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The organisational-cooperation mode of innovation and its prominence amongst European service firms

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Abstract

Analysing survey data concerning the innovation orientations of 2500 European firms, this paper uses the exploratory statistical technique of multiple correspondence analysis to identify three distinct modes of innovation: a product-research mode; a process-technologies mode; and an organisational-cooperation mode. The first two of these are forms of technological innovation that are well established in the innovation studies literature. The third is a form of organisational innovation, about which much less is known. Aside from identifying statistically these three modes of innovation, we show that firms of different sizes and in different sectors have different propensities to engage in each of them. High-technology firms are, for example, the most likely of all firms to engage in the product-research mode, whilst low-technology manufacturers are the most likely to engage in the process-technologies mode. Meanwhile, the organisational-cooperation mode, which involves supply-chain rather than research-based cooperative practices, is particularly prominent in services, especially in trade and distribution services. This fits with the view that innovation in services is often 'soft', rather than primarily technological, involving organisational and relational changes within supply-chains or networks.

Keywords: Innovation measurement; Organisational change; Cooperation; Services

1. Introduction and prior literature

Innovation is increasingly seen as fundamental to the competitiveness of firms and economies. Because of this significant resources are committed to its measurement. In Europe, innovation surveys are now being conducted every second year, with survey forms sent to many thousands of firms. The UK version of the fourth European Community Innovation Survey (CIS-4), for example, was sent to 28,000 firms.[1] Other countries, such as Italy, survey even more firms, and in some countries the survey is mandatory. The primary aim of these surveys is to inform policymakers of the extent of innovation and related activities, and to provide comparative statistics over time and space on the innovative performance of different types of firms (e.g., by size and sector), in different regions and countries. Summary informa-

[1] The surveying and data collection for the UK CIS-4 cost the UK Government around £400,000 (approximately €600,000, or $750,000) to undertake. This does not include the contributions of the respondents, or of government officials responsible for the survey, nor does it include the cost of any analysis.

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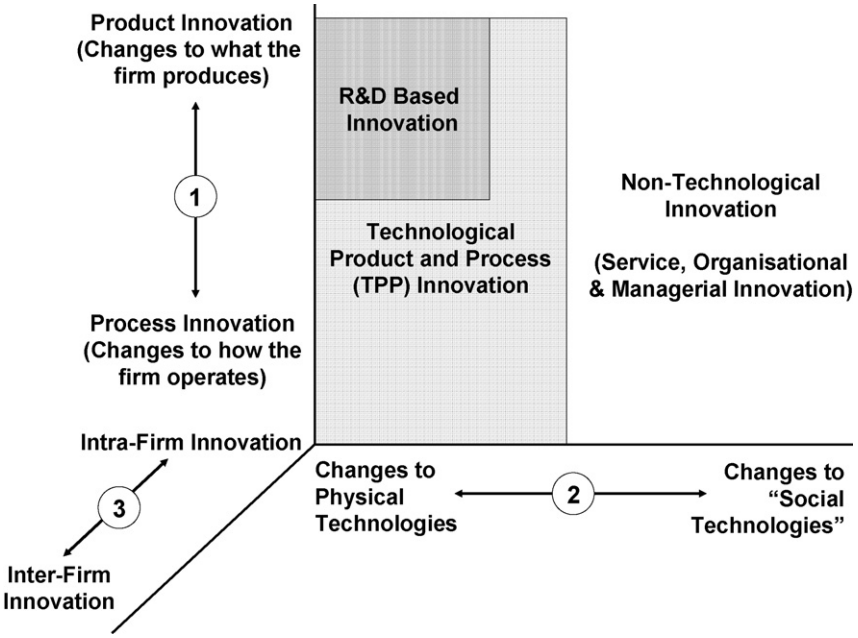

Fig. 1. A simple model of firm-based innovation and its measurement.

tion is published in the European Innovation Scoreboard and other government publications (e.g., Hollanders and Arundel, 2005).

The value of these surveys as means of benchmarking different sectors, regions or countries in terms of their innovation performance is clearly related to the effectiveness with which they capture the main innovation activities of firms. It is increasingly accepted that whilst considerable progress has been made in recent years, the instruments used to measure innovation provide an incomplete assessment of the innovative activities of firms, and by extension economies. Fig. 1 provides a simplified, first approximation model of innovation and how these activities are measured.[2] We use three dimensions. The first concerns the distinction between changes to what the firm provides or produces (generally 'product innovation') and changes to the means of production or provision (generally 'process innovation'). The second concerns what is changed—whether it is physical (or 'hard') technologies, or what Nelson and Sampat (2001) call "social technologies", which includes operating routines and intangible services. Alternatively, this dimension could follow Damanpour and Evan's (1984, p. 394) distinction between technical innovations – changes and improvements to the performance of the technical system of an organisation – and administrative innovations—changes that occur in the social system of an organisation. The third dimension concerns the locus of innovation, be that internal to the firm or inter-organisational, and distributed between firms through networks or supply-chains.

The form of innovation about which we know most is R&D-based innovation, as R&D has been extensively measured since the 1960s following the publication of the OECD's Frascati Manual (OECD, 2002). Notwithstanding the growth in recent years of R&D outsourcing and R&D focused strategic alliances, this form of innovation primarily involves intra-firm routines for technological product innovation, and is therefore predominantly in the top-left-rear of the diagram.

By the mid-1980s it was increasingly accepted that R&D efforts provide only a partial assessment of the innovative activities of firms, and efforts began to measure innovation more directly. This led to the first 'subject-based' innovation surveys, and to the development of the OECD's Oslo Manual (OECD, 1992), which provides 'proposed guidelines for collecting and interpreting technological innovation data'. Whilst the Oslo Manual extended the measurement of innovation beyond R&D, initially at least, it deliberately confined itself to technological product and process (TPP) innovation, i.e., the left side of Fig. 1.

The recommendations of the Oslo Manual were first implemented in 1993 through the first European Com-

[2] The model has been adapted and developed from Wengel et al. (2000, Figure 4).

munity Innovation Survey (CIS-1). This was designed with manufacturing in mind (Smith, 2005), and was in almost all countries confined to manufacturing, omitting both private and public services. Following minor revisions, essentially involving the replacement of the word 'product' for the word 'service' in the service sectors' version of the questionnaire, some private services were included in the second European CIS (CIS-2) undertaken in 1997 (Tether et al., 2001). The third and fourth rounds of the CIS have also included some (but not all) services.

Whilst considerable progress has been made in the measurement of innovation in the last 15 years, prior to which empirical studies were dependent on R&D statistics, analysing patents, and ad hoc datasets of innovations (e.g., Pavitt et al., 1987; Acs and Audretsch, 1990), critics argue that the Oslo Manual/CIS approach remains imperfect for at least three reasons: (1) the survey was initially designed with manufacturing in mind and arguably still applies a 'manufacturing mindset' to innovation, which may be problematic for studying services, and service innovation; (2) the survey was designed with technological innovation in mind and non-technological forms of innovation have yet to be given equal status; (3) the survey takes the firm as the unit of analysis, and distributed or networked forms of innovation may not be adequately captured.

If innovation and economic development is based on technological innovation undertaken by autonomous manufacturing firms then these may be minor issues. But services are the main sector of economic growth, organisational change is non-trivial and, to a significant extent, firms are inter-dependent in their innovation activities. As Keith Smith (2005, p. 169) points out: "In defence of the CIS approach it can be argued that it is, and was intended to be, manufacturing-specific and that extension to services would always be problematic. Similar problems arise with other non-technological aspects of innovation, such as organisational change. . . . The challenge for those who would go beyond this is whether they can generate definitional concepts, survey instruments, and collection methodologies that make sense for other sectors and other aspects of innovation".

Before turning to the dataset analysed in this paper, we set the context by briefly reviewing the literature and CIS evidence on innovation in services, organisational innovation, and distributed (inter-firm) innovation.

1.1. Innovation in services

Services have been extensively studied by management scholars, especially those in operations management and marketing,[3] but despite constituting the bulk of economic activities in advanced economies, services have received relatively little attention from scholars of innovation (Miles, 2005). In the past, innovation scholars have dismissed services as being 'supplier-dominated' users of technologies (Pavitt, 1984), rather than true innovators. In recent years services have however received increasing attention from innovation scholars, first from those such as Evangelista (2000) who applied received understandings of (technological) innovation to services, then by those such as Faiz Gallouj and Jon Sundbo (Gallouj and Weinstein, 1997; Gallouj, 2002; Sundbo, 1997, 1998; Sundbo and Gallouj, 2001; Djellal and Gallouj, 2001; van der Aa and Elfring, 2002) who highlighted the distinctiveness of innovation in services (vis-à-vis technological innovation in manufacturing), and advocated the need to extend understanding of innovation beyond technological advance and R&D. Indeed, Sundbo (1997) argues that innovation in services (and other non-'high-tech' activities) tends to be strategically determined and market driven, in contrast to the 'technological model' of R&D-based innovation which is prevalent in high-technology manufacturing.

Most recently, the community of scholars investigating innovation in services has been developing a synthesis approach, the aim of which is to forge an understanding of innovation that is applicable to all economic activities, but which does not privilege certain forms, such as R&D-based technological innovation, over others, such as organisational innovation (Drejer, 2004; Hipp and Grupp, 2005; Djellal and Gallouj, 2005; de Vries, 2006). This approach seeks to combine the insights gained from studies of technological innovation with those gained from a wider appreciation of innovation derived from studying services. A growing consensus also recognises that there is no clear distinction between how manufacturers and service firms innovate (Evangelista, 2000; Hollenstein, 2003), but studying services often brings to the fore aspects of innovation that have hitherto been neglected in manufacturing-based studies. See Gallouj (2002), Miles (2005) or Tether and Howells (2007) for more extensive reviews of the literature on innovation in services.

[3] There are well established textbooks on service operations management and service marketing. For example, Normann's "Service Management", first published in 1984 is now in its third edition, whilst Fitzsimmons and Fitzsimmons textbook on the same topic is now in its fourth edition, and Lovelock and Wirtz's "Service Marketing" is now in its sixth edition. There are also specialist journals, such as the Journal of Service Research and the Service Industries Journal.

There is no question that the CIS and similar surveys find that service firms innovate in terms of introducing new products and processes, and organisational changes (see Section 1.3). What is less clear is whether the Oslo Manual/CIS approach is as effective at measuring innovation in services as compared with manufacturing. It may be that the methodology has tended to under-record innovation in services, both in absolute terms and relative to manufacturing. Indeed, the third edition of the Oslo Manual accepts that this may be the case, recognising that: "Innovation in service-oriented sectors can differ substantially from innovation in many manufacturing-oriented sectors. It is often less formally organised, more incremental in nature and less technological" (OECD-Eurostat, 2005, p. 11; see also Tether, 2005). The Manual further recognises that in many services the distinction between product and process innovations is blurred, and that innovation activity in services often tends to be more continuous, consisting of numerous incremental changes, none of which may individually be considered an innovation, but which when taken together amount to significant innovation (OECD-Eurostat, 2005, paras 110–111).

As services constitute the bulk of advanced economies, and the only part of most of these that is growing in terms of value added and employment, this is potentially a significant weakness if our aim is to understand patterns of innovation throughout the economy.

1.2. Organisational innovation

A second, related criticism of the dominant Oslo Manual/CIS approach to measuring innovation is that it has favoured technological over other forms of innovation, notably intra- and inter-organisational change. As with services, this situation is changing. Whist the early versions of the CIS focused only on technological product and process innovation, both CIS-3 and CIS-4 included questions about organisational innovation. However, the questions about organisational changes (and other 'wider innovation') were deliberately placed at the end of the survey, encouraging the respondents to answer the main part of the questionnaire – which concerns firms' innovation related activities and their expenditures on these, the source of information or knowledge they use for innovation; their collaborative arrangements for innovation; the factors hampering innovation; their innovation protection strategies, etc. – only with reference to (technological) product and process innovation.

The Oslo Manual is also changing. Whereas the first edition (1992) deliberately omitted organisational innovation, this, alongside 'marketing innovation', has now been included in the third edition of the Manual (OECD-Eurostat, 2005), which defines organisational innovation as "the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations" (OECD-Eurostat, 2005, para 177). As with other forms of innovation, such as product and process innovations, difficulties arise in distinguishing between minor organisational changes and more substantial innovations. The Oslo Manual states: "The distinguishing feature of an organisational innovation compared to other organisational changes in a firm is the implementation of an organisational method that has not been used before in the firm and is the result of strategic decisions taken by management" (OECD-Eurostat, 2005, para 179).

The development of metrics to explore organisational innovation through large-scale survey work has not been helped by the literature on the subject. For although there is a substantial literature on organisational (administrative and managerial) innovation and change, according to Lam (2005, p. 138): "the concept [of organisational innovation] has been used in a loose and slippery manner in many writings and some authors are coy about stating definitions". Lam identifies three different streams of literature on organisational innovation: (1) organisational design theories which focus mainly on the link between structural forms and the propensity of an organisation to innovate (see also Wolfe, 1994). As such, this literature does not really concern itself with organisational innovation, but with the organisational characteristics associated with innovation; (2) theories on organisational cognition and learning, which focus on the micro-level processes of how organisations develop new ideas for problem solving. Empirical work in this tradition has typically involved in-depth case studies, rather than quantitative surveys; and (3) studies of organisational change and adaptation, and the processes underlying the creation of new organisational forms. It is this third strand which is closest to our concerns regarding the identification and measurement (through surveys) of organisational innovation.

In their report for the European Commission, Wengel et al. (2000) argue that there are two different kinds of organisational innovation (although these usually inter-relate): structural innovations and managerial innovations. Structural innovations concern the organisational arrangement of the firm and the division of labour within it, whereas managerial innovations concern the specific operations and procedures by which the firm organises its activities, such as the responsibilities of personnel, information flows, and the way they are dealt with. Wengel et al. also argue that organisational inno-

vations appear at three different levels: the sub-unit level (where innovations are confined to a particular department or function); the organisational level (where they apply to the whole firm); and the supra-organisational level, where they impact on the company's relations with its environment, particularly its interactions with other organisations.

In summary, there is growing recognition that organisational (managerial and other non-technological innovation) are important, both in their own right – Hamel (2006)[4] argues that the benefits of management innovation can far outweigh the benefits of more traditional product and process innovation – and in conjunction with technological innovations. It is increasingly recognised that the effective utilisation of new technologies often requires complementary changes in administration, skills and/or organisational structure (Bresnahan et al., 2002; Brynjolfsson and Hitt, 2000, 2003; Damanpour and Evan, 1984; Damanpour, 1987; Damanpour et al., 1989; David, 1990; Greenan, 2003; Lam, 2005; Wengel et al., 2000).

1.3. CIS-4: technological and organisational innovation in manufacturing and services

In this section, we provide a brief overview of the findings from the fourth European Community Innovation Surveys (CIS-4) concerning the extent of technological (i.e., product and process) and organisational innovation in manufacturing and service firms. The CIS-4 relates to the 3-year period between 2002 and 2004, and the data are drawn from Eurostat's Europa website;[5] this does not provide direct access to the microdata but rather provides country level data aggregated by sector and/or firm size. Data have been analysed for manufacturing as a whole and the core group of private services included in the CIS, i.e., wholesale trade (NACE 51), transport, storage and communications (NACE 60–64), financial intermediation (NACE 65–67) and 'computer and technical services', the last of which is an amalgamation of computer and related activities (NACE 72), architectural and engineering activities (NACE 74.2) and technical testing and analysis (NACE 74.3).

The CIS-4 defined product innovation as "the market introduction of a new good or service or a significantly improved good or service with respect to its capabilities" and process innovation as "the implementation of a new or significantly improved production process, distribution method, or support activity for [the firm's] goods or services". Innovations need not be new to the market or sector of activity, but must be new to the firm. Also, it did not matter whether the innovations were developed by the firm, or by another enterprise or institution. Firms that had introduced one or more product or process innovations, and those that had incomplete (i.e., ongoing or abandoned) product and process innovation activities were identified as 'enterprises with [technological] innovation activities'.

The extent to which firms were active in technological innovation varied widely across the 29 European countries for which data is available (the EU-27, plus Iceland and Norway), ranging from 16% in Bulgaria to 65% in Germany, but in 24 of these countries the proportion of manufacturing firms that were innovation active exceeded the corresponding proportion of service firms.[6] In the great majority of countries, wholesale and transport service companies were less likely to be innovation active than were manufacturers, but this was not true of financial and computer and technical service firms. In the great majority of countries, firms in these service activities were more likely to be innovation active than were manufacturers. This shows that whilst overall service firms tended to be less likely to be technologically innovation active than manufacturers, there are service sub-sectors with high proportions of technologically innovation active firms.

The CIS-4 defined organisational innovation as "the implementation of new or significant changes in firm structure or management methods that are intended to improve the firm's knowledge; the quality of its goods and services; or the efficiency of its work flows".[7] As with product and process innovation, the extent to which firms engaged in organisational innovation varied

[4] Hamel (2006, pp. 75–76) defines 'management innovation' as "a marked departure from traditional management principles, processes, and practices or a departure from customary organisational forms that significantly alters the way the work of management is performed. Put simply, management innovation changes how managers do what they do".

[5] This data is accessible via http://epp.eurostat.ec.europa.eu/ under the 'Science and Technology' theme.

[6] The exceptional countries were Estonia, Greece, Latvia, Luxembourg and Portugal.

[7] Organisational innovations could take three forms: (1) new or significantly improved knowledge management systems to better use or exchange information, knowledge and skills within the enterprise; (2) a major change to the organisation of work within the enterprise, such as changes in the management structure or integrating different departments or activities; and (3) new or significant changes in the firm's relations with other firms or public institutions, such as through alliances, partnerships, outsourcing or subcontracting, and each of these was asked about separately, but only aggregated data is available on the Eurostat website.

widely, from 12% in Bulgaria to 59% in Luxembourg. However, in contrast to product and process innovations, in the majority (13) of the (21) countries for which data is available,[8] the proportion of service firms that engaged in organisational innovation exceeded the corresponding proportion of manufacturing firms.[9] Organisational innovation appears to be particularly widespread in financial and computer and technical services. On average about half the firms engaged in those activities introduced an organisational innovation, and in 19 of the 21 countries the share of organisational innovators amongst financial service firms was greater than the share of organisational innovators amongst manufacturers, whilst in all 21 countries the share of organisational innovators amongst computer and technical service firms exceeded the corresponding share amongst manufacturers.

Within sectors and by country, the proportion of technological innovators was highly correlated with the proportion of organisational innovators (correlations range from 0.86 to 0.92). To some extent this is due to a substantial proportion of firms engaging in both types of innovation. However, in most countries manufacturing firms tended to be slightly more likely to engage in technological than organisational innovation, whereas, especially in transport and financial services, service (and construction) firms were slightly more likely to engage in organisational than technological innovation.[10] Amongst services, computer and technical services were the most similar to manufacturing, with the share of product and process innovators exceeding the share of organisational innovators in most countries.

Overall, therefore, the CIS-4 finds that product and process innovations are slightly more widespread in manufacturing, whilst organisational innovation is relatively more widespread in services. A similar pattern was also found by the CIS-3 (Kanerva et al., 2006).

1.4. Distributed innovation

Beyond innovation in services and organisational innovation, a third area of controversy arising from the results of the CIS is the extent to which firms engage in 'distributed forms of innovation'. Commentators have long argued that firms do not operate or innovate in isolation, but through enduring inter-relations with other firms and institutions (e.g., Håkansson, 1987; Freeman, 1991; Harland, 1996; Gulati et al., 2000; Coombs et al., 2003). And competition is often between supply-chains or networks rather than between individual firms (MacBeth and Ferguson, 1994; Oliver, 1990). Dyer and Singh (1998) have argued for the relational view of competitive advantage (as a parallel to the resource or capabilities-based view which tends to take the firm as the unit of analysis). They argue that combinations of firms in supply-chains or networks can outperform others when they invest in idiosyncratic and synergistic assets and capabilities, and employ effective governance mechanisms that lower the transaction costs between them (see also Powell, 1990). With regard to innovation, Teece (1986, p. 293) observed 20 years ago that the variety of assets and competences which is needed for even modestly complex technologies tends to be quite large, and often individual companies cannot keep pace in these multiple technologies themselves. Consequently, they rely on others, often sourcing technologies through alliances rather than conventional arms-length markets. Arguably, innovation has become increasingly interdependent in recent years (Chesbrough, 2003), an argument that the striking growth in innovation related strategic alliances would seem to support (Hagedoorn, 2002). Also notable is the striking growth of the 'supply-chain management' literature since the early 1990s (Giannakis et al., 2004), and IBM's recent survey Chief Executive Officers (IBM, 2006, p. 15), which found that three-quarters of CEOs considered collaborations and partnerships to be very important for innovation. Interestingly, internal R&D, the traditional locus of innovation, was regarded as a most significant source of innovative ideas by just 17% of these CEOs, well behind employees, business partners and customers.

By contrast, the CIS tends to find that only a minority of innovation active firms engage in cooperative arrangements for innovation, which the Oslo Manual (OECD-Eurostat, 2005, para 271) defines as involving 'active participation in joint innovation projects with other organisations.'[11] Both the CIS-3, which refers to 1998–2000, and the CIS-4, which refers to

[8] These are Norway and the EU27 countries except Ireland, Malta, Finland, Latvia, Sweden, Slovenia and the UK.

[9] In eight countries manufacturers were more likely to engage in organisational innovation than service firms.

[10] Also notable is that in five counties – Austria, Denmark, France, Luxembourg and Portugal – higher rates of organisational innovation than product and process innovations are consistently found for all the services sectors included in the CIS-4, whilst in Italy the rate of organisational innovations exceeds product and process innovations in all sectors except wholesale, where the rates are the same.

[11] These organisations may be other enterprises or non-commercial institutions. The partners need not derive immediate commercial benefit from the venture. Pure contracting out of work, where there is no active collaboration, is not regarded as cooperation.

2002–2004, found that about a quarter of Europe's [technologically] innovation active firms were involved in these arrangements. This proportion is higher in high-tech manufacturing, and lower in services, whilst the most common partner types were suppliers (CIS-4: 17%), clients or customers (14%) and universities (9%) (Eurostat, 2007).

This conflicting evidence can be resolved in two ways. Either academic studies have tended to over-estimate the true extent to which firms engage in cooperative activities for innovation, possibly because they tend to focus on high-technology activities or high level innovations for which such partnerships are more common (Tether, 2002). Or it may be that the CIS is tending to under-record the true extent of cooperative practices for innovation. It is notable, for example, that the CIS-4 finds as many innovation active firms in Germany (8%) and Italy (5%) collaborate with universities as collaborate with their clients or customers, whilst in Austria and Spain the proportions collaborating with universities exceed those collaborating with customers. These results seem unlikely, unless firms are tending to interpret the question narrowly and focus on technologically oriented (often R&D-based) cooperations rather than cooperation more generally.

In summary, the centre of gravity of the innovation measurement system as represented by the OECD's Frascati and Oslo Manuals and R&D and CIS-type Innovation Surveys has historically been towards the back and left of Fig. 1, with an emphasis on technological product and process innovation and the intra-mural R&D activities of individual firms. This situation is now changing, as new forms of innovation are being recognised, such as organisational innovation and marketing innovation. As yet, however, we know considerably less about the extent of these forms of innovation than we do about technological innovation. The aim of this paper is to shed some light on one form of organisational innovation, and the extent to which this is prevalent, particularly as a widespread mode of innovation amongst service firms.

2. Data source

The dataset examined in this paper is the "Innobarometer 2002". This survey was part of a series of surveys commissioned by DG-Enterprise of the European Commission and undertaken by EOS Gallup Europe. For this survey, managers in 3014 European firms employing at least 20 people were interviewed in September 2002 using computer aided telephone interviewing (CATI). These interviews used opinion polling techniques to gather managers' views on innovation, the innovation orientations of their firms, and other related matters. The exercise was less scientific than the CIS, but from our perspective has two advantages: it was more open concerning the types of innovation that managers could identify and, notably, asked about organisational changes alongside product and process innovation; and second it asked firms to state their main orientations to innovation, rather than whether or not they had introduced different types of innovation (as is the case with the CIS).

The sample to be interviewed was selected according to three criteria: country, firm size and industrial sector. In each of the largest member states of the European Union (EU-15): France, Germany, Italy, Spain and the UK, 300 firms were interviewed; in the smallest countries (Greece, Finland, Ireland, Luxembourg and Portugal), 100 firms were interviewed, whilst 200 firms per country were interviewed in the remaining, mid-sized member states (Austria, Belgium, Denmark, the Netherlands and Sweden). By size, firms were divided into three classes: small (20–49 employees), medium (50–249 employees) and large (250 or more employees), with sampling divided across these three bands, with 65% small, 20% medium and 15% large. This provided a deliberate over-sampling relative to the population of larger firms in order to reflect their greater economic significance. Finally, four sectors were identified: construction; industry (i.e., manufacturing and the production of raw materials); (wholesale and retail) trade; and (other) services. Sampling was divided across these four sectors in accordance with their economic significance in each country. Combined, the size and sector classifications provided a 12-cell matrix. The total number of firms to be interviewed in each country was divided according to the desired weights amongst this 12-cell matrix (and rounded to an integer). For each size-sector cell and in each country the required number of firms was selected at random from Dunn and Bradstreet's databases of European firms. Firms that refused to participate were replaced by another randomly drawn firm with the same size-sector-country characteristics, until the target number of responses was reached. Appendix A Table A1 reports the number of responses to the survey by country, firm size, and sector of activity.

In each firm the person interviewed was a top-level executive, but usually the chief executive or managing director. Unlike the CIS, the term "innovation" was not defined but was interpreted on the basis of the professional experience of the particular manager being interviewed (European Commission, 2002,p. 1). There are benefits and costs to this 'open approach' to studying innovation. The main benefit is that it is more inclusive as it does not impose a view of innovation upon the respon-

dents, whilst the main cost is a loss of control over the precise types of innovation included in the study. In the analysis that follows we will group firms according to their responses to three questions, rather than depend on their answers to a single question. This means our analysis is more robust than would be the case if we relied on the respondents' answers to a single question. We will also show that the patterns found are largely consistent with prior theory and evidence, which also enhances confidence in the validity of the findings. The "Innobarometer 2002" report provides further details of the survey and its findings (European Commission, 2002).

3. Data analysis—multiple correspondence analysis

For the analysis in this paper, we focus on the firms' answers to three questions: their orientations to innovation; their main sources of advanced technologies; and their perceived strengths at innovation.

Concerning orientations to innovation, the survey asked the firms: "Have your innovation efforts focused mainly on: the development of new products [if yes, q1-prd = 1, else 0]; the development of new production processes [if yes, q1-pro = 1, else 0], or the development of new organisational changes" [if yes, q1-org = 1, else 0]. According to the rules of the survey, the firms could identify one or two but not all three of these.

Concerning how the firms accessed advanced technologies, the survey suggested five sources: (1) "the acquisition of advanced machinery and equipment" [if yes, q2-acq = 1, else 0]; (2) "cooperation practices with suppliers and/or customers" [if yes, q2-cop = 1, else 0]; (3) "conducting in-house research and development" [if yes, q2-rad = 1, else 0]; (4) "cooperation practices with universities or R&D specialists" [if yes, q2-crd = 1, else 0]; and (5) "the acquisition of external intellectual property—such as licensing in" [if yes, q2-aip = 1, else 0]. The firms were also permitted to identify "other" sources if these were more important, or to state that no source was more important than the others. In general, however, the firms could identify up to two of these as being their most important sources of advanced technologies.

Concerning the firms' perceived strengths at innovation, the survey suggested that these might reside in six attributes: (1) "technological advance and research and development competencies" [if yes, q3-tec = 1, else 0]; (2) "efficient production methods and making the best use of resources" [if yes, q3-eff = 1, else 0]; (3) "flexibility and adaptability of production to market needs" [if yes, q3-flx = 1, else 0]; (4) "leadership in finding out and exploiting new market trends" [if yes, q3-mkt = 1, else 0]; (5) "good cooperation practices with suppliers, customers or trade associations" [if yes, q3-cop = 1, else 0]; and (6) "qualifications of staff and their professionalism" [if yes, q3-peo = 1, else 0]. The firms were also permitted to identify "other" strengths if these were considered more important, or to state that no strength was more important than the others. In general, however, according to the rules of the survey, the firms could identify up to two of these strengths at innovation.

Table 1 shows the simple response to these three questions. It is notable that the three innovation orientations had similar frequencies. Also shown in Table 1 are the distributions in the analysed sample used in this paper. For firms to be included in the analysis they had to have selected from the prescribed answers (excluding 'other', 'don't know', 'everything is equally important', etc.) for all three of the questions outlined above; 2578 (85.5%) of the 3014 firms in the full sample did this and were retained for further analysis. This high percentage suggests that most of the surveyed firms were content that the prescribed answers reflected their innovation orientations and activities.

We were interested in whether underlying patterns exist in how the firms answered these questions, and we therefore used multiple correspondence analysis, a statistical technique equivalent to principal components analysis for categorical data, to examine the data. In more detail, correspondence analysis is a descriptive/exploratory statistical technique designed to analyse two-way or multi-way tables containing some measure of correspondence between the rows and columns (e.g., types of firms and their strategies, or types of people and their habits, such as smoking). The two-variable cross-tabulation table is the simplest table of this type, and these are commonly analysed for statistical independence using the Chi-square test. One way of understanding correspondence analysis is to see it as a method for decomposing the overall Chi-square statistic by identifying a number of dimensions in which the deviations from the expected values (which would be zero if the variables were statistically independent) can be captured and represented. In correspondence analysis, dimensions are extracted so as to maximize the distances between the row or column points in the tables and therefore successive dimensions (which are independent of – or orthogonal to – one another) will 'explain' less and less of the overall deviance from independence between the variables in the table. Multiple correspondence analysis is an extension of simple correspondence analysis to more than two variables, and is a simple correspondence analy-

Table 1
The three analysed questions and their answers

Survey question and available answers	Variable	Frequency in full sample	Frequency in analysed sample[a]
Q1: Have your company's innovation efforts mainly concentrated on			
The development of new products	q1-prd	1153 (38%)	1112 (43%)
The development of new processes	q1-pro	1076 (36%)	1046 (41%)
The development of new organisational changes	q1-org	1303 (43%)	1221 (47%)
None of these, other, don't know, etc.		308 (10%)	n.a.
Q2: What are your company's main sources of advanced technology			
The acquisition of advanced machinery or equipment	q2-acq	1236 (41%)	1131 (44%)
Cooperation with suppliers or customers	q2-cop	1743 (58%)	1563 (61%)
Conducting in house R&D	q2-rad	908 (30%)	865 (34%)
Cooperation with universities or R&D specialists	q2-rdc	349 (12%)	335 (13%)
Acquisition of external intellectual property (e.g., licensing in)	q2-aip	268 (9%)	247 (10%)
Other, all or none of the above, don't know, etc.		169 (6%)	n.a.
Q3: Which factors best explain your company's strengths in innovation			
Technological advance and R&D competencies	q3-tec	424 (14%)	403 (16%)
Efficient production methods and making the best use of resources	q3-eff	546 (18%)	482 (19%)
Flexibility and adaptability of production to market needs	q3-flx	1092 (36%)	983 (38%)
Leadership in finding out and exploiting new market trends	q3-mkt	432 (14%)	387 (15%)
Good cooperation practices with suppliers, customers or trade associations	q3-cop	1182 (39%)	1028 (40%)
The qualifications and professionalism of our staff	q3-peo	1424 (47%)	1235 (48%)
Other, all or none of the above, don't know, etc.		74 (3%)	n.a.

[a] For firms to be included in the analysed sample, they had to identify answers from the choice sets available (excluding 'other', 'don't know', etc.) for all three questions. Of the total sample of 3014 firms, 2578 (85.5%) were included in the analysis.

sis carried out on an indicator matrix with cases (in our case firms) as rows and categories of variables (in our case innovation orientations, sources of technology, and perceived strengths at innovation) as columns. The extraction of dimensions in (multiple) correspondence analysis is similar to the identification of components in principal components analysis, or factors in factor analysis.

Although correspondence analysis can be put to a variety of uses, it is commonly used for exploratory, inductive research rather than hypothesis testing and deductive research. This is done by using the dimensions produced by the technique to generate scatter-plots with the scores of the column variables plotted in these dimensions. Variables with similar scores in these dimensions locate close together in these plots to reveal high degrees of association between them in the analysed dimensions. These associations are also stronger the further the points are from the origin of the plots. Although as many scatter-plots can be explored as there are binary combinations of the dimensions produced by the correspondence analysis, it is common to use only the first two or three dimensions, as these capture the greatest deviation from statistical independence in the data. See Greenacre (1984, 1993) for a comprehensive description of the method.

For this analysis, therefore, each of the prescribed answers to the three questions (on innovation orientations, sources of technologies, and perceived strengths at innovation) was coded for both their 'yes' and 'no' answers and included in a multiple correspondence analysis. We began with all the answers, but later excluded the variables for the perceived strength at innovation being (and not being) in "leadership in finding out and exploiting new market trends" and the variables for the source of advanced technologies being (and not being) the "acquisition of external intellectual property (e.g., licensing in)" as these variables did not have strong associations with any of the revealed dimensions, and therefore added very little to the analysis. It is worth noting that these were amongst the least frequently identified of the available responses.

The multiple correspondence analysis found 12 dimensions in the data, each of which accounted for between 17.3% and 1.9% of the total variation in the data (see Table 2). For simplicity, we will confine our attention to the first two dimensions, which individually accounted for the largest amount of variation in the data, and together accounted for 31% of the variance. Note that we also explored the third dimension, and plotted the scores of variables against the first two, but this did not reveal any clear clusters of variables.

Table 2
Revealed dimensions from multiple correspondence analysis

	Singular value	Principal inertia	Chi-square	Percent of total variation
Dimension 1	0.416	0.173	6844.9	17.3
Dimension 2	0.375	0.141	5561.5	14.1
Dimension 3	0.333	0.111	4372.2	11.1
Dimension 4	0.309	0.096	3781.9	9.6
Dimension 5	0.297	0.088	3481.1	8.8
Dimension 6	0.294	0.086	3406.9	8.6
Dimension 7	0.285	0.081	3206.9	8.1
Dimension 8	0.277	0.076	3020.9	7.7
Dimension 9	0.273	0.074	2939.7	7.4
Dimension 10	0.181	0.033	1297.5	3.3
Dimension 11	0.146	0.021	839.7	2.1
Dimension 12	0.137	0.019	738.7	1.9

Total degrees of freedom: 529.

Fig. 2 shows the plot of the variables included in the multiple correspondence analysis according to their scores in dimensions 1 and 2. As explained earlier, where variables are closely grouped together, particularly if this is at some distance from the origin, this shows variables with high levels of association. A clear cluster of variables appears in the bottom right corner of Fig. 2. This includes positive answers that the firm's orientation to innovation was (or included) the development of new products (q1-prd = 1); that its sources of advanced technology included the conduct of in-house R&D (q2-rad = 1) and/or cooperation with universities or R&D

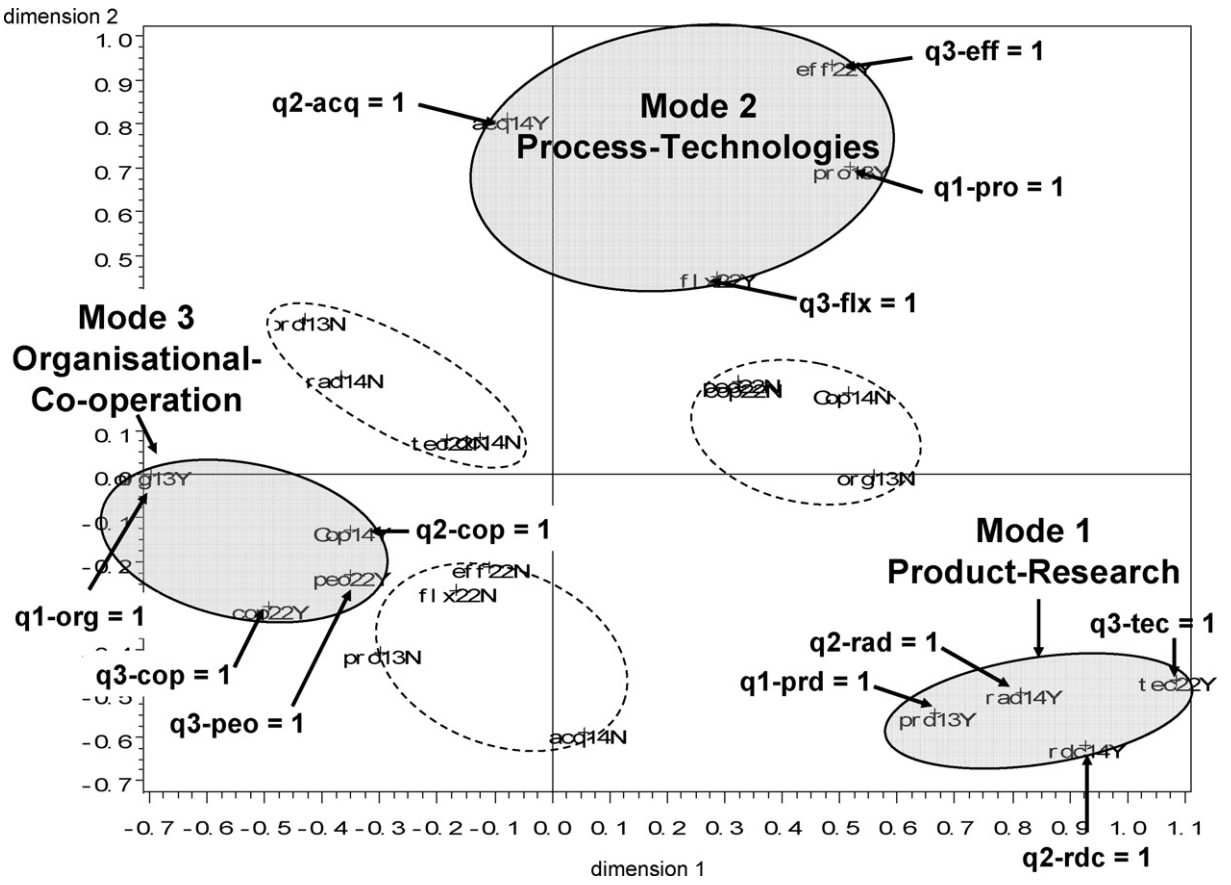

Fig. 2. Identifying the three modes of innovation.

specialists (q-2-rdc = 1), and that 'technological advance and R&D competencies' (q3-tec = 1) was amongst its perceived strengths at innovation. This grouping of variables – which associates product innovation with R&D activities both internal to the firm and undertaken through alliances with universities and R&D specialists – should be familiar to scholars of innovation, as it reflects the well known R&D or 'science-based' pattern of innovation (Pavitt, 1984; Evangelista, 2000; Hollenstein, 2003). For convenience, we label this the 'product-research' mode of innovation.

A second, less tightly grouped and therefore less closely associated cluster of variables is found at the top of the figure, with its centre slightly to the right of the vertical axis. This cluster also identifies four positive characteristics: that the firm's innovation efforts focused mainly on developing new production processes (q1-pro = 1); that its source(s) of advanced technologies was or included the acquisition of advanced machinery or equipment (q2-acq = 1); and that efficient production methods and making the best use of resources (q3-eff = 1) were, with the flexibility and adaptability of production to market needs (q3-flx = 1), considered the firm's main strength(s) at innovation. This group of variables – which is clearly associated with an internally oriented approach to innovation focused on the firm's production processes, their efficiency and/or flexibility, and with the associated "physical technologies" – should also be familiar to scholars of innovation, as it revolves around process innovation and technology adoption. For convenience, we label this the 'process-technologies' mode of innovation.

A third cluster of variables can be discerned to the left of the diagram, close to the horizontal axis. Like the other two, this group is associated with four positive characteristics: that the firm's innovation activities focused mainly on organisational changes (q1-org = 1); that its main source of advanced technology was cooperations with suppliers or customers (q2-cop = 1); and that good cooperation practices with suppliers, customers and trade associations (q3-cop = 1) were, with the qualifications and professionalism of the workforce (i.e., q3-peo = 1), considered the firm's main strength(s) at innovation. This group of variables points to a non-technological mode of innovation focused on 'soft' organisational changes and primarily oriented to cooperations within supply-chains and networks (rather than R&D-based collaborations or alliances). This mode of innovation might have been anticipated by scholars of innovation, although it is less familiar as a grouping of characteristics. It is perhaps closest to the 'ancillary innovations' which Damanpour (1987) identified alongside technological and administrative innovations. For Damanpour, 'ancillary innovations' are organisational-environment boundary-spanning innovations, the implementation of which is contingent upon cooperation and joint efforts of the organisation and some of its clients. For convenience, we label this the 'organisational-cooperation' mode of innovation.

The plot shown in Fig. 2 also shows three other clusters of variables, each located between two of the three identified above. These are comprised of the corresponding negative variables for the first three clusters. For example, the group of variables to the left of the vertical axis and above the horizontal axis is comprised of the 'no' answers to the variables in the product-research mode, i.e., it identifies the variables that firm's do not focus on product innovation, do not source acquired technologies through conducting in-house R&D, nor through cooperations with universities and R&D specialists, and do not consider technological advance and R&D competencies as their main strength at innovation. The equivalent negative cluster for the process-technologies mode is found just to the right of the positive variables identifying the organisation-cooperation mode, whilst the negative cluster for the organisation-cooperation mode lies between the positive clusters for the product-research and process-technologies modes.

4. Associating the modes of innovation with other characteristics of firms

Having identified these three modes, our interest turned to the question: what type or types of firms are associated with each of them. Before addressing this question, we stress that the identification of these groupings, or modes of innovation, does not mean they are the only modes of innovation to be found amongst the firms, only that these are the most readily identifiable modes. The multidimensionality of the data suggests the overall pattern is much more complex and many firms will not be clearly associated with any of these three modes of innovation. Unlike others (e.g., Hollenstein, 2003), our objective is not to classify all the firms by their mode or modes of innovation. Instead, our objective is to explore the three modes we have identified, and in particular the third 'organisational-cooperation' mode, which is less familiar to scholars of innovation.

We considered that if an individual firm claimed that its innovation activities were oriented to products, processes or organisational changes and that it identified at least two of the three associated variables concerning its sources of advanced technologies and strengths at innovation then that firm could be considered oriented

(although not necessarily exclusively) to the mode of innovation in question. In particular:

- Firms were identified as being engaged in the Product-Research (PR) mode of innovation if they stated that their innovation activities were oriented to the development of new products, and identified at least two of the three following characteristics: the firm sourced advanced technology through undertaking in-house R&D; it sourced advanced technologies through cooperations with universities or R&D specialists; it perceived 'technological advance and R&D competencies' as its strength at innovation. By definition, therefore, these firms were oriented to product innovation and engaged in R&D activities.
- Firms were identified as being engaged in the Process-Technologies (PT) mode of innovation if they stated that their innovation activities were oriented to developing new production processes, and identified at least two of the three following characteristics: the acquisition of advanced machinery or equipment was a primary source of advanced technologies; the firm perceived its main strength at innovation as being efficiency in production methods and making the best use of resources; it perceived its main strength at innovation to be the flexibility and adaptability of production to market needs.
- Firms were identified as being engaged in the Organisational-Cooperation (OC) mode of innovation if they stated that their innovation activities were oriented to organisational changes, and identified at least two of the three following characteristics: cooperations with suppliers or customers as a main source of advanced technology; good cooperation practices with suppliers, customers and trade associations as a main strength at innovation; the qualifications and professionalism of the workforce as a main strength at innovation. By definition, therefore, these firms were oriented to organisational changes and engaged in some supply-chain (rather than research-based) cooperative practices.

By these definitions, 218 firms were identified as being engaged in the product-research mode of innovation, 430 in the process-technologies mode, and 719 in the organisational-cooperation mode. Table 3 shows the extent to which firms allocated to each of the three modes exhibited the characteristics associated with each of them.

These definitions are a matter of judgement. If we insisted that firms had to exhibit all four of the characteristics associated with a mode to be identified as engaged in it, then only 46 firms would be identified as engaged in the product-research mode, only 64 in the process-technologies mode and only 211 in the organisation-cooperation mode.[12] Whilst the definitions outlined above do not confine the identification of firms engaged in these modes to these 'thoroughbreds', it is the case that few of the firms allocated to one mode had more than one of the characteristics associated with either of the other modes.

Using the definitions outlined above, half (51%) the eligible firms were identified as being engaged in one or more of the three modes of innovation, with the vast majority being identified as engaged in one mode: 202 firms were only identified as being engaged in the product-research mode, 382 as only active in the process-technologies mode, and 675 as only active in the organisational-cooperation mode. Meanwhile, 10 firms were identified as being engaged in both the product-research and process-technologies modes, 6 firms in both the product-research and organisational-cooperation mode, and 38 in both the process-technologies and organisational-cooperation modes. It is entirely reasonable that some firms will be pursuing two or more modes of innovation simultaneously, and the numbers identified above will underestimate the extent to which this is occurring because the survey asked firms to focus on their main innovation orientations, rather than all their innovation efforts.

As mentioned earlier, our objective is not to classify all the firms to one or more modes of innovation, but rather to investigate the extent to which firms of different types (by size and sector) engage in each of the three modes we have identified.

As the first two of these modes are well established in the literature, it follows that we can make a number of predictions concerning how they are likely to be distributed amongst different types of firms. Although we do not expect that any mode will be exclusively associated with any 'type' of firm (Hollenstein, 2003), we can expect, for example, that amongst firms engaged in high-technology activities a large proportion will be identified as being engaged in the product-research mode. As R&D

[12] By contrast, if we remove the requirement that firms' innovation activities had to be oriented to the specific types of innovation and instead required that the firms identify any three of the four characteristics associated with each mode then we could assign 231, 461 and 865 firms, respectively to each of the modes. We used this approach in an earlier version of this paper. Referees comments led us to change the allocation procedure to the current one, although the findings concerning the types of firms identified as being engaged in each of the modes are very similar.

Table 3
Revealed characteristics and the three modes of innovation

Firms associated with the product-research mode of innovation (No. 218)	
Innovation activities were oriented to the development of new products	100%
Main source(s) of advanced technology is/includes undertaking in-house R&D	90%
Main strength(s) at innovation is/includes 'technological advance & R&D competencies'.	81%
Main source(s) of advanced technologies is/includes cooperation with universities or R&D specialists	51%
Firms associated with the process-technologies mode of innovation (No. 430)	
Innovation activities were oriented to developing new production processes	100%
Main source(s) of advanced technology is/includes acquisition of advanced machinery or equipment	93%
Main strength(s) at innovation is/include being the flexibility and adaptability of production to market needs	71%
Main strength(s) at innovation is/include being oriented to efficiency in production methods and making the best use of resources	51%
Firms associated with the organisational-cooperation mode of innovation (N. 719)	
Innovation activities oriented to organisational changes	100%
Main source(s) of advanced technology is/includes cooperations with suppliers or customers.	94%
Main strength(s) at innovation is/includes qualifications and professionalism of the workforce.	69%
Main strength(s) at innovation is/includes good cooperation practices with suppliers, customers and trade associations.	66%

activities are known to be concentrated in relatively few, generally large firms, we can also expect that larger firms will be more likely to engage in this mode of innovation.

We can also anticipate that the process-technologies mode of innovation will be particularly prominent amongst lower technology manufacturing firms (i.e., those in the traditional manufacturing sectors that Pavitt (1984) labelled 'supplier-dominated'). The relationship between firm size and the process-technologies mode of innovation is less easily predicted. On the one hand, in the Abernathy-Utterback model this mode of innovation is associated with innovation late in the product-lifecycle (Abernathy and Utterback, 1978; Utterback and Abernathy, 1975), when innovating firms tend to be very large. But the Abernathy-Utterback model is now 30 years old, and arguably few businesses of this type remain, especially in high cost locations such as Western Europe; those that survive are likely to be in low cost locations like China. On the other hand, the process-technologies mode is close to Pavitt's (1984) category of 'supplier-dominated' firms, which he considered would compete on price, would focus mainly on process innovation and would source technologies from suppliers of machinery and equipment. Pavitt thought such firms would tend to be small.

As mentioned, less is known about the organisational-cooperation mode of innovation, and therefore the expected distribution of firms identified as being engaged in it. It might be suspected, however, that this mode is particularly prominent in services (de Vries, 2006; den Hertog, 2000; Djellal and Gallouj, 2001; Evangelista, 2000; Hipp and Grupp, 2005; Hollenstein, 2003; Skogli, 1998; van der Aa and Elfring, 2002).

Table 4 provides descriptive statistics concerning the extent to which firms of different sizes and in different sectors and countries were identified as being engaged in one or more of the three modes of innovation. German firms were the most likely (65%), and British firms the least likely (39%), to be identified as engaged in any of these modes, whilst by sector firms in high-technology activities were the most likely (57%), and firms in financial and business services were the least likely (44%), to be identified as engaged in these modes. By size, the extent of allocation varied only slightly. Fig. 3 shows the actual allocation of firms to these modes of innovation by size and sector. Here, S refers to small firms with 20–49 employees, M to medium sized firms with 50–249 employees, and L to large firms with 250 or more employees. Although only half the firms are identified as engaged in the modes, clear patterns emerge.

In line with our expectations, the product-research mode appears to be particularly prominent in high-technology activities, and especially amongst large high-tech firms, amongst which 45% are identified as being engaged in this mode of innovation. This mode is also prominent amongst medium–high-technology manufacturers, with roughly 30% of these firms identified as engaged in it. Overall, the product-research mode appears to be positively associated firm size and technological intensity, particularly within manufacturing. Also in line with our expectations, service firms (and those in construction and civil engineering) are rarely identified as engaged in this mode of innovation.

In contrast to the product-research mode and in line with expectations, the process-technologies mode appears to be prominent amongst smaller low and medium–low-technology manufacturers, amongst

Table 4
The allocation of firms to modes of innovation by sector, size and country

	PR mode (%)	PT mode (%)	OC mode (%)	Any mode(s) (%)	Analysed sample
All firms	8	17	28	51	2578
Sector of activity[a]					
Low tech manufacturing	7	34	10	49	377
Medium–low tech manufacturing	9	29	12	47	281
Medium–high-technology manufacturing	21	18	13	49	199
High-technology activities	32	11	17	58	142
Construction and civil engineering	3	16	36	54	276
Wholesale	7	9	41	55	432
Retail	2	6	46	52	228
Financial and business services	10	11	24	44	170
Functional services	2	14	41	56	152
Other services	6	11	32	46	236
Firm size					
20–49 employees	6	16	32	52	1614
50–249 employees	10	19	24	51	590
250–499 employees	19	18	15	47	165
500+ employees	18	13	18	48	209
Country[b]					
Germany	14	15	39	65	260
Austria	6	14	46	62	170
Belgium	12	17	33	59	162
Luxembourg	6	12	40	54	85
Denmark	8	18	30	53	153
Spain	7	26	22	52	261
Greece	7	28	19	51	90
France	6	15	30	50	271
Netherlands	11	17	27	49	162
Italy	9	20	20	48	291
Ireland	3	12	35	48	86
Portugal	3	14	26	43	94
Finland	8	24	10	42	99
Sweden	12	9	19	40	169
United Kingdom	7	9	24	39	225

[a] By sector, cased from Luxembourg are omitted due to missing sector classification data.
[b] Ranked by the share of firms identified as engaged in one or more of these modes of innovation.

which a third were identified as being engaged in this mode. Although some firms in all the size-sector classifications are identified as being engaged in this mode of innovation, the proportion of service sector firms identified as so engaged tends to be rather small.

The organisational-cooperation mode of innovation appears to follow a third pattern by size and sector. As with the process-technologies mode, some firms in all the size-sector classifications were identified as being engaged in this mode, but it appears to be much more prominent amongst service sector firms (and smaller construction and civil engineering firms). Nearly half the small and medium sized retailers in the sample were identified as being engaged in this mode, as were 40% of the small and medium sized wholesalers, and a similar proportion of functional service firms. By contrast, this mode appears to be less prominent amongst manufacturers, amongst which roughly one in ten firms were engaged in it (Tables 5 and 6).

To explore whether these patterns were statistically significant, we estimated three binary logistic regressions, one for each of the three modes of innovation.[13] Using low-technology manufacturing (LTM) firms based

[13] The correlations between these dependent variables are low: PR and PT = −0.099; PR and OC = −0.170; PT and OC = −0.190. A statistically more sophisticated approach to modelling this would be to use a trivariate binary regression with a probit link. Whilst technically superior, this approach is also more complex to report. For simplicity, and in view of the low correlations between the dependent variables, we report the results of the three binary logistic regressions.

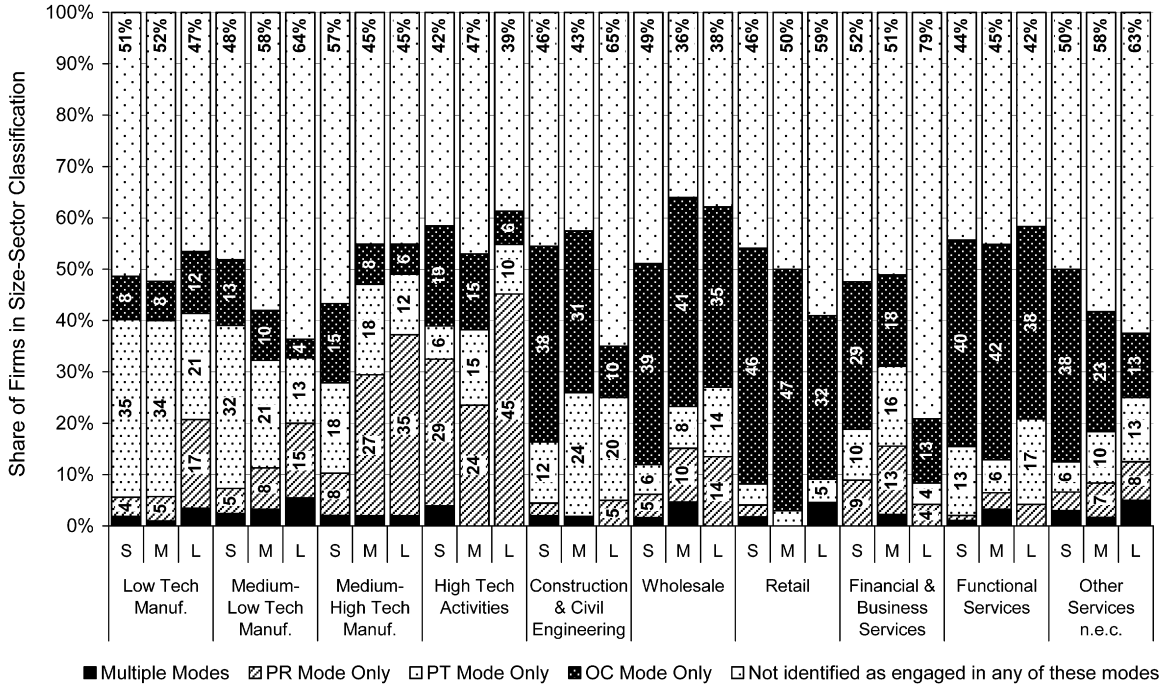

Fig. 3. Allocation of firms to modes of innovation by size and sector.

in France as the reference group, the binary logistic regression for the product-research (PR) mode shows, as expected, that firms engaged in high-technology activities and medium–high-technology manufacturing (MHTM) were significantly more likely to be engaged in this mode of innovation than were low-technology manufacturers. Indeed, in line with expectations, within manufacturing there is a clear relationship between technological intensity and the propensity to engage in this mode of innovation. Also in line with expectations is that the propensity to engage in this mode increases significantly with firm size. With regard to this mode of innovation and services, two sets of sectors can be identified. The first is comprised of wholesalers, financial and business service firms, and the miscellaneous 'other services' category. Firms in these sectors are not significantly less likely to engage in this mode of innovation than low-technology manufacturers (but are much less likely to engage in it than high-technology firms). The second set is comprised of retailers and functional services, which (like construction firms) are significantly less likely than even the low-technology manufacturers to engage in this mode of innovation.

The binary logistic model for the process-technologies (PT) mode shows, as expected, that this is most widespread amongst low-technology manufacturers (LTM). Within manufacturing, the propensity to engage in this mode of innovation declines with increasing technological intensity. This mode is also very much less widespread in services and construction than in low and medium–low-technology manufacturing, and also notable is that participation in this mode did not vary significantly with firm size.

With regard to the organisational-cooperation (OC) mode, it is notable that firms in all the service sectors and in construction were much more likely than low-technology manufacturers to be identified as engaged in this mode. Firms in high-technology activities also appear to be slightly more likely than low-technology manufacturers to be engaged in this mode of innovation. This mode is also more common amongst smaller firms, as the propensity to engage in it declines (albeit slightly) with firm size.

5. Conclusions: implications for innovation research and policy

In this paper, we analysed a dataset of over 2500 European firms and identified statistically three modes of innovation: a product-research mode that involves product innovation and R&D activities, both within firms and in collaboration with universities and R&D specialists; an internally focused process-technologies

Table 5
Independent variables, their description and descriptive statistics

Description	Value >0	Mean	S.D.	Minimum	Maximum	Statistical tolerance
Ln (employment)	2493	4.12	1.22	3.00	11.29	0.93
New firms established since 1997 (d)	201	0.08	0.27	0	1	0.94
Low-technology manufacturing (d)[a]	377	0.15	0.36	0	1	n.a.
Medium–low tech manufacturing (d)	281	0.11	0.32	0	1	0.64
Medium–high-technology manufacturing (d)	199	0.08	0.27	0	1	0.70
High-technology manufacturing and services (d)	142	0.06	0.23	0	1	0.74
Construction (d)	276	0.11	0.31	0	1	0.63
Wholesale (d)	432	0.17	0.38	0	1	0.55
Retail (d)	228	0.09	0.29	0	1	0.66
Financial & business services (d)	170	0.07	0.25	0	1	0.71
Functional services[b] (d)	152	0.06	0.24	0	1	0.75
Other services not elsewhere classified (d)	236	0.09	0.29	0	1	0.66
Country						
Austria (d)	170	0.07	0.25	0	1	0.65
Belgium (d)	162	0.06	0.25	0	1	0.67
Denmark (d)	153	0.06	0.24	0	1	0.67
Finland (d)	99	0.04	0.19	0	1	0.75
France (d)[a]	271	0.11	0.31	0	1	n.a.
Germany (d)	260	0.10	0.31	0	1	0.55
Greece (d)	90	0.04	0.19	0	1	0.77
Ireland (d)	86	0.03	0.18	0	1	0.78
Italy (d)	291	0.12	0.32	0	1	0.53
Netherlands (d)	162	0.06	0.25	0	1	0.66
Portugal (d)	94	0.04	0.19	0	1	0.73
Spain (d)	261	0.10	0.31	0	1	0.56
Sweden (d)	169	0.07	0.25	0	1	0.65
United Kingdom (d)	225	0.09	0.29	0	1	0.58

Based on 2493 cases (excludes Luxembourg due to missing data).
[a] Used as the reference categories in the modelling. No correlation between a pair of independent variables had an absolute value exceeding 0.2.
[b] Mainly acting on things, not people, i.e., cleaning, maintenance and repair services, transport of goods, etc. (d) denotes dummy variable.

mode that involves process innovation, is orientated to the flexibility and/or efficiency of production and involves the acquisition of advanced machinery and equipment; and an organisational-cooperation mode that is focused on organisational changes, is heavily dependent on the skills of the workforce and which involves cooperative practices with suppliers and customers. The first two of these modes are very familiar to scholars of innovation and, as expected, were found to be most prominent amongst high-technology firms and low-technology manufacturers, respectively. The third mode is less familiar, but has organisation boundary-spanning characteristics similar to Damanpour's (1987) 'ancillary innovations'. It appears to be particularly prominent in services. Thus, overall, we consider this study has made a contribution to the literature by using the exploratory statistical technique of multiple correspondence analysis to identify, alongside two well established modes of technological innovation, a third mode of innovation focused on organisational change and inter-organisational cooperation. We also find this mode to be particularly prominent in services – and especially in trade and distribution services – and construction. This is significant, as innovation in these activities is less well understood than innovation in manufacturing.

Our findings both resonate with and diverge from the findings of the CIS which were reviewed briefly earlier (Section 1.3). In keeping with the CIS, we find that organisational innovation (and in our case a particular form of organisational innovation) is more prominent in services than in manufacturing, but whereas the CIS tends to find rather small or marginal differences in behaviour between manufacturing and service firms, our study found more emphatic differences. There are probably several reasons for these differences, including: (1) unlike the CIS the Innobarometer survey which we utilised asks firms about organisational innovation alongside product and process innovation and this may have had an impact on how firms responded to both these

Table 6
Modelling group membership—binary logistic regressions: odds ratios

	PR mode	PT mode	OC mode
Ln (employment)	1.37***	0.96	0.85***
Newfirm	1.37	1.12	0.87
Medium–low tech manufacturing	1.21	0.80	1.29
Medium–high-technology manufacturing	3.39***	0.39***	1.27
High-technology activities	5.22***	0.23***	1.67*
Construction and civil Engineering	0.44**	0.32***	4.64***
Wholesale	1.10	0.17***	5.83***
Retail	0.33**	0.12***	6.91***
Financial and bussiness services	1.41	0.22***	2.68***
Functional services	0.23**	0.29***	5.96***
Other services	0.78	0.23***	4.26***
Austria	1.10	0.97	2.11***
Belgium	2.05*	1.15	1.21
Denmark	0.97	1.34	1.17
Finland	1.14	1.96**	0.27***
Germany	2.19**	1.31	1.56**
Greece	1.57	2.03**	0.53**
Ireland	0.70	0.84	1.14
Italy	1.46	1.13	0.78
Netherlands	1.79#	1.32	0.86
Portugal	0.56	0.62#	1.05
Spain	1.28	2.12***	0.64**
Sweden	1.83#	0.53**	0.63*
UK	1.24	0.61*	0.71#
Intercept	0.01***	0.56**	0.24***
No.	2493	2493	2493
Model χ^2	190.6***	207.8***	330.5***
−2LL	1264.6	2053.2	2601.0
Nagelkerke pseudo R^2	0.166	0.134	0.180

Reference firm is in France and is active in low-technology manufacturing.
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.
# Significant at 10–20%.

surveys; (2) unlike the CIS, the methodology used in our study encouraged the firms to identify their most important innovation activities, rather than all of their innovation activities; (3) our study includes a wider range of services than are included in the CIS. For example, retailing is included in our study but not in the CIS, and retailing (alongside functional services, most of which are also not included in the CIS) was found to be the sector in which the organisational-cooperation mode of innovation was the most widespread. Ultimately, we cannot fully reconcile the differences that arise in the results from the two surveys, and recognise the need for further quantitative and qualitative research to replicate and reinforce the findings of this study if the identification of an organisational-cooperation mode of innovation is to gain widespread acceptance.

This said, we consider that the findings presented in this paper have implications for research on innovation and its measurement, and for public policy concerning innovation. In particular, we agree with Jansen et al. (2007) that, despite the considerable literature which emphasises innovation as an interactive process in which firms interact with customers, suppliers and knowledge institutions, "there remains a bias amongst scholars and policymakers to consider innovation processes largely as aspects connected to formal processes of R&D, especially in science-based industries" (Jansen et al., 2007, p. 681). Jansen et al. go on to argue that because of this bias innovation studies and policies have tended to focus excessively on R&D, the role of trained scientists and engineers, industry-academic links, and 'high-tech' fields such as ICT, bio- and nano-technology. 'Low tech' industries, including most services, in which technolo-

gies are applied rather than developed, and in which innovation is based on 'doing, using and interacting' have suffered neglect. In the UK NESTA, the National Endowment for Science Technology and the Arts, has advanced a similar argument, claiming: "A striking feature of most innovation policies around the world is their similarity. Almost without exception, they focus on [high-technology] sectors such as IT, biotech and nanotech; on increasing public and private investment in R&D; and on strengthening links between the science base and industry" (NESTA, 2006, p. 38). NESTA points out that high-tech manufacturing industries account for only 2.5% of the UK's Gross Value Added (and a similar proportion of other advanced economies), and that obsession with these activities has led to a neglect of 'hidden innovation' throughout the economy, hidden innovation that is arguably more significant to the vitality of the UK and other advanced economies. Our study makes a contribution by pointing to one apparently important yet overlooked from of 'hidden innovation'.

In general, our study supports those who call for a broad understanding of innovation, and particularly the need to embrace and understand non- and less-technological forms of innovation such as organisational and management innovation. Furthermore, the complementarities between technological and organisational forms of innovation need to be more fully understood (Lam, 2005).[14] We also call for more general effort to study innovation in services, not only to understand directly the dynamics of these activities but also to shed light on hitherto neglected aspects of innovation that are found across the economy.

We appreciate and welcome the fact that the Oslo Manual and CIS, which is the main instrument for measuring innovation in Europe, is evolving and is incorporating non-technological forms of innovation such as organisational and marketing innovation. We would suggest two changes to the CIS: first, bringing together into one cluster or set, the questions about the different types of innovation—currently product and process innovations are asked about at the front of the questionnaire, whereas organisational and marketing innovation are asked about at the end; secondly, extending the surveying to include services that have hitherto been excluded from the 'core' target sectors investigated. Economically significant sectors that are currently excluded from the 'core', and which are therefore surveyed by countries on a voluntary basis, include retailing, hotels and catering, and many business services, including advertising, legal, accounting and management services.

One reason why it is important to gain an understanding of innovation across as much of the economy as possible is that different forms of innovation present different challenges both to firms and to policymakers. With the science-based/R&D mode of innovation, the supply of elite labour in the form of highly trained scientists and engineers is crucial, as is the conduct of R&D within firms and within public institutions such as universities. But these activities are less important for more devolved forms of innovation such as the organisational-cooperation mode of innovation identified in this paper. In this mode, knowledge tends to be more distributed within and between firms than is the case with the classic R&D mode, with greater involvement in innovation activities and solving problems of the general workforce. The full implications of this are beyond the scope of this paper, but it is clear that the approach to, and attributes required for this type of innovation are not identical to those required for R&D-centred innovation.

[14] Because of the nature of the data employed, our study cannot shed light on these complementarities.

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Appendix A

See Table A1.

Table A1
Survey response and analysed sample by size, sector and country

	Full survey response (A)	Included in the analysed sample (B)	B/A (%)
All firms	3014	2578	86
Small (20–49 employees)	1928	1614	84
Medium (50–249 employees)	666	590	89
Large (250+ employees)	420	374	89
Construction	376	305	81
Industry	994	909	91
Trade services	767	638	83
Other services	877	726	83
Austria	200	170	85
Belgium	207	162	78
Denmark	202	153	76
Germany	300	260	87
Greece	101	90	89
Finland	103	99	96
France	305	271	89
Ireland	100	86	86
Italy	301	291	97
Luxembourg	92	85	92
Netherlands	200	162	81
Portugal	100	94	94
Spain	300	261	87
Sweden	200	169	85
UK	303	225	74

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