Please cite this paper as:

Lancaster University Management School
Working Paper 2014:8

Reassessing the Scope of OR Practice: the Influences of Problem Structuring Methods and the Analytics Movement

J. C. Ranyard, R. Fildes[*] and Tun-I Hu

The Department of Management Science
Lancaster University Management School
Lancaster LA1 4YX
UK

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Reassessing the Scope of OR Practice: the Influences of Problem Structuring Methods and the Analytics Movement

J C Ranyard, R Fildes[*] and Tun-I Hu

Department of Management Science,

Lancaster University, UK

Abstract: This paper argues that if OR is to prosper it needs to more closely reflect the needs of organizations and its practitioners. Past research has highlighted a gap between theoretical research developments, applications and the methods most frequently used in organizations. The scope of OR applications has also been contested with arguments as to the expanding boundaries of OR. But despite this, anecdotal evidence suggests that OR has become marginalized in many contexts. In order to understand these changes, IFORS (International Federation of OR Societies) in 2009 conducted a survey of global OR practice. The aim was to provide current evidence on the usage of OR tools, areas of application, and the barriers to OR's uptake, as well as the educational background of OR practitioners. Results presented here show practitioners falling into three segments, which can be loosely characterized as those practicing 'traditional' OR, those adopting a range of softer techniques including Problem Structuring Methods (PSMs), and a Business Analytics cluster. When combined with other recent survey evidence, the use of PSMs and Business Analytics is apparently extending the scope of OR practice. In particular, the paper considers whether the Business Analytics movement, with an overlapping skill set to traditional OR but with a fast growing organizational base, offers a route to diminishing the gap between academic research and practice. The paper concludes with an exploration of whether this represents not just an opportunity for OR but also a serious challenge to its established practices.

Keywords: Analytics; Problem structuring; OR practice; Barriers to OR; OR skills

* Corresponding author: Tel: +44 (0)777 1663165, Fax: +44 (0)1524 592060
* Email: r.fildes@lancaster.ac.uk

"In theory, theory and practice are the same. In practice, they are not." Multiple attributions including Einstein and Yogi Berra

Prologue

This paper is stimulated by a survey of global OR practice, sponsored by IFORS. In placing the new results in the context of other practice surveys it has become clear that the gap between academic research and practice – the 'natural drift' for professions identified by Corbett and Van Wassenhove (1993) – still exists and that changes in the organizational environment make the need to address the gap more urgent. Further, although the scope of OR practice continues to extend and evolve, particularly arising from Problem Structuring Methods (PSMs) sometimes referred to as Soft OR, a new and distinct movement, 'Business Analytics' has recently emerged, capitalizing on the 'Big Data revolution'. These developments present both a threat to and an opportunity for the OR community. This paper reviews these developments from an OR practice perspective and suggests how the OR community should respond in order to ensure long term survival.

1. Introduction

What's the point of studying OR practice? The practice of OR was fundamental to its early development in the USA and the UK (see Kirby, 2000, 2003; McCloskey, 1987). Early academic research to support practice was quick to find a post-war foothold in the USA though, in the UK, university based OR developed more slowly. OR as a separate discipline was established still more slowly elsewhere in the world, for example, in Germany there was a long history of research in industrial engineering but a coherent professional society was not established until late in the 1960s (Hamacher, 2011). The interchange between the practices of OR workers in government and industry and academic researchers has always been regarded as important for the health of the discipline (Sodhi & Tang, 2010) although even from the earliest exchanges, some perceived a developing division between the two. In fact, a number of studies have lamented any gap as potentially dangerous, even going so far as to suggest it might lead to the demise of the discipline (e.g. Abbott, 1988). Building on Abbot's analysis, Corbett and Van Wassenhove (1993) saw a polarization between the development of novel OR tools on the one hand and management practice on the other, leaving the middle ground of 'management engineering' to contract. The early link between practice and tool development had become broken. Certainly the declining emphasis on OR in general management publications such as the Harvard Business Review (Corbett & Van Wassenhove, 1993), in MBA programmes (Sodhi & Tang, 2010), evidence supported by the survey in Fildes, Ranyard and Crymble (1999) reflect an apparent decline in OR's organizational importance. In turn, this has

damaged the standing of OR in universities (Sodhi & Tang, 2010) with the implicit threat of falling numbers of both expert staff and graduates and the rise of competing disciplines, contesting the territory once the preserve of OR. In many organizations, Business Analytics, with a tool set that overlaps that of OR, is fast becoming acknowledged as a critical skill set offering strategic advantage (Davenport & Harris, 2013).

Nevertheless, occasional papers at EURO, INFORMS and the UK OR Society conferences, surveys of practice, case analyses and, in addition, scholarly papers such as Ormerod (2002) or Ulrich (2012) continue to examine OR practice and generate interest. But these academic engagements with OR practice are limited and infrequent despite those such as Ormerod (2002) who reaffirm the claim that "OR is defined as its practice" and not by "the maintenance of its body of knowledge". However, a cursory examination of the journals and most conferences show the dominance of mathematical OR disassociated from practice, even though critical voices continue to be raised, such as Ryan's in a plenary address to the IFORS (International Federation of OR Societies) conference in 1999 (Ryan, 1999). More formal analysis confirms this abstract mathematical dominance where tools or models are developed without practical grounding (Reisman & Kirschnick, 1994; Ormerod & Kiossis, 1997; Ormerod, 2002). With such limited academic engagement with practice why is understanding the state of OR practice important to organizations such as IFORS and EURO whose role it is to sustain and develop OR?

Many OR societies certainly recognize the need to strengthen the links between theoretical research and practice with attempts made to stimulate journal and conference papers focusing on applications. For example, INFORMS and the OR Society have jointly promoted a 'Science of Better' initiative aimed at publicizing the achievements of OR practice to potential client organizations. INFORMS runs a separate practitioner-oriented conference (now branded Business Analytics and OR) and the OR Society now runs a practitioner-oriented day, 'Making an Impact' within its national conference. Awards such as the Edelman (sponsored by INFORMS), the EURO award for Excellence in Practice and the UK Society's President's Medal are attempts to publicize the organizational benefits and innovation arising from the link. To draw out this link more explicitly, the member societies of IFORS prosper from the size of their membership, attendance at conferences, and crucially the job market for OR expertise which is much broader and more dynamic than merely academic posts but also depends on the organizational culture in which OR is perceived valuable. Many of the member

societies have faced challenges on all three dimensions: experiencing falling membership (as in the US to 2011 and UK to 2012), criticism of their conferences with practitioners finding little on offer of relevance, and a job market that looks for skills quite distinct from those emphasized in much academic research (Sodhi & Son, 2008; Sodhi & Son, 2010). As a response to these concerns and, acknowledging the limited knowledge of how OR is practiced in many of its 49 member countries, in 2009 IFORS, through its administrative committee, commissioned a survey of OR practice. The sponsor's survey objectives, the widest in scope for many years, were to gain a better understanding of the usage of quantitative tools, techniques and approaches and their impact on decision-making in organisations and also the background of the OR analysts involved. It should, be "a potential tool..[to]..: identify training needs; stimulate appropriate courses of action such as identifying the need/source of specific research expertise and computer software and stimulating communities of practice for sharing common interests.... potentially one step towards a more positive and fruitful collaboration between academics and practitioners". At around the same time as the IFORS survey, INFORMS was investigating the growth of the 'Business Analytics' movement, which is based on the analysis of large datasets (Big Data) that are increasingly available in large organisations. Their analysis uses many techniques available to OR practitioners. With so little known of the developing practice of OR (and analytics) and its changing scope, this paper considers recent survey evidence to identify these changes and, in particular, whether the polarisation between tool development and practice is being at least in part reversed by these new developments.

In section 2 of the paper we summarise discussions of OR, in particular the scope of OR, based on the understanding gained from previous surveys of OR practice. We see two strands of analysis with the potential to extend OR from its traditional base: Problem Structuring Methods (sometimes referred to as Soft OR), which use various facilitation approaches designed to address 'messy' problems involving multiple stakeholders and conflicting objectives and the rapidly expanding area of Business Analytics (whose definition and emergence we discuss fully in section 4.1). Section 3 presents the current survey evidence, while in section 4 we discuss these diverse strands of OR, and their potential for bridging at least part of the gap observed between the activities of practitioners and academics. Section 5 reflects on these developments from the perspective of OR practice as its scope changes, as revealed by the analysis of survey and case data. This lays out the argument in support of the conclusions, presented in the final section, as to the opportunities and threats facing OR and OR Societies

The overall goal of the paper is to promote a more self-aware OR profession, able to deal successfully with the undoubted challenges it is facing but also take advantage of the increased opportunities offered by the sudden emergence of the Business Analytics movement.

2. Perspectives on OR Practice

Discussions of OR practice have formed part of OR's self-reflection on its contribution since the early publications and conferences: criticisms were made even in the 1950s that OR was becoming too abstract and mathematical. However, in those early days, conferences and publication were heavily influenced by practitioners where approximately 50% of published articles considered applications and over 50% of contributors to the first two IFORS conferences (1957 and 1960) were practitioners (Fildes & Ranyard, 1997). Without attempting to examine the debate in full (see Fildes and Ranyard's discussion of the scope of OR, pp. 340 – 343 and, more recently, Ulrich, 2012), these issues were brought to a head by Ackoff in his 1977 UK OR Society conference presentation (Ackoff, 1979). Here he blamed the mathematisation of OR (as recorded in OR journals), and misuse of OR techniques (in some practitioner groups) as a core reason for it being pigeon holed into studying relatively unimportant problems and not wicked messes, in particular the problems that much strategy development and planning entails. Ackoff's criticisms were controversial (Kirby, 2003). In the UK, many practitioners regarded them as outdated, since internal OR groups had become increasingly client-oriented, focusing less on the mathematical formulation (Ranyard, 1995; 2000). In the US, Ackoff's criticisms had little influence (Kirby, 2007), and this can be confirmed by his lack of citations in the core US journals. But the result of the argument as to OR's organizational role was, however, a stand-off with some holding that OR's contribution was primarily tactical and well-below board level (e.g. Eilon, 1980) while others provided evidence that major strategic contributions were being made (e.g. Ormerod, 1996; Ranyard, 1995). More recently, various contributions authored by Bell (Bell, 1998; Bell & Anderson, 2002; Bell, Anderson, & Kaiser, 2003)), in particular Bell and Anderson's discussion of the Edelman award entries provided further evidence of OR's successful strategic innovations. Elsewhere, the UK OR Society's President's Medal and the EURO Excellence in Practice competition add more weight. However most of those engaged in the debate on practice accepted that new approaches were needed if OR was to be more effective at the strategic level and on issues of social planning, which often involves multiple stakeholders with conflicting goals and differing perspectives.. Even in those cases where the tactical 'smart bits', Ormerod's 1997 term for the core of traditional OR, mathematical and algorithmic modelling, are of such importance as to instigate strategic change, process issues may arise in their

implementation; these may require a commitment to effective process-change approaches, which require effective facilitation, rather than just a reliance on analytical approaches. These Ormerod describes as 'helpful ways' in his characterisation of distinct strands of practice.

As we have argued, the scope of OR was contested from its earliest days; for example, the 1964 conference on OR and the Social Sciences (Lawrence, 1966) was aimed at broadening the scope of OR interventions by either the "inclusion of social scientists" in mixed OR project teams or partnerships with social scientists. Even then several speakers noted that mixed discipline OR teams were already a thing of the past, although they had been regarded as one of the strengths of early OR. Few at the anniversary conference 25 years later saw much evidence that this interdisciplinary goal had been achieved, although some OR groups did recruit social scientists, including in the UK's National Coal Board, where effective client management strategies were developed, labelled by Boothroyd as 'articulate intervention' (Boothroyd, 1978; Ormerod, 2013), a precursor of Ormerod's 'helpful ways'. However, the recognition that successful implementation should itself be a part of OR, and an important topic of research in itself was not widely embraced. The CONDOR report of 1987 (Committee On the Next Decade in Operations, 1988) on what the next decade held for OR made no reference to these issues, an omission noted by Wagner et al. (1989) in a commentary. The UK Commission report on the future practice of OR of about the same time (Rosenhead & Mitchell, 1986) had a quite different tone with issues of practice a core theme but again with no acknowledgement that it was a proper and necessary area of study.

Despite the failure of these reports to acknowledge the process of OR as practiced as a valuable subject of study, early research on process (through strategic choice) had been developed in the 1960s through the Institute for Operational Research (Friend, Norris, & Stringer, 1988). The Institute itself had been set up with the explicit objective of "extend[ing] the scope of OR, in terms of both applications and methods". This initiative was followed by the development of other problem structuring methods (PSMs), again aimed at extending the scope of OR, in particular the soft systems methodology (SSM) of Checkland and cognitive mapping/Strategic Options Development and Analysis (SODA) by Eden (see Rosenhead & Mingers, 2001, for an overview; Mingers, 2011, most recently, Ormerod, 2014). These methods can be seen as complementing and clarifying the role of OR in organisational problem solving. Fildes and Ranyard (1997) argued that such OR interventions could all be seen through the perspective of consultancy, with Ormerod (1997, 2002) going a step further in clarifying the core consultancy

competencies of OR, as 'smart bits' and 'helpful ways' , supplemented by context competence.[1].

A potential hazard from an extension of the scope of OR into process consultancy is that the change could weaken its organizational identity and its understanding by potential clients, a long-standing problem for OR in gaining organizational acceptance (Fildes and Ranyard, 1997). Conventional (hard) OR had gained acceptance worldwide because at the time (1950s and 1960s) there were few, if any, direct competitors offering similar services, (exceptions include niche alternatives such as statisticians examining quality). This has not been the case for process consultancy. Rather than becoming one of the badged OR skills, Ormerod (1997) predicted that process consultancy would become the preserve of large external consultancies but distinct from OR, or, alternatively, reside within small niche consultancies. Thus, it is not surprising that such an elevation of the scope of OR to problems focussed on the processes of problem structuring have seen limited acceptance worldwide. This has been notable particularly in academia with the premier US journals of Management Science and Operations Research taking quite a rejectionist line (Mingers, 2011).

We have so far argued that the extended scope of OR offered by PSMs has gained only limited and contested acceptance. This conclusion can be examined further by searching for relevant terms (using the key phrases, "strategy tools", "problem structuring", "soft OR" or "soft methods") in the Web of Science. Within the premier US (INFORMS) journals no articles (from over 1000 from 2010 to end 2014) included any of these terms! *Interfaces*, the practitioner journal fared no better although a longer time span uncovers some discussion of these. Looking at articles published from 2010 to end 2014 in the non-US journals, EJOR, JORS and Omega, some 1% of articles (58 of 4296) in these three journals included one of these key phrases. Thus Problem Structuring Methods (PSMs) have gained some partial acceptance, but with a limited number of articles published in the area (though this interest has

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[1] PSMs extend the scope of OR through a range of novel tools focussed on a reinterpretation of problem types. More generally, 'helpful ways' aim to increase the effectiveness of traditional (hard) OR as well as extending the scope through its focus on process. Context competence is concerned with both internal organizational understanding and the appropriate boundaries to draw in defining the problem's scope.

been somewhat consolidated by strong conference streams). This demonstrates both the established geographical division in the field and the priorities of the academy. What it does not demonstrate is whether such a division is important in influencing practice, merely reflective of current practice or even is irrelevant to OR as practiced. Here we must rely on general surveys of practice.

2.1 Surveys of OR practice
The most complete survey of OR practice was carried out for the UK OR Society in 1994/5 by Fildes, Ranyard and Crymble (Fildes et al., 1997; 1999), the focus being to gain an understanding of OR's organizational presence and the factors that were inducing change. We refer to this as the Success and Survival of OR groups (SSOR) study. It was stimulated by the closure of some high profile OR groups in the UK in the early nineties and built on earlier work in the UK (Rosenhead and Mitchell, 1986), which had stimulated a small number of surveys of practice elsewhere in the world – in Finland (Kivijarvi, Kuula, & Wallenius, 1995), Hungary (Harnos, Komlosi, Rapcsak, & Szantai, 1995), Iceland (Olafsson, 1995), South Africa (Stewart, 1995) and UAR (Kemp & Yousef, 1995). These surveys have not been updated but a more recent survey was carried out in Taiwan in 2002 (Chen & Wei, 2002). Perhaps particularly curious is the omission of any work updating that of Abdel-Malek, Wolf, Johnson and Spencer (1999) in the USA. While these surveys have had slightly differing foci they typically discuss the same topics:

- Industry where OR activity is located
- Organizational name and context for delivering the OR service (e.g. internal centralized consultancy versus external general consultants versus specialist consultancy services)
- Characteristics of OR staff including education and training
- The management of the OR group including the skills valued
- The types of application areas where OR has flourished, e.g. logistics
- The OR techniques and software used to support OR
- The perceived barriers to the wider use of OR.

A full summary of these results would not be particularly informative since the material is dated. However, some findings are common and are supported by the more recent study of Chen and Wei (2002).

i. The industries where OR is typically applied are broadly spread apart from the services (Taiwan excepted where considerable activity in services was found). These specializations change over time and geography of course, as demonstrated in section 3.

ii. The branding of OR is poor: its name remains controversial and commands no common agreement.

iii. OR is delivered less and less through in-house consultancy.

iv. The education level of OR workers is at least at graduate level but more often at master's level with specialisms in mathematically related subjects including (of course) OR.

v. The techniques most often used beyond basic spreadsheet skills and statistics are simulation and forecasting.

vi. Different organizational location and history in different countries probably influence the techniques most frequently used, so project management, for example, figures highly in Taiwan. O'Brien (2011) offers a recent summary of usage of different techniques, primarily in the UK and focused, in part, on 'soft OR methods' to support strategy.

Some surveys have also explored the barriers to using OR, an issue particularly important for practitioners, OR academics and the national societies. Fildes and Ranyard (1997), following on from Kathawala (1988), summarized the barriers identified in previous research as 'management untrained in their use [of OR tools]', 'benefits not clearly understood' and management's 'lack of knowledge of the techniques'. Recent Taiwanese evidence (Chen & Wei, 2002) is more positive as to gaining top management support while data problems and problem structuring were seen as presenting greater difficulties. The issue of data availability is seen as particularly important in implementing a modelling approach (e.g. in Fildes & Hastings' 1994, discussion of forecasting). We can conclude from these past surveys that different application areas face different problems in gaining organizational traction, though senior managers' understanding and attitudes to OR's potential benefits are a critical problem and these are culturally dependent.

In addition, various case studies of particular OR groups have added detail to our knowledge (e.g.Benoist, Gardi, & Jeanjean, 2012; Fortuin & Zijlstra, 2000; Olavson & Cargille, 2008; Ranyard et al., 1997). These again point to the diversity in organizational practice. For example, Fortuin and Zijlstra (2000) described OR in Phillips (a very large electrical appliance manufacturer) and the independent consultancy which subsequently developed from the internal Phillips OR group, as more focussed on logistics; the group had moved away from production models over the 15 years being analysed from 1981. Stochastic models (including

inventory) remained popular throughout the period. This longitudinal examination of OR group performance allowed Corbett et al. (1995) and Overmeer et al. (1998) to develop hypotheses as to how groups develop, prosper and wither, a theme also taken up by Ranyard et al. (1997) who focused on lessons that can be learnt for the successful (and unsuccessful) management of internal OR consultancies. The key skills that these case studies identify is the management of a portfolio of OR projects, whilst ensuring a good balance of clients, so that economies of scale and context knowledge are capitalized on.

To a certain extent, our knowledge of OR practice has been supplemented more recently by surveys of particular areas of application, whether it be a class of OR techniques (such as forecasting, simulation or problem structuring) or a problem area (e.g. services or strategy). For example, forecasting has been well served in the USA with regular surveys by Mentzer and his colleagues with McCarthy, Davis, Golicic and Mentzer (2006) providing a recent update and summary. Simulation has also been well covered (Jahangirian, Eldabi, Naseer, Stergioulas & Young, 2010; Greasley, 2008). However, the area of optimisation has proved too broad for any general survey of applications. In addition to these surveys focused on techniques, sometimes application areas have been joined with techniques to give more detailed insight e.g. Kirchhof and Meseth (2012) on simulation in German health care.

The use of problem structuring methods is of particular interest in relation to the scope of OR. O'Brien (2011) offers a recent view of the use of strategic planning tools by UK OR practitioners, in particular PSMs, though her literature review covers other groups of respondents and a wider range of techniques. Her overall conclusion is that while various strategic planning tools such as SWOT and Balanced Scorecard have been widely adopted, the methods developed within the OR community such as SSM or SODA have not been so successful. A follow up paper (O'Brien, 2015), in which she interviewed four experienced OR practitioners who were involved in supporting strategy in their organisations, concludes (unsurprisingly) that 'hard' OR methods e.g. simulation, statistics, spreadsheets and modelling, are being used to support strategy. However, that there was little direct involvement in the process of strategy 'formulation'. An argument favouring the use of PSMs is given by Li and Zhu (2014) who claim that China's development path requires a move away from reliance on hard OR to embrace the multiple stakeholder perspectives in order to help solve the wicked problems that China faces. But while several new soft methods have been developed, uptake remains limited. In seeking an explanation for this, Ackermann (2012) critically examined the

development of Soft OR/PSMs. Clear benefits have been established from their use: they enable the management of complexity; accommodate multiple perspectives; integrate process and content; and many successful case studies have been reported. However, their limitations include the unhelpful label (problem 'structuring' rather than the more managerial 'solving'), the lack of rigour and variability in application with no unique 'right' answer, and the difficulties in training potential users. This last point is, at least in part, because the use of PSMs requires a 'facilitation' approach, rather than an 'analytical' approach which is the core of OR Master's courses. Whilst some master's courses introduce students to PSMs, only limited further training is available e.g. some short courses run by the UK OR Society. Ormerod (2013) details the additional skills and competences required and the difficulties to be faced in acquiring them. To this we would add that alternative approaches for structuring messy problems originating from outside the OR community are not considered or compared. The current evidence then on the use of PSMs to extend OR's scope is limited and somewhat negative, at least as far as diffusion is concerned.

2.2 The gap between theory and practice

Further insight into practice has come about through the occasional discussions of the gap between theory and practice, a recurrent if intermittent theme throughout OR's history (e.g. Ackoff, 1979; Corbett & Van Wassenhove, 1993). A root cause that these discussions identify is the requirement for academics to publish in high quality journals (Sodhi and Tang, 2008). The scope of the established journals is limited primarily to innovative 'smart bits' but in addition, the journals have been dominated by theoretical modelling unattached to OR practice, that is to say models and their solution which are not embedded in any problem observed in practice (Reisman & Kirschnick, 1994, 1995; Ormerod & Kiossis, 1997; Ormerod, Delibassi, & Morris, 2000) though Guide and Van Wassenhove (2007) take a more optimistic view.

Practitioners can make only a limited contribution to bridging the gap between the world of academic OR and the world of OR practice. In contrast to the publishing demands of academics, practitioners are expected to carry out successful projects and satisfy clients but have a limited incentive to present their work externally. Confidentiality too remains an issue. In an attempt to rectify this, in addition to the various practice prizes already mentioned, the gap is an occasional topic for discussion at OR conferences. For example, Overmeer (1997) condemned OR teaching for concentrating too much on theory, suggested that universities should only hire staff with experience of OR practice and that OR practice itself should be researched. In recent years, the UK OR Society's annual conference has included a session

devoted to networking between academics and practitioners, in an attempt to identify jointly beneficial areas for collaboration. Strong practice communities exist in the US (via the Roundtable) and the UK (via the Heads of OR Forum) and probably elsewhere, though not apparently in such a distinctive form.

2.3 Summary

The story from these earlier surveys, case work and conference discussions is that OR is primarily a consultancy activity focusing on the tactical albeit providing a strategic advantage to some organisations. However there is as yet limited evidence of substantial strategic implementation. The development of problem structuring methods and soft OR has potentially enhanced the effectiveness and the scope of OR: but the evidence of OR's involvement in messy (often strategic problems) which emphasizes a skill-set of 'helpful ways' using PSMs and facilitation is limited.

The older survey and case based evidence raises some key points: what is the current scope of OR practice including PSMs, in what ways are those in the OR profession engaged with practice served by its institutions and, looking to the future, what are seen as the key tools for an OR worker? It also raises the issue of the range of applications and whether it is limited by the skills base of OR practitioners with academia complicit in this neglect. Finally, and of increasing importance because of its high public profile, what are the threats and opportunities to OR posed by the Business Analytics movement? The surveys and case studies all pre-date its rise. The survey results which follow present the latest evidence to address these issues.

3. The IFORS survey of OR practice

Understanding current OR practice is important for the evidence it can provide on services to support the health of the profession and stimulate membership activities in the professional societies as well as to attract new recruits. Without any formal recent evidence, in 2009 the IFORS Administrative Committee sponsored a survey to this end. This section summarises aspects of these new results, collected in 2008/9 with fuller details available from the authors. The aim of the main questionnaire was to collect detailed information from individual OR analysts/consultants on aspects of their OR activities. The questionnaire comprised three main sections:

Context Information: e.g. country, position in organisation.

Organisational Information: e.g. size of the organisation, industrial sector, details of the respondent's OR group, and barriers to the use of OR.

Personal Experience of OR Practice: This includes academic background, on-the-job training; membership of professional societies; use/understanding of OR techniques and OR software; and the main application areas of the OR work.

The web-based main questionnaire is available at: https://sakai.lancs.ac.uk/x/UagROo with a pdf version at https://sakai.lancs.ac.uk/x/zo5cjF. 254 usable responses from 180 organisations were received. The responses were dominated by the UK (32%) and the USA (29%), a total of 154 out of 254 or 61%. As a consequence, only the UK and North America provide country-specific evidence. However, there is a good balance of organisational types represented with 30% from the public sector and 31% from the private with 22% from consultancies. The remaining 17% were from academics who carry out consultancy based on their research expertise.

3.1 Education, Training and Job Requirements
The IFORS survey results show:

i) All respondents have a first degree and as expected maths, statistics and engineering are the most common subjects, making up almost two thirds of the total.

ii) Overall, 85% of respondents have a postgraduate qualification and about one third have a Master's degree in OR (or its equivalent). Just over one third have PhDs, with about half having OR (or its equivalent) as the main subject. Self-evidently, the recruitment and training policies of organisations should reflect the priorities of the job and to a large extent define the scope of their engagement with OR. The evidence from job advertisements presented by Sodhi and Son (2008; 2010) and an earlier survey of UK OR managers' valuation of OR skills (Fildes and Ranyard, 1999) underline the point that for many OR jobs, advanced mathematical skills are not required: rather, soft 'consultancy' skills are critical, which include communications (such as writing effective reports), giving presentations, project management, understanding the organisational culture and interacting sensitively with clients and stakeholders.

Master's courses in OR are offered in many developed countries and their programmes provide a benchmark for the technical skills required by OR practitioners. Thus, OR recruits without a master's degree will need to develop the missing technical skills through post-experience training courses. Also many of the consultancy skills can only be developed in conjunction with work experience and together with the demand for some technical skills training, various OR post-experience training courses have developed to fulfil these requirements. Previous work (Fildes et al., 1999) had indicated that there are four main types of post-experience

training: OR techniques and methods; statistics; the use of software packages; and consultancy skills. The survey evidence shows that on the job (post-experience) training is commonplace, with, on average, each respondent taking two types of training, although 59 respondents (23%) reported receiving no such training at all. Whilst guidance on software packages was marginally most common, consultancy skills courses were undertaken by over half of respondents, with OR techniques courses not far behind.

3.2 Scope of OR

Knowledge and Use of OR Techniques
As in earlier studies, respondents were asked as to their knowledge and use of various techniques, using a four point scale: no knowledge; awareness; occasional use (1-3 times per year); and frequent use (> 3 times per year). We have coded users as to whether they are occasional or frequent users. Usage of any problem structuring method has been correspondingly coded (i.e. 1 if any PSM has been used at least occasionally). As can be seen in Fig. 1, many OR (and related) techniques are used, at least occasionally, by most respondents. Respondents were also asked to note any additional techniques they used that were not on the pre-selected list but few did so and only two were mentioned more than once, Theory of Constraints (2 mentions) and Mind Maps (2 mentions). The results in Fig. 1, which are based on 245 responses, show little difference from earlier surveys: spreadsheets, statistics, optimisation, strategic planning tools, simulation and forecasting lead the way (but as was pointed out in the summary of earlier surveys, some techniques are more heavily used in different countries and different organisations). The remaining techniques starting with the 11th, risk analysis, are noticeably less frequently used. The mean (and median) number of techniques used by the respondents is 11 from the 23 listed (where PSMs were counted as a single technique).

Usage of OR Techniques - Top 10 (Max. responses 245)
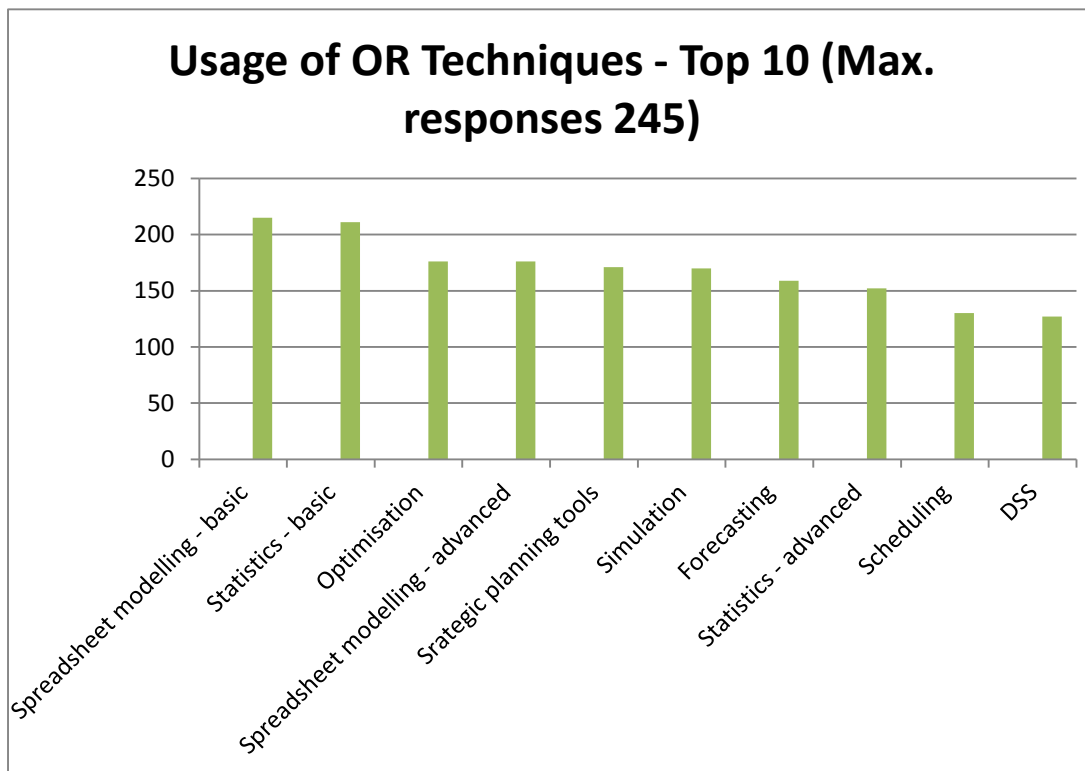
* 9 respondents did not record any techniques

Fig. 1 Understanding and usage of OR and related techniques (Top 10 techniques)

The high score given to strategic planning deserves further analysis: as O'Brien (2011) makes clear, 'strategic planning' cannot really be regarded as a technique but rather a bundle of techniques and processes. By examining the correlation between strategic planning methods and the usage of other techniques we gain some insight into its constituents: it was defined in the survey as including Cost Benefit Analysis, Performance Management, Balanced Scorecard, Scenario Planning but the correlated techniques of Risk Analysis, Multi-Criteria Decision Analysis and Decision Support and System Dynamics also fit into its purview.

Usage of Soft OR & Problem Structuring Methods
Problem Structuring Methods (sometimes referred to as 'Soft OR') and often linked to strategic questions have figured prominently in discussions of OR practice but as we have already explained, the depth of their application in practice is arguable (O'Brien, 2011).

Table 1

Usage of Problem Structuring Methods

Problem Structuring Method (PSM)	Number of Responses (Occasional + Frequent Use)		
	UK (81)	Rest of World (173)	Overall (254)
Cognitive Mapping*	39 (48%)	37 (23%)	76 (31%)
Soft Systems Methodology (SSM)	30 (37%)	27 (16%)	57 (23%)
Strategic Choice Analysis (SCA)	20 (25%)	18 (11%)	38 (16%)
Other Methods	< 3 each	< 3 each	17 (7%)
Any PSM	50 (62%)	44 (27%)	94 (38%)
Total Responses	81	164**	245

* including SODA, Journey Making, Influence Diagrams

** 9 respondents did not record using any techniques

Table 1 describes the different constituents of the methodology and shows that three approaches, Cognitive Mapping/SODA, Soft Systems Methodology (SSM) and Strategic Choice Analysis (SCA) are used fairly regularly in the UK but much less frequently elsewhere. The use of several other approaches was reported but none received more than two mentions. UK usage of the three main methods seems to have increased compared to the results from SSOR (Fildes et al., 1999) reported 15 years ago. However, the evidence presented by O'Brien (2011), who surveyed the views of primarily UK practitioners, suggested that whilst awareness of their possible use in strategic planning has increased over the past 15 years, actual usage to support strategic planning has remained low. The IFORS survey evidence offers a more positive view of the diffusion of these soft OR techniques in the UK, though diffusion in the rest of the world remains low. Overall, the use of soft OR/ PSMs is apparently increasing but from a low base.

The survey results raise the question of the application areas where Problem Structuring Methods are most often used. The survey can only give indirect guidance on this but Table 2 tabulates the relationship between the 'at least occasional use' of PSMs and their applications= (by the respondent) in strategic planning, which, as section 2 made clear, is where such methods are often needed. None of the application areas, including 'strategic planning', were defined in the questionnaire but we regard it as involving the formulation, planning and implementation of an organisation's strategy. OR can support strategic planning via the use of specific tools, defined in the questionnaire as cost benefit analysis, scenario planning, balanced scorecard and performance management. However, the use of traditional 'hard' OR tools can provide strategic advantage in many organisations, such as revenue management, logistics, credit and risk scorecards with many examples being provided in Interfaces, particularly the issues containing the Edelman competition finalists.

Some PSMs, for example SODA (strategic options development and analysis) and SCA (strategic choice analysis), are designed to support the strategic planning process (Ackerman 2012). Therefore, it is not surprising that those respondents using PSMs (48.9%), are much more likely to engage with strategic planning than those that don't (92.6% vs. 7.4%), supporting the view that such methods are more frequently used in strategic planning. Those not engaged with strategic planning applications are typically non-users of PSMs (89.6% vs. 10.4%). We can also speculate on the sectors in which they are used – the survey suggests that use in the public sector is more common and this is supported by O'Brien's (2011) survey.

Table 2
Proportion of respondents engaging with strategic planning and using PSMs (at least occasionally).

		Didn't Use PSMs			Did Use PSMs			Total Respondents	
		Count	Row %	Col. %	Count	Row %	Col. %	Count	%
Respondents working in Strategic Planning?	Not working	60	**89.6**	39.6	7	**10.4**	**7.4**	67	27.3
	Working	91	**51.1**	60.3	87	**48.9**	**92.6**	178	72.7
	Totals	151			94			245*	

* 9 respondents did not record any techniques and/or application areas. The table shows the number of respondents falling in each box, the row and column totals, the row percentages and column percentages. The figures in bold are referenced in the text.

Software use was also investigated in the survey but added little to our knowledge beyond the dominance of Excel. Various statistical packages are also widely used, with SAS the principal supplier. In optimisation CPlex is the package of choice. No simulation package was widely identified.

3.3 Delivering OR Services

The way OR has been delivered in organisations has changed from the base of the early OR groups located in government, defence and large industrial companies. Even in 1986 (in the UK) the Commission on the Future Practice of OR saw (the future of) OR as primarily delivered in such groups (Rosenhead & Mitchell, 1986). Limited information exists on other

countries, for example Selhausen (1985) examined a number of companies in Bavaria around that time and found little evidence of activity and no large groups. Müller-Merbach (1988) summarising a wider range of studies in Germany, commented "There exist OR *groups* in German enterprises, but not very many. …there seems to be limited understanding of the top management problems". In addition Müller-Merbach commented both on the scope of OR studies and competition to OR groups as follows: "little concern seems to be given to the *complexity of problem solving*. But there are *planning departments* as well, and they apply much of the OR methodology without using the term OR at all". Various other studies of OR practice in diverse countries were also included in a special issue of Omega (Collcutt, 1988) but add little to our themes and had little to say about how OR was organised. However, by the time of the SSOR study of the UK ten years later, delivery of OR services had become much more fragmented.

In the SSOR study the key issues affecting delivery were identified as the type of group, internal to the organisation or as an external consultancy, and for internal groups, their location and reporting structure. After studying the role of OR in organisations, Fildes et al. (1999) suggested five possible roles for OR which we here extend to include external consultants in the definitions:

(a) Broad based consultancy: this may include process consultancy.

(b) Focused analytical consultant, where the group offers a wide range of OR modelling expertise: this will typically be concerned with Ormerod's 'smart bits'.

(c) Decision Support System (DSS) designer within the IT function, where the group's primary task is the design and support of management systems, usually based on quantitative models – primarily an internal role.

(d) Technical niche, where the group has a primary function for one client in the organisation, sometimes including line responsibility for some aspects. (While primarily an internal role, this is sometimes outsourced, e.g. the outsourcing of the analysis of Tesco's club card data to Dunn Humby, or the management of the forecasting function for supply and operations planning).

(e) Middle-man, where a small group acts as intermediary between outside consulting services and the internal clients.

The IFORS responses here indicate that most respondents fall into the focused analytical consultant and the niche specialism roles. Compared to the SSOR results for the UK (Fildes et al., 1999) this sees a comparative decline in the broad-based internal consultants and an apparent rise in niche specialisms. However, the nature of the membership of national OR

societies may itself be biased away from large consultancies – it remains moot, therefore, as to the balance of external consultancy between broad-based consultancy, focused or technical niche.

The question of the role of OR in organisations is made concrete through the debate as to how the OR activity should be labelled, a long standing matter of contention. In the IFORS survey, the labels "operational research" (or "operations research" in the USA) are infrequently used by practitioner groups – only 29% overall and 23% if UK government groups are excluded. (OR has flourished in the UK government sector for over 50 years and has managed to retain the operational research label.) The next most popular labels are "operations management" (UK) and "industrial engineering" (USA), with 6%, and the new label of "analytics", also with 6%, (all in USA): many other labels are also used.

Evidence of role is also provided through the reporting structure and objectives: if academic organisations are excluded, the most popular locations are operations/logistics, R&D and strategy. As expected, the "provision of OR services" proved to be the most common objective for respondents. The most common alternatives seemed to reflect the location of the group in the organisation, e.g. (analytical) support to manufacturing, logistics, marketing; in effect the technical niche role.

Strategy, Tactical or Operational OR: tools for the job?
One of the features of OR practice from 1995 on, seen both from the UK SSOR survey (Fildes et al., 1999) and from anecdotal evidence since, is the growth of specialist services which draw on OR's skill sets.. The IFORS questionnaire collected evidence on the clients for OR services which showed that OR applications are spread fairly evenly across all functions of client organisations. Strategic planning is the most common application area, possibly reflecting a resolution to the Ackoff critique (described in section 2) that OR had been pigeonholed into working on unimportant problems. Logistics and supply chain is the second major area of application.

Different techniques of course apply to different application areas. From the survey, there is the self-evident relations between strategic planning applications and the use of the associated techniques of cost-benefit analysis, performance management, scenario planning and balanced scorecard supplemented through PSMs, system dynamics and risk analysis. Of the other application areas, only service operations attracts much use of PSMs (e.g. in health), suggesting

that most of the work done in other areas, such as logistics, are primarily tactical or operational. Overall, the use of tools matches the areas of application, much as expected, so, for example, optimisation is most used in production and logistics, risk analysis in finance.

Barriers to the Use of OR

Earlier research had examined barriers to the use of OR in organisations (and is usefully thought of as a contribution to the extensive literature on the barriers to innovation). Based on previous survey work, in particular (Fildes et al., 1997), which collected views of OR managers on possible success factors for OR groups, three broad categories of barriers to OR's adoption were postulated: cost of the OR activity, limitations when delivering OR services (such as expertise of the OR staff, adequacy of OR software, data limitations), and client resistance (with 5 sub-categories). The most important proved to be aspects of client resistance (particularly the company's lack of awareness of OR and potential client's lack of understanding of OR. Data limitations, staff lacking expertise, and the cost of the OR activity were also rated as important though none stood out particularly. Perhaps more interesting is the finding that computer software and support were seen as relatively unimportant barriers to delivering OR services.

These IFORS results are fully compatible with those in the UK SSOR and earlier studies but also the more recent study of Taiwanese OR (Chen & Wei, 2002)). These all highlight the lack of awareness of OR, as well as the limited organisational expertise available. All studies agreed to the importance of data limitations. (The recent rise of the Business Analytics movement suggests that this may now be less of a problem.) Cost factors were also given more prominence by IFORS respondents than in the Taiwanese study, particularly in the private sector. The issue of leadership of the OR group itself had proved an important factor in OR group organisational success in the SSOR study (Ranyard et al., 1997) but was not explored in the IFORS survey. In short, OR as a brand still faces the same problems of gaining organizational traction as in the previous 30 years, an issue facing all national societies and also academics, and one we turn to in the final sections of this paper.

Overall, the survey results given in this section conform, in the main, to earlier practice surveys, except that there is some indication that facilitation-type OR, via Problem Structuring Methods is gradually increasing and extending the scope of OR practice (though it remains limited in geographical coverage). It is also worth emphasizing that only a minority of OR groups use OR to label their group!

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4. Reversing the Natural Drift – Can the Analytics Movement Help?

The 'natural drift' in OR, as in other professional groups, occurs where the practice (of OR) and academic research diverge, leaving a gap between the two. This is explored fully by Corbett and Van Wassenhove (1993) and some of the core issues are summarised in section 2, where, over these past twenty years, surveys and case studies have provided evidence of just such a gap. Further, the barriers to OR adoption which are identified in this latest survey remain similar to those identified in earlier surveys (though we should add here that country by country there are apparent differences). In particular despite an organisational history of 50+ years, management knowledge of the benefits of OR seems to remain limited. Whilst OR is strongly established in government, many private organisations and external consultancies, only a few of the UK's top 100 companies have recognised OR groups (according to the UK OR Society). Apparently many use OR and analytical techniques as part of their mainstream activities but these were outside the scope of the IFORS survey so we know little about their scale. With poor employer demand this limits OR's organisational diffusion, of course, constraining the ability of educational programmes to recruit students; perversely, this can lead to recruitment shortages in those few organisations that do look to OR for analytical support, potentially a negative spiral towards organizational demise.

Do the survey results provide evidence of change or are the problems of the gap identified twenty or more years ago (and really going back to the very earliest controversies) totally intractable? Corbett and Van Wassenhove (1993), quoting Abbott (1988), identified with the view "Professional regression seems to be extremely pronounced in fields like operations research where a small, but very elite, core maintains intellectual control over a much wider jurisdiction…. [professions such as OR] must be flexible enough to move in directions that enable organizational survival". Abbott continues, the requirement of "finding these directions and initiating the corresponding movement is a major challenge facing the professional societies". Despite their agreement with this proposition Corbett and Van Wassenhove, writing in 1993, were in fact quite optimistic as to OR's future, seeing a variety of routes by which OR could prosper. We highlight two elements in their argument. One has gained a lot of professional support: improved marketing of OR. Its aim is to overcome the lack of understanding and knowledge of OR's potential. This has been implemented, for example, through "the science of the better" marketing initiative by the US and UK societies and publicizes OR organizational success stories. The second core recommendation of Corbett and

Van Wassenhove was to recognize that OR comprises a number of different pathways and they particularly wished to rekindle the notion of OR as engineering, bridging the gap in activity between OR theory and OR as practiced. Here the aim is to prioritize the development of tools that are closely aligned with organisational problems, although, as they remarked, this requires a greater understanding of the processes that arise in any OR applications. But in their discussion there is no hint of how such a change could take place when the OR elite still remain in control as Sodhi and Tang (2008) have charged. The changes Corbett and Van Wassenhove proposed, long identified as necessary, have been slow to arrive. But such cultural changes are often stimulated by external events, external here to the OR profession. The rise of the analytics movement and the ubiquity of 'big data' is potentially just such a stimulus.

4.1 The rise of the 'Analytics movement'
Definitions of analytics vary from the succinct official INFORMS definition: "Analytics, the scientific process of transforming data into insight for making better decisions" to an expanded version from IBM authors Apte, Dietrich (Former INFORMS president) and Fleming (2012):

> *"as the discipline of making fact-based decisions using data, rigorous mathematical formalisms such as relational algebra (which underlies database technology), statistics, statistical modeling, machine learning, data mining, simulation, and optimization to evaluate choices and optimize business outcomes."*

No hard dating is possible for the rise of the Business Analytics movement though Google tells us that in 2002 there were 12K references to the topic, defined here by the key words "marketing analytics" and "business analytics". Even by 2007, after the publication of Davenport's (2006) popularising article in the Harvard Business Review (HBR), citations had only reached 35K. By 2014, the figure had reached 1.94M, compared with 53K, 86k and 1.07M for operations(al) research in the corresponding years (including "data analytics" generates 4.5M)[2]. Using Corbett and Van Wassenhove's (1993) test of gaining attention through the popularising management outlet of the Harvard Business Review, 24 references to Analytics (the "business" is superfluous here) compared to just 3 for operations research, were found for the period 2006 to 2014. After drawing boundaries around Analytics, Mortenson et al. (2015) comment on its importance to the OR community and also on the lack of current research in Analytics that takes an OR perspective, identifying several areas which could yield significant returns.

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[2] Figures based on a Google web search on 23/01/2015.

Developments are constrained by a significant and expanding shortage of those capable of carrying out business analytics, now labelled 'data scientists' (for UK evidence see, e-skills UK 2013; Big Data Analytics: Assessment of Technology Partnerships, October 2014) such that some large organisations are outsourcing their analytics capability to 3rd world countries such as India and China. (Fogerty and Bell, 2014). INFORMS has targeted the Analytics community aggressively in recent years, including the introduction of a Certified Analytics Professional (CAP) accreditation, such that attendances at their main conferences have increased significantly: attendance at their practitioner conference (relabelled 'Business Analytics and OR') has almost doubled whilst attendance at their autumn conference has risen to a record 5,500 delegates (October 2014).

A cynic outside North America might wonder what 'Analytics' is adding to conventional OR, or is this merely a rebranding exercise? The INFORMS definition is barely distinguishable from OR whilst the IBM authors make much more of the intensity of data usage and their definition is clearly linked to the development and exploitation of large data bases. However, there are clear differences between OR and Analytics, at least in the minds of the respondents to a survey of INFORMS members carried out by Liberatore and Luo (2013), which produced 2195 responses. In their potentially biased population, principally of OR analysts, Analytics was characterised as more heavily engaged in statistics and data based methods (visualization, data management and mining), as shown in Table 3, while the quantitative skill requirements of OR analysts were similar to those identified from previous surveys. In fact the survey evidence suggests that, at least as far as INFORMS members were concerned, some of the standard techniques such as simulation and optimization, mentioned in the Apte et al. (2012) definition, were not thought particularly important. However, the rankings were based on respondents familiar with both topic areas. Those who identify more with Analytics tended to rate more highly the importance of data visualization and optimization to Analytics and also overrated the importance of data visualization and data management to OR.

Table 3

Ranking of quantitative skills in terms of importance for Analytics and OR (Scale 1: Unimportant -5: Very Important). Responses from 1206 of the 2195 INFORMS members responding to the survey familiar with both OR and Analytics.

	Analytics		**OR**		Relative importance:
Variable	Mean	Rank	Mean	Rank	Analytics vs. OR∗
Statistics	4.62	1	3.90	6	+ Analytics
Data visualization	4.46	2	3.43	8	+ Analytics
Data management	4.44	3	3.48	7	+ Analytics
Data mining	4.42	4	3.24	9	+ Analytics
Decision analysis	4.12	5	4.35	2	+ OR
Risk analysis	3.99	6	3.98	5	—
Simulation	3.87	7	4.30	3	+ OR
Programming	3.77	8	4.11	4	+ OR
Optimization	3.61	9	4.84	1	+ OR

Noted differences in relative importance based on *t*-test with significance at the p <000001 level.- (from Liberatore and Luo, 2013).

Statistical skills were seen as relatively unimportant for OR analysts (in contrast to the Analytics specialist), at least in this survey, a result in stark contrast to almost all earlier ones. The OR analyst was here expected to have just the traditional priorities of optimization, simulation and decision analysis.

Liberatore and Luo (2013) also looked at the relative importance of soft (consultancy) skills required by the two types of analysts. Problem formulation and to a lesser extent, problem recognition were seen as more important for the OR analyst (though were rated as important for both groups). Unfortunately, Problem Structuring Methods were not considered explicitly in the Liberatore/ Luo survey, reflecting the common neglect of such approaches in North America. At the bottom of the list for both groups was change management, a ranking that supports the view of OR as primarily a consultancy service!

To understand the various types of OR practice in greater detail the IFORS survey results

described in section 3 can be used to examine whether there is any evidence to support the emergence of analysts focussed on extending OR's boundaries beyond traditional OR to include problem structuring or analytics. Factor analysis (with varimax rotation) was used to identify factors describing all the sample and then the respondents were clustered on the factors. Varimax rotation aims to achieve a simple interpretative structure for a small number of factors (or components) that capture much of the variability in the data (here the usage of the different OR techniques). The 23 techniques we have identified from the questionnaire were therefore grouped through this analysis into 6 fairly distinct groups of techniques and approaches, which we interpret as follows (with the techniques ordered according to their importance, i.e. their factor weights). Where techniques are regarded as core to defining the component they are shown in bold. (Details are available from the authors.)

Component 1: **Problem structuring methods (PSMs)**, risk analysis, system dynamics, and strategic planning (defined as cost benefit analysis, performance management, balanced scorecard and scenario planning). Users in this group are heavily client and stakeholder oriented with much of their work based on facilitation.

Component 2: Scheduling, **Optimisation,** Inventory Models, **Simulation** and Queuing (i.e various traditional OR techniques). Probably based in manufacturing and logistics.

Component 3: **Data Mining**, Statistics (basic and **advanced**). These users are clearly in the field of business analytics.

Component 4: Revenue Management, Forecasting and Financial Analysis. These users probably have a focus on pricing and can also be considered as carrying out predictive business analytics.

Component 5: Spreadsheets (basic and advanced) and basic statistics. These users are carrying out basic analysis.

Component 6: Project management and Quality. These represent somewhat distinct tool sets from traditional OR. Few respondents were involved with quality.

The methods included in Components 3 and 4 we interpret broadly as the core of Business Analytics, an observation supported by the inclusion of these topics match within the contents

of master's degrees in Business Analytics in the US and UK. Components 5 and 6 are not used further in the analysis because they capture less of the variability of users' responses.

While occasional use of one or two of the tools falling into these tool sets cannot be regarded as substantial evidence of engagement, we have chosen to define clusters of users (developed through a cluster analysis) as those using a core technique (such as optimisation) together with being occasional or frequent users of related tools in the tool set (e.g. scheduling). The cut-off in defining a user cluster has been set somewhat arbitrarily at using 70% of the tools in the set. These two features: use of at least one of the core techniques (shown in bold above) as well as use of a wide range of related techniques effectively define clusters of users. Four groups are easily identified: the Traditional OR (TradOR) analyst, the Decision Support and Problem Structuring Method (DSPSM) specialist, and the Business Analytics (BA) specialist. The final group constituted those not falling into any of the other three. The results are shown in Table 4 below where, for example 38% of the sample (92 respondents in all) were regular users of traditional OR, of whom 46% did not use any other tool set.

Table 4

Percentage of respondents using particular sets of tools

Tool set	% of respondents using the tool set	% specialising only in the tool set
Traditional OR (TradOR)	38%	46%
DecisionSupport/PSM (DSPSM)	31%	34%
Business Analytics (BA)	25%	31%
Low engagement users*	39%	n.r.
All	61%	36%

*not engaged with any particular tool set

Around 39% were low engagement users while 36% of the engaged users were primarily specialists. Business Analytics specialists formed the smallest sub-group, though given the sample was taken from the individual country OR society members this is perhaps hardly surprising and is part of the challenge OR faces of attracting in those practitioners who have come to Business Analytics from a different path, be it statistics, computing or information systems. In this particular sample the Business Analytics users came primarily from North America, while there is little difference between North America, UK and the rest of the world

in the use of DSPSM. However if we just focus on the use of Problem Structuring Methods, the UK respondents were much the heaviest users.

While it is all too easy to get immersed in the details of the analysis, the limitations of the sample ensure that such differences are best understood as hypotheses to be confirmed, if necessary, by further analysis. However, the observations we have made from the analysis have high face validity. And the North American dominance in Business Analytics is particularly important.

The IFORS and Liberatore/ Luo (2013) INFORMS surveys provided evidence of practitioner and academic involvement in Analytics. However, its increasingly high profile, stimulated by developments in the 'big data' agenda, owned by computer and information scientists, as well as new techniques in data mining and machine learning (e.g. neural networks), have led some OR societies to develop analytics initiatives. Both INFORMS and the UK OR Society commissioned independent investigations into the potential impact of the 'Analytics/Big Data' revolution on OR, with both concluding that it is here to stay, not just a passing management fad, and its growth needs to be addressed by OR Societies. As a consequence, INFORMS has founded a practitioner oriented journal (magazine), with free online access (http://www.analytics-magazine.org/), has set up professional certification courses (CAP) and competency exams and rebranded the annual practitioners conference as 'Business Analytics and Operations Research' (Robinson, 2013). The UK Society has established an analytics network, annual meetings on 'Developments in Advanced Analytics and Big Data', an Analytics Quarterly magazine, with a new academic journal under consideration.

Liberatore and Luo (2010) examined the challenges and possible responses posed by these rapid developments. They include educational programmes at master's level where there is a rapid growth, at the very least in changes of name, to recognize the opportunities. They differ from OR/ Industrial Engineering master's degrees in a much heavier emphasis on data intensive computing. Conferences are also proliferating where the major speakers focus on the organisational role, management and tools that success in analytics entails.

From this evidence, the core difference between analytics and OR is not merely in the tool set, important though this is, but also on the organisational abilities to recognize opportunities to reengineer core processes, perhaps revenue management offering one of the clearest examples.

This increased emphasis on business context, "things that matter" in Ormerod's terminology, also places demands on educational programmes, not least in the associated time commitments and problem/ sector specificity.

However, there remains noticeable resistance from the traditional OR community to the need to respond to the distinctive features of analytics. As we have argued, the academic journals remain gatekeepers of both an individual researcher's academic progress and the development of different paradigms, witness the damage done to PSMs by the US journals' rejection of PSMs as a proper area of study (Mingers, 2011). Does analytics fare any better? And will it? At present Management Science[3] (2 analytics-oriented publications between 2006 and 2014 apart from a 2014 special issue), Operations Research (0), Journal of the OR Society (two including the 2013 President's address (Royston, 2013), Omega (0) and EJOR (5 with 3 published in 2014) all have so far failed to meet the need to redefine the scope of OR. Other disciplines, most noticeably computer science and statistics, have perhaps an equal stake in the area and computer science through Information Systems departments may well have more leverage. In addition, OR academics in INFORMS are not particularly inclined to shift their research into the broad territory of analytics (Liberatore and Luo, 2011). In general, the INFORMS membership showed limited interest in analytics (see Table 7, Liberatore and Luo, 2011). The natural drift for OR will not so easily be reversed.

5. Reflections

The scope of OR is increasingly a contested territory: this has, we argue, major implications for the professional societies that determine the boundaries and the activities that define OR. Both the range of techniques in particular, Problem Structuring Methods and Business Analytics, and of application areas, are fought over by various contestants, be they other parts of a consultancy, software suppliers or academic departments arguing over the ownership of 'big data analytics'. In bringing together the various strands of our argument, based on recent surveys, we first considered the tools and the corresponding tool sets that analysts may use, suggesting a useful classification that aids in understanding the distinct roles that practitioners have adopted. We then considered the application areas and how different tool sets are used to support these organisational applications. Our conclusion is that, *de facto*, the scope of OR has been extended both by practitioners, who have developed effective client management strategies (largely unreported in the literature) and by using PSMs and facilitation-oriented OR;

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[3] Special issues on Analytics are in preparation for example in EJOR and Omega with the Management Science one already published.

and by the analytics movement. However, for OR to consolidate ownership of this new territory requires imaginative and bold responses. But can this lead to a reversal of the natural drift that OR has undergone, the threat of irrelevancy foreseen by Corbett and Van Wassenhoeve as far back as1993?

The sources of evidence for the contested boundary claims are disparate: surveys of OR practice and, critically, the new evidence that has become available from the recent IFORS and INFORMS membership surveys. They demonstrated that OR workers engage with distinct tool sets and that while many engage with more than one, nevertheless the traditional OR cluster of respondents, the largest in the IFORS survey, tended to a more exclusive view of OR (Table 4).

Which tools fall into the Business Analytics tool set is still an open question: from the definitions given earlier it seems to include all of OR (with the exception of PSMs). An analysis of the course content of master's degrees in both the US and UK with the title 'Business Analytics' or 'Predictive Analytics' shows they emphasize data mining methods, sometimes containing forecasting, as well as including a greater emphasis on computing issues. But such courses may also incorporate traditional OR techniques. Application areas are varied but most often take in marketing. The recent analysis by Liberatore and Luo (2013) focussed on the different skill sets of the Business Analytics and Traditional OR clusters.   Their study of INFORMS members' views on the importance of different tools showed quite different rankings for the traditional OR practitioner compared to the Analytics specialist. This is shown in Table 3 where for the Analytics specialist statistics and data mining are significantly more highly ranked than for the OR specialist. The presentation from one particular OR group in US industry, Hewlett Packard by Olavson and Cargille (2008), of their corporate skill requirements emphasized various soft skills (incorporated in part in the Libertore and Luo (2013) analysis): But their emphasis was on informal problem structuring (rather than formal methods). In addition, and in agreement with the more recent IFORS survey, various spreadsheet skills were seen as highly valuable.

The recent survey evidence on the application of these tool sets is imperfect: O'Brien (2011, 2014), Li and Zhu (2014), as well the IFORS data all have limitations arising from their samples. They tentatively support the view that DSPSM (Decision Support and Problem Structuring Methods) is increasing in importance but from a low base. We have little evidence from these or other surveys on the Business Analytics group of practitioners. However, as

noted earlier, conference attendance and involvement has increased in the US with INFORMS' new emphasis on the area. This interest in Analytics gains further confirmation from the Libertore and Luo (2011) summary of views of the membership.

It might be expected that different tool sets would be adopted to match different organizational applications. At least in the IFORS survey there was some evidence of such specialization. The DSPSM cluster focussed on strategic planning and the service industries, the Traditional OR cluster on production, logistics and supply chain. As described in Table 2, Strategic Planning is primarily supported by those focussed on using Problem Structuring Methods and more broadly the DSPSM tool set. Also, relatively few of the strategic planning applications used a mixture of PSMs and traditional OR. Overall, the Business Analytics specialists were involved in fewer application areas. This suggests that at the time when this IFORS evidence was collected, 2008/9, it was early in the development of Business Analytics as an activity distinct from traditional OR, at least as far as the survey respondents were concerned. Nor did Sodhi and Son's (2010) analysis of OR job requirements clarify the matter further, although it showed skill sets to be clearly dependent on sector of employment; again, it may be a matter of timing, raising the important unresolved question of education and training requirements. Certainly industry priorities for analytical skills are as yet under-specified (see e-skills, 2013 and SAS and Tech Partnership, 2014 on Big Data Analytics).

How effectively are these three groups, Traditional OR, DSPSM and Business Analytics, supported by the professional societies? And can the various professional OR societies capture the new territory that is being mapped out by DSPSM and its focus on strategy, and also the almost grandiose and contested claims made for Business Analytics? It is useful to reflect on why the societies should want to. Most obviously, both sets of tools can enhance the effectiveness of traditional OR. Ackermann (2012) has argued the case for DSPSM as expanding OR's "remit and boundaries", seeing its key role, as suggested above, as a 'mixed method', i.e. in combination with traditional OR. The case for Business Analytics is that it includes a novel tool set that has only been partially absorbed into OR, whilst expanding the range of applications, e.g. in credit & risk scoring or on-line marketing. The result is an expansion of OR's opportunities.

5.1 The Challenge for National OR Societies

The national OR societies typically have as important elements in their main objectives, to support members, acquire and share knowledge and offer support to their careers. Traditional OR has always been well provided for, in particular through many well-established journals, conferences, Master's programmes and post experience training.

DSPSM is reasonably supported through EURO and the UK OR society: both JORS and EJOR regularly publish articles on the topic, including both methodological and case studies. In contrast, as we have shown, the INFORMS journals have refused to engage with the topic, at least the formal problem structuring component. While only indicative, the UK is proportionally the primary home of the DSPSM cluster of respondents, at least those focussed on PSMs. However, researching practice has attracted less interest, as is illustrated by the small number of contributions in recent EURO and IFORS conferences.

Analytics is new to the national societies. INFORMS has embraced it more fully with the term appearing in its vision statement as "the premier organization for advancing the profession, practice, and science of analytics, operations research and management science", an ambitious claim for a contested territory. As noted earlier it has rebadged its practitioner conference, launched the Analytics on-line magazine and has developed professional certification in the area. The OR Society claims to be "at the heart of Analytics" and the Irish OR Society has renamed itself 'The Analytics Society of Ireland' but other societies have not yet moved far along this path, although the German OR Society included Analytics as part of its conference theme in 2014. The IFORS conference in 2014 had only three of over 150 streams linked to Analytics: but data mining features quite strongly. However the next IFORS triennial conference in 2017 already has the strapline "OR/Analytics for a Better World". As yet, the area is not served by an academic research publication.

In many IFORS countries, the societies and the university sector have developed an education and training programme to support traditional OR. As the IFORS and INFORMS surveys showed, most respondents had at least a master's degree. But the requirements to develop a Business Analytics specialist or a DSPSM specialist differ from those of traditional OR. A would-be analytics specialist faces a different set of priorities than an OR specialist (Olavson and Cargille, 2008; Libertore and Luo, 2013). The educational constraint here is time: it is hard to see that someone could, within the constraints of a master's degree, be rigorously trained in the complete tool set of both OR and Analytics, although a common core plus OR and

Analytics options may provide an acceptable compromise. Thus far this need has been partially recognized by the growth in both specialist analytics masters degrees and post-experience training courses, provided by various professional societies.

The training of DSPSM specialists and particularly the potential users of PSMs, raises even more of an educational challenge in that an organizational and personal maturity is needed to deal with the complexity and the lack of a unique "right answer" implicit in PSMs (Ackerman, 2012). A distinctive master's degree designed specifically for the Soft OR facilitator has not yet been offered but some aspects are included on several traditional OR master's courses, with some short post experience training courses being used as identified in the IFORS survey. The attested rise of the 'Analytics Movement' poses an even more substantial challenge to OR and its societies The loosely defined area of analytics has drawn in a variety of interest groups apart from OR, in particular statisticians and computer and information scientists. In an organisational setting it is far from clear who the innovators and problem owners will prove to be, despite the impetus given through the effective publicizing of the challenges arising from the unarguable growth of big data within many organizations. The problem for OR is that its role as an internal consultancy gives the ownership of the various organizational processes and the associated data to others. In effect, the technical niche roles in OR, which have undoubtedly become more important are best positioned to provide the analytics champions that are needed. But as yet evidence is lacking.

Both PSMs and Business Analytics are influencing the organizational role of OR. The development of Problem Structuring Methods and 'Soft OR' has delivered a distinct tool set complementary to existing tool sets and has been successfully embraced by elements of the OR community, particularly in the UK. However, whilst these enable support to strategic and 'messy' problems, these methods are not the unique province of the OR practitioner within an organisational setting and fail to add a clear competitive professional advantage. In contrast, the development of Business Analytics is more challenging to OR's established role and function. The Analytics movement is positioned somewhat distinctively from OR and has quickly gained a higher public profile, with the IFORS survey demonstrating some limited rebranding of OR groups taking an Analytics label. According to the IFORS survey, less than 25% of OR analysts now work under the OR label. Although OR and Analytics use many of the same techniques, they are distinct and any attempt to claim Analytics as just another name

for OR is likely to fail. Analytics is seen as core to the business in many organisations, whereas OR is usually identified as a consultancy service (Robinson, 2013).

The various surveys of practice described here tell us of changing practitioner perspectives and sets of activities and consequently different needs, from the academic journals which set the boundaries of OR too narrowly, to new master's degrees that aim to develop analytics specialists and professional development programmes to extend the range of the OR worker. These changes in practice require institutional responses if the OR profession is to reverse the natural drift. In particular, this paper has demonstrated the need to examine critically current practice with a view to responding and capitalising on its needs. Abbott's words (quoted by Corbett and Van Wassenhoeve, 1993) still resonate disturbingly: "No profession can stretch its jurisdiction infinitely. For the more diverse a set of jurisdictions, the more abstract must be the cognitive structure binding them together. But the more abstract the binding ideas, the more vulnerable they are to specialization within and to diffusion into the common culture without." Thus, if the OR and Analytics communities are to integrate in some way, the common strengths but more importantly, the distinct differences, need to be acknowledged and addressed. And if the natural drift is to be reversed, more detailed research on practice is needed, including a set of richer case studies with the features Ormerod (2014) describes which in particular discuss the organizational context and the processes and problems of implementation. We face a period when the boundaries are being stretched and there is no guarantee that OR will be able to absorb the changes this implies.

6. Concluding Comments

The IFORS survey of global OR practice has provided a platform to examine two related questions: (i) whether the scope of OR practice has been extended by the introduction of Problem Structuring Methodologies and the developing Analytics movement, and (ii), whether the previously reported gap between academic research and practice (the 'natural drift') – a potential problem for all professional communities – has been affected by these changes.

The results of our global practice survey, incomplete as they are, which are presented in section 3, indicate that the tools used by practitioners can be grouped into 3 overlapping classes: 'Traditional OR' with applications concentrating mainly on production, logistics and supply chain; 'Decision Support and PSMs' concentrating on strategic planning and the service industries, and 'Business Analytics' focused on financial and marketing applications, with the

latter two classes extending the scope of OR as conventionally defined by its leading journals. But established OR journals have yet to catch up with these extensions and in particular the increased emphasis on problem structure and organizational context. Practitioners themselves have necessarily developed effective client management strategies and context sensitive consulting skills although these are rarely reported in the research literature, and omitted even from published case studies (Ormerod, 2013).

The development of PSMs, more generally Ormerod's 'helpful ways', have enabled 'messy' and strategic problems to be addressed – thus extending the scope of OR - but dissemination has been slow and significant hurdles need to be overcome before they can be more widely accepted and used (Ackermann, 2013; Ormerod, 2013) not least its limited acceptance in research journals.

The second major extension of scope, the Analytics movement, is impacting on OR and presents both a threat to and an opportunity for OR Societies. A survey of INFORMS members indicates that Analytics and OR tool sets overlap but with analytics tending to focus more on data mining approaches and computing issues. Currently there is limited education and training for analytics (though master's degrees focussing on big data are fast developing). But it seems unlikely that a single Master's course will enable the requirements of both Analytics and OR staff to be met. Current course designs show the compromises being made.

The Analytics/Big Data label has quickly gained a higher public profile than OR, whereas a majority of practitioner 'OR' groups do not even use the OR label! Also, it appears that the Analytics movement has already secured a stronger organisational position, in part by being embedded in key organisational processes in contrast to OR which is largely consultancy based. But OR groups have the potential to become 'analytics champions', because of the overlapping skills set and their lengthier establishment. A response to these challenges is required from OR Societies if OR is to prosper in the longer term. In part this will require the recognition that Business Analytics differs in some key respects from traditional OR and needs to be supported through the established journals, educational programmes and conferences under the direction of the national societies.

This investigation has shown that the gap between academic research and practice persists, although some OR Societies are making vigorous efforts to close it. The Analytics movement

has emerged from practice and technological changes, just as OR itself did some 75 years ago. Harnessing the strengths of both but acknowledging the limitations of each may well be an opportunity to narrow the gap.

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