

Submission to National Endowment for Science Technology and the Arts

“Measuring Innovation in the UK”;

Strand 1

“Innovation growth accounting”

**Bid by Imperial College Business School
and
UK Office for National Statistics**

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This proposal follows the headings in the NESTA Guidance Notes. Supporting Annexes set out more details, including a point-by-point commentary on how our proposal relates to the requirements in the Research Brief and to the scoring criteria.

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1) An introduction to and credentials of our work/organisation.

Jonathan Haskel is Professor of Economics at Imperial College Business School. He has worked to create the ONS microdata lab and, in the last two years, on intangible assets, innovation and economic growth. He has worked on secondments to the UK Treasury and the UK Office of National Statistics (ONS). He is on the editorial panel of *Economica*, and a member of the UK Competition Commission. He is Director of CeRiBA, a research centre based on microeconomic analysis of ONS business data focusing on productivity issues. HM Treasury in 2006 funded Jonathan to develop the first UK innovation and growth accounts, including intangibles. NESTA in summer 2008 funded Jonathan to repeat this exercise at industry level. Jonathan is currently working with Charles Hulten and Carol Corrado on comparison of US and UK spending on intangibles and productivity, and leading an 7 country EU funded project on international comparisons.

Imperial College Business School is a top-rated Business School, part of the world-renown Imperial College, London. In the just-published RAE, Imperial came joint first (with the London Business School) for the percentage of research activity assessed as world-leading or internationally excellent (4* and 3* work combined). The School has extensive experience of running successful research projects; this project would fit well with the ESRC-funded Innovation Research Centre, newly established at Imperial and Cambridge. The depth of comments and expertise available at Imperial will benefit the project. Since its foundation in 1907, Imperial's contributions to society include the discovery of penicillin, the development of holography and the foundations of fibre optics. In the new RAE, 73% of staff had research judged world-leading or internationally excellent, the highest percentage of any UK multi-faculty university.

Tony Clayton is Deputy Director, Economic Interpretation at ONS, leading a team of economists in micro and macroeconomic analysis. He has led projects including new estimates for software investment in National Accounts, estimates of R&D capital to meet new SNA requirements, and a series of UK and international studies on impacts of ICT investment and use. Most recently he led a 13 country project linking micro and macro analysis, and showed the central importance of ICTs at all stages of the innovation process. Tony is chair of the OECD's Working Party on Indicators for the Information Society, leading development of international indicators, and a contributor to OECD's advisory board on S&T Indicators. Before joining ONS, Tony was Director at business research firm PIMS Associates, working on innovation and growth strategies for major international clients. He led early work to develop the EU Lisbon Strategy, and a series of studies on the role of intangible assets in competitiveness and growth. He has a first degree in physics, and a masters in economics.

The Office for National Statistics is the independent government department, under the UK Statistics Authority, to provide rigorous, trusted, evidence on the development of society and the economy. It conducts internationally agreed firm level surveys on R&D, ICT use and innovation, working with DIUS, BERR and other government departments to meet policy needs. ONS compiles the UK National Accounts, and contributes to international development of NA concepts to keep pace with the changing structure of economic activity. ONS economists have a leading role in international institutions working on the incorporation of intangible assets into national accounts, including the current OECD task force on capitalisation of R&D. ONS has pioneered new questionnaires to elicit data from firms on service innovation, and (with NESTA) on firm investment in non-technical innovation expenditure.

2) One-page summary of our approach

Over the past couple of years Jonathan Haskel, Tony Clayton and colleagues have worked together to develop measures of intangible spending, fit the measures into national accounts and organise them in a growth accounting /productivity framework for the market sector. We are now in a position to (a) relate the work explicitly to innovation and (b) develop such work to greatly improve robustness.

We described in detail the growth accounting – innovation links in section 1 of our NESTA summer paper and related it to existing measures. Here we briefly summarise our theoretical arguments. Our argument starts from asking: how an economy generates growth and new goods *without* innovation? The answer is to use the same ideas, but duplicate existing capital and labour inputs. Ryanair could fly more passengers on an existing route by simply buying another airplane and hiring another set of crew. McDonalds could sell more food by opening at another location buying more cooking equipment and hiring another set of staff. In both cases outputs increase in line with inputs, but no further. *Thus innovation is not just the production of more goods, but the production of more goods over and above that which would occur with simple duplication of existing labour and physical capital.*

Our NESTA summer paper shows how this approach helps clarify many of the existing definitions. It concludes what needs to be measured, which is what our project will do: the spending by firms on new knowledge; we term this *innovation accounting*) the contribution to growth of such knowledge spending and freely available knowledge inputs; we term this *growth accounting* and envisage that the index will be the fraction of total growth due to new knowledge inputs.

We have demonstrated that such analysis can be done. We measure spending on knowledge assets used by Corrado et al, similar to categories used by Competition Commission calculating intangible assets for competition analysis. These are

- (a) computerised information (mainly software),
- (b) innovative property (mainly scientific R&D and non-scientific R&D, design, spending on artistic originals and innovation spending in financial services)
- (c) firm competencies (company spending on the following dimensions of capital: reputation, human and organisational capital).

Our proposal here will address material gaps in knowledge about the most economically significant assets, so we concentrate on software, design, financial services and human and organisational capital. We will prioritise our work by gathering data where the biggest expenditures on knowledge are least well quantified. Thus we shall

1. Run an “extended” R&D survey to obtain
 - a. more complete data on the major knowledge spending categories of software, design, human capital, organisational capital
 - b. more data on life lengths
2. Convene “industry fora”, as successfully used in ONS software work, to test definitions of innovation investment, and to gain more details of occupational time use and in-house spending on design, financial services and managerial time use. These fora will also inform our survey work.

We will use the information from these new sources to structure existing ONS and other data over 20 years into an innovation accounting framework, and a growth accounting framework, measuring innovation effects, which can be repeated for future years.

3) Supporting argument

The supporting argument is given more fully in our Summer paper for NESTA. Here we comment on two main points: (a) our measure of innovation and (b) why we have chosen the particular areas to focus.

On the question of our choice of innovation index, there are three main current approaches to such an index. The first is to propose a definition of innovation and then produce an index. Thus far there are plenty of proposals but rather fewer implementations. Annex 1 includes a summary of the definitional standards for innovation used internationally. The second approach is the reverse, namely to calculate an index and assume (explicitly or implicitly) it is related to innovation. The EU innovation scoreboard is an example of this. The third is to suspend the notion of an index altogether and do something else (Innovation Measurement, US 2008).

Our proposal is the following. Our innovation measure is the contribution of investment in knowledge or intangible capital to GDP growth. We argue that this contribution results from spending on knowledge/intangible assets and from TFP growth.¹ Thus our measure of innovation is the growth in GDP over and above that growth due to additional physical capital and labour. Thus we argue that our innovation measure is not only methodologically superior but theoretically it views innovation holistically. For instance, NESTA (2007) propose “change associated with the creation and adoption of ideas that are new-to-world, new-to-nation/region, new-to-industry or new-to-firm”. We operationalise in economic terms what change is. Annex 1 sets out more details on how our measure relates to other definitions.

We have decided to focus on particular knowledge assets, shown in the following table:

Intangible investment type	Includes the following intangibles	Focus of work	Deliverable
<i>Computerised info</i>	(1) Computer software	Develop existing ONS work	<i>data</i>
<i>Innovative property</i>	(1) Scientific R&D	Develop existing ONS work	<i>data</i>
	(2) Mineral exploration	<i>Rely on existing ONS work</i>	<i>data</i>
	(3) Copyright and license costs	<i>Rely on existing ONS work</i>	<i>data</i>
	(4) New product developmt costs in financial services	Small occupational study using ASHE with information from Conference Board / NSF	<i>forum and data</i>
	(5) New architectural and engineering designs	Administer questionnaire via Design Council /Imperial. Analyse Design Council data.	<i>forum and data</i>
	(6) R&D social science	<i>Rely on existing ONS work</i>	<i>data</i>
<i>Economic competencies</i>	(1) Brand Equity	Literature search using existing data and scoping with marketing experts	<i>scoping and review note</i>
	(2) Firm-specific human capital	Incorporate existing data via DIOS. Cross check with other data sets. Recommendations for new data collection.	<i>survey, data and review</i>
	(3) Organisational structure	Small scale managerial time use survey.	<i>forum, review and data</i>

The first two columns consist of the intangible assets that we will focus on, following Corrado et al (2004, 2006) and discussed extensively in Annex 1 to our Summer NESTA paper. In the third column we set out what work we shall do on each asset in this project.

We have prioritised our bid to address the main gaps in the intangible growth accounting area as follows.

1. we shall not spend time on small items (minerals, copyright, social science).
2. the main spending is on software, R&D, design spending, financial services, marketing, human capital and organisational capital; of these, ONS has tackled software and R&D, with some improvement possible.

¹ If necessary we can also add investment by workers into human capital into the innovation index.

3. advertising is stable and does not appear a major contributor to growth

This then leaves the following areas. First, we shall run an extension to the traditional R&D survey. We have piloted such a survey (with NESTA support) and have obtained initial promising results. The purpose of the survey is (a) We ask firms for data on both their “technical” R&D, and their “non-technical R&D”, where the latter group contains data on spending on the major intangibles (b) the survey also asks for data on service life lengths for these expenditure categories. This is innovative because no such data on service lives exists for the UK and the CIS questions on some intangible areas have a low response rate, especially for larger firms and omits some intangibles categories.

Using the data from the extended R&D survey is part of our data gathering effort. The second part is to run industry fora to understand better some of the crucial parameters that we use for particularly own-account and expenditure/investment data. This follows the software method, which is the following. To estimate purchased software one runs a purchasing survey. To get own account software one goes to the labour force data, identifies the wage bill of occupations that create long lived software, estimates the fraction of time they spend on such activities, estimates the other production costs necessary besides wages, and applies a life length to the software they create.

To apply this to other assets, the information we need from industry fora are:
 an expert view on the typical occupation titles of their knowledge asset creating workers, in e.g. design, organisational capital building and financial services.
 estimates of the fraction of time that they spend on such activities.
 data on the associated costs besides wages for production
 finally, we need data on the life lengths of the knowledge products they make.

We propose to run such fora to answer these and other questions for the following assets. First, we have been in contact with the Design Council to explore design investment and have an agreement in principle to proceed. We also propose to explore contacts at Design London via Imperial College which has a dedicated design research group closely associated with Design London.

Second, we wish to explore financial services. This is an area where measurement conventions have been stress tested to the limit by recent events. We will use the results of US work which attempts, by interviews, to see in what occupational groupings knowledge workers reside. We aim to convene an industry forum in the UK to explore this, using contacts at ONS, the Competition Commission (who have worked extensively on banking and financial services) and the FSA.

Finally, we will explore organisational capital building by senior managers, - the extent to which they spend time on issues that differentiate organisational capital of good from bad companies and develop innovative business processes. We have approached the CBI to continue discussions on this theme, which started last year, and the IoD has indicated that we can build on their survey work.

In principle the framework we have developed, and will improve here for the market sector, is applicable to the public sector. Practical implementation depends on the accuracy with which statistics measure real inputs to and outputs from government activity, for most of which market based valuations are not directly available, and our ability to identify knowledge investment. The UK Centre for Measurement of Government Activity (UKCeMGA) at ONS leads in developing measures to assess outputs related to government expenditure, and applying multifactor productivity analysis for specific public services. We will work together to assess how far the approach can be taken.

4. Costs, timescale, deliverables

Our costs are summarised in the following table, and resources described below.

We shall recruit to the project (by line above):

- 1) Four economic advisors based at ONS with expertise in human capital (Richard Jones), economic methods (Khalid Khan), public sector productivity (Mike Phelps) and management of major analytical projects involving intangibles (Mark Franklin). Richard, Khalid to contribute 20% of their time, Mark, Mike 10%,
- 2) The equivalent of one full time assistant economist at ONS whose work will focus on the review of deflators and expenditure data sources, assembly of datasets and the development of macro estimates from micro data sources. This work will be started by Peter Stam, who has worked over the last year with Professor Eric Bartelsman on a 13 country international project on ICT impacts, applying these skills. Liaison with ONS National Accounts will be an important part of this work
- 3) A research economist at Imperial College working on the development of growth accounting models, testing the use and effects of alternative datasets and assumptions, and integrating the available sources to specify the innovation measure
- 4) Administrative and accounting support from Imperial College, to handle financial and cost accounting for the project, and administrative support for the fora
- 5) 10% of time for Tony Clayton, to provide expertise and management for the ONS input to the project, chair the internal project board, and lead government dissemination
- 6) 20% of time for Jonathan Haskel, to drive methodological development and liaise with key industry stakeholders and academics in the UK , US , EU and elsewhere, lead the industry fora, and dissemination to academia and policy audiences
- 7) Resources to conduct an extended R&D survey which could come from ONS, as an extension to the 2009 R&D survey, led by the head of ONS innovation surveys building on the 2008/9 pilot , or from Imperial College Business School, drawing on research assistants to contact firms using input from ONS experience
- 8) Imperial and ONS resources to run three workshops / fora to pool expert industry knowledge on treatment of inputs to design, financial services and business process / organisation innovation; we shall use Imperial facilities and pay travel expenses. As

follow on from the process / organisation workshop we aim to run a short pilot survey on management time use, which could inform the extended R&D survey

The justifications for these costs are as follows. To do growth accounting one also needs all the data on tangible assets, qualifications of the labour force and market-sector value added. We believe it would require at least a person and a quarter at ONS to update the spending categories, examine options on sources and deflators for different types of innovation investment, liaise with National Accounts and put the data structure and software in place to enable relatively updating with successive revisions of the data. They would have to be supervised by at least one-quarter time person in the organisation and a quarter of someone's time outside who has experience doing this work. This would be needed for the duration of the project. Jonathan Haskel and Tony Clayton will lead the work, with Jonathan focusing on methodology development, academic input, and supervision of a full time researcher at Imperial College

Turning to deliverables, we have two main deliverables as set out in the NESTA request, namely the initial estimate in September 2009 and the index in September 2010. Deliverables and timescale are shown in the chart on the next page on activities required to achieve NESTA's objectives. Our work on new sources will focus on methods and definitions to specify the index. We do not have time or resource to undertake new survey work on deflators but will take advantage of developments in service price indices by ONS and other national statistics offices. This is in line with international practice, which uses, with few exceptions, deflators available from existing sources.

Second, timing. For the deliverable in September 2009, we should have first look at the Blue Book in June 2009, which will give data up to 2007. Thus the initial version of the index will be up to 2007. That will use data for as many assets as possible up to 2007, which will be tangible assets, labour market-based data and R&D. Other assets, such as training, may need to be interpolated. For an interim deliverable in 2009, most intangible spending categories would be based on existing data sources, supplemented by the pilot 'extended R&D survey', and assumptions and would be available for the whole economy.

Software, R&D, financial services, minerals and copyright would be updated based on whatever contemporaneous data exists. Design, advertising and market research would have to be updated using the 2007 ABI. Training depends if such surveys have been updated (but additional waves of training surveys should improve on previous work) and organisational change data on developing use of the ASHE data. These measures will be based on the existing method, set out in the Summer 2008 NESTA report, retaining our existing assumptions but updating the index to the most recent period. We will aim to use the outputs of industry fora to improve working assumptions on the inputs to the spending categories of the index. We will also update all the other measures, such as spending on tangible investment, breaking the labour force down into skills and calculating market sector output in order to calculate the growth contributions of the intangible assets (which depend endogenously on those contributions of the other assets too). Reconciling this with existing ONS data will require a lot more work as National Accounts methods have changed this year.

For September 2010, we aim to be using data up to 2008. But the major contribution will be full use of data collected from industry fora and a fully developed extended R&D survey, on definition, expenditure and depreciation of knowledge assets. We would be able to use, for this deliverable this additional important data, as well as a review of deflators.

We see engagement with industry as an important anchor for the dissemination part of the project, to establish its credibility outside the academic economist world. Our engagement with CBI and IoD gives us a platform to build on, and our principle deliverables are set out in Annex 4. The other deliverables would be sensitively analysis, production infrastructure, a short review on application to the public sector.

Deliverables and timescale	1st deliverable								2nd Deliverable								Internal allocation of tasks				
	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10		Jun-10	Jul-10	Aug-10	
<i>Growth Accounting Production Tasks</i>																					
Method/assumptions to demark what is innovation and what is not, when estimates are derived from broader investment measures.																					Workshops/ONS/IC , MTU
Conceptual demarcation of investment in innovation and investment in business process																					Workshops + ONS + IC
Economic framework: Growth Accounting and TFP Contribution																					IC + ONS
Methodologies/assumptions that justify the treatment of issues including price deflators, depreciation and obsolescence.																					IC + ONS
Provide analysis of UK innovation performance, highlighting areas of weakness and strength.																					IC + ONS
Growth Accounting estimates production																					IC + ONS
Conduct a sensitivity analysis of different assumptions using appropriate techniques.																					IC + ONS
Provide a full set of index production infrastructure i.e., spreadsheets and databases containing data series used to construct these estimates. With a production manual for the future producers.																					ONS + IC, ext R&D survey
<i>Spillover Tasks</i>																					
How these metrics can be used to benchmark UK's innovation performance, for instance across countries over time.																					ONS + IC, (FP7)
Assess how the framework might be extended to produce estimates for investment in innovation in the public sector.																					Mike Phelps/ONS
Collaboration with other research teams working on the Index project.																					ONS + IC
Engagement with industry to guide and validate approach assumptions and findings and dissemination of results.																					ONS + IC

Notes: IC = Imperial College; + shows jointly done

5) Summary of relevant experience

Section 1 outlines our previous work in this area, which is also referred to in Section 3. It is worth emphasising three main points.

The team making this bid has developed most of the practical implementation of intangibles accounting in the UK over the last three years; we have consulted widely with government through GES and other presentations, with industry through CBI and IoD, and with academia, supporting a special session at the 2008 Royal Economic Society conference at Warwick. This has exposed us to critiques of the approach, and these challenges have helped shape the work programme we propose.

The combination of methodology development by academic teams and access to official data through ONS has been central to our relationship since 2001. Over this period work by Jonathan has helped to improve ONS data and systems, and access to the data has provided the opportunity for new conceptual development. While this partnership is not unique, it is the only one that has been continuous, and has focused on different aspects of innovation and the knowledge economy. NESTA can therefore be confident that it will deliver in a form which is sustainable and repeatable going forward.

Both ONS and the academic lead in this project have strong international reputations and links, through EU projects, OECD, Eurostat, and direct links to leading academics and statistics offices. NESTA will be able to draw on these links to help establish the results of the project and influence thinking outside the UK

6) Evidence that our proposal is unique

First, our proposal includes a survey which adds to estimates of the intangible investment at micro-level; building on ONS survey capability, and the experience built up in pilot work, we can be sure this will deliver new knowledge. International colleagues have already shown interest in the approach. The project will create new datasets for ONS and develop new surveys and methods for data collection.

Second, Jonathan Haskel is currently leading an EU project comparing intangible measures across countries, which also pays for one research assistant. That project is focused on international comparison, the development of computer code for data arrangement, growth accounting and international comparisons of productivity levels and some limited comparable microdata work. Benefits for our proposal include:

- the code used in that project will be used for free in this project and,
- if comparability is possible, there will be an international dimension to the innovation index, courtesy of EU support. There can also be sharing of dissemination activities.

Third, ONS work on R&D capitalisation has made some progress already. This uses existing R&D sources and has not developed usable code for looking at the effects of R&D or other intangible assets on growth. This work remains to be done. It is true that ONS currently capitalises some intangible assets, software being the most notable, but that is not being charged for here.

Supporting Annexes

Annex 1. Additional information on our argument ‘what is innovation’

This discussion is based on the introduction and non-technical summary to our NESTA summer project.

a. Relation of our index to other definitions.

We discussed above the relation of our index to the NESTA innovation definitions. What is the relation to other definitions? The Frascati Manual (2002), the official R&D manual proposes, “Technological innovation activities are all of the scientific, technological, organisational, financial and commercial steps, including investments in new knowledge, which actually, or are intended to, lead to the implementation of technologically new or improved products and processes”. As it is evident this definition is constrained to innovation in “technology” and consequently innovation in financial services, in business processes or via design is ruled out by definition. Nor does it define how “implementation” might be measured.

The Oslo manual broadens the definition to include organisational innovations, “A technological product innovation is the implementation/commercialisation of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer. A technological process innovation is the implementation/adoption of new or significantly improved production or delivery methods. It may involve changes in equipment, human resources, working methods or a combination of these”, it introduces the term “objectively new or improved” without defining it or making it operational.

Finally, the US Advisory Committee propose “ The design, invention, development and/or implementation of new or altered products, services, processes, systems, organizational structures, or business models for the purpose of creating new value for customers and financial returns for the firm”, which is broadens the scope of innovation activities and corresponds very much to what we will do.

b. More on justifying how our measure relates to innovation

The logic of our approach to innovation contains four key steps. The first is to ask why we are interested in innovation. For many, the reason is because we believe it is a prime cause of economic growth and specifically that the commercialisation of innovations has been a key factor in converting technological improvements to economic growth in the past two hundred years.² Thus we propose to concentrate on the output of more and new goods and services as our main reason for interest in innovation. As we stress below, to implement this, we shall measure output as value added or GDP, a key variable which avoids output double counting problems and is tightly related to measures of increased living standards and welfare.

But how does innovation contribute to this increased output? To answer this, the second step follows the question set by Jorgensen (2007) in his evidence to the US Advisory Committee: how would we get more output with *no* innovation? His answer is to use the same ideas, but duplicate existing capital and labour inputs. So Ryanair could fly more passengers on an existing route by simply buying another airplane and hiring another set of crew. McDonalds could sell more food by opening at another location buying more cooking equipment and hiring another set of staff. Thus innovation is not just the production of more goods, but the production of more goods over and above that which would occur with simple duplication of existing labour and physical capital.

A number of points are worth making. First, how does this relate to the definitions above? The NESTA definition refers to “change” and the Frascati Manual to the production of “objectively new or improved goods”. The definition operationalises this by referring to more goods. Second, by referring to more goods net of increases in physical capital and labour, it helps clarify a number of ambiguities in the literature. For example, innovation is sometimes defined as something that is new. Now, many would argue that the advent of low-cost airlines flying routes with an entirely new business model is an innovation. But few would argue that a low-cost airline, already flying from A to B in the morning, who then adds an evening service, has innovated. Similarly, many firms who describe themselves as innovative are often alleged by others not to be so since they are simply adopting the innovations of others. So, buying a new aircraft that flies twice as many passengers as before at the same cost, under the definition above, would not be an example of an innovation in the airline industry. But, under our definition, it would be an innovation in the aircraft industry, for the improved aircraft, assuming that it used new ideas, would be an example of an increase in output over and above that from simply duplicating capital and labour inputs in the aircraft industry.

The third step is to ask: if innovation is the extra output over and above capital and labour, where does this extra output come from? This requires us to make an explicit assumption about what inputs cause output. So we assume that production comes from labour, physical/tangible capital and knowledge/intangible capital. Thus extra production due to innovation, since we have ruled out more physical capital and labour, comes from more knowledge capital or ideas. But where does the increased knowledge capital or ideas come from? Unlike tangible capital, which has a location and cannot be used by others, intangible capital may be non-rivalrous. So some firms might get ideas for free by simply imitating what other firms did. Other firms might discover new ideas themselves. Such discoveries, we assume, will take resources. R&D is the usual measure for the spending needed to generate new ideas, but the innovation definitions above suggest that we broaden the scope of spending to other spending that builds knowledge capital: spending on software, design, training, organisational capital at firms. This assumption is described by Corrado (2007) as tantamount to trying measure innovation spending at all stages of the innovation process: both the upstream spending of scientists, artists and designers on new ideas and the downstream spending on the commercialisation of these ideas by means of marketing, training and organisational change. Both spending on innovative ideas and obtaining them for free will show up as innovation in our measure, but in different ways, as we shall show below.

The final step is to account for how much this extra spending on knowledge raises output. For this we apply the economic theory of growth accounting, which uses

observable prices and quantities to infer the impact of increased inputs on outputs. This step involves a number of assumptions, such as competitive markets, the depreciation of the knowledge stock and prices of knowledge all of which will be tested for robustness and require further work. Thus our proposed index will be the part of capital deepening in the economy that is knowledge capital deepening plus TFP growth.

There are of course a number of things that our work does not do. First, as mentioned above, we do not count new ideas. We count the value of the new output stemming from new ideas and we will count investment in new ideas. Second, since we focus on output, we have obvious problems with the hard-to-measure sectors. Thus at the moment data is not readily available to cover most parts of the public sector, and many parts of financial services are also likely to be hard.

Third, it is often argued that an important, possibly the most important, knowledge capital source is education. To the extent that this is paid for by firms, we count it as firm investment. To the extent that it is paid for by the public sector or households, it shows up (albeit somewhat indirectly) via our labour quality measures and so might be regarded as part of the public sector contribution to innovation.³ Fourth, our approach of locating innovation via its effect on growth, clearly relies on a number of assumptions, in particular, using, respectively, knowledge capital deepening and TFP as summary measures of the growth impact of new ideas paid and not paid for by firms. For those who find the assumptions in building these measures unacceptable, we do provide data on spending on series of knowledge/intangible assets which should be of interest, (even if the assumptions on the mechanism by which such spending then changes output are of no interest).

c. Relation of our measure to usual TFP measures

For specialist economists, our definition of innovation is TFP plus the part of capital deepening accounted for by new knowledge investment. It therefore follows the research program set out in the expanded view of capital and TFP measurement proposed by Corrado, Hulten and Sichel (2004, 2006), which builds of course in turn on the work on growth accounting set out for example in the Jorgenson volumes (Jorgenson, 2007). The motivation for the index builds on an argument made by Jorgenson (2007) in his evidence to the Gutierrez committee. An important point of this work is that the Corrado, Hulten and Sichel argument that admission of intangible spending as building a knowledge asset requires both the re-computation of inputs, since knowledge/intangible capital is an additional input and also output (value added) since the capitalisation of intangible spending removes it from intermediate spending and so raises value added. Thus both output, inputs and TFP are recalculated relative to the case where intangible spending is treated as an expense.

³ As a matter of official National Accounting measurement practice, households are not regarded as producers and so their education spending is not investment.

Annex 2. Comments vs criteria in section 4.1 in NESTA ITT Research Brief

NESTA has set out the following requirements (*in italics*).

1. A historical and up-to-date time-series of investment in innovation that goes beyond R&D and accounts for other forms of investment in innovation, related to categories which might include organisational innovation, business model innovation, training, design, advertising and market research and mineral exploration.

This is precisely what our project aims to do. How up-to-date we can be depends on the availability of these surveys for detailed analysis of expenditure categories and timing of ONS delivery of the 2009 and 2010 Blue Books including supply use analysis of expenditure and investment by industry. We expect to be able to deliver full growth accounting analysis up to 2007 based on the 2009 Blue Book by September 2009, and to be able to update by a further year to 2008 in 2010. We will examine how much of innovation investment can be estimated from labour market data on a more timely basis (to 2009), using short term indicators and labour market data, reflecting the fact that much 'knowledge capital' is capitalisation of labour input (this is the principle already used for software).

2. Estimates of the contribution of investment in innovation to productivity growth, which distinguish between the impact that different types of investment in innovation have on productivity.

The contribution of each type of investment will be its share-weighted average growth rate over a particular time interval. Two points are worth noting. First, the share weight will have to use the rental price of the asset concerned, for that is the conceptually correct measure to use. This will be endogenously determined in our computer programme so that the payments to the various factors are consistent with the factor shares and GDP all of which we shall be re-computing. Second, it is unfortunately beyond the scope of this project to consider the case of imperfect competition where the factor shares are not the appropriate measure of the contribution of each factor.

3. Improved measures of total factor productivity (TFP) growth which capture the wider impacts of innovation that cannot be linked to specific investments in innovation.

Implicit in our output will be such improved measures. We cannot rely on conventionally calculated TFP for it relegates any intangible spending to the residual, which is not very informative about the components of innovation and, because investment in knowledge is not capitalised, uses the wrong output measure. Our measure will deal with this problem

NESTA also asks "*wherever feasible, these measures should also be developed at the industry and regional level for industry and region data if possible*".

We should be able to develop some of these measures at the industry level, subject to qualifications set out in Gil and Haskel's (2008) report for BERR. The industry attribution of an intangible asset is difficult to assign in some cases. For example, advertising by a supermarket of a particular product might invest in the reputational

capital of both the supermarket and the manufacturer of the product. We are also reliant on the accuracy of the input/output tables to do this. We will be able to produce industry results, but only for the six industries set out in our NESTA Summer report.

The geographical location of the impact of an intangible asset is much harder to assign. The knowledge capital in Boots the chemist does not presumably reside in just Nottingham. Thus we do not believe that current data and concepts can be used to pin down use of innovation investment through regional data accurately. Production of knowledge assets through capitalised labour should however be feasible.

In addition the NESTA document also asks about the following:

1. Develop an economic framework for innovation metrics building on a framework that is consistent with the national accounts such as growth accounting.

We believe our index will do precisely this, see the supporting annex and the Clayton, Dal Borgo and Haskel Summer 2008 report for NESTA

(<http://www.innovationindex.org.uk/forum/attachment/download?id=2132323%3AUploadedFi38%3A1661>)

2. In cases where estimates of investment in innovation are being derived from broader investment measures, implement rigorous methodologies to establish what innovation is and what it is not. Importantly, investment in innovation should include innovation-related investment in both tangible and intangible assets.

Our approach will do this, through detailed analysis of investment types and sensitivity analysis in growth accounting work, and through review of assumptions in industry fora, and the ‘extended R&D survey’ which will test our assumptions with a wider set of businesses.

3. Present a conceptual framework and practical rules for establishing where one type of investment ends and another begins e.g. where software investment ends and investment in innovative business processes begins.

Initial conclusions on this are starting to emerge from our pilot ‘extended R&D’ interviews with firms. These will be developed and refined as a key output from fora that we will convene.

4. Apply clear methodologies to justify the treatments of issues including price deflators, depreciation and obsolescence. The estimates of investment in innovation need to go far enough back in time to compute accurate estimates of capital services arising from the capital stock, based on assumptions about depreciation processes.

Our service lives work is designed directly to gather evidence on life lengths and depreciation. We will not, with the time available have the opportunity to do new survey work on deflators, but will take advantage of recent advances in service producer price indices for firm purchases of services which fall within the categories we are interested in.

5. Use a combination of existing data from the Office for National Statistics (ONS) and other sources whenever feasible, and collect new data for categories of investment in innovation which are not currently collected. The proposal should outline the structure of any pilot or full survey that would be implemented within the scope of the project.

The proposal will build on the pilot work done on ‘extended R&D’ in 2008/9, and our preferred option is to collect it as an extension of the regular R&D survey. In addition we aim to conduct, early in the project, a pilot survey to follow up the business process / organisation forum, to develop our knowledge of how this area of activity can be better measured within firms. The objective of this study will be to improve the way we ask about this topic in the ‘extended R&D’ survey.

6. Consider the ease by which the underlying data can be collected on a regular basis going forward. The Index does not intend to be a one-off publication but instead an annual review of innovation in the UK. Therefore, the data need to be able to be collected on a regular, such as annual, basis.

By doing this alongside the ONS National Accounts and survey teams, we believe that we have the best chance do this. We propose to develop the methods in parallel with existing ONS R&D capitalisation work, which is responsible for capitalising R&D in the new System of National Accounts, and to work closely with the R&D innovation and R&D survey team, further embedding the project into ONS.

Our survey work and for a within the project will contribute to the development of ONS surveys, and will also improve the framework within regular surveys are used to estimate knowledge inputs to industries.

7. Collaborate with the other research teams working on the Index project, building in particular on the project developing industry-based metrics of innovation activity.

We would very much like if the industry-based activity was to look at such issues in more detail, such as life-length, industry estimates of quantities spent on various classes of intangible assets and the link between such spending and investment. To this end, a number of potential bidders for the project 2 have approached us. To try to level the playing field we have supplied them with both the questionnaires that we have been piloting so that they can see what issues are interested in gathering data on and, in the last days, when we have had clearance, we have put together a non -disclosure version of the report to NESTA on the extended survey that we have been working on.

8. Engage with practitioners in the industry, through interviews and other types of consultation to guide and validate the approach, assumptions and findings.

This is what our fora and pilot surveys are designed to do.

9. Set out how the framework might in principle be extended to produce estimates of investment in innovation in the public sector.

The UK Centre for Measurement of Government Activity (UKCeMGA) at ONS is a leader in developing measures to assess outputs related to government expenditure, and in application of multifactor productivity analysis for specific public services. Its results are used in UK National Accounts for certain services (e.g. health and education).

To apply innovation accounting to the public sector, this approach would need to be extended to take account of investments in knowledge using similar definitions and criteria, which would add ‘knowledge capital’ to the inputs being used to deliver public sector output, and add extra output for the public sector reflecting investment in assets created

A review of public service data (from procurement and labour input sources) could establish how far this could be done, distinguishing knowledge investment among the inputs. There are likely to be complex issues distinguishing knowledge inputs in the

public sector itself, and in suppliers of goods and services (e.g. pharmaceuticals and equipment in the health service).

We have agreement for a short paper to be delivered from James Barlow's unit at Imperial College Business School, HACRIC, which has been researching issues on measuring public sector productivity in health.

10. Demonstrate how the metrics developed can be used to rigorously benchmark the UK's innovation performance, for example across countries or over time.

This would be done using the insights from Jonathan Haskel's European project funded by FP7. It is unlikely to cover all elements of innovation investment that we decide to use for a UK index, due to differences in data available in participating countries. However, this offers the best prospect available to make effective international comparisons.

Benchmarking performance over time will be possible over the 20 year dataset we assemble for the UK (and which is available in roughly comparable terms for the US; it is not yet clear what time periods will be available for other countries).

11. Provide an analysis of UK's innovation performance, highlighting areas of strengths and weaknesses, for the publication of the Innovation Index in 2009 and 2010.

This will be a key output of the work programme contained in our proposal. Note that we will be producing two parts to this work. First, our innovation accounting would provide a breakdown of spending on knowledge activities by asset. This will of course be subject to the measurement assumptions made but for those readers who do not like growth accounting, and for those who are interested in what the UK economy spends on knowledge-building activities, we believe that this will be of immediate policy interest. Growth accounting will provide our measure of those types of innovation not measured through the investment data.

12. Conduct a thorough analysis of the robustness of the final estimates to different assumptions using appropriate techniques.

Software developed in intangibles work to date performs a series of robustness checks and sensitivity analyses on the data. We will combine and develop the approaches used by ONS and Jonathan's work, aiming to develop analytical software which deal with the full range of issues which are identified in our industry fora and through academic and industry engagement, .

13. Provide a full set of spreadsheets and databases containing the estimates of investment in innovation and the constituent data series used to construct these estimates. These should be accompanied by comprehensive documentation and metadata explaining how users can reproduce them.

This will be a major task of the research team – with growth accounting methods and analysis led by Imperial, and source data and survey background led by ONS. Note that the release of any data would be subject to normal ONS disclosure rules.

Annex 3. Comments on how our proposal meets the selection criteria in section 4.1 of the NESTA guidance notes

Areas	Criterion	Comments
Well-defined research proposal <i>Max 15 points</i>	<ul style="list-style-type: none"> • Extensive knowledge of existing research and current research activity in relevant fields; • Fit with the research questions and specifications in the invitation to tender. 	<ol style="list-style-type: none"> 1. We believe we have such knowledge, e.g. our recognitions by grants (HMT, FP7, OECD, NESTA) and our being part of the community setting standards in this area, especially in our extended R&D survey. 2. We believe we have done this (Annex 3) which shows our fit with criteria desired.
Track record of research unit, Principal Investigator and other team members <i>Max 15 points</i>	<ul style="list-style-type: none"> • Experience in innovation research and relevant discipline knowledge; • Experience of producing research that has had an influence on policy. 	<ol style="list-style-type: none"> 3. Evidence of this is set out on our CVS and includes: Intangibles work for Treasury / DTI / NESTA, National Accounts; Microdata/innovation work on productivity (JH) ICT impact work for DTI / EU (ONS team); Innovation & growth work (TC) 4. We have had policy recognition, for example the extensive recognition of our work in successive Pre-Budget reports and in BERR documents. We have also had influence through OECD and EU bodies: for example, JH has been contacted by the European Investment Bank to lead on an EU intangibles project and there is interest from EcFin in our work.
Research design and methodology <i>Max 20 points</i>	<ul style="list-style-type: none"> • Robustness and suitability of proposed design and methods. 	<ol style="list-style-type: none"> 5. We have established a track record with our summer miniproject and work before that for HMT to show that this work is feasible. As we state in the proposal, it is now time to move beyond the duplication of Corrado / Hulten / Sichel methodology. Their

		contribution has been to set out the questions that we need to answer, particularly in the area of better data. This will be a major contribution of the work.
Proposal innovation in both approach and content <i>Max 10 points</i>	<ul style="list-style-type: none"> • Relevance and extent ideas and insights. 	6. We set out in our summer project what we define as innovation, which helps clarify and operationalise many other suggestions. In the context of economics literature on growth and TFP the key innovation is mostly in the data approach and new data that we shall gather, including new surveys. To relate our definition to innovation definitions outside Economics, there is more work to be done (linking stream 2).
Delivery schedule <i>Max 15 points</i>	<ul style="list-style-type: none"> • Thought-through approach to delivering the research on time including a work plan, timeline, interim deliverables and milestones. 	7. We have provided such a plan, based on previous experience of producing the index. We can therefore show that it will be feasible.
Dissemination plan <i>Max 10 points</i>	<ul style="list-style-type: none"> • Willingness to participate in the dissemination of results. 	8. We have provided such a plan and we think we have some track record in this area. We are indeed happy to lead on dissemination to business, academia and government.
Value for money <i>Max 15 points</i>	<ul style="list-style-type: none"> • Detailed budget; Statement that a same or similar application is not current with another organisation; • Reasonable overhead. 	9. We have provided a Budget. We confirm that the same or similar application is not current with another organisation. For Imperial we have simply used the standard FEC overheads as set out by ESRC.

Annex 4. Dissemination strategy

Our dissemination strategy focuses on the following channels:

- a. Academic: The UK academic community will be involved at various stages via events and publications through Imperial College and the international community through planned dissemination of the Jonathan Haskel's FP7 project
- b. Government: via channels for publication of economic analysis (ONS web site and journals), connections with government stakeholders in the UK, through OECD and DGEcFin for other countries (we have already contributed to EU and OECD workshops based on earlier work and have good contacts in both)
- c. Statistical bureaux: via ONS position as a leader on this topic in Eurostat, and via academic connections
- d. Business: via Imperial College Business School and ONS contacts, which we will use to provide interactive feedback to participants in our fora and surveys: we will also use NESTA contacts we will build links with the winners of Project 2 of the call, with the aim of integrating industry engagement..

In more detail, we expect the project will produce working papers, databases and software. Working papers will be available on the internet and disseminated widely, see below. To cater for diverse groups, working papers will include policy briefs for non-specialist policy-makers. Academic working papers will be submitted to peer-reviewed journals. We believe our team have experience in this area and reputation in the field. We aim also to have a non-technical conference to air the results more generally. The database will be available, subject to confidentiality, on the internet, likewise the software for generating the results.

We would also plan to have a launch event at Imperial and ONS for the partial index and the full index (we are not sure what NESTA's plans are for this and what branding is to be applied to the index, but we would wish to have, if possible, Imperial and ONS recognition). With our connections we would expect to be able to gain widespread attention. Similarly, we would do this in connection with the ESRC Innovation Research Centre at Imperial.

We would also organise a dissemination event at least one external venue via our international connections on JH's FP7 project and Tony Clayton's involvement with OECD. This might be at OECD and/or Brussels. Finally, we would hope to gain recognition for the work in the media: *Business Week* and the *Economist* have both published articles on intangible assets in the past and we would aim to build on these contacts and interest. Again, we are not sure at this stage of drafting what NESTA's plans are, or whether they are to be in the hands of the research groups, but we are happy to co-operate with NESTA.

Annex 5: Engagement terms and conditions

Imperial has a standard set of engagement terms and conditions. These are based on BERR / DIUS standard terms for collaborative projects, and are therefore an 'industry standard' for this type of project in the UK.

They are acceptable to ONS, subject to the following understandings:
any survey data, results or interviews undertaken must be subject to ONS statutory duty of confidentiality to respondents, to guarantee that no disclosure takes place. ONS disclosure rules will be used to ensure confidentiality
ONS input to the project remains subject to a requirement that data is produced in the public interest, for publication (subject to disclosure rules) and cannot be appropriated for private gain.
ONS work is subject to the National Statistics Code of Conduct, which places obligations on us to disseminate results in ways which provide the widest possible access, and which do not discriminate between users of statistics
Outputs in this case should be presented as analysis based on National Statistics sources, but not as National Statistics in themselves

Since the Imperial terms are 17 pages long we omit them here in the interests of space but can provide on request.

We will invoice for the overall project in two equal amounts, one in September 2009, and the other in September 2010, subject to delivery of all the outputs in the project plan for each of the two phases. We may ask for some limited pre-funding to cover items which are direct external costs for Imperial and ONS, and will cover this in discussions.

Annex 6: Suggested Referees

Dave Ramsden, HM Treasury – who commissioned our work on Intangible Assets and the Knowledge Economy
or Vicky Price, who has been involved as key policy user in a range of productivity studies
(these two are joint heads of the Government Economic Service, so we also suggest an independent source)

Ian McAfferty, Chief Economist of the CBI,

Annex 7: CVs of Project Participants

Attached on separate sheets.