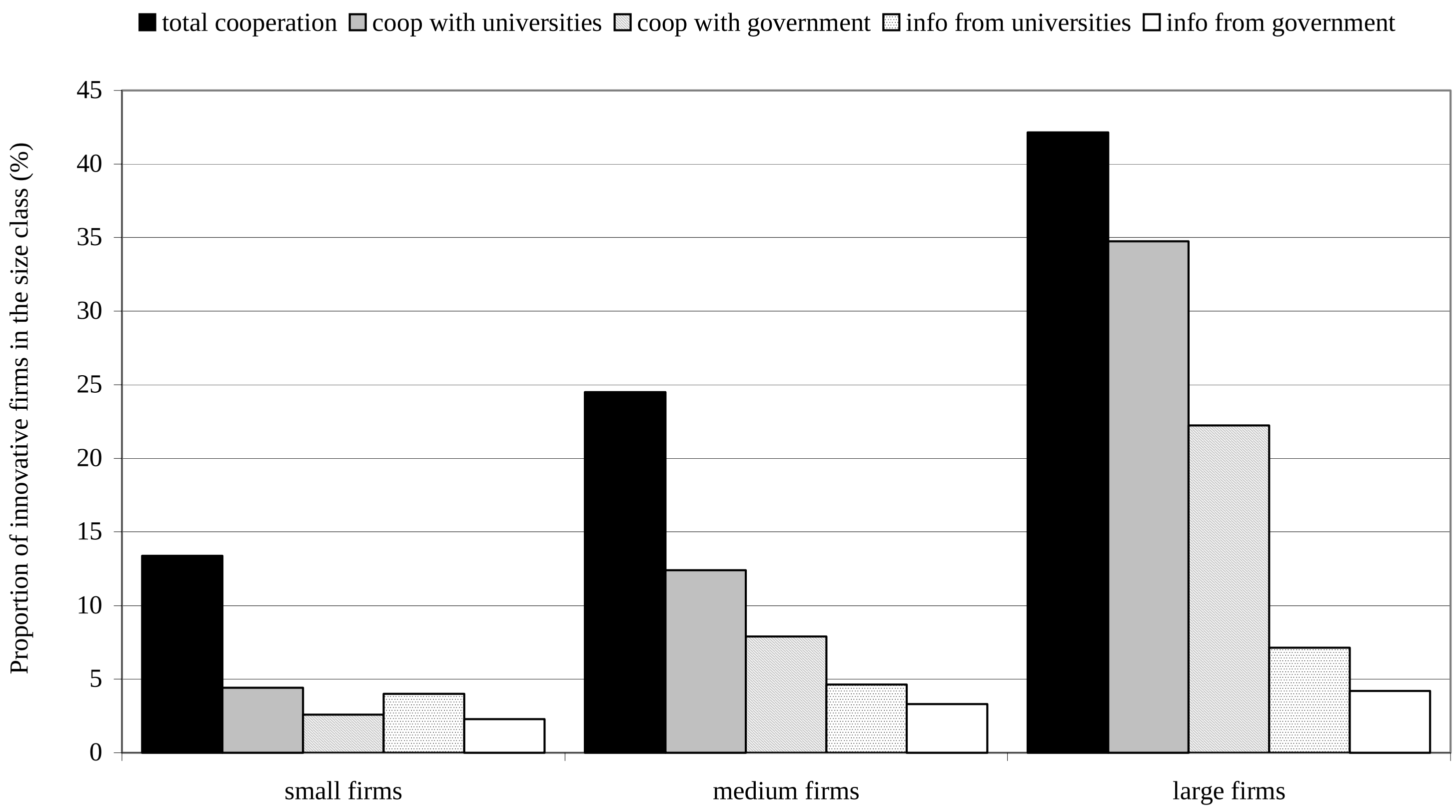


Notes

1. The size class aggregates are calculated by taking a weighted average of the individual countries' observations for the size class and using as country weight the country's share in the total population of firms working in the size class in all included countries. The proportion of a specific type of protection in aggregate protection is calculated as the ratio of the proportion of firms using this specific type of protection to the sum of the proportions of firms using the various types of protection.

Source: Community Innovation Survey 3 (European Commission).

Figure 18. **Co-operation by firm size**[1]

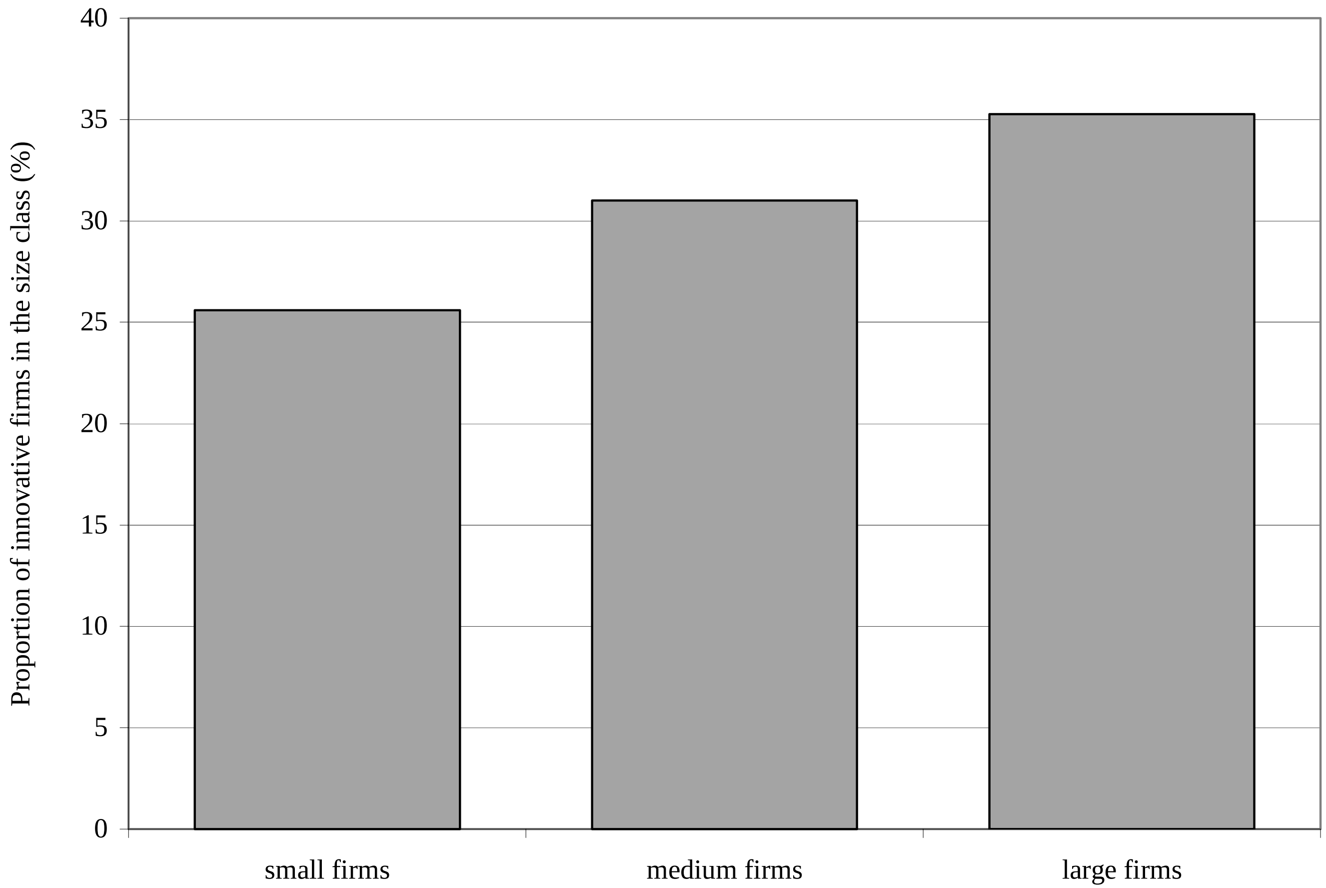


Notes

1. The size class aggregates are calculated by taking a weighted average of the individual countries' observations for the size class and using as country weight the country's share in the total population of firms working in the size class in all included countries. Total co-operation refers to the proportion of innovative firms which had a co-operation arrangement , irrespective of the co-operation partner. "Co-op with universities (government) refers to the proportion of innovative firms which had a co-operation arrangement with universities (government). Finally, "Info from universities (government)" refers to the proportion of firms which cite universities (government) as a highly important source of information for innovation.

Source: Community Innovation Survey 3 (European Commission).

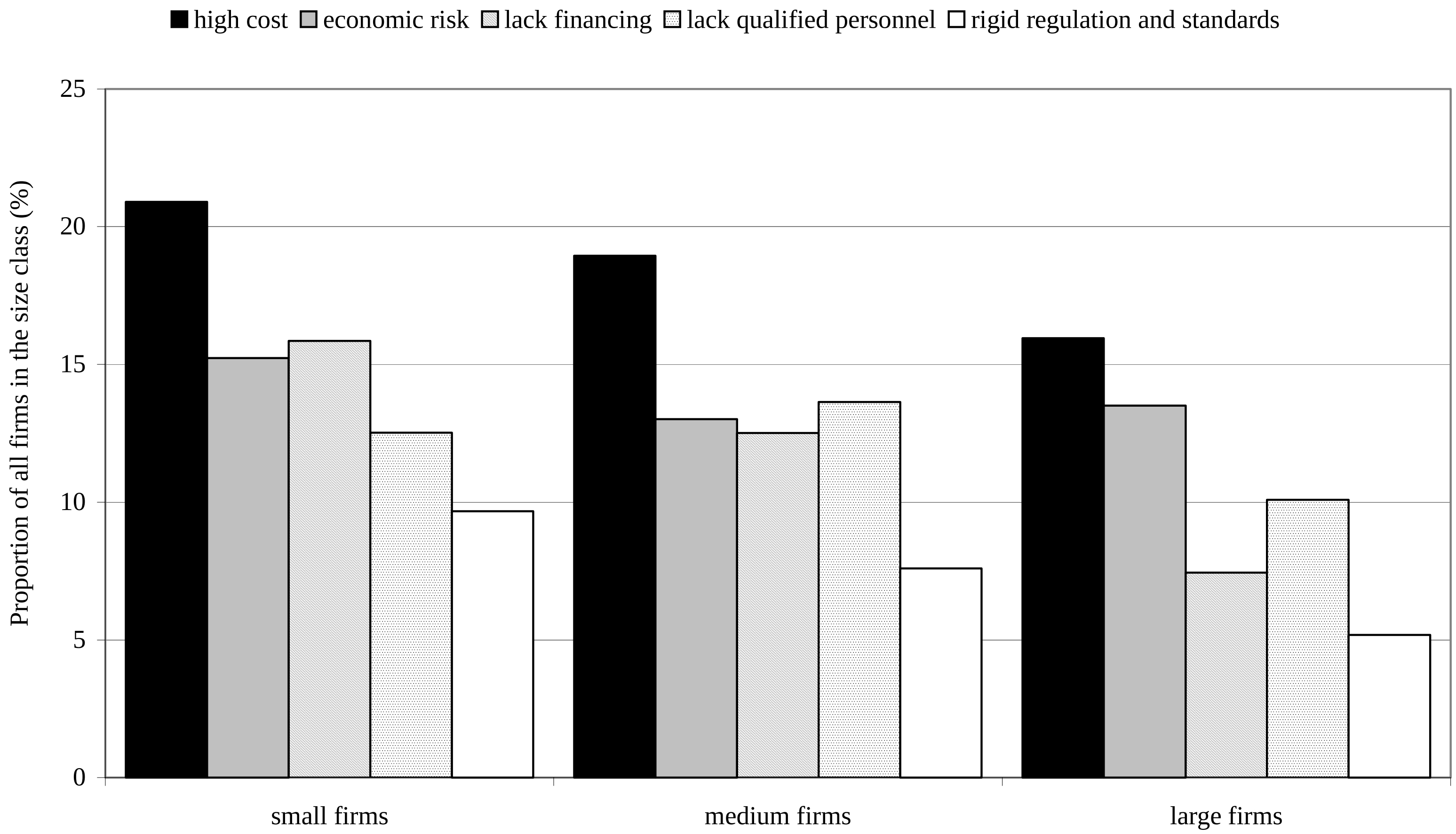
Figure 19. **Public funding for innovation by firm size**[1]



Notes
1. The size class aggregates are calculated by taking a weighted average of the individual countries' observations for the size class and using as country weight the country's share in the total population of firms working in the size class in all included countries.
Public funding refers to the proportion of innovative firms which received public funding for innovation.

Source: Community Innovation Survey 3 (European Commission).

Figure 20. **Highly impeding obstacles for innovation by firm size**[1]



Notes

1. The size class aggregates are calculated by taking a weighted average of the individual countries' observations for the size class and using as country weight the country's share in the total population of firms working in the size class in all included countries. The data refer to the proportions of firms citing a given obstacle as highly impeding for innovation. Firms were allowed to choose multiple obstacles and therefore the proportions do not add up to 1.

Source: Community Innovation Survey 3 (European Commission).

REFERENCES

Eurostat (2004), *Innovation In Europe, 2004 Edition*, Eurostat: Brussels.

Faber and Hesen (2004), "Innovation Capabilities of European Nations: Cross-National Analyses of Patents and Sales of Product Innovations", *Research Policy*, vol. 33, Issue 2, pp. 193-207.

Jaumotte, F. and N. Pain (2005a), "Innovation Policies and Innovation in the Business Sector", OECD Economics Department Working Paper no.459.

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Jaumotte, F. and N. Pain (2005c), "An Overview of Public Policies to Support Innovation", OECD Economics Department Working Paper no.456.

Mairesse, J. and P. Mohnen (2001), "To Be or Not To Be Innovative: An Exercise in Measurement", *NBER Working Paper* 8644.

Mairesse, J. and P. Mohnen (2004), "The Importance of R&D for Innovation: A Reassessment Using French Survey Data", *NBER Working Paper* 10897.

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