Accounting for Impact at Imperial College London

Markus Perkmann, Riccardo Fini, Jan-Michael Ross, Ammon Salter, Cleo Silvestri, Valentina Tartari
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A report on the activities and outputs by Imperial academics relevant for economic and social impact

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EXECUTIVE SUMMARY

We report findings of a study of academic engagement and commercialisation at Imperial College London. We detail the extent of collaboration with industry, consulting, patenting and entrepreneurship by Imperial academics, as well as individuals’ motivations and perceived barriers to engagement. The data stems from archival records held by the College, complemented by external databases, and a survey conducted among all academic staff in 2013.

MAIN FINDINGS

- Imperial academics engage across a broad range of external organisations using various channels, including contract research, consulting and advisory board membership, as well as patenting and entrepreneurship. Our methods allow us to estimate the extent of activities not tracked by internal College records. Accordingly, we illustrate that consulting, patenting and entrepreneurship (founding of companies) are considerably more widely practiced than suggested by College-held records. Depending on faculty affiliation, the extent of consulting may be 50% to 100% higher than reflected in those records. Patenting is 40% higher and entrepreneurship a multiple of the figures derived from the archives.

- For Imperial academics, the most important aspects of the College’s mission are the traditional academic objectives of worldwide academic advancement, training of future academics, and teaching and learning. Many see engagement with industry and other users as complementary to their research.

- The most frequently perceived barrier to academic engagement (industry collaboration, consulting, etc.) refers to the difficulty in finding appropriate partners for collaboration. Engineers specifically also report that they have concern over potential conflicts with partners regarding intellectual property rights.

- The various types of academic engagement and commercialisation (patenting, entrepreneurship) are correlated on an individual level, meaning that individuals tend to have portfolios of multiple activities. There is also a concentration of these activities among relatively few individuals. For instance, the top 10% of individuals are responsible for 90% of all income from research contracts and 98% of the consulting that is routed through the College’s consulting company. Just 4% of individuals had their patent licenced.

- Junior researchers play an important part in the overall entrepreneurial activities at Imperial, as they represent more than a third of the total number of entrepreneurs. One may extrapolate that they contribute significantly to other impact-relevant activities as well.
PRACTICE IMPLICATIONS

- Priority should be given to facilitating engagement with industry where there are strong complementarities between academic and economic/social impact. Genuine university-industry collaboration should be preferred to service provision.

- In view of the concentration of impact-relevant activities among few individuals, attention should be given to broadening participation in these activities.

- Compared to their own beliefs about the College’s mission, Imperial academics perceive the College’s senior management to be relatively more preoccupied with commercialisation and industry collaboration. This suggests attention should be given to aligning academics’ views with those held by the College leadership.

- Our findings suggest that the impact generated by academics at Imperial College London, and possibly other UK universities, is likely to be considerably more extensive than commonly reported. This has implications for the methods and systems used for assessing and measuring impact-relevant activities.
FOREWORD

This research report provides a useful and timely picture of how engineers, scientists and medics at Imperial College London engage with research collaborators and users. The analysis shows how different forms of engagement create opportunities for impact from research. Academics engage in industry collaboration and entrepreneurial activities because this in turn helps them develop better ideas and sometimes funding for their research. Detailed analysis of survey results and interviews suggests that engagement and the potential for impact is considerably higher than suggested by commonly available data.

I was particularly pleased with the close cooperation between Imperial College’s Business School research team, Imperial’s Faculty leaders, ICT department, Research Office and Imperial Innovations. This provided support from many different stakeholders across the College which helped to develop a rich picture of activities.

The Report provided a very useful input to the review of Imperial’s Technology Transfer and Translation activities, informing its 2015 Strategy.

It is important that universities consider a wide range of mechanisms for delivering impact. Publication of the report following the recent UK Research Excellence Framework will, I hope, stimulate continued discussion of effective mechanisms for research impact.

Professor David Gann
Vice-President (Development and Innovation)
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ACKNOWLEDGEMENTS

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We appreciate the valuable assistance of Maria Vittoria Amaduzzi, Antonella Bedini, Caterina Bissoni, Adele Gori and Andrea Maisto. We are also grateful to Professor Francesco Lissoni for granting us access to the APE-INV database.

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BACKGROUND AND CONTEXT

GENERAL CASE

Universities play a set of important roles in society. Alongside their traditional roles as educators and research institutions, they also help to support economic and social development. This economic role is primarily a function of their first two roles – the training and education of students and the generation of new knowledge. It is clear that these efforts have significant impact on economic development, and accrue a high rate of social return.

However, universities are increasingly important economic players in their own right. They act as a social magnet, bringing together individuals from around the globe to engage and share ideas. As such, they contribute to the development of ‘local buzz’ associated with successful and dynamic local economies, and through their international reach they provide an important ‘global pipeline’ for national economies. UK universities are also important sources of exports, accounting for more than £10b of this activity. They leave a large social and economic footprint in their host cities, creating employment and increasing demand for services.

Over the past 30 years, there has been an increased policy emphasis on the economic and social role of universities. These policies have led to a secular trend across OECD countries, encouraging universities to become more active in directly supporting economic development. Government support for universities to engage in technology transfer, support spin-offs and wider social impact has become institutionalised with public funding. In the early stages of this effort, policy focused on supporting the development of technology transfer offices at universities, but this focus has increasingly widened towards a broader notion of knowledge exchange. In addition, research funding has been increasingly tied to the demonstration of impact of the research conducted, encouraging researchers to explore how their work might result in economic or societal benefits.

As result of these policy changes, universities have encouraged their students and staff to become more entrepreneurial, actively engaging in more commercial activities. Moreover, they urge their staff to be more externally facing, engage the public in their research and influence practice.

These demands on academics are not new. Indeed, UK academics have traditionally had high levels of engagement with non-academics and are often keen to explore opportunities to ensure their research is impactful on the wider world. When asked, academics often see engaging with non-academics as a way of improving their own research efforts by securing greater resources, generating more take and spread of their research, identifying interesting research problems and finding employment for their students (D’Este & Perkmann, 2011; Hughes & Kitson, 2012; Perkmann & Walsh, 2009; Salter, Tartari, D’Este, & Neely, 2010). Although the data is partial and incomplete, evidence suggests that UK academics’ levels of engagement with non-academics appears to be similar to other OECD countries and suggests that they are ‘punching at their weight’ (Perkmann et al., 2013).
However, academics also complain they are now expected to be ‘five legged sheep’, demonstrating mastery of teaching, publications, grant winning, commercial exploitation, and public engagement (van den Brink & Benschop, 2014). Although promotion within academe is still largely driven by research achievements and teaching performance, increasingly impact and engagement have become relevant for promotion panel decisions. In response, academics have had to learn to be active in a broad range of areas to demonstrate to current and future employers their ability to deliver on the wider mission of the university.

To do this, academics need to maintain a broad portfolio of activities. In other words, they have to wear many hats and act as researchers, teachers, mentors, entrepreneurs, supervisors, managers and public personalities. The challenges of delivering on these various roles are not well understood.

The above is the general context in which we initiated our study entitled ‘Academic Engagement at Imperial College London’. The goal of the project was to generate new knowledge on the nature of academic work in light of these changing pressures and circumstances. In doing so, we have focused on the experience and attitudes of individual academics, rather than considering evidence on a more aggregate level. To this purpose, we have brought together information held within archival records at Imperial College London and information provided by academics themselves via a survey that we conducted. In addition, we also mapped the public trace of academics in the wider world, including patenting, firm directorships, and publications. Equally, we sought to bring light to the less public aspect of academic life, including academics’ perceptions of their job and their conception of what universities – and Imperial College London specifically – are for. By combining the public and private aspects of the life of academics, we can gain new insights into how academics confront, adapt and deliver in their various roles. We can also explore what factors shape the development of successful academic careers in this new environment, and how different parts of an academics’ portfolio of efforts interact and shape each other.

**THE CONTEXT: IMPERIAL COLLEGE LONDON**

The College is a large research university specialising in the sciences, engineering and medicine. It has approximately 14,000 students, and employs 1,200 faculty and 2,200 research staff. In 2012, it received £314m in research grants and contracts of which £102m were research council grants. It is regularly ranked among the best universities globally.

Imperial College London was founded in 1907 by bringing together a number of colleges, including the Royal School of Mines and the Royal College of Science. Its founding charter stipulated that it provide the ‘most advanced instruction (…), training and research in various branches of science, especially in its application to industry.’ These objectives are reiterated in the College’s mission today, and it is widely recognised as one of the UK leaders in generating impact for its research via spin-offs, licences, and industry funded research centres and contracts.
THE TRIC\(^1\) STUDY

Our study explores central questions about the relationship between academic research and broader economic and societal impact. First, we paint a comprehensive picture of the whole range of research-related activities that are likely to result in impact and generalise the conclusions from this, whereas previous studies have often focused on narrow outputs such as patenting or very successful cases. Second, we intend to explore in depth the inputs required for the generation of impacts. Our approach is built on the recognition that science is done by scientists, and that all scientific, economic and societal impact of research funding depends quite simply on their skills, motivation and activities. In other words, it is not the grants that produce scientific, social, economic and human capital outcomes; rather, the outcomes are generated by the individuals and their teams who are performing the research. Scientists pursue long-term scientific research agendas by engaging in multiple projects funded by different sources and involving different people.

In order to achieve the above objectives, we have compiled a rich, longitudinal dataset that captures the career and impact pathways of Imperial staff and the full range of their efforts. The TRIC database covers the whole spectrum of academic engagement and impact, ranging from commercialisation via entrepreneurship or patenting, to consulting and contract research, to non-commercial types of impact such as the shaping for clinical practice or community engagement.

In order to obtain an accurate picture of how these different types of impacts are enabled and facilitated, we sought to collect detailed information about the characteristics and achievements of individuals as well as the context in which they work. Therefore, it was important to gather basic information of staff demographic attributes as well as their organisational roles, the amount of resources they acquire via grants or contracts for their research, and the nature and extent of their academic productivity. This information enables us to analyse the particular combinations of resources and people that prove especially fruitful in terms of generating impact. Having a longitudinal dataset that tracks activities and outputs by individuals over multiple years provides us with statistical power, allowing for stronger claims of inference.

In this report, we focus on exploring the extent to which Imperial academics engage in activities with impact potential. In order to achieve this, we proceeded in three stages. First, we pooled existing College records on the patenting of inventions, creation of spin-off businesses, collaboration with industrial partners and consulting activity to generate a detailed picture of the determinants and consequences of industry engagement. We subsequently linked these records to external public databases. Third, we carried out a survey among the College’s academic staff, designed to collect information that was not contained within the existing records.

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\(^1\) TRIC stands for Transfer at Imperial College London.
RESULTS

The results of our study show the varied character of academics’ involvement in engagement efforts. First, we explore patterns of academic engagement with non-academics, focusing on collaborations with industry and consultancy. Second, we focus on academics’ perceptions of engagement, gauging both the positive and negative aspects of undertaking engagement activities. Third, we examine the entrepreneurial efforts of commercialisation, focusing on patenting and entrepreneurialism. Finally, we draw lessons for policy and academic practice.

Since we draw from different sets of information, the populations differ across our analyses. For the archival records, we present results for the population of all 9,874 individuals employed in an academic role at Imperial College London between 2001 and 2011. The proportion of women to men is 35:65.

Of this population, 45% are associated with the Faculty of Medicine, 29% with the Faculty of Natural Sciences, 23% with the Faculty of Engineering and 3% with the Business School. A total of 83 individuals identified as belonging to an ‘other’ faculty, mostly comprised of members of staff in a central college role (e.g. pro-rector). In terms of seniority, 72% of this population are junior researchers, 11% are senior faculty, 14% are junior faculty, and 3% are senior researchers.\(^2\) Regarding terminology, we use ‘senior faculty’ to refer to readers and full professors, ‘junior faculty’ to lecturers and senior lecturers, ‘senior researchers’ to senior research fellows and principal research fellows, and ‘junior researchers’ to research assistants, research associates and research fellows.

By contrast, the survey findings apply to the population of 3,725 individuals employed in an academic role at Imperial in 2013, of which 1,909 responded to the survey.

ACADEMIC ENGAGEMENT

We define academic engagement as the set of activities by Imperial faculty that involve reaching out and collaborating with businesses, the public sector or non-profit organisations. This includes collaboration with industry via contract research, consulting, and participation in external advisory boards, as well as civic engagement. We treat patenting and entrepreneurship separately from academic engagement and provide details of those commercialisation activities further below.

Collaboration with industry

To measure the extent of collaboration with industry, we considered projects funded by private sector entities. The overarching majority of these projects are classified as contracts but they also include a small number of grants and donations. Our figures relate to the period 2004-2010, and are calculated as annual per person figures. We calculated the figures by

\(^2\) A small number of individuals transferred from one faculty to another during the period of observation. In this case, the individual’s activities are considered separately for each faculty of association. Approximately 25 individuals who were classified as belonging to the Humanities Faculty were reclassified as belonging to the Business School.
dividing the total research income for each project by the number of investigators on each project. We then calculated annual figures by dividing the per person income for each project by the number of years of project duration and counting for each year only the proportion of the project conducted in that year.

**Figure 1. Collaboration with industry**
Annual income from industry contracts per person (2004–2010)

![Figure 1. Collaboration with industry](image)

Figure 1 shows the annual research income from industry contracts per person according to faculty and position. The Medicine Faculty are the most prolific industry collaborators, with per person income of £25,900, followed by Engineering (£23,900), Natural Sciences (£10,800) and the Business School (£4,000). These per person averages are calculated without taking into account junior researchers whose income from research contracts is negligible.

These average figures obscure the fact that income from research contracts is highly skewed. The top 10% of individuals are responsible for 90% of all income, while almost three quarters (74%) of staff do not engage in collaborative research with industry. There is a considerable, statistically significant difference in terms of gender, with women having an average industry contract income of £12,400, with a corresponding figure for males of £21,900. This difference is likely to be driven primarily by differences between women and men in terms of seniority and faculty affiliation.

Collaborating with industry is positively correlated with individuals’ scientific record. We constructed an index that is equal to the sum of the ISI impact factors of the respective journals for each article that an individual published over their career, divided by their academic age (starting with the year of first publication). Collaborators have an average scientific record value of more than 15, compared to 10 for non-collaborators.
Advisory board positions

Many Imperial academics are also members of scientific and technical advisory boards of firms. Our survey results suggest that there is approximately one such position for every two members of Imperial staff (without junior researchers), with the highest incidence in the Faculty of Medicine (89 positions for every 100 staff), followed by Engineering (60), the Business School (58) and Natural Sciences (42).

Civic engagement

In our survey, we asked respondents how often they had given talks in schools, museums and community organisations. The results suggest that, on average, each member of Imperial engages in such activity once every year. Business School academics exhibit the highest level of engagement (1.71 times per person), and Engineering Faculty the lowest (0.92 times per person). This represents a category of engagement where both men and women are active to approximately the same degree. The figures in this section are calculated with junior researchers; by and large the latter staff group exhibits a similar level of civic engagement compared to their senior colleagues.

Consulting

Consulting is an important channel for academics to engage external actors. We use figures provided by Imperial Consultants as well as information provided by our survey to describe the extent of consulting within the College. The College encourages but does not require staff to route their consulting activities through Imperial Consultants, a fully owned subsidiary that returns its profits to the College. For this reason, the volume of activity recorded by Imperial Consultants may underestimate the actual volume of consulting. Our data provides a rare opportunity to shed some light on the ratio of consulting carried out via Imperial Consultants and that pursued on a personal basis.

Imperial Consultants categorise projects into different types that include consulting in a strict sense as well as activities as diverse as expert witness services, testing and research for the European Commission. We first report the volume of all of these activities taken together, which we refer to as ‘IC services’ (short for Imperial Consultants services).

Figure 2 shows the distribution of annual income generated on average by each academic (without considering junior researchers). With £12,500 per person, staff in the Engineering Faculty have the highest annual income per person, followed by the Business School with an average of £4,500, Medicine with £4,400 and Natural Sciences with £2,900. Overall, the majority of consulting income is generated by senior faculty, except for the Engineering Faculty where the highest levels of income are generated by senior researchers. This may reflect the fact that some consulting activities support research teams in the College. There is a statistically significant difference in terms of gender, with women having an average income of £2,100, with a corresponding figure for men of £7,000. This difference is, in all likelihood, primarily due to differences in seniority between men and women in the College.
If one takes only consulting activities in a strict sense into account – we refer to this as ‘IC consulting’ – the values obtained are around half the values for the whole of IC services, while the distribution across faculties remains largely the same (see Table 1, column 1).

We also obtained via the survey an estimate of the number of days of consulting carried out by Imperial academic staff in 2012 and we were able to compare those figures with the ones on consulting activities routed via Imperial Consultants.\(^3\) We assume that when providing information on the extent of consulting, our survey respondents intended this to apply to their consulting in a strict sense (excluding EU projects, testing, etc.), and hence this information should be compared to IC consulting (rather than IC services) as defined above.

If one assumes an average of £1,200 as a daily rate for consultancy (including IC overheads), one can calculate figures for an estimated volume of funds raised (column 4). Comparing these latter figures with the volume of IC consulting (i.e. the narrow definition of consulting), we calculate the difference between the two and report them in column 5.

**Figure 2. Consulting**

Annual income from Imperial Consultants services per person (2004–2010)

Accordingly, the engineers conduct the highest proportion (64%) of consulting via Imperial Consultants. This may be explained by the fact that the engineers conduct by far the highest volume of consulting, and many projects are likely to involve university equipment. It is also

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\(^3\) Our figures on IC consulting related to 2010 while the survey relates to 2012. Our analysis suggests that consulting activities have remained largely stable across different years.
noteworthy that the relatively small cohort of senior researchers in Engineering have the highest per person values for consulting (£34,000 per year), even before Engineering senior faculty. The amount of consulting routed through Imperial Consultants by Medicine, Natural Sciences and Business School academics ranges from 39% to 48% of their survey-reported consulting activities.

**Table 1. Comparison of consulting routes**

Annual income per person (excluding junior researchers) from consulting activities and annual estimated income

<table>
<thead>
<tr>
<th></th>
<th>(1) IC services (broad) £</th>
<th>(2) IC consulting (narrow) £</th>
<th>(3) Consulting (from survey), days</th>
<th>(4) Consulting (from survey), estimated £</th>
<th>(5) % routed IC (2)/(4)*100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>12,500</td>
<td>5,600</td>
<td>7.35</td>
<td>8,818</td>
<td>64%</td>
</tr>
<tr>
<td>Natural Sciences</td>
<td>2,900</td>
<td>1,800</td>
<td>3.24</td>
<td>3,884</td>
<td>48%</td>
</tr>
<tr>
<td>Medicine</td>
<td>4,400</td>
<td>1,300</td>
<td>2.92</td>
<td>3,500</td>
<td>39%</td>
</tr>
<tr>
<td>Business School</td>
<td>4,500</td>
<td>2,900</td>
<td>6.71</td>
<td>8,000</td>
<td>47%</td>
</tr>
</tbody>
</table>

The table compares the amount of services and consulting routed through Imperial Consultants (columns 1 and 2), the number of consulting days as reported by individuals via the survey (3) and the estimated income from the latter (4). Column 5 indicates the estimated share of consulting activities routed via Imperial Consultants by calculating the percentage of IC consulting as reported in column 2 in the overall volume of consulting as reported in column 4.

Overall, Imperial faculty conduct about 4.5 days of consulting per year, of which just over a half is routed through Imperial Consultants. However, similar to industry contracts, the distribution of consulting activity is highly skewed (see Figure 3, data calculated without junior researchers). Of the total volume of IC consulting services, for instance, 98% is conducted by the top 10% of individuals. The concentration of activity is lower if one considers the self-reported number of consulting days from the survey; here the top 10% of individuals account for 62% of activity. This suggests that Imperial academics by and large use Imperial Consultants for larger projects while smaller projects are carried out on a personal basis without involving the College.4

Consulting is positively correlated with individuals' scientific record. Those who consult have a scientific record value of 14, compared to 11 for non-consultants.

Our results suggest that consulting is an important element in the portfolio of activities associated with industry engagement. In addition, formal reporting of consulting via Imperial Consultants is likely not to capture the full scale of consulting performed by academics. Extrapolating further, the level of consulting by UK academics in the STEM disciplines, taking

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4 In any case, disclosure via the register of interests is required.
variation between faculties into account, could be 50% to 100% higher than reported in national statistics.

Figure 3. Distribution of consulting
Average per decile

![Distribution of consulting](image)

**MOTIVES FOR ACADEMIC ENGAGEMENT**

In the survey, we asked respondents what influences their decision to reach out and collaborate with businesses, the public sector or non-profit organisations (defined as ‘academic engagement’). We included a range of potential motives, some of which were more strictly related to research, such as obtaining inspiration for research projects or learning about problems that are relevant in practice, while others were more related to financial incentives, such as securing additional income. We asked respondents to rate the importance of each motive on a 5-point Likert scale, ranging from ‘not at all important’ to ‘crucial’. We conducted the analysis of the responses by faculty and by position.

Figure 4 shows that the motivations most commonly cited as ‘important’ or ‘crucial’ were access to resources (data, materials, etc.), learning about problems relevant in practice and obtaining research income. The ranking of these priorities between faculties in Imperial is fairly consistent, suggesting there are common objectives that drive academic engagement across the College.
However, some differences are present. For example, researchers in Engineering and the Business School practice academic engagement to also obtain inspiration for new research projects (73% and 72% respectively). By contrast, a relatively small share of academics (approx. 25%) collaborate with external entities in order to gain intellectual property and gain personal income. This suggests that engagement is primarily driven by furthering research objectives rather than pursuing commercial or personal gain.

Figure 4. Motives for academic engagement, by faculty

In Figure 5, we explore differences in factors that motivate academic engagement by position. Overall, there are few differences between the grades of staff using academic engagement as a vehicle to enhance their research efforts. However, the most important factor influencing the decision to collaborate with external entities for junior staff members is increasing the chances of obtaining research grants. For more senior members of the College, learning about problems that are relevant in practice is the most common factor cited as being ‘important’ or ‘crucial’. Interestingly, junior researchers, as opposed to junior faculty, are the population most likely to cite pecuniary gain as a motive for academic engagement.
We were able to compare our results with two previous surveys that were conducted in 2004 and 2009 respectively, and collected information from EPSRC investigators across all UK universities. The comparison can only be approximate because the previous surveys are biased towards more senior academics. Broadly speaking, Imperial academics express a greater desire to hold intellectual property and are more interested in learning about problems that industry faces.

Our results suggest that there is a close relationship between engagement and individuals’ desire to further their research agendas, and therefore attempts to promote engagement or impact need to focus on these research-related motivations of researchers. In particular, the ability to attract resources for research as well as access to new and interesting problems appear to be potent drivers of engagement.

**BARRIERS TO ACADEMIC ENGAGEMENT**

Working with external entities may sometimes be challenging. We asked Imperial academics to indicate which potential barriers to interaction – from a given list – they experienced when collaborating or seeking to collaborate with external entities.

Table 2 shows that the most frequently cited barrier (27% of respondents) was the difficulty in finding appropriate partners for collaboration. Many engineers (24%) specifically have experienced potential conflicts with partners regarding intellectual property rights. By contrast, for those in Medicine and Natural Sciences, an oft-cited barrier to collaboration is that the nature of their research is not linked with partners’ interests or needs (21% and 29% respectively). Imperial’s policies and support structures appear to be very well suited for
supporting engagements, as respondents reported no problems in this respect. Respondents also appear to be unaffected by cultural disparities between academia and industry, as none indicated the mutual lack of understanding about expectations and working priorities and the short-term orientation of partner research as barriers to collaboration.

Table 2. Barriers to interaction, by faculty

<table>
<thead>
<tr>
<th></th>
<th>Business School</th>
<th>Engineering</th>
<th>Medicine</th>
<th>Natural Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>78</td>
<td>640</td>
<td>663</td>
<td>528</td>
</tr>
<tr>
<td>Absence of established College procedures for collaboration</td>
<td>17%</td>
<td>14%</td>
<td>20%</td>
<td>16%</td>
</tr>
<tr>
<td>Difficulty in finding appropriate partners (e.g. highly innovative companies)</td>
<td>29%</td>
<td>31%</td>
<td>22%</td>
<td>28%</td>
</tr>
<tr>
<td>High personnel turnover and lack of continuity in partners’ research strategies</td>
<td>19%</td>
<td>15%</td>
<td>12%</td>
<td>10%</td>
</tr>
<tr>
<td>Lack of suitable government funding programmes for research with partners</td>
<td>10%</td>
<td>21%</td>
<td>17%</td>
<td>18%</td>
</tr>
<tr>
<td>Mutual lack of understanding about expectations and working priorities</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Partners impose delays in dissemination of research outcomes and publications</td>
<td>14%</td>
<td>13%</td>
<td>14%</td>
<td>11%</td>
</tr>
<tr>
<td>College policies governing collaborations are unsuitable</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Potential conflicts with partners regarding intellectual property rights</td>
<td>12%</td>
<td>24%</td>
<td>15%</td>
<td>19%</td>
</tr>
<tr>
<td>Rules and regulations imposed by government funding agencies</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Short term orientation of partner research</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Lack of support by technology transfer office or corporate partnership staff</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>The nature of my research is not linked with partners’ interests or needs</td>
<td>15%</td>
<td>14%</td>
<td>21%</td>
<td>29%</td>
</tr>
</tbody>
</table>

Table 3 reports the result by position. Faculty members (both junior and senior) – as opposed to research staff – tend to report higher barriers to collaboration. In particular, the difference between faculty and research staff is statistically significant for the following barriers: difficulty in finding appropriate partners, high personnel turnover and lack of continuity in partners’ research strategies, lack of suitable government funding programmes for research with partners, and potential conflicts with partners regarding intellectual property rights. Moreover, on average, senior members of staff (both faculty and non-faculty) seem to experience higher barriers to collaboration than junior members of staff. Both results indicate that increased experience with engagement may actually increase the perceived incidence of barriers – this is a result that echoes previous research on barriers to collaboration (Bruneel, D’Este, & Salter, 2010).

Compared to the results of previous surveys of EPSRC investigators across all UK universities, Imperial academics perceive the level of barriers as generally slightly lower. In particular, Imperial academics report fewer difficulties in finding appropriate partners, fewer funding problems and have fewer complaints about misfit with industry research. However,
they cite intellectual property related conflicts slightly more frequently than their UK counterparts.

Overall, the difficulty of finding the right partner is seen as the single most relevant barrier to engagement by many Imperial academics. This indicates that intervention efforts should focus on ‘match-making’, bringing academics together with potential industry collaborators.

Table 3. Barriers to interaction, by position

<table>
<thead>
<tr>
<th>N</th>
<th>Junior researcher</th>
<th>Senior researcher</th>
<th>Junior faculty</th>
<th>Senior faculty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absence of established College procedures for collaboration</td>
<td>17%</td>
<td>11%</td>
<td>18%</td>
<td>15%</td>
</tr>
<tr>
<td>Difficulty in finding appropriate partners (e.g. highly innovative companies)</td>
<td>24%</td>
<td>22%</td>
<td>33%</td>
<td>29%</td>
</tr>
<tr>
<td>High personnel turnover and lack of continuity in partners’ research strategies</td>
<td>10%</td>
<td>9%</td>
<td>14%</td>
<td>17%</td>
</tr>
<tr>
<td>Lack of suitable government funding programmes for research with partners</td>
<td>15%</td>
<td>20%</td>
<td>19%</td>
<td>23%</td>
</tr>
<tr>
<td>Partners impose delays in dissemination of research outcomes and publications</td>
<td>12%</td>
<td>11%</td>
<td>11%</td>
<td>14%</td>
</tr>
<tr>
<td>Potential conflicts with partners regarding intellectual property rights</td>
<td>14%</td>
<td>19%</td>
<td>21%</td>
<td>26%</td>
</tr>
<tr>
<td>The nature of my research is not linked with partners’ interests or needs</td>
<td>19%</td>
<td>27%</td>
<td>24%</td>
<td>20%</td>
</tr>
</tbody>
</table>

INTELLECTUAL PROPERTY

In this section, we consider the creation of intellectual property, particularly patents, at Imperial. Patent applications feed from a pool of disclosures made by Imperial academics whereby they notify the College of a potentially valuable discovery. Our database contains a total of 3,381 disclosures of which 2,189 were filed in the period from 2001 to 2011. Below, we report figures applicable to this period only.

Disclosures are relatively broadly distributed across individuals, with 1,028 individuals (10% of the population) filing at least one disclosure; on average each of these individuals filed 2.98 disclosures. The annual disclosing rate is 6.26 disclosures per 100 Imperial academics. From this pool, the College filed 710 patents, invented by 558 staff. This results in an annual patenting rate of approximately 2 patents per 100 Imperial academics.\(^5\)

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\(^5\) The figures refer to ‘patent families’, i.e. the set of patents with the same content filed in different jurisdictions. This means even if there are several patents in a patent family, this is counted as only one patent.
Internal and external patenting

Here we present an in-depth analysis of patenting at Imperial by focusing on the subset of patents granted to Imperial inventors by the European Patent Office (EPO).

The focus on EPO patents allowed us to collect full information on inventive activity at Imperial. The Imperial-held records contain information only on those patents that are assigned to Imperial College London or its associated entities, such as Imperial Innovations. By using official patent data held by the EPO, we were able to identify the patents that were invented by an Imperial academic yet not assigned to Imperial. This means the patent was not filed by Imperial but by another entity (e.g. a firm). We refer to this latter type of patent as an ‘external patent’. By contrast, we use the term ‘internal patent’ to refer to a patent invented by an Imperial academic and subsequently assigned to Imperial. The limitation to EPO patents is justifiable on the grounds that valuable patents will usually be filed with EPO, along with filings with other important patent offices. Forthwith, when we refer to ‘patents’ in this section, we mean ‘EPO patents’.

Our analysis considers all EPO patents invented at Imperial, independent of whether they are assigned to Imperial or to another unrelated entity. The ‘data overview’ section above contains a detailed outline of the procedure that we used to identify external patents. This kind of analysis is rarely conducted on university patenting because universities usually capture information only on patents that are assigned to them and which they therefore own.

As our analysis suggests, a unique focus on university-assigned patents underestimates the production of intellectual property at universities considerably. In fact, out of 513 EPO patents invented by Imperial academics, 368 (72%) are internal patents and 145 (28%) are external patents. This means the number of internal patents – commonly used as a measure of academic patenting – has to be increased by approximately 40% to reflect the true number of inventive activity by academics at Imperial.

The total 513 external and internal patents were invented by 346 individuals, representing 3.5% of Imperial academics. Among these, 309 (89%) hold internal patents and 66 (19%) hold external patents, with some individuals holding both.

In terms of technological content, the majority of patents are associated with two broad (OST7)6 patent classes (see Figure 6): pharmaceuticals and biotechnology (class 4) and instruments categories (class 2). The ratio of external patents versus internal patents is high (80%) in chemicals and materials (class 3), and is higher than average in Electrical Engineering and Electronics (class 1), and pharmaceuticals and biotechnology (class 4).

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6 OST7 refers to a standardised patent class typology that features seven technology categories, while the more fine-grained OST30 typology contains 30 categories.
Using the more fine-grained ‘OST30’ classification, the results show high absolute numbers of external patents in pharmaceuticals, cosmetics and biotechnologies. By contrast, the ‘control, measures, analysis’ and medical engineering areas feature high numbers of internal patents.

The distribution of inventive activity across Imperial's faculties is shown in Figure 7. Overall patenting activity is highest in the Engineering Faculty, with approximately 1.6 patents per 100 individuals per year, arising from a pool of approximately 7 invention disclosures per 100 individuals. This means about a fifth of disclosures are converted into an EPO patent; this is a conservative estimate as some disclosures are likely to have been converted into patents in other jurisdictions. Conversion rates as well as the ratio between internal and external patents are similar across faculties (except the Business School).

In terms of individuals’ position, senior faculty are the most prolific inventors, with 2.8 patents per 100 persons per year. By contrast, senior researchers hold the highest number of external patents compared to internal patents per person per year; 39% of their patents are external compared to an average value of 28%.

Patenting is positively correlated with individuals’ scientific record. Individuals with patents have a scientific record score of 18, compared to 10 for non-collaborators. The difference is even more pronounced for individuals whose patents were subsequently licenced out (value of 20), compared to those whose patents were not licenced (value of 11). This suggests that the economic value of patents is positively correlated with the quality and volume of inventors’ scientific production.
**Who owns external patents?**

One may presume that many of the patents invented by Imperial academics, but not owned by Imperial, may instead be assigned to Imperial’s numerous spin-out companies. In fact, we find that approximately 63% of external patents are owned by a company where an Imperial academic is a founding director. In turn, two thirds of these patents are assigned to a ‘supported spin-out’, that is a company classed by Imperial Innovations as a spin-out (see Figure 8). The remaining third of these patents are assigned to companies founded by Imperial academics but not otherwise supported by the College (‘independent spin-out’).
A further 7% of external patents are assigned to firms that funded the inventor’s research via contract research or a consulting contract (‘related parties’). A further 24% of external patents belong to 9 firms unrelated to Imperial (‘other company’), with the balance being assigned to another university or public research institution (‘University or Lab’, 5%), and individuals (1%).

**ENTREPRENEURSHIP**

Of our total population of Imperial academics, 470 are company directors involved in 507 companies, of which 62 are classed by Imperial Innovations plc as spin-outs. We refer to these latter spin-out firms as ‘supported spin-outs’ and the remaining 445 firms as ‘independent spin-outs’. Of the 470 directors, 325 (3.3% of our population) can be classified as ‘entrepreneurs’ which we define as individuals who hold a directorship position in a company from year one of its existence. These entrepreneurs founded a total number of 360 companies. A total of 16% of entrepreneurs are women.

**Figure 9. Entrepreneurship by department**

2001–2011. Note: ‘Environment and Climate’ includes the ‘Centre for Environmental Policy’ and ‘The Grantham Institute for Climate Change’
In our analysis below, we focus on the subset of entrepreneurs, as defined above, and their companies. Because this is a relatively narrow definition of entrepreneurship, this provides a conservative estimate of Imperial’s entrepreneurial output. For instance, many more Imperial spin-out companies are founded by PhD students, emeritus professors or ex-employees. Others are Imperial Innovations supported companies that are built on Imperial-generated intellectual property but do not feature the inventor academics as founders.

At the same time, it should be noted that many of the companies founded by entrepreneurs as defined in this report (i.e. employed academic faculty being a director of a company from year one) are not high-growth technology firms built on intellectual property but are consultancy firms or medical practices. In this sense, our definition is broader than what would usually be seen as entrepreneurship in an economic sense.  

Figure 9 shows the distribution of entrepreneurs across faculties and departments. The columns refer to the absolute number of entrepreneurs while the squares refer to the relative number of people, normalised by the size of each department they belonged to. In absolute terms, the Department of Medicine\(^9\) is home to the majority of entrepreneurs (67 individuals). Relative to department size, however, the Business School has the highest proportion of entrepreneurs, with approximately seven entrepreneurs per 100 staff.

**Figure 10. Comparison of entrepreneurs and non-entrepreneurs**

Values for non-entrepreneurs normalised to 100 (period of 2004 to 2010)

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8. Our evidence does not provide information on the precise nature of the link between these companies’ business activities and academics’ activities at the College.

9. Note that within the Faculty of Medicine, there is a Department of Medicine to which this statistic refers.
Characteristics and outputs of entrepreneurs

We further established how being an entrepreneur correlates with other characteristics of an individual.

We probed how entrepreneurs differ from non-entrepreneurs with respect to three characteristics: scientific record, industry income and IC services income (i.e. consulting broadly speaking). In Figure 10 we normalise non-entrepreneurs’ characteristics for each measure to a value of 100, and plot the corresponding value for entrepreneurs. The results suggest that, compared to non-entrepreneurs, entrepreneurs’ scientific record is 40% higher, research income is 3 times higher, and IC services income is almost 4 times higher. Entrepreneurs also have more than 4 times as many scientific and technical advisory board positions than non-entrepreneurs.

We also examined the relationship between being an inventor (an individual appearing as inventor on an internal or external patent) and being an entrepreneur (an individual serving as a founding director of a company). Our results suggest that on average entrepreneurs have 6 times the number of patents than non-entrepreneurs; the multiple is the highest in Natural Sciences where entrepreneurs have 12.5 patents per 100 individuals per year compared to 1.3 patents per 100 individuals per year for non-entrepreneurs (Figure 11).

Entrepreneurs also have a higher count of external patents relative to internal patents. In fact, on average, 37% of entrepreneurs’ patents are external compared to 16% for non-entrepreneurs. Looking at the faculty level among entrepreneurs, the proportion of external patents is the highest in Natural Sciences (46%), and the lowest in Engineering (18%). This result mirrors the fact that a large number of external patents are associated with chemicals and materials, and pharmaceuticals. In turn, non-entrepreneurs have the highest proportion of external patents in Engineering (27%), and the lowest in Natural Sciences (8%).
Figure 11. **Average number of patents per year by faculty and entrepreneurial experience**

EPO patents from 2001 to 2008

![Figure 11](image)

**Sectoral distribution of spin-out companies**

In terms of sectorial distribution (2-digit SIC codes) of the firms founded by Imperial entrepreneurs, the highest number of firms belongs to ‘professional, scientific and technical activities’ (107 firms), followed by companies associated with ‘information and communication’ (54 firms) and ‘human health and social work activities’ (50 firms), and ‘administrative and support service activities’ (20 firms) (see Figure 12).

Among the 107 firms belonging to ‘professional, scientific and technical activities’, 56 (52%) are related to ‘research and experimental development on Natural Sciences and Engineering’; among the latter, 17 companies are supported spin-outs.
RELATIONSHIP BETWEEN ACADEMIC ENGAGEMENT AND COMMERCIALISATION

Engagement and commercialisation activities are positively correlated within individuals (see Table 4). Collaborating within industry and consulting are most highly correlated given the similar types of activities covered. At the same time, these two types of academic engagement are also positively correlated with both patenting and entrepreneurship, suggesting a close affinity between engagement and commercialisation.

Table 4. Correlations between engagement, commercialisation and research record

<table>
<thead>
<tr>
<th></th>
<th>Industry collaboration</th>
<th>Consulting</th>
<th>Patenting</th>
<th>Entrepreneurship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry collaboration</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consulting</td>
<td>0.43*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patents</td>
<td>0.26*</td>
<td>0.16*</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>0.19*</td>
<td>0.16*</td>
<td>0.16*</td>
<td>1</td>
</tr>
</tbody>
</table>

*p < .05. The table correlates the participation (at least once) of individuals in each of the activities.
VALUES AND ATTITUDES OF IMPERIAL ACADEMICS

What do Imperial academics value about their jobs?

In the survey, we asked respondents to indicate the aspects of their jobs as academics that they regard as important. Among the job attributes we listed, some related to ‘extrinsic’ aspects (such as salary and opportunities for career advancement) while others related to ‘intrinsic’ aspects of academic work (such as intellectual challenge and independence). Respondents were asked to rate the importance of each of these factors on a 1 to 5 Likert scale from ‘not at all important’ to ‘crucial’. We conducted the analysis by faculty.

Figure 13 shows that academics attribute very high importance to the independence and intellectual challenge offered by their work. There are, however, some differences across faculties. While researchers in Medicine and the Natural Sciences value job security highly, this is considered important by only slightly over 50% of Business School academics. Medicine Faculty staff stand out with respect to the level of responsibility given to them and the opportunities for career advancement that they consider more important compared to individuals in other faculties.

Figure 13. What Imperial academics value about their jobs

Survey responses to the question: ‘When thinking about your job as an academic, how important are each of the following factors to you?’

[Diagram showing the importance of various factors to different faculties]
FACULTY VIEWS ABOUT IMPERIAL’S MISSION

In the survey, we probed the attitudes of academic staff regarding the College’s mission. We asked respondents to compile objectives by choosing from a given list. First, we asked them to select the objectives that they consider critical to achieve the College mission. Subsequently, we asked them to list the objectives that they believe are important to Imperial’s senior management. Figure 13 illustrates that both lists do not necessarily overlap; the values in this diagram indicate the percentage of respondents that choose a specific objective as important. While staff believe that contributing to worldwide academic advancement (75%) and training highly skilled researchers (71%) – the traditional academic mission of a university – are very important to the College’s mission, they perceive senior management to be relatively more focused on attracting private-sector R&D investment (63%) and commercialising and exploiting research results (53%), in addition to the traditional academic values. Staff with teaching responsibilities (both junior and senior) are, as expected, more concerned than research staff about the educational mission, as exemplified by the objectives of training highly skilled researchers, and improving teaching and learning.

Figure 14. Mission of Imperial College London

Imperial academics’ beliefs about what the College’s objectives are (from survey).
CONCLUSIONS

In this report, we presented evidence from archival and survey data on a wide range of impact-relevant activities by academics at Imperial College London. These activities include on the one hand ‘academic engagement’, by which we mean academics’ collaboration with external, non-academic organisations including businesses, public sector bodies and non-profit organisations. On the other hand, they include ‘commercialisation’ which encompasses patenting and the founding of spin-out companies. In addition to gauging the extent to which Imperial academics are involved in these activities, we also probed their motives to do so, and their perception of the barriers to engagement. Finally, we provide information on what Imperial academics believe is important about their job, and what they believe should be the College’s mission.

WE HAVE UNCOVERED THE EXTENT OF PREVIOUSLY HIDDEN ENGAGEMENT

In methodological terms, our augmented data approach consisted of pooling university-held archival records, data from non-university databases and survey data. By collecting a far larger number of data points for each scientist compared to existing studies, we uncovered a range of impact-relevant activities that commonly remain hidden. Extant work may therefore likely underestimate the volume of impact-relevant activities undertaken by academics.

Specifically, we uncovered three types of activities which are likely to be frequently underreported. First, we found that the number of patents invented by Imperial academics increases by 40% if one adds patents which are not assigned to Imperial but list an Imperial academic as inventor. Second, by comparing survey and archival data, we were able to provide a rare estimate of the volume of personal consulting activities that academics conduct – approximately twice the amount of consulting compared to that routed via the university’s consulting company. This suggests that a considerable share of consulting by UK academics may be going unreported.

Third, we explored academics’ involvement in founding firms by taking account of all firms, rather than merely those facilitated by the university’s technology transfer office and built on university-owned intellectual property. In this way, we established that the number of companies where an Imperial academic is a founding director is a multiple of the companies that are classed as ‘supported’ spin-outs.

We demonstrate that the volume of impact-relevant activities by academics is considerably higher if one connects university records with external data and conducts a complementary survey, rather than relying on university-held records only.

Moreover, by using direct source micro data on industry contracts, we are able to provide an extraordinarily detailed picture of academics’ collaboration with industry. This contrasts with previous work that has gauged the volume of collaboration with industry from survey questionnaires, a procedure inevitably fraught with inaccuracy.
ENGAGEMENT IS WIDE-RANGING YET CONCENTRATED AMONG RELATIVELY FEW HIGH-IMPACT INDIVIDUALS

In Table 5 we provide a summary for each type of impact-relevant activity considered in this report. For each, we report an average value across the whole population of Imperial academics (excluding junior researchers), and the percentage of individuals engaging in it at least once during the studied period.

**Table 5. Summary table of impact-relevant activities**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Measure</th>
<th>Average per person</th>
<th>% of staff involved*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic engagement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaboration with industry</td>
<td>Contracts with firms</td>
<td>£19,897</td>
<td>29%</td>
</tr>
<tr>
<td>Consulting</td>
<td>Days consulted</td>
<td>4.48</td>
<td>41%**</td>
</tr>
<tr>
<td>Advisory boards</td>
<td>Number of positions</td>
<td>0.64</td>
<td>29%</td>
</tr>
<tr>
<td>Civic engagement</td>
<td>Number of talks</td>
<td>1.3</td>
<td>41%</td>
</tr>
<tr>
<td>Commercialisation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inventions</td>
<td>Disclosures</td>
<td>14 per 100 individuals</td>
<td>26%</td>
</tr>
<tr>
<td>Patenting</td>
<td>Patents granted</td>
<td>4.5 per 100 individuals</td>
<td>13%</td>
</tr>
<tr>
<td>Commercialised IP</td>
<td>Licenced patents</td>
<td>0.85 per 100 individuals</td>
<td>4%</td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>Founding directorships</td>
<td>9.6 per 100 individuals</td>
<td>8%</td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>Founding directorships (incl. junior researchers)</td>
<td>3.6 per 100 individuals</td>
<td>3%</td>
</tr>
</tbody>
</table>

All figures calculated on an annual basis for the population of Imperial academics without junior researchers unless otherwise stated.

* The participation rate (% of staff involved) indicates whether an individual has participated at least once in a multi-year period.

** The figures for consulting stem from survey data and apply to 2012 only.

Overall, we can draw the following conclusions.

**Breadth of impact-relevant activities:** Imperial academics engage in a wide variety of activities, including academic engagement with external organisations via contract research, consulting, advisory board membership and civic engagement. They also include commercialisation activities via inventions, patenting, licencing of patents, and entrepreneurship, defined as the founding of companies.

**Correlation between impact-relevant activities:** All activities are positively correlated, meaning that individuals who engage in one of these activities are also likely to engage in the others. All impact-relevant activities are also positively correlated with an individuals’ scientific record (publications adjusted for academic age). This indicates that scientifically more accomplished individuals are more likely to pursue these activities.

The above means that, on an individual level, academic engagement (working with external organisations) and commercialisation (patenting and entrepreneurship) often go hand in hand, with the likely implication that engagement helps academics to develop valuable...
inventions. It is interesting to note that the proportion of individuals who collaborate with industry is broadly in line with the proportion of individuals who file disclosures with the college (26%). However, there is a relative attrition effect with commercialisation as only a third of disclosures are converted into patents, and even fewer are converted into a licence. Therefore, the share of Imperial academics involved in actual commercialisation is significantly lower than involvement in academic engagement (industry collaboration and consulting), attesting to the importance of the latter to the College.

**Motivation for academic engagement:** Imperial academics reach out to external organisations primarily in order to support and drive their research agendas, either by obtaining ideas, accessing resources such as data or materials, and acquiring financial resources for their research. Indeed, the extent of academic engagement and academics’ research records are positively correlated, even though a causal relationship cannot be claimed.

The above is consistent with most Imperial academics’ belief that the College’s primary mission comprises the traditional academic objectives of worldwide academic advancement, training of future academics and furthering teaching and learning. Simultaneously, they perceive Imperial’s senior management to be relatively more focused on the objectives of commercialisation and attracting private sector R&D investment.

**Barriers to academic engagement:** The most frequently perceived barriers refer to the difficulty in finding appropriate partners for collaboration. Engineers specifically report that they have concerns over potential conflicts with partners regarding intellectual property rights. By contrast, for researchers in Medicine and in Natural Sciences, an oft-cited barrier to collaboration is that the nature of their research is not linked with partners’ interests or needs. On the whole, the perceived barriers to collaboration tend to relate to academics’ type of research rather than to transactional difficulties.

Imperial’s policies and support structures appear to be very well suited for supporting engagements as no respondents linked them to any barriers. Respondents also appear to be unaffected by cultural differences between academia and industry, as none indicated a mutual lack of understanding about expectations and working priorities or the short term orientation of industry research as barriers to collaboration.

**Academic entrepreneurship:** Imperial employs a significant number of entrepreneurs, i.e. academic staff who founded a company. Their companies belong to a wide spectrum of sectors, and undertake a diverse range of activities beyond the classic pattern of technology commercialisation, including providing services in various technology areas and health. Consequently, there is no single model of academic entrepreneurship. The highest concentration of entrepreneurial activity can be found in the Business School, Computing, Biomedical Engineering, Clinical Sciences, and Surgery and Cancer departments. It is noteworthy that among the entrepreneurs are many junior researchers (e.g. research associates); they constitute more than a third (39%) of the total number of entrepreneurs. This suggests that young researchers play an important part in overall entrepreneurial activities at Imperial, and most likely also reflects the sharing of entrepreneurial exploitation within the Imperial research teams.
**Concentration of impact-relevant activities:** Participation in both academic engagement and commercialisation is relatively skewed, meaning that relatively few individuals are responsible for the majority of these activities. The top 10% of individuals are responsible for 90% of all income from research contracts, and 98% of consulting routed through the College’s consulting company. While 13% of individuals have a patent in their name, only 4% of individuals had their patent licenced.

**IMPLICATIONS FOR UNIVERSITY MANAGEMENT AND POLICY**

Our findings have several practical implications.

First, while many of the activities undertaken by Imperial College London academics described in this report result in social and economic impact, it is important to note that engagement (industry collaboration and consulting) particularly is often pursued synergistically with individuals’ research agenda. In other words, on average, surveyed Imperial scientists believe that the decision to engage with industry should be strongly informed by complementarities with their research.

Given this potential dual benefit of engagement for both impact and academic research, one may argue that research-intensive universities especially should put a particular focus on exploiting complementarities of engagement with academic research. Rather than encouraging engagement only for the sake of impact, dual purpose engagement (resulting in both academic and economic/social impact) represents a win-win situation where the academic logic remains uncompromised. From this viewpoint, firms should be seen as true collaborators rather than ‘clients’ and be involved in terms of engagement that emphasise the dual purpose of pursuing both academic and industrial aims.

Second, we found a concentration of impact-relevant activities among relatively few ‘high-impact’ individuals. As a general rule, senior, highly scientifically productive men are responsible for most of industry collaboration, consulting, advising, patenting and entrepreneurship in the College. This is partly a natural consequence of how high-achievers in senior positions operate and partly a result of a common cycle of academic careers, according to which junior individuals privilege scientific production and senior individuals proceed to ‘exploitation’. However, action could be taken to broaden participation in the kind of activities that we described in this report. This is particularly pertinent in light of the above point relating to the dual benefit of engagement. If, and only if, engagement actually has the potential to further scientists’ academic productivity, encouraging the broadening of participation would make sense for a research-driven institution.

Third, our project has demonstrated the value of pooling information from various sets of archival records at Imperial College London. For instance, by sharing information on academics’ resource acquisition (industry contracts, grants, consulting) with records on publications and commercialisation outcomes (patents, licences, firms) it is possible to relate inputs to outputs over time without having to rely on individuals’ self-reported information, as is the case with research councils’ ‘Researchfish’ system. Importantly, by linking university records with external databases on firms and patents, we also demonstrated that impact-relevant activity at universities may be significantly higher than commonly reported by universities themselves. By
implication, this means that the figures reported nationally via the HEBCI (Higher Education Business and Community Interaction) survey are likely to underestimate the extent of activities being pursued at UK universities as these figures are based on universities’ own records. Policy-makers need accurate estimates of the frequency of engagement as well as information on who engages and why. In this respect, the methodology that we applied in this study can inform a larger-scale implementation of engagement and commercialisation measurement.
APPENDIX: RESEARCH METHODS AND DATA

INITIATION AND STAKEHOLDERS

The TRIC database was created in 2011 with the support of the College’s Management Board, and approval from the Research Ethics Committee. Subsequently, the research team obtained the support of the Information and Communication Technologies (ICT) department, part of the College’s Support Services function, in building the technical infrastructure for the database and populating it with data from across the College. Throughout the project, the ICT department played a central role as the technical owner of the database. The research team also sought and obtained assistance from the Human Resources department, the Research Office, Imperial Innovations, Imperial Consultants, the Research and Academic Support Team, the Finance division, the Development & Corporate Affairs team, and the legal team.

PRIVACY AND ETHICS

Privacy. Accessing information about individuals raises data protection and privacy issues. The data stored within a University’s personnel database is ‘Personal Data’ and thereby covered by the UK Data Protection Act. The Research exemption stated in section 33 of the Data Protection Act is narrow and does not give any exemption over compliance with the first data protection principle (‘personal data shall be processed fairly and lawfully’).

Accordingly, all current staff were informed about the use of their data. All academic employees were sent an email explaining the research project and how their personal details were to be used (for research only). Moreover, staff were informed that their personnel data would be linked with other databases held by the College, such as information on grants and contracts, intellectual property (inventions, patents, and licences), publications, etc. They were also assured that no information classed as sensitive in the way defined by the Data Protection Act 1998 was to be stored in the database. This means no information on individuals’ religious beliefs, sexual orientation, or health was used.

Individuals were also given the chance to opt out of the research project via a dedicated webpage designed to record such requests. A total of 11 individuals chose to opt out, and their details were consequently removed from all the TRIC data tables.

The research team assured participants that the research was to be conducted in full independence of any interested party, including the management of the College.

Data management. In order to safeguard individuals’ privacy, a series of measures were taken to ensure data confidentiality and safety.

The ICT team acted as data owners and performed the anonymisation of the dataset. As the various data tables were imported from the systems owned by various administrative departments, individuals’ direct identifiers (names, email addresses, College Identification Numbers = CIDs) were replaced with an anonymous unique identifier (‘encrypted CID’). This ensured that the data used by the research team contained no names. Simultaneously, it
enabled the ICT team to convert the encrypted CIDs back to individuals’ identity by maintaining a key. This was important when additional data, such as survey results, had to be added to the dataset. In this case the encrypted CID was used to associate the new information with the correct individuals in the database. The key for this procedure was kept by the ICT team, and not disclosed to the research team or other parties. In addition, the ICT department was responsible for authorising individual researchers to access the database that was securely housed on Imperial ICT servers.

Despite anonymisation, information in the TRIC database could potentially be used to deduce details on specific individuals. Therefore, all the stakeholders were ensured that information that could potentially identify individuals would not be published in any form. Results would only be reported in aggregate form, as arising from the statistical analysis.

### DATA OVERVIEW

The TRIC database captures individual-level information on the full population of approximately 10,000 academics, including postdoctoral researchers, employed by Imperial College London during the period 2001 – 2011. For a summary, see Table 6.

The data infrastructure was developed from Imperial’s administrative records in collaboration with several administrative departments. The TRIC database represents one of the most detailed archives of academic scientists compiled for research purposes. TRIC includes information on all grant applications and awards for all individuals acting as investigators as well as the postdoctoral researchers associated with them. The recorded awards include grants and donations, given by various types of research funders both in the UK and abroad. They also include information on all research contracts acquired by academics, stemming from collaboration with business, public-sector and non-profit organisations. Furthermore, the data contains individuals’ publication records, invention disclosures, patents, courses taught, and the supervision of PhD students. Each individual record also includes demographic and Human Resources related information.

Specifically for Medical Research Council grants (MRC), the database includes detailed information on research outputs that are recorded by the MRC via its ‘Researchfish’ (previously ‘e-Val’) system. With a few exceptions, all of the above data varies across time for individual researchers (with some time series starting in 2005), allowing for longitudinal panel studies.

A survey among all Imperial staff was carried out in October 2013 to capture data not available from records of academics affiliated with the College at that date.

To retrieve additional information on entrepreneurial and patenting activities, we linked the TRIC records with the FAME and AMADEUS databases – containing information on UK and European public and private companies – as well as the European Patent Office database.

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10 For similar efforts see Dahlander and McFarland (2013) on Stanford University, and Bolzani, Fini, Grimaldi, Santoni, and Sobrero (2014) on the population of Italian STEM Universities.
Publications

We retrieved information on individuals' journal publications using Symplectic, a software application that stores details on publications and other professional activities. The application was introduced in 2004 for the Faculty of Medicine, and in 2006 for the rest of the College. Symplectic automatically retrieves publication information from a variety of bibliographic databases, including Web of Science and PubMed. By default, Symplectic searches for publications that match an individual’s surname and initial. In order to perform name disambiguation, Symplectic establishes how common a surname-initial combination is by comparing it with the entire list of names from the US census. For common name combinations, it selects those publications that show an association with Imperial College London and its associated entities in the ‘affiliation’ fields of the bibliographic databases.

Table 6. Data overview

<table>
<thead>
<tr>
<th>Data</th>
<th>Source</th>
<th>Owner</th>
<th>Observation period</th>
<th>Records</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics and employment</td>
<td>Human Resources</td>
<td>Imperial</td>
<td>01/01/2001 to 10/10/2013</td>
<td>9,874 employed individuals (10,899 including survey)</td>
</tr>
<tr>
<td>Publications</td>
<td>Symplectic</td>
<td>Imperial</td>
<td>01/01/1949 to 18/09/2013</td>
<td>214,000</td>
</tr>
<tr>
<td>Grant applications</td>
<td>InfoEd (Research Office)</td>
<td>Imperial</td>
<td>01/01/2001 to 18/09/2013</td>
<td>33,000</td>
</tr>
<tr>
<td>Grants and contracts</td>
<td>Grant Management System (Research Office)</td>
<td>Imperial</td>
<td>01/01/2001 to 18/03/2014</td>
<td>10,000 grants, 3,600 contracts, 200 donations</td>
</tr>
<tr>
<td>Intellectual property</td>
<td>Wellspring (Imperial Innovations &amp; Research Office)</td>
<td>Imperial</td>
<td>01/01/2001 to 22/11/2013</td>
<td>4,100 disclosures, 1,200 patents (368 EPO patents)</td>
</tr>
<tr>
<td>External patents</td>
<td>European Patent Office</td>
<td>EPO</td>
<td>31/03/1983 to 10/10/2008</td>
<td>145 EPO patents</td>
</tr>
<tr>
<td>Consulting</td>
<td>Imperial Consultants</td>
<td>Imperial</td>
<td>01/01/2004 to 1/12/2011</td>
<td>2,700 contracts</td>
</tr>
<tr>
<td>Teaching</td>
<td>SOLE system</td>
<td>Imperial</td>
<td>01/01/2007 to 1/01/2012</td>
<td>83,000 courses</td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>FAME and AMADEUS (data from Companies House)</td>
<td>Bureau Van Dijk</td>
<td>08/10/1988 to 1/01/2012</td>
<td>507 spin-out firms</td>
</tr>
<tr>
<td>Research project outcomes</td>
<td>Medical Research Council ('Researchfish')</td>
<td>MRC</td>
<td>01/01/2001 to 1/01/2012</td>
<td>255 projects</td>
</tr>
<tr>
<td>Engagement, work-life balance, academic practice</td>
<td>Survey of all Imperial academics, Sep 2013</td>
<td>Imperial</td>
<td>10/10/2013 to 20/11/2013</td>
<td>3,148 responses (1,909 from employed staff)</td>
</tr>
</tbody>
</table>

Symplectic subsequently provides the list of retrieved publications to each Imperial employee for ‘approval’. Once individuals confirm publications as their own, they appear on the ‘publications’ section of individuals’ public personal Imperial webpages. If publications are missing, individuals can manually add those to their public list of publications and, by implication, to the Symplectic database. This feature of the Symplectic process ensures that
the overarching majority of publication records are vetted by their respective authors. The publication records contained in Symplectic can therefore be considered more accurate than those harvested purely on the basis of automatised name disambiguation algorithms.

An issue potentially affecting the accuracy of the Symplectic database is that a number of individuals have no publications on their records. This may be because they effectively do not have any publications or because they may have never approved Symplectic’s automatically retrieved list. This issue, however, is mostly confined to junior researchers (research associates, research assistants) who often may not have activated their own personal webpage.

Symplectic also does not retrieve publications for individuals once they have left the College. Between 2002 and 2012, about 1,500 academics, with at least one publication already stored in Symplectic, left the College. For those individuals we created a list of publications since their departure from the Scopus bibliographic database and added this information to the TRIC database.

**Awards (grants, contracts, and donations)**

The College maintains two systems for administering awards (grants, contracts, and donations). One system, InfoEd, is used for administering the grant application process, while GMS supports the administration of the projects once funding has been provided. Both systems have been fully operational since 2004 and have been fed into our database. The records contain full information on all funded and non-funded awards, including the identity of principal and co-investigators, individuals employed, identity of the sponsors, financial details, duration, and so on.

**Grant outputs (external data)**

We matched the TRIC database with output data from the UK Medical Research Council (MRC)-funded research projects led by Imperial principal investigators. The output data is recorded via MRC’s e-Val system (today absorbed into ‘Researchfish’) and builds on annual reports of grant outputs submitted by each grant recipient, over the grant duration and after its termination. Records include project outputs, such as publications, IP and licensing, products and interventions, influence on policy and practice, spin-out firms, awards and recognition. Data refers to 255 projects started between 2001 and 2011.

**Disclosures**

Imperial’s database maintains a database called Wellspring, documenting the inventions disclosed to the College’s Research Office which stores information on:

- The inventor
- The invention, such as the disclosure date, whether the technology has originated any IP, the type of IP and whether the technology is linked to a spin-out;
- Agreements linked with an invention, with information including agreement start and termination date, the type of agreement, involved parties, etc. Agreement types include, for example: Funding Agreement, Licence, Clinical Trial, Confidentiality Agreement, Consultancy and Collaboration

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Accounting for Impact at Imperial College London 39
Patents

The Wellspring system contains information on all patents based on technologies disclosed to the College’s Research Office. These patents are assigned to Imperial and, for the purpose of this report, are labelled as ‘internal patents’.

We also retrieved information on ‘external patents’, i.e. patents invented by Imperial researchers yet not assigned to Imperial, by using the database of the European Patent Office. To uniquely identify these external patents that are not recorded via Wellspring, we implemented the following four-step procedure.

First, using the Symplectic bibliographic database, we compiled the list of authors with an Imperial affiliation between 2002 and 2012, identifying their name, last name and middle name. Second, we used the APE-INV Database (www.esf-ape-inv.eu), which contains name-disambiguated information for all EPO-patent holders up to 2008, to compile a list of EPO inventors with a UK address. Third, we manually matched the two lists of authors and inventors using as linking fields the name, middle name and last name. Fourth, in order to remove false positives (i.e. those inventors who share their name with Imperial academics), we employed a two-step matching procedure. We first verified whether any keywords from the titles of individuals’ journal publications, grants or existing internal patents matched a key word in an EPO patent. We then matched the academics’ research area to the patent’s research domain.

If both steps resulted in a positive match, we counted the EPO patent as an external Imperial patent, i.e. a patent invented by an Imperial academic yet not assigned to Imperial, and linked the patent to the individual’s encrypted CID in our database. As a final step, we retained only those patents filed when the inventor was employed at Imperial. In this way, we identified 145 EPO ‘external patents’ filed between 1983 and 2008 by 66 Imperial academics. The list obtained via the above procedure represents a highly accurate picture of external patenting at Imperial, with the limitation that we capture EPO patents only.

Entrepreneurship and directorships

We collected data on directorship positions held by Imperial academics, cross-referencing each individual on the Bureau Van Dijk’s FAME and AMADEUS databases. FAME stores longitudinal, multilevel information on 3m public and private UK and Irish companies, whereas AMADEUS includes information on 11m European companies. Both systems include time-variant data on shareholders and directors since incorporation.

Consulting

The database contains information on consulting activities by Imperial academics between 2004 and 2011. Each contract includes information on start and end dates, description of the job, the identity of the client, as well as the total project value. The information is linked to the other college repositories via individuals’ unique identification number.
SURVEY

We carried out a survey of Imperial academics to gather the views of College staff on essential aspects of academic life. The survey focused specifically on information not contained in College records, such as attitudes, informal activities, and work patterns. The survey also sought to create synergies with UK-wide surveys of academics previously carried out by our research group (Salter et al., 2010).

The data was collected through an online questionnaire administered to the full population of Imperial academics in September 2013. The survey went live on 10 October 2013 and was closed on 20 November 2013, comprising 6,639 individuals registered by Imperial’s Human Resources Division as either employed academic staff (3,725 individuals) or ‘associates’ (visiting researchers, adjunct professors, honorary academics, etc.).

The survey questionnaire contained five sections:

Academic engagement: This section focused on individuals’ reasons for pursuing academic engagement, the frequency and form of engagement activities, and perceived barriers. The section builds on questions and scales used previously in UK-wide surveys of EPSRC investigators in 2004 (D’Este & Perkmann, 2011) and 2009 (Salter et al., 2010).

Academic practice: Here we asked respondents about the perceived importance of specific job characteristics that we replicated from the National Science Foundation’s Survey of Doctorate Recipients. Furthermore, building on Campbell and colleagues (2002) and Blumenthal, Campbell, Anderson, Causino, and Louis (1997), we requested information on data and information sharing behaviours among academics.

You and Imperial: This set of questions explores how individuals perceive Imperial as an organisation and what they believe the organisation should ideally be. The questions build on the ‘Pathways to Impact’ typology proposed by Research Councils UK and was constructed in accordance with the work by Foreman and Whetten (2002) on multi-identity organisations. An additional question explores individuals’ degree of identification with Imperial as an organisation, based on an instrument proposed by Bergami and Bagozzi (2000).

Family and work-life balance: One question probed the effect of family life on the academics’ work, following a scale used by Netemeyer, Boles, and McMurrian (1996). Building on Rhoads and Rhoads (2012), a second question asked about the division of labour in academics' households while the youngest child was under school age. Additional questions concerned work patterns (full/part-time), spouse occupations, children and commuting times.

Personal background: This section requested information on academics’ training and previous work experience. A final question covered the extent to which an individual’s career was aided by a senior person, building on items developed by DiTomaso, Post, and Parks-Yancy (2007).

The survey was administered via a web-based survey software application developed within our team. Before launching the survey, we conducted a pilot to test the comprehensibility and appropriateness of the questions and gain feedback on the usability of the survey tool. We contacted 18 researchers at Imperial and other universities and asked them to respond to the
draft questionnaire. We received written feedback from 12 researchers and observed four additional researchers while they were responding to the questionnaire, documenting their comments and subsequently discussing any problems. We used this feedback to optimise both the content of the questionnaire as well as the technical aspects of the survey tool.

The survey invite was sent to individuals on behalf of their respective faculty deans. The invitation email explained the purpose of the study and contained links to the survey as well as a webpage providing detailed background information on the project and FAQ list. After two weeks we sent a first reminder and after another ten days we sent a final reminder. This procedure generated 2,921 responses. A telephone follow-up addressed to all non-respondents employed in an academic role (excluding non-employed ‘associates’) increased the number of responses to 3,148. For our most relevant population of 3,725 employed faculty members, we received 1,909 usable responses (i.e., at least one question was fully answered), giving a response rate of 51%.

We conducted an analysis exploring whether non-response biased our sample compared to the targeted population. To do this, we examined whether key characteristics, including individuals’ gender, faculty affiliation and job position, differed between respondents (1,909) and non-respondents (1,816) (see Table 7). In the sample, women are slightly underrepresented, with a significant difference between respondents and non-respondents ($p < 0.05$). Regarding faculty affiliation, in the sample Engineering and Natural Science academics are overrepresented, and Medicine academics are underrepresented. Again, the difference between respondents and non-respondents is significant ($p < 0.005$). Equally, we have a significant difference between respondents and non-respondents concerning their job position ($p < 0.005$), with senior faculty being considerably overrepresented.

Table 7. Comparison between population and respondents

<table>
<thead>
<tr>
<th></th>
<th>Population %</th>
<th>Respondents %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>33%</td>
<td>31%</td>
</tr>
<tr>
<td>Medicine</td>
<td>42%</td>
<td>35%</td>
</tr>
<tr>
<td>Business</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Engineering</td>
<td>29%</td>
<td>34%</td>
</tr>
<tr>
<td>Natural Sciences</td>
<td>25%</td>
<td>28%</td>
</tr>
<tr>
<td>Senior Faculty</td>
<td>20%</td>
<td>29%</td>
</tr>
<tr>
<td>Junior Faculty</td>
<td>16%</td>
<td>19%</td>
</tr>
<tr>
<td>Senior Researcher</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Junior Researcher</td>
<td>61%</td>
<td>49%</td>
</tr>
</tbody>
</table>
REFERENCES


