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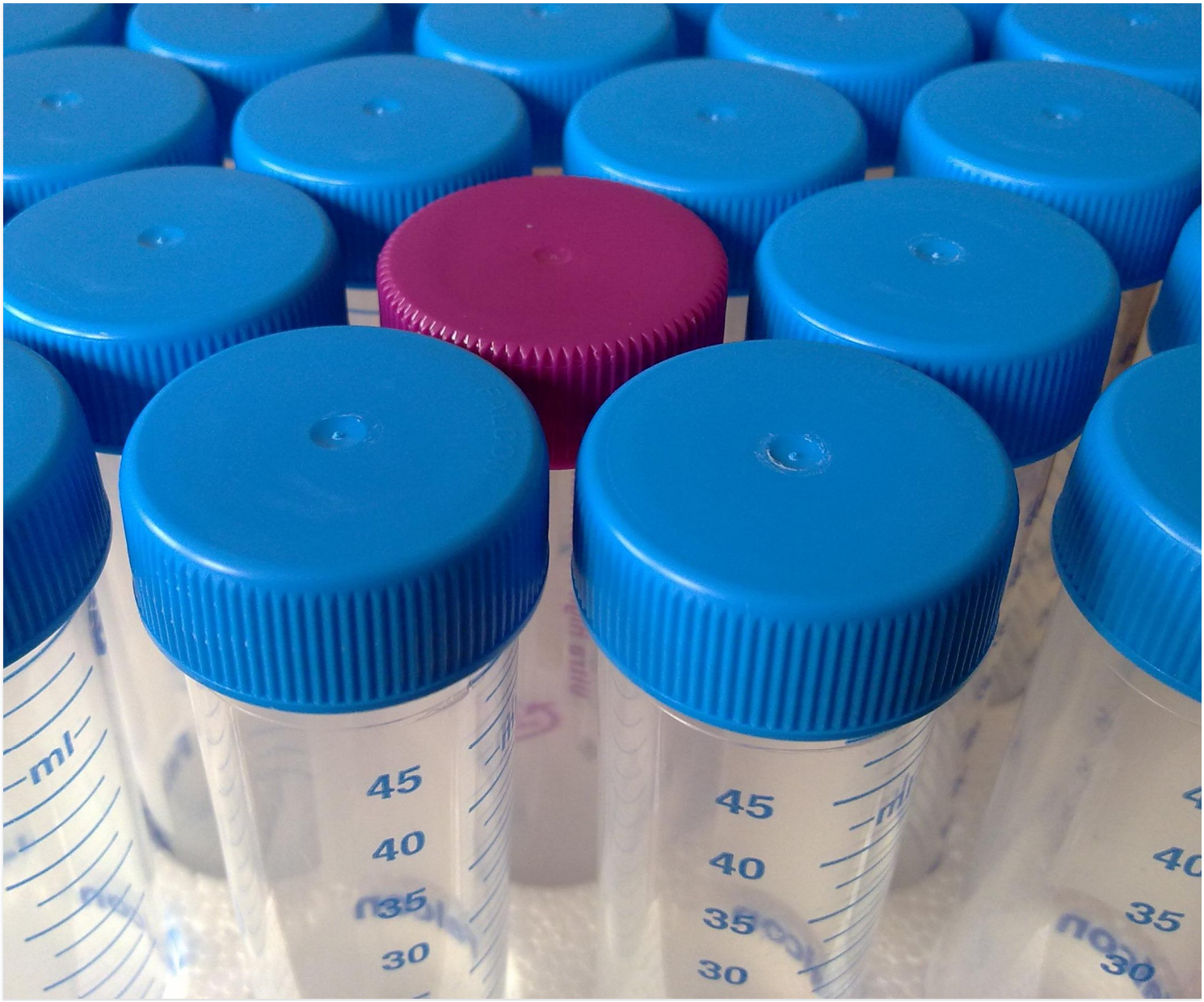
What is the evidence on the impact of research on international development?



July 2014

A DFID literature review

Contents

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Any errors or omissions remain those of the authors.

Every effort has been made to give a fair and balanced summary. In some areas where the evidence base is not clear-cut there is inevitably a subjective element. If readers consider that the evidence on any issue is not accurately described or misses important studies which may change the balance, please let us know by emailing evidencereview@dfid.gov.uk so that we can consider this when correcting or updating the paper.

1. Executive summary

Governments of low-income countries and international development donors are increasing their funding for research at least in part on the assumption that research has positive impacts on socioeconomic development. Four pathways are commonly cited to describe how research will contribute to development:

1. Investment in research will drive economic growth
2. Investment in research will increase human capital
3. Investment in research will lead to the development of pro-poor products and technologies
4. Investment in research will provide evidence to inform policies and practice

This literature review examines the evidence base related to each of these four pathways. It demonstrates that research does make important and significant contributions to socioeconomic development but that some commonly held assumptions about how research leads to change are not backed up by the evidence. Brief summaries of the findings relating to each path are given below.

Economic growth

Contrary to popular belief, there is little evidence that public investment in research was a major contributor to the 'Asian development miracle'. Furthermore, the evidence suggests that the potential for research and innovation to contribute to technology-transfer fuelled growth in low-income countries tends to be overestimated.

Human capital

There is a great need for the skills which can be developed through involvement in research in low-income countries. Such skills can be built through higher education, although it is unclear whether involvement of higher education institutions in research contributes to teaching standards. In addition, skills can be built by capacity building programmes. However, many such schemes in the past have had mixed impact.

Products and technologies

Many inventions have had positive impacts on the poor. Public-private partnerships have been particularly successful in funding and incentivising the development of new products and technologies. Some products and technologies have less impact than intended due to a mismatch between the product and actual need.

Evidence-informed policy and programmes

There are two major ways in which research can inform decision makers: it can inform decisions on specific interventions and it can inform decision makers' general understanding of the context. There are numerous examples of both types of influence. However the evidence also reveals that there are significant gaps in the capacity, incentives and systems necessary to ensure that research is systematically used in decision making.

The paper also reviews approaches to calculating the economic impacts of research investments. Most studies suggest that research leads to positive economic returns. However, these studies are sensitive to a range of assumptions and results must be treated cautiously.

The paper ends with a summary of conclusions and a proposed theory of change based on the research evidence presented.

1. Introduction

There has been extensive debate for many years about the extent to which development funders and governments of low-income countries should invest in research and evidence as a means to drive socioeconomic development. Ironically, these debates have often been rather evidence free. Those who are pro-research have sometimes been guilty of promoting investment in research as the end goal (as opposed to seeing it as a potential means to an end). Those who oppose research funding have argued that it is too difficult to demonstrate how research will lead to benefits and that it wastes money which could be spent on more direct poverty reduction interventions.

There is clearly an opportunity cost associated with investing in research: the investment used for research cannot be used for other potentially useful interventions. However, given that many previous development interventions have not succeeded in their goals and that many development problems continue to be relatively intractable, there is a clear rationale for seeking to better understand contexts and potential interventions to inform future development activities. This paper attempts to appraise and summarise the evidence regarding the developmental impacts of publicly-funded[*] investment in research.

About this paper

Who is this paper for?

The primary audiences for this paper are policy makers in low-income countries and development funders who are required to make decisions on how much to invest in research and what type of research activity to prioritise.

What does this paper aim to do?

The paper does not provide policy guidance on research priorities. Rather, it examines the potential pathways by which research investment may lead to positive impacts, and describes the evidence base underlying each of these. It will assist decision makers in thinking about how investment in research can contribute to their principal objectives.

Justifying investment in research

In recent years, a number of international development donors have renewed and strengthened their commitments to research.[1,2,3] In addition, the amount spent by governments of low-income countries on research is increasing.[4]

To understand how development funders and policy makers from low-income countries have justified investing in research as means of achieving development impacts, a review of policy statements on research from major development funders and policy makers from

[*] For the purpose of this paper, publicly-funded development research will include research funded by governments (including governments of low-income countries and bi-lateral 'donor' governments). It will also include research funded by multilateral agencies and philanthropic foundations where the research generated is intended to benefit the public.

low-income countries was carried out along with informal interviews with development research funders and research capacity building organisations. An overview of types of research is provided in box 1.

The following four justifications were commonly used:

Research for economic growth

Policy makers in low-income countries often justify investment in research and innovation on the basis that it leads to economic growth.[5] The manner in which research investment leads to economic growth is often not specified. But when further details are given, it is generally implied that basic research, invention and discovery leads to the development of commercially viable technologies, which in turn stimulates private sector-led economic development (a process sometimes termed 'technology transfer'). In this context, the terms 'Science', 'Technology' and 'Innovation' tend to be preferred to the term 'research'. For example, in 2012, Nigeria launched a new Science, Technology and Innovation Policy[6] which states:

> *"The new policy on ST&I thus has as its core mission the evolution of a new Nigeria that harnesses, develops and utilises ST&I to build a large, strong, diversified, sustainable and competitive economy that guarantees a high standard of living and quality of life to its citizens. Specifically, the new ST&I Policy is designed to provide a strong platform for science, technology and innovation engagements with the private sector for the purpose of promoting sound economic transformation that is citizen centred".*

Uganda's 'Science, Technology and Innovation National Plan'[7] states:

> *"The priorities of the Government of Uganda in this regard include creation of all round capacities in STI infrastructure in universities and research institutions, creating a critical mass of scientists and engineers that are necessary for spearheading and sustaining industrial development and economic transformation…".*

Malawi's National Commission for Science and Technology[8] has the mission to:

> *"to promote, support, coordinate and regulate the development and application of STI so as to create wealth in order to improve the quality of life".*

The Indian government's Science, Technology and Innovation Policy[9] lists a number of potential paths by which research can lead to development but the most prominent is that it will lead to innovation which will drive economic growth. It states:

> *"Scientific research utilizes money to generate knowledge and, by providing solutions, innovation converts knowledge into wealth and/or value. Innovation thus implies S&T-based solutions that are successfully deployed in the economy or the society… The national S&T enterprise must now embrace S&T led innovation as a driver for development".*

Research to build human capital

Some donors and NGOs advocate investment in public research institutes by suggesting (implicitly or explicitly) that this will lead to improvements in human capital, particularly by driving up standards of tertiary education. For example, the Swedish International Development Agency research strategy[2] states:

"Interaction between research and education is crucial to development in both areas. Research findings enrich the content of educational programmes and courses, primarily at higher study level. The quality and content of the education offered is in turn a decisive factor in the recruitment of researchers".

Some members of DFID's Higher Education Taskforce, which advised DFID on its approach to Higher Education from September 2013 – May 2014, have also emphasised the need to invest in research capacity of Higher Education institutions, in part because of the complementarity of teaching and research.[10]

In addition to the perceived impact on higher education provision, some research funders justify their investment in research in part on the basis that funding research in low-income countries will build future capacity to carry out research and that this capacity will contribute to socioeconomic development. However there are mixed views on whether investment in research will in itself build capacity and some donors believe that generation of high quality research cannot be mixed with efforts to build research capacity.[11]

Research to develop pro-poor[†] products and technology

Both policy makers from low-income countries and international development donors have justified investment in research on the basis that research leads to new products and technologies which improve the lives of poor people. For example, in a speech[12], Kenya's president stated:

"This is what science, research, technology and innovation should do: meet the people at the point of their greatest need…. I expect [a new Kenyan laboratory] to eliminate quite a number of notorious headaches".

The USAID website has a page on Science, Technology and Innovation[13] which states:

"…the global community accelerated investments in new technologies and forged innovative public-private partnerships to generate groundbreaking new solutions. This approach enabled some of the most significant achievements in modern development… Today, through investments in science, technology and innovation, USAID is harnessing the same forces that yielded the great breakthroughs of the past to transform more lives than ever before".

A number of philanthropic funders support research for development and have a strong focus on development of pro-poor products and technologies. For example, the Gates Foundation website[14] states:

"Our Global Health Division aims to harness advances in science and technology to save lives in low-income countries. We work with partners to deliver proven tools—including vaccines, drugs, and diagnostics—as well as discover pathbreaking new solutions that are affordable and reliable".

Similarly the Wellcome Trust International Strategy[15] states that:

[†] This descriptor is used for products and technologies which directly benefit poor people above and beyond any commercial benefits they generate. The term is not intended to imply that poor people always require different products and technologies than rich people; many pro-poor products and technologies will also benefit rich individuals.

"We provide support for the best people and research teams so that, over time, we can help to develop critical mass in strategically important areas of the biomedical sciences and combat health problems of regional or global importance."

Research for evidence-informed policy and practice

Finally, there has been a growing trend, particularly amongst international development donors, to advocate for investment in research on the basis that it drives evidence-informed policy and practice which in turn leads to socioeconomic development. The emphasis on evidence-informed policy has often focussed on the 'What works' agenda: the use of research to assess the impact of interventions. For example, in a speech in 2013[16], Justine Greening, UK Secretary of State for International Development has stated:

"I want to make sure that we invest in what works. Where we don't know, I want to find out…. I want to champion research and evidence to make sure that we are learning all we can, and we know that our approach is actually going to work…".

The World Bank research department describes its roles as primarily about supporting evidence-informed policy. Their website[17] states:

"Research at the Bank encompasses analytic work designed to produce results with wide applicability across countries or sectors. Bank research… is directed toward recognized and emerging policy issues and is focused on yielding better policy advice."

The Swedish International Development Agency has a strong focus in its research strategy on creating a 'Knowledge Society'[2] highlighting that:

"Research . . . has an important function as a basis for decision-making."

The Gates Foundation website[14] highlights that, as well as supporting research to develop new products and technology, it also investigates the practice of how these can be delivered:

"Equally important is innovation in how we bring health interventions to those who need them most."

Box 1: Types of research

There are multiple different ways to classify research whether by thematic area, academic discipline or methodology. Within DFID, research activities are commonly classified into the following categories:

Research to develop products and technologies

This category includes all research which is designed to produce a new product, technology or process which will either have direct pro-poor impacts or will generate income and thus contribute to development through growth.

Research to understand what works and why

This category includes any research which aims to understand if and how an intervention works. Experimental methodologies are particularly useful for investigating whether a given intervention achieves the intended impact in a given context. However, experimental methodologies are not always feasible and thus some research to investigate impacts will use alternative methodologies. Operational research that uses a variety of methods to

investigate how systems and processes can be improved would be included in this category. This category also includes a range of observational research which aims to understand the mechanisms which lead to interventions or systems working or not working.

Research to understand the world around us

This category includes a broad range of research which aims to understand better the context in which development activities take place. It will include research using both quantitative and qualitative observational designs on topics including health systems, economics, governance, environment and social development.

Research capacity building activities

In addition to these three categories of research mentioned above, DFID considers one additional category of research activity, namely activities which have the main aim of building research capacity. This category covers a range of activities including training, mentoring and advising in order to build the knowledge, skills and attitudes of beneficiaries. It may include activities which aim to build the capacity of researchers to generate research, or activities designed to build the capacity of decision makers to use research.

Theory of change

The mechanisms described in section 2.1 by which research has been hypothesised to contribute to development can be categorised into four major pathways:

1. Economic growth: research leads to basic discovery and invention, and in turn to the creation of technology; technology leads to growth both where it is developed, and in other places when it is transferred. This pathway is based on endogenous growth theories which stipulate that growth will be stimulated by new innovation.
2. Human capital: human capital is built by 'doing' research; through specific capacity building activities; and through impacts of research on tertiary education.
3. Products and technologies: products and technologies have direct positive impacts.
4. Evidence-informed policy/practice: policy and practice decisions are better as a result of using research evidence.

These pathways were combined to create a theory of change[‡] outlining how research is commonly assumed to lead to development impacts (see figure 1).

It is clear that achieving any of the four outcomes described above will require a 'supply' of relevant research. However our theory of change also considers the 'demand' for research evidence which we define as the capacity **and** incentives to use the outputs of research. In some literatures, the capacity and incentives to use research outputs is referred to as the 'absorptive capacity'. The relevant research outputs will differ for the four pathways:

[‡]A theory of change is a conceptual framework which outlines how inputs are hypothesised to lead to outcomes and impacts. Theories of change are commonly created by those implementing International Development programmes and projects. They enable implementers to surface their assumptions about how change will happen and provide a framework for monitoring progress. A theory of change can be expressed as a narrative and/or as a diagram.

research results, human capital, new or improved products and technologies and research knowledge respectively.

Thus the theory of change proposes:

1. If there is an adequate investment in commercially-relevant research and researchers and industry partners are able to understand, adapt and use research results, the private sector will be stimulated and this will result in economic growth which will contribute to poverty reduction and improved quality of life.
2. If there is an adequate investment in building individuals with research expertise and if there are opportunities and incentives for these individuals to contribute to socioeconomic development within developing countries, increased human capital will contribute to poverty reduction and improved quality of life.
3. If there is an adequate investment in research to develop pro-poor products and technologies and if there is a need for and the capacity to benefit from these, pro-poor products and technology will be developed and these will contribute to poverty reduction and improved quality of life.
4. If there is an adequate investment in policy/practice-relevant research and if policy/practice decision makers have adequate access to this research, and adequate capacity and incentives to use it, there will be more evidence-informed policy and practice and this will contribute to poverty reduction and improved quality of life.[§]

These logical pathways are summarised in figure 1.

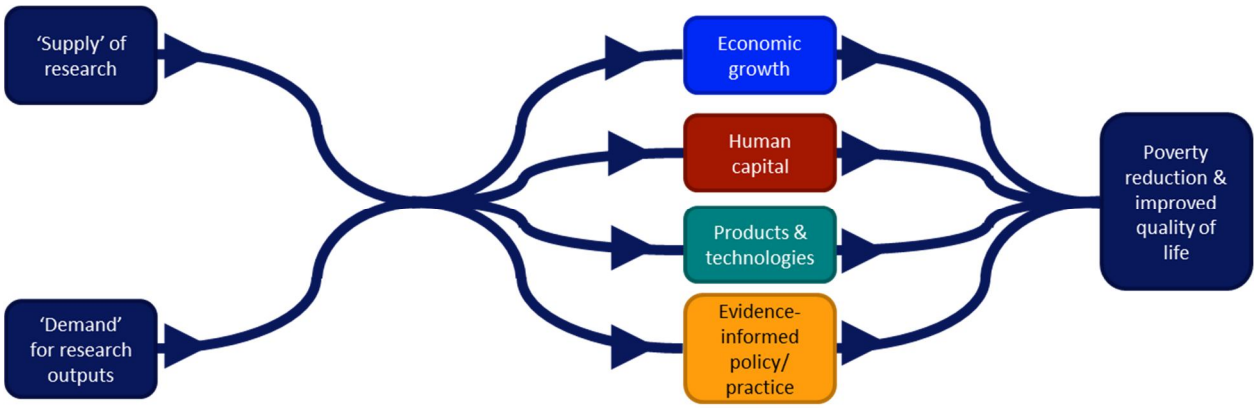

Figure 1: Theory of change.

[§] It is important to note that the assumption that using evidence will lead to policies and practice which contribute to poverty reduction and improved quality of life rely on a further assumption that policy makers and practitioners *intend* to contribute to poverty reduction and improved quality of life. If policy makers and practitioners have more nefarious aims, it would be possible for them to use evidence to achieve these. It is also worth noting that, in addition to leading to improvements in particular policy outcomes, evidence-informed policy can be seen as part of a more general transparency agenda leading to greater citizen and investor confidence. This is another mechanism through which it can contribute to poverty reduction and improved quality of life.

Like all conceptual frameworks, this theory of change is a simplification and therefore has limitations. In particular:

- While it can be useful to analyse the functions of ‘supply’ and ‘demand’ separately, in reality the boundary lines may be blurred and individuals and organisations may be involved in both.
- The theory of change suggests a linear process whereas in reality change happens in a more iterative and ‘messy’ way.
- The theory of change does not reflect the interconnectedness of the four different pathways. For example, it is clear that development of products and technologies feeds into economic growth as well as having direct impacts on development; the benefits of human capital development will feed into all of the other pathways; and evidence-informed policy may itself improve the environment for economic growth and so on.

Furthermore, the theory of change is based only on the common assumptions about how research leads to change within justifications used for investing in research. It is derived from multiple opinions and statements and it is unlikely to fully represent the views of any one person. As such, it is a ‘straw man’ theory of change.

Nevertheless, it is a useful starting point for understanding assumptions, mapping the research literature, and exploring the evidence base. A revised theory of change which reflects the findings of the review is presented in the conclusion.

2. Economic growth

The research evidence demonstrates that while economic growth is not sufficient to achieve socioeconomic development,[18,19,20,21] it is clearly necessary for both poverty reduction[22,23,24] and human development.[25]

While debates between supporters of different theories of economic growth continue,[26,27] endogenous growth theories have become highly influential. Endogenous growth theories (also known as 'New growth theories') postulate that 'knowledge' (in the form of human capital and innovation) can increase returns on investment and that policies which maximise creation of knowledge are crucial drivers of growth.[28,29] In political discussions the concept of 'knowledge', which is at the centre of endogenous growth theories, has sometimes become narrowly defined as academic research outputs. For this reason, as outlined in section 2.2.1, endogenous growth theories have been widely used, both implicitly and explicitly, as justification for public investment in research.

Here we examine the empirical research investigating the contribution of research investment to economic growth.

Does investment in research lead to development via economic growth?

Historical relationships between research and growth

There is clear evidence that investment in research is *correlated* with economic growth.[30] However, the issue of whether investment in research, and in particular public investment in research, *causes* economic growth is far less certain. A review of evidence on research investment in high-income countries[31] found that *firm-level* investment in research did lead to significant returns both for firms themselves and 'social' or spillover returns. However, the review reveals that much *publically-funded* research had returns of near zero. The review acknowledges that a minority of publically-funded research does lead to impacts on growth but cautions that general increases to public funding for research in order to boost growth are unlikely to be successful.

Two further reviews of literature on the economic benefits of publically-funded research[32,33] find heterogeneous impacts of research according to sector. For example, the aerospace, computer and telecommunication industries were found to draw heavily on public research outputs while other industries such as non-electrical machinery and metal and plastic products used little public research. Both these reviews cite a number of studies suggesting that many private sector innovations would not have been possible without public investment in basic research. However they also highlight that the production of 'tacit knowledge' embodied in people (either University graduates or research staff) are likely to be as important if not more important as an output of public research funding (see sections 3.2 and 4 for more details).

Some have suggested that publically-funded research may be particularly important to drive economic growth in emerging economies. The example of the Asian Tigers, which achieved

rapid economic growth in the 1980s is often cited. For example, a recent communique from the governments of Ethiopia, Mozambique, Rwanda, Senegal, and Uganda on Higher Education for Science, Technology and Innovation states:

> *"Inspired by the recent success of the Asian Tigers, We, the African governments, resolve to adopt a strategy that uses strategic investments in science and technology to accelerate Africa's development into a developed knowledge-based society within one generation."*[34]

However, there is little evidence to suggest that public investment in research *was* a major contributor to economic growth in the 'Asian tiger' countries. Some studies suggest that much of the growth rates can be explained by increases in inputs as opposed to increases in productivity driven by new knowledge.[35] Other studies suggest that acquisition of 'knowledge' was indeed a major factor in economic growth.[36] Although, detailed case studies of firms which contributed to the rapid growth in Asian countries[37,38,39] reveal that the acquisition of 'knowledge' which drove their growth rarely corresponded to acquisition of publically-funded research knowledge. In the early stages of growth, the 'knowledge' was acquired from elsewhere. This included 'reverse engineering' to discover how products had been made, but also learning about processes and management such as the 'lean manufacturing' models used in more developed economies. Whether or not knowledge played a role, it is widely acknowledged that many other factors did contribute to economic growth.

The findings from the Asian Tiger countries are echoed in a 2003 report which examined the factors which drove economic growth in OECD countries between 1971 and 1998.[40] The report found that business-level investment in Research and Development did have positive impacts on the economy. However it found no evidence that public investment in research was a significant driver of growth.

Taken together, the historic data suggest that acquisition of knowledge may be one factor in driving economic growth. However, there is little evidence that publicly-funded research outputs are a major source of this knowledge for low-income countries.

Commercialisation of research knowledge

One way in which new knowledge produced via publically-funded research can contribute to economic growth is through the licensing of new products/services, the development of 'spin-off' industries or through the improvement of efficiency of existing firms. A cross-national regression analysis of data (1975-1999) from the United States Patent & Trademark Office (USPTO) finds that a one percent increase in the number of patents issued by the USPTO to residents of a specific country (they can be issued to foreign as well as domestic applicants) is associated with a 0.19 per cent increase in annual economic growth of that country, and a 0.2 per cent increase in output per worker. [41] If the number of patents granted is associated with public investment in research, this could demonstrate that public investment in research is associated with economic growth however this would not demonstrate any causal linkage.

One commonly used proxy for the commercialisation of public research is the ratio of income from licencing of new products/technologies to total research spend. Note that while this provides an indication of the economic benefit to the institution itself (i.e. the money for the licence) – the actual benefit to the national economy (i.e. all future revenues resulting

from production of the technology) is likely to be higher. Some high-income countries have invested heavily in a technology transfer sector, including technology transfer offices in major universities and innovation incubator centres. Countries with established research sectors making such investments in technology transfer may achieve returns of between 1% and 5% of total research investment as licence income. For example, over the period of 2004 to 2011 the US achieved average license returns of 4.8%, Australia achieved 2.2% while Europe achieved 1.7%.[42] It should be noted that the actual percentage return varies considerably amongst institutions and is disproportionally generated by a small number of elite research institutions. For example, within Europe, 10% of Universities account for around 85% of the licensing income.[43] Given that the cost of operating technology transfer offices is likely to be between 1 and 3% of total research expenditure, it is clear that many technology transfer offices in high-income countries operate at a loss. Equivalent figures do not exist for low-income countries but those studies that do exist suggest that generating income from licensing or spin-off creation is currently rare in low-income countries.[44] A paper which examined licencing ratios for high- and middle-income countries and drew out implications for low-income countries concluded that

> *"Without a well-funded, high quality research system, it is unlikely that a technology transfer programme will make any significant contribution to economic development. It is also not clear that any other country can simply emulate performance of the USA in deriving benefit from technology transfer due to differing social and economic conditions".* [45]

Given that research institutions in low-income countries are relatively lacking in research capacity,[46,47,48] it is likely that there would need to be sustained investment in research for many years, if not decades, before rates of return similar to those found in high-income countries could be derived from technology transfer bodies.

Investment in public research or technology transfer sectors in low-income countries is unlikely to lead to growth through commercialisation in the short to medium term as there is insufficient capacity to develop new technologies which can be commercialised.

Science parks

In some cases, products and technologies developed through public research may fuel the establishment of a new firm. One mechanism to encourage the development of this type of spin-off organisations is the creation of 'science parks' or incubation hubs. Some science parks in the US have achieved remarkable and high profile success in driving the local economy.[49] This success has driven many policy makers in low- and middle-income countries to establish science parks (or similar) in an attempt to drive economic growth. There is very little research on science parks in low-income countries but a large body of research from middle and high income countries. Research suggests that whilst widely supported in emerging economies such as China, science parks have achieved mixed success.[50,51,52]

Research has demonstrated that while Universities do support firms in science parks through provision of training and information, commercialisation of University-generated outputs by firms located in science parks is rare and of marginal importance to firms' innovation or success.[53,54,55,56,57] Furthermore, there are mixed findings on whether location within a science park is beneficial to firms compared to location elsewhere.[58,52,59,60,61,62]

Research from Norway suggests that 'open-mindedness' and international collaboration are far more important in driving firm innovation than clustering of tech start-up firms and local level linkages.[63]

Science parks are often established with the explicit aim of driving regeneration of deprived areas. However, despite anecdotal evidence of successes and failures, there is limited rigorous research with which to determine the value of this approach. In some cases, science parks have succeeded in attracting tenants but have not demonstrated any additional benefits compared to other property developments.[64]

Some authors have expressed concern that these parks represent 'cargo culture' approaches which attempt to recreate an environment which is superficially similar to US science parks without any of the underlying factors necessary for success and many have questioned the continuing support for science parks given the poor evidence of their success. [49,65,66] Further, some authors have highlighted that science parks differ enormously in the models they use to support firms and that it is therefore not appropriate to ask if science parks 'work' but rather to ask whether a given model achieves what it is aiming to achieve in a given context. [67]

Overall, while there have been high profile examples of successful science parks, particularly in the USA, research suggests that most science parks do not drive commercialisation of university-derived research outputs. Firms do report some benefits from locating in a science park, however it is unclear whether location in a science park is beneficial to firms' performance overall compared to location elsewhere. There is little evidence on the impact of science parks on local regeneration of deprived areas.

Other academic-industry engagement

There are many other potential linkages between publicly funded research institutes and industry. These include research collaboration, contract research, provision of knowledge through publications and conference presentations and provision of advice and networking. These activities have been termed 'academic engagement' to distinguish them from the direct commercialisation (through licensing and spin-offs) generated by specific technology transfer initiatives.[68] There is evidence from high-income countries that academic engagement with industry has greater economic benefit than direct commercialisation.[69,70]

A review of different types of university-industry linkage in China demonstrates that both direct commercialisation and other linkages (in particular collaborative research) are increasing, though there is no data on their impact.[71] Similarly, case studies from countries with varying poverty levels reveal a wide range of academic engagement with industry and suggest that activities other than direct commercialisation are likely to be most economically important for lower income countries.[72,73,74]

Research suggests that the most common forms of academic-industry relationship in low-income countries are 'traditional' links based on the Universities' role in providing training.[72,75] For example, many universities include a private sector placement as part of relevant degree programmes.[72] This finding is consistent with evidence from the UK which

shows that the most important university linkages which UK firms identify relate to development of human capital.[76]

New research techniques and instruments can also be developed via public research funding and lead to improvements in industrial research.[31]

Although less common than linkages based on training and information, [72,75,] there is some evidence of private sector organisations carrying out collaborative research with academics. For example:

- Collaboration between a building supplies manufacturer in Uganda and the department of Mechanical Engineering of Makerere University (funded by the British Council) led to improved energy conservation and the development of alternative fuels for firing clay which, in turn, led to increased efficiency and sales improvements.[77]
- Collaboration between an aluminium company in Egypt and faculty in the Engineering Department of the University of Cairo has led to numerous improvements in processes which have led to increased productivity.[72]
- A Thai electronics company has long-standing collaborations with a number of Universities which provide bespoke training courses for company engineers.[78]

A recent systematic review of academic engagement with industry in high-income countries revealed that the extent of industry engagement was positively related to indicators of individual academics' research productivity and research quality.[70] This finding is relevant to low-income countries where the relatively low levels of investment in research have resulted in relatively low levels of research productivity and academic quality.[79,80,81] Indeed, a recent rigorous literature review on the impacts of tertiary education suggests that academic-industry engagement activities in low-income countries remain rare and will therefore have relatively low impact on growth.[82]
It is important to note that 'academic engagement' may have negative impacts on other aspects of researchers' work. A 'consultancy culture' in research institutions, is often cited as a major factor in poor research and teaching quality, particularly in Africa.[83,84]

Taken together, the evidence suggests that academic-industry engagement *can* lead to positive impacts, but there is relatively little evidence that this is having a significant impact on economic growth at present. Further research would be needed to find out if there is potential for such engagement to be scaled up and whether this would have positive impacts on growth.

Institutional factors affecting technology transfer

Research from both high income and middle-income countries demonstrates that there are many institutional factors which can prevent new research results contributing to economic growth. A UK report[85] identified a number of 'Wider Framework Conditions' which need to be in place to enable innovation to contribute to growth including factors relating to 'Business environment and competition'; 'Entrepreneurship and finance'; and 'Infrastructure and Services'. Comparative studies from Italy[86], Spain[87] and China and South Africa[88] have highlighted that institutional factors including property rights, government support and the state of the economy are crucial factors in the success of University Science Parks. It is beyond the scope of this paper to examine in detail the role of these factors in driving

innovation but it is important to note that without favourable conditions, neither investment in research nor the absorptive capacity to use research will be sufficient to drive economic growth.

There are many factors involved in driving economic growth and without a permissive context, attempts to drive growth through research and innovation are unlikely to succeed.

Does increased demand for research lead to development via economic growth?

In addition to the possibility of generating new and profitable ideas, investment in research activities can enhance a country's ability to adapt and adopt ideas which have been generated either locally or internationally. The uptake of research knowledge generated elsewhere may be a particularly important feature of research in low-income countries which are attempting to catch-up with technological developments from elsewhere. Some authors have suggested that a higher proportion of 'adaptive' research could mean a reduction in lag periods between investment in research and economic benefit in low-income countries.[89]

A number of authors have argued that innovation will only contribute to economic growth if the private sector has the 'absorptive capacity' to take up new systems, products and technologies.[90] Indeed there is a strong body of evidence which suggests that, for low-income countries, the ability to take up and use knowledge and technology is a better predictor of growth than the ability to generate new knowledge and technologies within a country.[91,92 93] This is summed up in a 2011 paper from the World Institute for Development Economics Research[94,,] which concludes:

> *"Results from cross-country regressions covering 31 Sub-Saharan African countries suggest that growth in Africa is not simply a question of capital accumulation, fertility rates, aid dependency, and stable macroeconomic environment. It is also about strengthening the capacity of African countries to assimilate and effectively use knowledge and technology. Contrary to the views held by many analysts, the growth of African economies does not depend so much on their ability to innovate, but rather on their capacity to absorb and effectively use new technologies."*

A recent rigorous literature review on the impacts of tertiary education[82] concluded that:

> *"…there is some evidence to suggest that the proportion of workers with higher education within a given context may increase the likelihood of technological uptake and adaptation".*

Research suggests that one of the key ways in which the private sector can increase its capacity to take up research is by doing research itself: carrying out in-house research enabled firms to make better use of external research.[95,96] But studies have also demonstrated that public investment in research is also a crucial contributor to private sector absorptive capacity. A major way in which this happens is via the impact that involvement in research has on University graduates who go on to work in private sector (see also section 4.2).[32,97] In addition, collaboration between University and industry has been shown to increase the absorptive capacity of private sector firms.[76]

A systematic review by Bruno and Campos observes that the academic literature generally finds that levels of human capital and technological advancement have a multiplier effect on the economic impact of foreign direct investment (FDI).[98]

The OECD has produced an innovation strategy providing policy recommendations to drive innovation *"to strengthen growth and address global and social challenges"*[99] as well as numerous papers related specifically to innovation and development.[100,101] These papers are based on both research and expert advice. It is notable that they recognise that the key mechanism by which low-income countries can benefit from innovation is by strengthening their capacity to absorb and adapt innovations from elsewhere.

The evidence indicates that increased capacity of academia and industry to absorb and adapt existing research knowledge plays an important role in driving economic growth.

Areas for further research

While there has been considerable research to map the direct commercialisation of research findings by research institutions, there is little systematic data on the prevalence, distribution and economic impacts of other forms of academic-industry engagement including collaborative research and consultancies. A number of research papers suggest that activities other than direct commercialisation of research results are likely to be most important to low-income country research institutions, but it would be valuable to gather more empirical data to test if this is true.

Furthermore, it would be useful to test out approaches to fostering academic-industry linkages to find out which (if any) offer significant economic returns for low-income countries.

Summary

Countries with low levels of research capacity are unlikely to achieve economic growth through direct commercialisation of research (at least in the short to medium term). Other forms of academic-industry partnership *may* be more effective at driving growth but there is relatively little research on this at present.

There is evidence that the capacity to adapt and absorb research results is a stronger factor in economic growth in low-income countries than the production of new research knowledge. A large component of this 'absorptive capacity' is related to human capital.

3. Human capital

For the purpose of this paper, 'Human capital' refers to the sum of the knowledge, skills and attitudes present in the population. There is strong evidence that human capital is correlated with both social and economic development levels[102] and is a key driver of foreign direct investment.[103,104,105] Furthermore, there is a growing body of evidence that human capital, [106] and cognitive skills in particular, [107] are key drivers of economic growth. A recent rigorous literature review on the impacts of tertiary education found strong evidence that tertiary education increases the individual earning potential of graduates, and some evidence that it also leads to strengthened institutions.[82]

This chapter considers ways in which public investment in research activities can contribute to human capital. It then explores the extent to which there is the demand and opportunity for human capital, developed through research activities, to contribute to development impacts.

Box 2: Brain drain

There is growing concern regarding emigration of highly skilled workers from low-income countries. Research on the overall impact of skilled migration is mixed. There is evidence that in the short-term, emigration is likely to lead to economic disadvantage for remaining families[108] and that the overall impact on human capital is negative.[109] However, emigration of skilled workers can lead to remittances sent home to family members which may be used to invest further in education. In the longer term, those who emigrate and then return will bring back additional skills and networks which may contribute to economic growth, a phenomena which has been termed 'brain circulation'.[110,111,112] Cross-country analysis suggests that there are large differences in the impacts of brain drain in different countries with some 'winners' and some 'losers'.[113]

Does investment in research lead to development via increased human capital?

Human capital built through funding of research

The outputs of research projects are often thought of in terms of knowledge and research findings. However another important output is individuals with deep understanding of the topic investigated. These experts may go on to draw on their expertise to contribute to socioeconomic development. For example:

- Some researchers go on to work within policy making institutions. Examples include Chris Whitty, a British malaria researcher, who joined the UK Department for International Development as Chief Scientific Advisor and Head of Research in 2009. He has had a significant impact on DFID's approach to generating and using research evidence.[114] Similarly, Hassan Mshinda, a Tanzanian epidemiologist, is the current Director General of the Tanzanian Commission for Science and Technology[115] and has been influential in various government policies.[116]

- Other researchers may remain in academia but achieve influence as advisors and public intellectuals. Examples include Ghanaian economist George Ayitteh, Indonesian political scientist Anies Baswedan, and Indian neuroscientist V.S. Ramachandran.[117]
- Researchers who enter private sector organisations contribute to those organisations' ability to innovate and to draw on evidence. [32,118]

In addition to the new knowledge that research produces, it also produces research experts who can go on to have impacts in a range of fields.

Human capital built through research capacity building activities

Regarding research, human 'capital' is commonly included as a major part of the concept of 'research capacity'. Research capacity can be considered at three levels: individual, organisational and environmental/institutional. For the purposes of this paper, individual capacity – the knowledge, skills, attitudes and competencies present in an individual – will be considered as the building block of human capital.

Individual research capacity is a multi-faceted concept which will differ depending on individual roles and academic discipline. It may include specific technical knowledge, skills in research approaches, communication and IT skills and so on, as well as attitudes which enable the researcher to ask questions and seek out new knowledge. Researchers have highlighted that capacity building (and indeed learning in general) can be supported by outsiders but must be led by the individual.[119,120]

In some cases, research funders have assumed that carrying out research in or including collaborators from low-income countries will inevitably lead to improved research capacity. This approach has been widely criticised because it doesn't work as a capacity building approach and because it can be seen as using researchers from low-income countries without investing in their development.[121,122,123] For this reason, many funders now support specific capacity building activities.

Some funders incorporate capacity building activities into collaborative research programmes between research institutions in low and high income countries. This has been advocated as an effective way to build capacity, particularly when there is strong leadership in both places[133]. However, others have argued that programmes which seek to fund excellent research and build capacity, will not adequately meet either objective because by definition, these programmes will involve people with low capacity.[11]

An alternative approach is to run 'stand-alone' research capacity building programmes. There are relatively few rigorous impact evaluations of research capacity building programmes, and those that exist report mixed outcomes. Some evaluations have shown that capacity building activities have increased the research capacity of participants,[124,125] whilst other evaluations describe capacity building efforts that have failed to achieve the intended outcomes.[126,127,128] In some cases, rigorous measurement of outcomes has shown far lower levels of success than the subjective assessment by implementers would suggest.[129,130]

A review of evaluations on research capacity building programmes[131], based largely in Africa, highlighted a range of achievements including greater dissemination of research findings, increased enrolment on postgraduate programmes, better research administration

and management capacities, and overall improved research quality. However, the review notes that research generated through these programmes suffered from limited demand and a lack of quality assurance. The review also points out that the programmes had difficulty achieving impact on policy, although other authors have emphasised the long-term nature of capacity building efforts and suggest that it may be unrealistic to identify 'downstream' outcomes such as policy impact.[131]

A systematic review on Agricultural Research Capacity Building[132] found some evidence that the capacity which had been 'built' led to positive development outcomes via new products or services. For example, improved biotechnology research capacity has resulted in the adoption of new crop varieties in Asia and a new seaweed-based industry was developed in Tanzania based on one individual's PhD research work. However the review acknowledges that these directly attributable links between investment in research capacity and tangible impacts are rare.

That there is a variety of outcomes from different capacity building programmes may be a consequence of a diversity of approaches taken. At present, there is very little rigorous evidence with which to determine the best approach to building research capacity. The systematic review of agricultural research capacity building programmes concluded that while it is possible to state that interventions were generally successful in increasing immediate and intermediate outcomes (improved skills, knowledge and tools), it was not possible to draw conclusions about what types of capacity building work best.[132]

Box 3: Experiential evidence on capacity building

To make up for the gap in rigorous evidence on research capacity building approaches, many authors have drawn on their experience of capacity building projects to write guidelines for implementing effective research capacity building programmes.[133,134,135,136,137,138,139] Such lists are clearly prone to bias – they only describe the factors which people *believe* are responsible for the success or failure of a given intervention. However, at present they may be the strongest form of evidence available. Some key themes emerge from these documents:

- Implementers need to understand the context and in particular what capacity exists and what capacity needs are priorities.[134,135,139]
- It is important that local actors have ownership of capacity-building programme.[134,135]
- Since capacity building is about learning, implementers need to make sure those who are delivering the programme are able to effectively facilitate learning. In some cases they need to build capacity *to build capacity*.[135,135]
- Implementers need to think broadly about individual capacities. Good capacity building it is not just about imparting new knowledge and skills but supporting people to become adaptive, self-driven learners.[138]
- It is important to select participants who have the necessary base level of skills to benefit from the capacity building; are motivated to develop and will have the opportunity to put their new learning into use.[133,135,139.]
- It is important to consider whether and how capacity can be built at organisational and environmental level as well. In particular, consider whether individuals have viable career structures which will allow them to make use of their skills.[133,136, 137]

- Organisational level research capacity building programmes may need to include a strand focussing on support structures including finance and management.[137]
- Making use of local networks and partnerships can improve sustainability.[135,136]
- Capacity building efforts need to be long-term but it is also important for implementers to plan for 'withdrawal' from the outset.[134,135]
- A clear monitoring and evaluation procedure, built in from the outset, will enable implementers to check if capacity is 'being built' – and adapt plans if it is not.[134, 135]

The evidence suggests that some capacity building efforts are successful but that others do not achieve the intended outcomes. There is experiential evidence pointing to effective capacity building approaches (see box 3) but there is a lack of rigorous evaluations to compare different approaches.

Impact of research on tertiary education

There is a widely held assumption, particularly amongst academics, that there is a strong causal link between the quality of research carried out and the quality of teaching within tertiary education establishments. In other words, there is an assumption that a university needs to be carrying out high quality research activities in order for it to provide a high quality education to its students.

The evidence base on the link between investment in research and quality of tertiary education is weak and meta-analyses of correlation studies[140] and narrative syntheses[141] of the research literature find no evidence to back up the assumption that they are connected. [**]. One of the more rigorous attempts to investigate this issue is a research study focussing on academics from a large Australian University.[142] This study found no significant association between the overall rating of individual lecturer's teaching quality and either the total number of publications or the overall quality rating of publications. This finding was unchanged if lecturers who had not published at all were excluded from the analysis. The finding was consistent across 20 different departments.

What research there is on research-teaching links in tertiary education mainly comes from high income settings and very little research has been carried out in in low-income countries. It is possible that the relationship between research and education quality is non-linear. For example, it is possible that at very low levels of research capacity, there may be a positive correlation between research investment and teaching quality which may disappear once research capacity reaches a certain level.

The evidence on links between research and teaching are particularly relevant to the recent emphasis on 'unbundling' of tertiary education services – the suggestion that different functions of Higher Education Institutions could be offered by different providers.[143]

[**] Please note that this refers to the relationship between carrying out research in a thematic area and the quality of teaching provided on that theme. For example, whether carrying out research on governance reform increases the quality of teaching on governance reform. The relationship between research *into teaching practice* (e.g. research into effective pedagogical techniques) and teaching quality (i.e. evidence-informed teaching practice) is not considered here.

Overall the evidence suggests there is little or no relationship between quality and/or quantity of research and quality of tertiary education in high-income countries. No rigorous studies on this relationship have been carried out in low-income settings.

Box 4: Lessons from adult learning and pedagogy literature

Because developing human capital fundamentally relies on facilitating learning, studies on how adults learn and what constitutes good pedagogical approaches are relevant. In recent years there has been growing interest in evidence-informed pedagogy. For example, a ten year research project on Teaching and Learning identified ten 'Evidence-informed principles' of effective pedagogy:[144]

1. Effective pedagogy equips learners for life in its broadest sense.
2. Effective pedagogy engages with valued forms of knowledge.
3. Effective pedagogy recognises the importance of prior experience and learning.
4. Effective pedagogy requires learning to be 'scaffolded'.
5. Effective pedagogy needs assessment to be congruent with learning.
6. Effective pedagogy promotes the active engagement of the learner.
7. Effective pedagogy fosters both individual and social processes and outcomes.
8. Effective pedagogy recognises the significance of informal learning.
9. Effective pedagogy depends on the learning of all those who support the learning of others.
10. Effective pedagogy demands consistent policy frameworks with support for learning as their primary focus.

There is considerable overlap between these principals and the guidelines for effective research capacity building discussed in box 3.

There has been some work to support and develop more effective pedagogical approaches in higher education in low-income countries.[145] There is little evidence that research evidence on pedagogy has informed efforts to build research capacity.

Does increased capacity and incentives to use research lead to development via increased human capital?

Need for technical capacity for economic growth

There is evidence that a lack of scientific and technical capacity is hampering economic development. For example:

- There is evidence that a lack of statistical research capacity is hampering African efforts to accurately measure and thereby respond to socioeconomic deprivation.[146,147]
- Research in twelve African countries suggests that low numbers of scientifically trained biotechnologists is hampering plant breeding programmes which could develop new and enhanced crops.[148]
- Low levels of agricultural research capacity is hampering development in Bangladesh, Laos, Nepal, Pakistan, and Sri Lanka and the situation is being exacerbated by emigration due to low salaries for government researchers.[149]

In a survey of over 600 transnational companies, 39% indicated that 'Ability to hire technical professionals' was 'very influential' in their decision of where to invest.[150] There is evidence that enhanced human capital is likely to lead to increased foreign direct investment which will in turn contribute to economic growth.[151,152]

The evidence suggests that there is a need for scientific and technical skills for a number of services and industries in developing countries.

Critical thinking

The above section concentrated on the technical skills needed to drive economic development. However there is evidence that the less tangible skills that research exposure builds may be even more important for driving development.[107] Some authors have argued that research skills such as seeking and finding information and problem solving are key components of the human capital needed to drive socioeconomic development.[153,120] Various terms have been used to describe this combination of skills. The term 'critical thinking' is used in the field of education research and pedagogy and has been defined as:

> *"…the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information… as a guide to belief and action."*[154]

'Information literacy', a term usually used by academic librarians, has been defined as:

> *"…knowing when and why you need information, where to find it, and how to evaluate, use and communicate it in an ethical manner."*[155]

The term 'Research Awareness' is used in the field of medicine and nursing. It has been defined as:

> *". . .a recognition that questions can and should be asked, that reading of research articles and research based texts is essential, and that research findings should be assessed in terms of their usefulness, their relevance, and their potential for implementation"*[156]

In this paper we will use the term 'critical thinking' to cover all of these related terms. Research evidence suggests that education systems in many low-income countries are particularly weak in developing critical thinking skills. International comparative tests of learning outcomes demonstrate that levels of educational attainment in low-income countries are often very low.[157,158] There are many factors underlying this including the dominance of 'teacher-centric' or rote-learning teaching approaches which do not encourage critical thinking and problem solving.[159,160] There have been numerous attempts to update teaching approaches in low-income countries to improve childrens' critical thinking capacities.[161,162,163,164] However this work has proved challenging since conceptions about teaching and learning are deeply ingrained. A report of educational reform in Malawi[163] acknowledges the challenge of changing teaching practices and concludes:

> *"Veteran teachers who have been lecturing for years can find using active-learning pedagogies burdensome, while new teachers, who likely were taught using rote-learning, difficult to put the new methods into practice."*

Research suggests that the deficits in critical thinking in primary and secondary education are not being adequately overcome in the tertiary education sector. A series of case studies

in African universities found that academics had poor skills in searching for and using research information.[165] Similarly, a study of three African universities concluded that:

> *"Many graduates currently lack information literacy, critical thinking and independent learning capabilities. The students were often described as passive and embracing a 'least effort' culture..."*. [166]

Taken together the evidence suggests that there are major gaps in the system for developing critical thinking skills in in low-income countries. Some have suggested that a lack of critical thinking skills is a key barrier to socioeconomic development although little research has been undertaken on this issue.

Areas for further research

Evidence from high-income countries suggests that there is a limited link between research capacity and quality of tertiary education. However there is very little research exploring this issue in low-income countries. Given that funding for research in low income countries is sometimes justified on the basis that it will strengthen tertiary education, there is an urgent need for research to investigate whether this assumption is correct. If not, there is a need to consider what activities are effective in improving tertiary education.

There are many other potential benefits to research capacity building which are not achieved via its impact on tertiary education. However, there is a need for a much stronger evidence base on what works in research capacity building. A key part of this work will be consideration by those funding and delivering capacity building programmes of what outcomes capacity building programmes are seeking to achieve. These outcomes need to be realistic.

Summary

Funders who wish to build human capital by strengthening tertiary education should be aware that evidence from high-income countries suggests that there is almost no link between research quality and quality of teaching. There is currently little evidence examining whether such a link does exist in low-income countries. Funding research in low-income countries does not necessarily lead to increased human capital unless effective capacity building activities are included. One important output of investment in research capacity may be the development of experts who can act as advisors to decision makers. There is an urgent need for people with the technical and critical thinking skills which can be built through research.

4. Pro-poor products and technologies

Pro-poor products and technologies can be generated by research institutions in low-, medium- and high-income countries. For the purpose of this paper, we will consider pro-poor products and technologies to be those which have a direct beneficial impact on the lives of poor people.[††]

Does investment in research lead to development via new pro-poor products and technologies?

Pro-poor products and technologies can be generated by research institutions in low-, medium- or high-income countries. Public investment in research into products and technologies can be channelled through research institutions and public-private partnerships.

Research institutions

Investment in research institutions, both in the developed and the developing world, has generated numerous pro-poor products and technologies, particularly in the agriculture and health sectors. For example:

- The development of modern maize varieties is estimated to have moved over a million people per year out of poverty in the last decade. Over half of these impacts have been attributed to research carried out in two public research institutions: the International Institute of Tropical Agriculture (IITA) in Nigeria and the International Maize and Wheat Improvement Center (CIMMYT) based in Mexico.[167]
- Insecticide-treated bed nets (which were first developed by the military) were demonstrated to be an effective anti-malarial strategy in large-scale trials carried out by public research institutions.[168] There is now rigorous evidence that access to insecticide-treated bed nets leads to significant health benefits for pregnant women and children.[169,170]
- Many vaccines which have made substantial contributions to socioeconomic development were developed wholly or partially in public research institutions. For example, the live attenuated polio vaccine was developed at the University of Cincinnati.[171]

There is evidence of many pro-poor products and technologies developed by public research institutions.

[††] In this section we consider direct impacts of products and technologies on poor people (for example medicines which directly contribute to health or crops which directly contribute to nutrition). Economic benefits which are delivered through commercialisation of products and technologies are considered in section 3.1.

Public private partnerships

Public private partnerships (PPPs) take various forms, with some geared specifically towards boosting investment in research and innovation. For example, health investment funds and product development partnerships (PDPs) are both forms of PPP that aim to develop new pro-poor products. Where the costs of developing new medicines and vaccines are high but potential profits are low (common in interventions for diseases in low-income countries), public private partnerships can help overcome market failures. They help the private sector share the costs of research by matching public funds with private investment at project inception, or during project implementation.

Whilst the effects of PDPs have sometimes been uneven, there is general consensus that they have been highly successful in developing new products in the health sector.[172] Some examples of PDPs include the Medicines for Malaria Venture, the International Aids Vaccine Initiative, and the African Comprehensive HIV/AIDS Partnership.[173,174,175]

Some PDPs have extended their remit beyond developing new products to other activities including: building local research capacity; ensuring equitable access to newly developed products; and providing policy advice to low-income country governments. There are differing views on whether PDPs are best-placed to carry out these additional functions or whether they should focus purely on product development.[176]

Challenge Funds are a further public private partnership mechanism that seeks to overcome market failure. Again, they can be targeted specifically at research and innovation, releasing funds to entrepreneurs on delivery of a solution to problems previously lacking commercial attention. Examples include: DFID's Financial Deepening Challenge Fund (FDCF) which supported the roll-out costs for Vodafone's M-PESA mobile money transfer service; the Africa Enterprise Challenge Fund, which encourages businesses to commercialise technologies developed within public agricultural research systems; and the Food Retail Industry Challenge Fund, which assists agribusiness to link smallholders to agricultural export supply chains.[177]

Within agricultural research, there has been interest in public private partnership mechanisms for more than ten years, with some 75 PPPs operating within the CGIAR agricultural research consortium alone, although systematic assessment of the effects of these PPPs has not yet been conducted.[178]

Alternative public private mechanisms include university-industry collaboration. For example, the Indonesian pharmaceutical company Bio Farma collaborates with universities within Indonesia and overseas to improve their products.[179]

National governments may also choose to develop policies to financially incentivise private firms to carry out research. Although this is not direct public investment in research, it is another way in which public money can be used to drive private research and innovation. For example, the Indian government has implemented a range of policies including provision of start-up funding, tax-free profits and high tariff protection to encourage the private sector to develop pharmaceutical research.[180]

Public-private partnerships such as Product Development Partnerships are a successful mechanism for development of new pro-poor products and technologies.

Local versus international research

Pro-poor products and technologies can be created anywhere in the world and many of the examples given above were developed by high-income country-led research programmes. However many have argued that low and middle-income countries may be best placed to develop solutions which respond to the particular challenges they encounter. China and India have been highly successful in fostering local innovation[181] and India has been particularly lauded for supporting 'frugal innovation': innovation which produces products and/or technologies which are significantly cheaper than those previously available.[182]
It has been argued that the relative technological disadvantages that low-income countries have can be at least partially overcome by the 'Latecomer Advantage': the ability to 'leapfrog' over relatively poor 'first-generation' technologies and instead make use of technology which has been tested and optimised.[183]

Many pro-poor products and technologies are developed by high-income based researchers however there is evidence that middle-income countries are becoming increasing important producers of innovation.

Does increased demand for research-derived pro-poor products and technologies lead to development?

As described above, public research has resulted in many products and technologies which have had transformational effects on the poor. Many products or technologies developed through research can be taken up and used by the population without any need for additional skills building. This is particularly true if the new product or technology leads to genuine and immediate benefits for the individual. For example, M-PESA mobile banking technology has spread at dramatic speed in Kenya without the need for any interventions to build people's capacity to use it.[184]

However, there are also numerous examples of products and services produced through research that have not led to the expected impacts. For example:

- An evaluation of 'Playpumps' (water pumps linked to children's roundabouts) found that in some cases women were forced to use the roundabout for hours or to pay children to use the equipment in order to get adequate water supplies.[185]
- New high-yield varieties of barley were not taken up in Syria unless farmers were involved in the breeding programme which developed them.[186]
- The roll-out of improved cookstoves in India did not lead to the predicted positive impacts on health or fuel consumption since they were not used regularly and were poorly maintained.[187]

The tendency to overestimate the impact of new products and technologies is of course not limited to the international development sector. Many authors have highlighted a general human tendency to seek out 'technological fixes' even when the roots of a problem are social, and to overestimate the impact that new products and technologies will have.[188,189,190]

It is therefore vital to fully understand the needs and demands of potential users of new products and technologies before investing large quantities of research money in their development. Research to develop new products and technologies must also be accompanied by 'research to understand the world around us' (see box 1) and research to understand the roll-out and uptake of products. Furthermore, strategies may be needed to

challenge the tendency for optimism bias when funding the development of new products and technologies.

Many products and technologies developed through public research have been readily used in developing countries and have led to positive impacts. However, not all products have had the intended impact and evidence suggests meeting user needs is an important factor in successful product and technology design.

Areas for further research

Existing research suggests that research funders sometimes overestimate the impact that their new products and technologies will have and underestimate the barriers to uptake. It would be valuable to investigate what measures funders could put in place to more effectively challenge the tendency towards optimism bias.

Pro-poor products and technologies have been successfully developed by public research institutions, by public-private partnerships and by the private sector. It would be useful to analyse which of these mechanisms is most appropriate for the development of different types of products and technologies.

Public-private partnerships have mainly been used to drive the production of health and agriculture products and technologies. It would be useful to understand whether market failures are inhibiting the development of other pro-poor products or technologies and if so whether public-private partnerships be used to incentivise innovation.

Summary

There are many examples of new products and technologies developed through publically-funded research which have had direct positive impacts on poor people. A number of funding models can be used to support the development of pro-poor products and technologies. There are also examples of products and technologies which have had less positive impact than expected. Measures should be taken to overcome the optimism bias that is sometimes present when developing new products and technologies. Involving end-users in the development of new products and technologies can increase the likelihood that they are wanted and used.

5. Evidence-informed policy and practice

For the purposes of this paper, 'Evidence-informed policy and practice' means policies and practices which have been developed using a process which includes a search for and analysis of relevant evidence (including research, evaluation and statistical data). An important aspect of this is that wherever possible, the full range of evidence should be considered (rather than just evidence backing up a pre-existing position) and that an assessment is made of the strength of evidence underlying different assumptions.[191] This definition does not imply that evidence is the only, or even the main, influence on decision making; merely that it is one factor *informing* decisions.

Research can inform policy and practice in two ways: it may inform decisions on specific interventions (e.g. what intervention to use in response to a given problem), and it may be used in a more subtle way to inform a decision maker's understanding of a context.
It is clear that using evidence to inform decisions on specific interventions leads to better policy outcomes. For example, there is evidence from the field of medical practice that decisions resting on evidence-based clinical guidelines lead to better outcomes compared to relying on 'expert opinion' as long as the guidelines are well-written and well-informed by the evidence, and clinicians have the skills to interpret them.[192,193,194,195] In some cases, the use of standardised evidence-informed checklists can also improve patient outcomes by, for example, reducing hospital acquired infections,[196] reducing prescribing errors[197] and increase surgical safety.[198] Use of checklists, as opposed to reliance on expert judgement, has proven successful for a range of sectors including policing[199], aircraft piloting[200] and nuclear power plants.[201] Similarly, decades of research have demonstrated that using actuarial methods (based on statistical formulae) is more accurate than reliance on expert 'clinical' judgement in a range of situations including the diagnosis of mental ill-health,[202,203] prediction of violent behaviour,[204] and employee and student selection decisions.[205]
It is more difficult to show impacts of the use of evidence to inform decision makers' understanding. However, case studies show how damaging it can be when decision makers are *not* well informed about context. For example:

- An American entrepreneur faced a wave of opposition after he attempted to start a new charity movement to send used T-shirts to Africa.[206] Critics complained that he had not taken the time to understand the real needs of African people before designing his intervention.
- Some interventions intended to reduce the prevalence of Female Genital Cutting have failed to achieve their intended results in part due to poor understanding of the cultural factors driving the practice.[207]
- There is evidence from a number of African countries that poor statistical data is negatively impacting on provision of services by governments and international organisations.[147] For example, unreliable estimates of the population of different areas of Nigeria mean distribution of services including health and education is unlikely to correspond with actual need. Similarly, the results of a recent census in

Kenya, which were used to determine distribution of two government funding schemes, have been disputed.[208]

Below we discuss what supply and demand factors impact on evidence-informed policy and practice.

Does investment in research lead to development via more evidence-informed policy and practice?

There is a large body of case study evidence which demonstrates that research results can and do contribute to policy and/or practice impacts.

Type of change	How change happened: Symbolic	How change happened: Indirect	How change happened: Direct
Instrumental	Research being used to legitimise a decision that has already been made	General ideas from research being used to influence a specific policy/ practice/ piece of research etc.	Specific research influencing a specific policy/ practice/ piece of research etc.
Conceptual	N/A	General ideas from research feeding in to general enlightenment about particular concepts	Specific research influencing the way people think about or understand an issue
Capacity	N/A	General ideas from research or relationships from a research partnership improving the capacity of individuals or organisations	Specific research activities or ideas improving the capacity of individuals or organisations

Table 1: 'The Punton Framework': A model of how research leads to change

Frameworks for understanding impacts

Many authors have created frameworks which describe different ways in which research knowledge can lead to impacts. Two recent papers have provided overviews of some of the key publications and models for understanding research impact in international development.[209,210] An example of a framework for understanding research impact is the 'Punton framework'[211] which attempts to bring together some of the elements described in other frameworks (table 1). In this model, two axis of research influence are considered.

Firstly, the *type* of change is classified as follows:

- Capacity changes are changes in the knowledge, skills and/or attitudes of researchers, policy makers or others involved in the research activity (these changes were discussed in section 4).
- Conceptual changes are changes in the way people conceptualise a given issue including changes in people's general awareness of a given topic.
- Instrumental changes are concrete, specific changes to a policy or programme.

Secondly, the *manner* in which research has led to that change is classified into the following categories:

- Symbolic use of evidence is when evidence is used to legitimise a decision which had already been made.

- Indirect use of evidence is when research leads to a change in some intermediate variable which in turn leads to a policy/programme change.
- Direct use of evidence is when a specific research finding is applied to change something.

There are many collections of case studies which outline how research findings have led to development impacts.[212,213,214,215,216,217] These case studies can provide useful examples of where research results have led to change however they also need to be analysed with caution for a number of reasons:

- Case studies are often written, at least in part, in order to demonstrate the positive impacts that research can have and thereby justify continued investment in research. For this reason, selection of case studies is likely to be biased towards research projects which have achieved impact and therefore examination of case studies can result in an overestimation of the policy impact of research.
- There may be little incentive to document symbolic use of research and this is likely to be underrepresented in case studies.
- It is often very difficult to prove and quantify the extent to which research contributed to policy/practice changes and thus claims of contribution must be viewed with caution.
- Certain types of impact (i.e. direct, instrumental impacts) are likely to be overrepresented since they are relatively easy to 'prove'.

Concerns about the objectivity of case studies of policy influence were also raised in a systematic review of methodologies for assessing the impact of research on policy.[218] The review cautions that evaluations of research impact in international development:

". . . stray dangerously close to the line between evaluation and promotion".

Despite these caveats, case studies of research impact can provide useful insights into the pathways by which research can lead to impact.

There is a large body of case study evidence describing how research findings have led to policy and practice impacts. Various frameworks have been proposed to categorise different types of impact.

Decisions on specific interventions

The most 'appealing' case studies of evidence-informed policy are those which fall into the 'Instrumental/Direct' box of the Punton framework. Indeed, some authors have cautioned that the tendency of research funders to search for this type of impact can create the unhelpful impression that such impacts are the norm and that they represent the ideal type of impact. A wide-ranging research programme on the impacts of UK social scientists refers to:

"…the incessant search by funding bodies for evidence that individual pieces of funded research had some specific impact".[219]

The authors go on to note that:

"Almost all the academics stressed to us that this is not how the world works, and that when they did have impact it was often a reflection of the work of many different people, for which they happened to be the immediate agent of change".

Nevertheless, instrumental/direct changes do occur and, probably due to demand for these from funding agencies, are well-represented in published case studies. Such impacts are particularly related to impact evaluation: research into specific interventions which aims to find out 'what works'. Examples of such cases include:

- The PROGRESA programme in Mexico gave cash directly to poor families as long as their children attended school and medical appointments. Evaluations found significant positive effects and the programme was scaled up under a new administration under the name Opportunidades.[220,221]
- Research into modes of distribution of anti-malarial bed nets found that charging for the net significantly reduced usage. Policy and practice in a number of NGOs and governments changed as a result.[222]

There are numerous examples of interventions which were assumed to deliver certain outputs/outcomes but research evidence has demonstrated that the assumptions were incorrect. Such research can lead to direct impacts when policies and practice are changed as a result. For example:

- Community-driven development/reconstruction is an approach which aims to build community cohesion by providing funds and supporting the community to set up a council to determine collectively how to spend them. The evidence demonstrates that it is an effective method of disbursing aid but there is little evidence that it has any impact on social cohesion. [223]
- There was general assumption that getting people to pay small amount for health interventions such as anti-malarial bed nets, rather than providing them for free, would increase usage since people would value them more. However, evidence demonstrates that this is not true and that interventions which deliver bed nets for free achieve the greatest benefit.[224]
- Guidelines for treating critically ill children have for decades recommended giving a large initial infusion of saline. However research evidence has now demonstrated that this does more harm than good.[225]

Applied research which aims to optimise the delivery of an intervention or the roll out of a policy may also lead to 'Instrumental/Direct' impacts. This includes research classified as Operational Research, Process Evaluations, and Implementation Research. For example:

- Case study evidence from Tanzania shows that operational demographic surveillance data has been a crucial component of ongoing efforts to reform health care delivery. [226] District Health Management Teams (DHMTs) in the large-population districts of Rufiji and Morogoro have worked with the Tanzania Essential Health Interventions Project (TEHIP) to increase the efficiency of district health systems by trying to ensure that funds are allocated more proportionally to key interventions for the major

local causes of death and disability. Child mortality in the two districts fell by over 40% in the 5 years following the introduction of evidence-based planning and death rates for men and women between 15 and 60 years old declined by 18%.

- A case study of Operational Research in India revealed that all patients who were positive for both HIV and TB should receive anti-retroviral treatment. This research led to a national health policy to this effect in 2011.[227]

In addition to the direct impacts listed above, it is possible to have Instrumental/Indirect impacts. This category includes specific changes to policies or practices which have been influenced by general ideas from research. For example, a case study examining changes to the Dairy Marketing Policy in Kenya to protect small-scale milk vendors concluded that research had: *". . . catalyzed, speeded up, and swayed [the debate] in one direction"*. [228]

It is important to note that some examples where research appears to have influenced a specific decision may be more complicated than they first appear. Many authors have highlighted that predetermined policy/practice changes may be justified by research results.

Examples of such cases include:

- Donor staff in Uganda who had been advocating for social protection policies for many years were able to use research which revealed the extent of chronic poverty in Uganda to support their argument.[211]
- A study of use of evidence in DFID 'business cases' for statebuilding programmes in fragile states[229] highlights that: *"One official noted how they would insert widely used terms and concepts into these documents in order to score 'brownie points' with senior management without necessarily exploring those concepts in any depth. Essentially, research is often sought selectively and subsequently retrofitted to predetermined or pre-existing programmes."*
- A study of urban resilience interventions in the Philippines found that: *". . . demand for use of scientific knowledge by policy makers is linked to the occurrence of a natural disaster, rather than risk of a natural disaster"*.[230]

It is also important to note that the drive to ensure research leads to impact can have unintended negative consequences, and that the fact that a piece of research has led to an 'impact' does not necessarily mean that the best and most evidence-informed decision has been made. Proponents of evidence-informed policy making have emphasised that decisions should be informed by consideration of the full body of evidence, weighted according to quality. There are examples where policy/practice informed by a partial view of the evidence has not led to the best overall outcomes for people living in poverty. For example:

- A quality-weighted literature review on decentralisation of government services revealed that the standard policy interpretation that there is no strong evidence either for or against decentralisation is incorrect. [231] In fact, higher quality evidence consistently reveals that decentralisation has positive impacts on service delivery.
- There was huge enthusiasm amongst international development actors for micro-finance and micro-credit based on poor quality research results, but systematic reviews of quality research suggest there is little evidence of their efficacy in reducing poverty.[232,233]

- Community-driven development has been suggested as an effective peace-building strategy based on anecdotes and low-quality studies, but synthesis of high-quality studies demonstrates that it has little impact on social cohesion.[234]

In summary, there are many documented examples of research evidence influencing decisions on specific interventions. There are some cases in which decision makers use research findings symbolically to back up pre-existing ideas. Decisions informed by individual studies – particularly where these are low quality – may not achieve optimal outcomes.

Impacts on decision makers' understanding of context

Achieving the 'impact' of 'poverty reduction and improved quality of life' is the expressed over-riding goal of many development funders and national governments of low-income countries. However, knowing the final goal does not always mean that you know what path to take to get there. Indeed, problems such as poverty and insecurity have been described as 'wicked problems': problems which are difficult to define and understand and for which clear-cut solutions may not exist.[235] An important part of the job of a decision maker who aims to achieve socioeconomic development is therefore to understand the nature of the problem and, based on that knowledge, to create a plausible 'theory of change'. In this context, the term theory of change may mean an explicit written account or diagram which sets out a series of intermediate outcomes which the decision maker believes will contribute to the end goal of poverty reduction. However, it also includes 'implicit' theories of change which comprise the beliefs which that decision maker has about how socioeconomic development can be achieved.

Research impact on these beliefs is difficult to document, but some authors have argued that it is the most important pathway by which research leads to impacts on policy and/or practice. Changes in personal theories of change may be derived from research which gets 'into the ether' and influences the way people (including but not limited to policy makers) see the world. This process has been referred to as research 'enlightenment'.[236,237] A key feature is that the decision makers who are 'enlightened' by research are rarely able to identify individual research findings which have contributed to their world view. This makes these types of impact very difficult to track and attribute.

This category of evidence-informed decision making is likely to draw particularly on 'Research to understand the world around us' (box 1), including both qualitative and quantitative observational research.

There are some documented examples where evidence has led to shifts in 'theories of change'. For example:

- A research project into old-age and poverty in India raised awareness of this issue amongst the general public and policy makers.[238]
- Research into chronic poverty is thought to have raised the profile of chronic poverty on the global agenda and influenced the way people thought about social protection.[211]
- A study of policy advisors working in fragile states notes that: *". . . policymakers spoke about the influence of research through process of 'osmosis and seepage' and*

'selective absorption' whereby they come into contact with concepts 'floating around' and generally shaping the debate". [229]

The examples given above concern specific research findings which altered a theory of change however, an important way in which research feeds into this type of decision making is through the development of thematic experts who build up their own theories of change over many years of carrying out research. Such experts can be called upon by policy makers to inform their view or, in some cases, such experts themselves become policy or practice decision makers and thus the knowledge they acquired through research is put into practice directly. Some examples of former researchers who become influential in policy making were discussed in section 4.1 under the heading 'Human capital built through the funding of research'.

Overall the evidence demonstrates that research can influence decision makers' understanding of context and that this can go on to have significant impacts on policy and programmes.

Box 5: Research uptake/communications guidance

Many authors have attempted to draw lessons on 'what works' to improve the uptake of research into policy/practice.[212,219,239,240,241,242,243,244,245,290], Some of the characteristics of research projects which have been successful in supporting the uptake of research include:
- The existence of a clear demand for the research results
- The cultivation of links and relationships with key decision makers
- An effective communication strategy which is planned from the outset of the project.

Nevertheless, recommendations to adapt projects to include these characteristics must be interpreted cautiously. It is important not to conflate causation and correlation; i.e. adoption of conditions which exist in research projects which have been influential will not necessarily make other research projects more influential. Perhaps an even more important reason for caution about recommendations for achieving research impact is that they can incentivise researchers to become lobbyists and advocates for particular policy outcomes which may be based on a partial or biased view of the evidence.

Research communication/uptake approaches

Researchers can choose to play different roles when it comes to facilitating the 'uptake' of their results. Pielke discusses different roles which researchers can adopt, ranging from the 'pure scientist' who focusses purely on generating empirical evidence with no consideration of how it will be used, to the 'issue advocate' who is fundamentally interested in promoting a specific policy outcome and carries out research in order to support this viewpoint.[246] There are different views on which of these roles different scientists should take. Some feel it is a moral imperative for scientist to ensure that useful findings are used, while others argue that scientists should remain impartial and that their involvement in lobbying and advocacy goes against the principals of evidence-informed policy which should objectively take account of a wide range of research.

Interventions which aim to increase the supply and/or communication of research results in order to achieve evidence-informed policy/practice have had mixed results. One systematic

review which considered interventions to increase decision makers' access to systematic reviews found that the majority of interventions – including efforts to make evidence available via online databases and one intervention to employ an in-house evidence broker - did not lead to measurable increases in the use of evidence.[247]

There is much advice on how to increase the impact of research but there are mixed views about whether this is an effective or appropriate mechanism to drive evidence-informed policy.

Does increased demand for research lead to development via more evidence-informed policy and practice?

Ability to use evidence

A number of studies have interviewed policy makers/practitioners to find out what they believe supports or inhibits their use of evidence.[248,249,250,251] Such studies generally reveal that policy makers feel that lack of time and poor communication of research results inhibit their use of evidence, while clear writing and inclusion of policy implications or recommendations increases their use of evidence. However, policy makers' perception of why they do or do not use evidence is not necessarily the same as the objective reality.[252]

There is a moderate body of evidence which indicates that policy makers and practitioners in low-income countries lack the necessary skills to understand and use research evidence and that this is a major barrier to evidence-informed policy/practice. No synthesis of research into skills in use of evidence exists, however an overview of some of the individual studies is given here:

- A survey of staff from the Zambian parliament who had self-reported as needing to use research in their roles found that they had poor understanding of research and research methodologies. For example, only one in five was able to pick from a list the correct definition of a randomised controlled trial (RCT) while only one in three believed there was consensus that the CIA *did not* invent HIV.[253]
- A study on scientific capacity in the Ugandan parliament found low levels of scientific literacy and low skills in finding and appraising the quality of research evidence.[254]
- A series of studies of health sector policy makers and practitioners in Nigeria identified capacity constraints at both the individual and the organisational level.[255,256,257]
- A synthesis paper of four case studies of policy debates in Africa concluded that there is a *"fundamental, structural lack of capacity to undertake, use and understand research-based evidence"*.[258]
- A study of a Public Health Association in Burkina Faso concluded that the lack of staff with knowledge of research methods limited their ability to make use of research.[259]
- A survey of over 300 Southern Civil Society Organisations (CSOs) found that the majority believe their influence to be substantially limited because *"policymakers are not used to drawing on research and evidence"*, *"policymakers have limited capacity to use and adapt evidence in policy processes"*, and *"CSOs have limited capacity to use and adapt evidence in policy processes"*.[260]

- Qualitative research into the use of climate science data to inform local adaptation practices in Africa reveals that most practitioners and policy makers lack the skills to find and interpret relevant information. It concludes that *"despite a growing recognition of the issues surrounding climate change among researchers and practitioners, there are very few examples where the climate change model data have actually been used to inform decision-making."*[261]
- A study of five African countries found that *". . . there is potential rather than actual technical capacity to manage, undertake and demand evaluations. This is a major constraint on the use of evaluation."*[262]

The finding that lack of skills and knowledge is a major barrier to evidence-informed policy/practice is supported by a study which finds that policy makers' educational standing is correlated with their use of evidence.[263]

Given that policy and practice in low-income countries is also influenced by decision makers working in international organisations, it is also relevant to consider their ability to use evidence. Two development organisations (UK DFID and the World Bank) have recently carried out surveys to assess the use of evidence amongst their staff.[264,265] The DFID survey included questions on perceptions of skills and some diagnostic skills tests. Two thirds of those surveyed have confidence in their skills to find and use evidence, and this was largely backed up by the diagnostic test results which revealed a generally good level of understanding of research concepts. Nevertheless, many staff in DFID reported that they would welcome additional training and support in the use of evidence.

Overall the evidence suggests that there is low capacity amongst policy makers in low-income countries to access and use research evidence.

Incentives and motivation of policy makers to use evidence

There is a moderate body of evidence which indicates that policy makers and practitioners in low-income countries are not incentivised to make use of research evidence.

Studies that have surveyed policy makers to assess their interest in evidence suggest that they profess a high level of individual enthusiasm for evidence but feel that in general evidence is not used sufficiently in decision making.[254,265,264,266] A number of qualitative observational studies have examined the motivations and incentives which drive decision makers in low-income countries to use (or not to use) evidence.

- A study of Philippine Mayoral candidates found that they were relatively uninterested in use of evidence because they did not think it would be an important factor in the electorate's voting behaviour.[267]
- A study in Indonesia found that decision makers rarely viewed use of evidence as an important factor in itself and were mainly motivated to use evidence where this would help them achieve political, economic or influencing goals.[268]
- A study in Vietnam found that evidence is a relatively minor influence on policy decisions compared to other factors such as political ideology and patronage systems.[269]
- A paper drawing on evidence from longitudinal research programmes in Ethiopia, India, Vietnam and Peru concludes that politics is the key factor in political decision

making and urges those who seek to get research into use to be realistic about its role in decision making.[270]

- A synthesis of four case studies revealed that research evidence was cited relatively frequently in African policy debates but that, compared to other factors, it had a relatively weak influence on decisions.[258] The study concludes: *". . . it would be easy to overestimate the role research-based evidence plays. Even when it is used, research is often poorly referenced and seemingly selective; the full implications of research findings are poorly understood; and the logical leap required to move from research cited in relation to a specific policy problem (e.g. HIV/AIDS transmission trends in Uganda) to the policy prescription or solution proposed (e.g. the criminalisation of HIV/AIDS transmission) is often vast. Sometimes, research-based evidence plays almost no role, and arguments on one or more sides of the debate are driven by personal prediction, assumption, reflection on past precedent and commitment to the idea of progress."*

Taken together, the evidence suggests that use of evidence is generally not a major factor for decision makers in low-income countries. This finding is consistent with studies carried out in high-income countries,[271,246] although this is counterbalanced to some extent by stronger structures and processes to support use of evidence (see next section). There has been a conscious shift in terminology in recent years from evidence-based to evidence-informed policy/practice in recognition of the reality that policy will never and should never be 'based' purely on evidence but that evidence should be one of many factors influencing decisions.

A study on the supply of and demand for evaluation evidence in five African countries aimed to draw conclusions about the potential drivers for evaluation usage in either neopatrimonial or developmental patrimonial contexts.[262] The report concludes that the role of evidence in informing policy in either situation is weak but that there are some potential entry points for those seeking to promote the uptake and use of evaluation evidence. In neopatrimonial states, the many competing actors seeking to influence policy do present opportunities for evidence to feed into debates. In developmental patrimonial states, it is less easy for non-government actors to influence policy making however the overriding incentives to achieve development can mean that technocrats are more willing to consider evidence if they believe it will enhance policy outcomes.

While evidence is low on the priority list for most decision makers, there are individuals in policy making institutions who are particular 'evidence champions' and there are organisations which have a strong culture of evidence use. For example, a study of DFID staff working in fragile and conflict affected states noted that:

"Many interviewees were aware of current debates in the field, had read or at least consulted key statebuilding research outputs and knew many of the leading names or research centres working on statebuilding issues. Furthermore, many advisors were clearly passionate about the subject, influenced by a distinct culture within DFID that places a premium on keeping up with the latest research, in part to maintain credibility amongst colleagues". [229]

Similarly, interviews with staff of a public health association in Burkina Faso revealed that use of evidence was a key priority for the organisation and this motivated the efforts of staff:

"One respondent in an informal discussion . . . was proud to emphasize that the utilization of research findings is a core value of the association, to serve the advancement of the population's health". [259]

Overall, the evidence suggests that most decision makers are not 'naturally' motivated to use research evidence. However there are exceptions where policy making institutions have prioritised a culture of evidence-use.

Systems and processes for use of evidence

One study from the UK suggests that, given that use of evidence tends to be low on decision makers' priority list, it is important that processes and systems are in place to force decision makers to consider and apply evidence.[272] This conclusion was echoed by respondents to DFID's evidence survey who felt that the requirement to consider evidence as part of the business case process has significantly improved use of evidence.[264]

Evidence from low-income countries suggests that use of evidence is generally ad hoc and that systems and support functions to support the use of evidence in decision making processes are particularly weak. For example:

- Although the government of Vietnam has systems in place where it can request research reports from state research institutions, informants felt that most ministries did not make effective use of this service.[269]
- The Parliament of Uganda has a Research Service which can produce reports for MPs on key debates but the service is mainly used for briefing reports for MPs attending external conferences rather than to inform parliamentary business, the quality of many reports is poor, and there is no system in place to share reports leading to much duplication of effort.[254]
- A study in Indonesia concluded that *"formal bureaucratic rules appeared to be weak in incentivising policy-makers to invest in, demand and use knowledge in order to draft policies"*.[268]
- A study of health policy making in Cambodia found that the demand for research evidence was not well-embedded and instead relied on a small number of overworked individuals.[273]
- A study of disaster resilience policy making in the Philippines found that linkages between policy makers and research institutions did occur but were the exception rather than the rule.[274]
- A study of rice policy making in Ghana found that research-policy linkages were ad hoc and weak.[275]

Putting in place appropriate processes can increase use of evidence. Such systems are generally lacking in low-income countries at present.

Areas for further research

Although there is evidence to suggest that there is a lack of capacity, incentives and systems to use research in low-income country policy making institutions, there is a need

for more rigorous and objective research to understand the current situation. This evidence will be required in order to properly assess the impacts of interventions designed to increase use research.

Summary

There is evidence that knowledge generated from public investment in research can and does feed into policy and practice decisions. However the pathways by which evidence informs policy and practice are often indirect and difficult to track. Funders who wish to fund research to improve evidence-informed policy need to be realistic that direct, attributable policy impacts are relatively rare but that evidence can and does make important contributions to how decision makers frame issues and to selection of interventions which have a higher change of success.

There is evidence that the capacity to access, evaluate and use research evidence amongst low-income country policy makers is low. Unless there is sufficient capacity to absorb research results, no amount of research supply will have positive impacts.

6. Quantifying economic impacts

Assessing the economic impact of investment in research is complicated and contested. Researchers have developed a variety of methodologies which attempt to capture the economic effects of research investment. However, even researchers involved in calculating and analysing rates of return to research stress that the figures they arrive at must be interpreted cautiously. For example, the authors of a meta-analysis of rates of return to agricultural research investment conclude:

> *"…the rate of return literature and the numerous rate of return estimates in that literature have a low signal-to-noise ratio that does not lend them to meaningful analysis by ad hoc inspection"*. [276]

Similarly, an opinion piece in the journal Nature[277] stated that:

> *"Beneath the rhetoric, . . . there is considerable unease that the economic benefits of science spending are being oversold. . . . The problem, economists say, is that the numbers attached to widely quoted economic benefits of research have been extrapolated from a small number of studies, many of which were undertaken with the explicit aim of building support for research investment, rather than being objective assessments."*

Nevertheless, numerous methodologies for calculating rates of return to research exist and have been used to estimate economic impacts of various types of research in various contexts. Estimates derived using four key approaches are summarised in Table 2 and described in more detail below.

Licensing rates

As described in section 3.1, it is possible to calculate the ratio of income from licencing of new products/technologies to total research spend. Licensing rates will only capture the returns of a relatively limited type of technology transfer (licensing) and they only capture the benefit to the academic institution itself as opposed to the impacts on the entire economy which will be larger. Despite these caveats, these rates are often used as a proxy for the 'health' of the technology transfer environment. The most recently available annual rates for the USA, Australia and Europe are 0.048, 0.022 and 0.017.

Econometric approaches

One method for assessing impacts of research investment examines some indicator of economic growth over a period of time and uses regression modelling to estimate the contribution of research knowledge to that growth. However it should be noted that such regression modelling is highly susceptible to omitted variable bias, that is, the possibility that the impact ascribed to research investment is in part due to one or more other variable which has not been considered. Some econometric approaches are based on the implicit or explicit assumption that economic growth occurs through a linear pathway connecting

research to the private sector via technology transfer. As discussed in section 3, there is limited evidence that this occurs, at least to the extent that has sometimes been assumed. Therefore the plausibility of some results which suggest large rates of return based on this model are questionable. Furthermore, many agricultural research regression analyses consider both the 'supply' of research and the extension activities to

Approach	Impact pathway				Context	Publication date	Annual rate of return on investment[‡‡]	Bibliog. ref.
	Economic growth	Human capital	Pro-poor products/techologies	Evidence-informed policy/ practice				
Licensing rates	■				University research in USA	2013	0.048	42
					University research in Australia	2013	0.022	
					University research in UK	2013	0.017	
Econometric approaches	■	■	■	■	Agriculture research in Africa	2010	0.33	290
					Agricultural research (meta-analysis of global literature base up to 1998)	2000	Median: 0.53 Range: −0.01 to 12.19	278
Simulation modelling			■	■	Agricultural research (meta-analysis of global literature base up to 1998)	2000	Median: 0.46 Range: −1 to 56.45	
					Agriculture research in low-income countries	2010	Range: 0-1	290
					Medical research in UK	2008	Cardiovascular research: 0.39 Mental health research: 0.37	291
				■	Influence of Think Tanks' research on policy/practice	2013	Microfinance in Bolivia: 31 Promoting growth in Tanzania: 8.5 Resource curse Ghana: 170 Democracy strengthening Ghana: 420[§§]	279, 280 281, 282 283, 284 285, 286
Research mediation		■		■	UK Social Science		5.82	219

Table 2: Approaches to calculating rates of return to research investment

disseminate results together and it is not clear whether generating new knowledge or disseminating information is most correlated with growth.

This technique has been used by many authors to calculate returns on investment from agricultural research. A meta-analysis of all studies using this type of approach found a range of annual rates of return varying from −0.1 to 12.19. [287] A more recent study which

[‡‡] The rate indicates the multiple of the original investment which will be recouped each year. For example, if there was an investment of £100 with a rate of return of 0.5, the amount gained in economic benefit each year would be £50 while if the rate of return was 5, the amount gained in economic benefit each year would be £500.

[§§] The rates of return were calculated in this research project as the total benefit which would be achieved over a ten year period. The rates given here are one tenth of the total benefit calculated and therefore represent the average annual rate of return over a ten year period.

focussed specifically on the impacts of agricultural research in Africa found an annual rate of return of 0.33.[288]

Simulation modelling

Another method for calculating impact on the economy is simulation modelling or economic surplus modelling. This approach can be used where a body of research contributes to one or more tangible outcomes, for example where research has led to the production of a new strain of seed which has enhanced nutritional value, or where research has led to improvements to healthcare. In such a case, the economic benefit of the outcome can be estimated and compared to the total cost of all the research which contributed to this outcome. A major disadvantage of this approach is that it will only include research which was designed to contribute to the specific outcome under investigation; it will not include the cost of research which did not lead to any new product or service and thus the rates of return calculated are likely to be overestimations of the actual rates of return of research investment. In addition, and in common with regression modelling, it is difficult to separate out the benefits which have resulted specifically from research results as opposed to benefits from other factors. Where the relative contribution of research is estimated, there is a risk that those involved in research will inadvertently overestimate their contribution.

The above-mentioned meta-analysis of rates of return literature for agriculture research found a range of annual rates of return calculated using simulation modelling varying from −1 to 56.45. [289] A more recent literature review of rates of return to development research reported rates of return to agriculture research varying from 0 to 1.[290] Most rates of return were calculated using simulation models, although some econometric studies were also included. Both literature reviews conclude that investment in research to develop high-yielding crop varieties generates particularly high rates of return.

Simulation modelling has also been used to estimate the rates of return to investment in medical research on cardiovascular disease and mental health in the UK.[291] For each area, they calculated the economic value associated with ‘Quality Adjusted Life-Years’ gained and estimated the proportion of this which could be attributed to research advances and compared to research investment. In addition, they added a figure of 0.3 for the spillover effects of research investment on the economy. The figure of 0.3 is an estimate based on previous work on agricultural research. Based on these calculations they estimate that investment in cardiovascular research results in an annual rates of return 0.39 while the figure for investment in mental health research is 0.37.

As well as being used to estimate rates of return to research which generates products and technologies, simulation modelling can be used to estimate the rate of return to research which influences policy and/or practice. The approach was used to investigate four policy/practice changes which were influenced by research carried out by Think Tanks.[279,280,281,282,283,284,285,286,] In each case the estimated economic benefit of the policy/practice change was calculated over a ten year period. In addition, an estimation of the relative contribution of the Think Tanks’ research to that change was estimated based on interviews with relevant stakeholders. By comparing these figures with the amount invested in the research, rates of return were calculated. The authors of this study acknowledge that the figures they calculate are ‘rough’ and ‘speculative’.

Research mediation calculation

It has been argued that most social science research does not deliver impact through the production of products or codified knowledge. For this reason the methods described above would not be suitable for estimating rates of return. To overcome this problem, one research group has developed a methodology for placing a value on the services delivered by social science expertise based on how much government bodies or other organisation are willing to pay for it.[219,292] They make the assumption that such expertise could only have been developed through the involvement of these experts in previous research projects. They calculate the annual cost, including both salary and overhead costs, of employing people whose role they classify as 'social science mediation' in three sectors in the UK: Banking and finance; Public Administration, health and education; and Other services (including consulting). This figure is compared to the overall cost of supporting social science research in the UK annually. This generates a figure of an annual return on investment for UK social science of 5.82.

In common with the other methods described above, this method is highly sensitive to the assumptions used. For example, there could be debate about which individuals are classified as social science mediators and the authors of the study acknowledge that some critics feel their classification was too broad. On the other hand, the analysis only includes a sub-section of UK sectors and will have excluded some social science mediators in other sectors or industry.

Modified Internal Rates of Return

A recent study has questioned the tendency of economists to express rates of return to agricultural research using Internal Rates of Return (IRRs) which assume that any returns generated will be 're-invested' and will generate the same rate of return as the original investment.[293] The authors argue that this assumption is unrealistic and therefore leads to rates of return figures which are implausibly high. They suggest that a Modified Internal Rate of Return (MIRR), which uses a discounted rate of return for re-investment profits, would give a figure more reflective of reality.

This is undoubtedly an important contribution to the literature, although it must be remembered that all the concerns about rates of return discussed above are true whether an IRR or an MIRR is used.

Areas for further research

Future econometric research on rates of return to research will need to demonstrate more convincingly that alternative confounding variables have been excluded. In addition, econometric analysis will only be convincing if a plausible explanation for how the investment in research has led to economic benefits is provided.

As discussed above, the major drawback to simulation modelling techniques is the exclusion of some of the true costs of research because: only 'success stories' are considered; the full economic cost of research is not used; or important 'basic research' is excluded. An important area for future research will be overviews of entire research institutions or sectors comparing the full economic costs of supporting research to the portfolio of benefits derived. To fully capture benefits, researchers will need to go beyond the focus on pro-poor products and technologies and build on the promising work to

develop methods for assessing the economic impact of other benefits including human capital development and evidence-informed policy and practice.

Finally, further work is needed to determine whether rates of returns are most accurately expressed as IRR, MIRR or some alternative metric.

Summary

Taken together, the evidence on rates of return to research indicates that there are methodologies available to investigate returns on investment in research. Econometric analysis and simulation modelling have been used to calculate rates of return to agricultural and health research. More recently, research mediation modelling has been used to calculate a rate of return to investment in UK social science research. However all these methods are highly sensitive to a range of assumptions and for this reason, a wide range of rates of return have been calculated. Most studies do suggest that research leads to positive economic returns and taken together there is evidence that research can have positive economic impacts. However given the huge variation, any single rate of return must be viewed cautiously and must be interpreted in light of the specific research type and context considered and the assumptions used in the calculation.

7. Conclusions

Investment in research activities can lead to development impacts. However, research is not a panacea; Investments in some research projects will lead to large development gains while investment in some activities will lead to little or no impact.

Having said that, it is possible to consider the general theory of change by which we expect research to lead to impacts and to draw some conclusions on what type of research activity we should invest in to achieve different outcomes.

Key findings

This literature review reveals some general principals regarding investment in research:

- Investment in public research in low-income countries is unlikely to lead to substantial levels of direct commercialisation of research outputs in the short to medium term. Informal academic engagement with industry may be more economically important but some activities (particularly consultancy contracts) may have negative impacts on research capacity. While the generation of new innovations within low-income countries is unlikely to be a major driver of growth, the absorptive capacity of industry (i.e. the ability to adapt and make use of existing research knowledge) will be a vital driver of growth and interventions which would increase this absorptive capacity (e.g. strengthening of tertiary education) are likely to have large impacts.
- Research from developed economies reveals that, in contrast to the beliefs of most academics, there is no strong link between the research outputs and teaching quality of tertiary education establishments. As yet there is no evidence to indicate if such a link exists in low-income countries so efforts to improve tertiary education through investment in research should be treated with caution. The human capital developed through investment in research and research capacity building can have multiple positive impacts on development including via the spill-over of former researchers into government and industry and the generation of research experts who can act as policy advisors. Research suggests that investment in doing research in low-income countries on its own will not lead to improved research capacity and that an effective and explicit capacity building strategy must be developed.
- Investment from both developed and low-income countries in research in public institutions and/or public-private partnerships can generate pro-poor products and technologies. Some of these products and technologies have had dramatic impacts on development. However, there are also multiple products and technologies which have not had the expected impact. When investing in the development of products and technologies, it is vital to carry out research to ensure there is a demand for it and that there are no barriers which will prevent it from having positive impacts.
- Using evidence to inform policy and practice decisions can help ensure policies and practice achieve their desired impact. Two categories of decisions can be informed by evidence. Firstly, research to understand what works and why can be used to inform

decisions on specific interventions. Secondly, evidence which describes the existing context can inform general theories of change. Major barriers to use of evidence are the low capacity of policy makers and practitioners to understand and use research evidence, and the absence of incentives to drive research usage. Interventions which succeed in increasing use of evidence by policy makers and practitioners may lead to important impacts.

- There are a number of methods which have been used to quantify the economic benefits of investment in research. All methods suggest positive rates of return to research however individual figures are highly sensitive to the assumptions used in the calculations and therefore need to be interpreted cautiously.

Revised theory of change

Taking the findings outlined in this paper, it is possible to redraw the theory of change presented in the introduction (section 2.3) to more accurately reflect the findings.

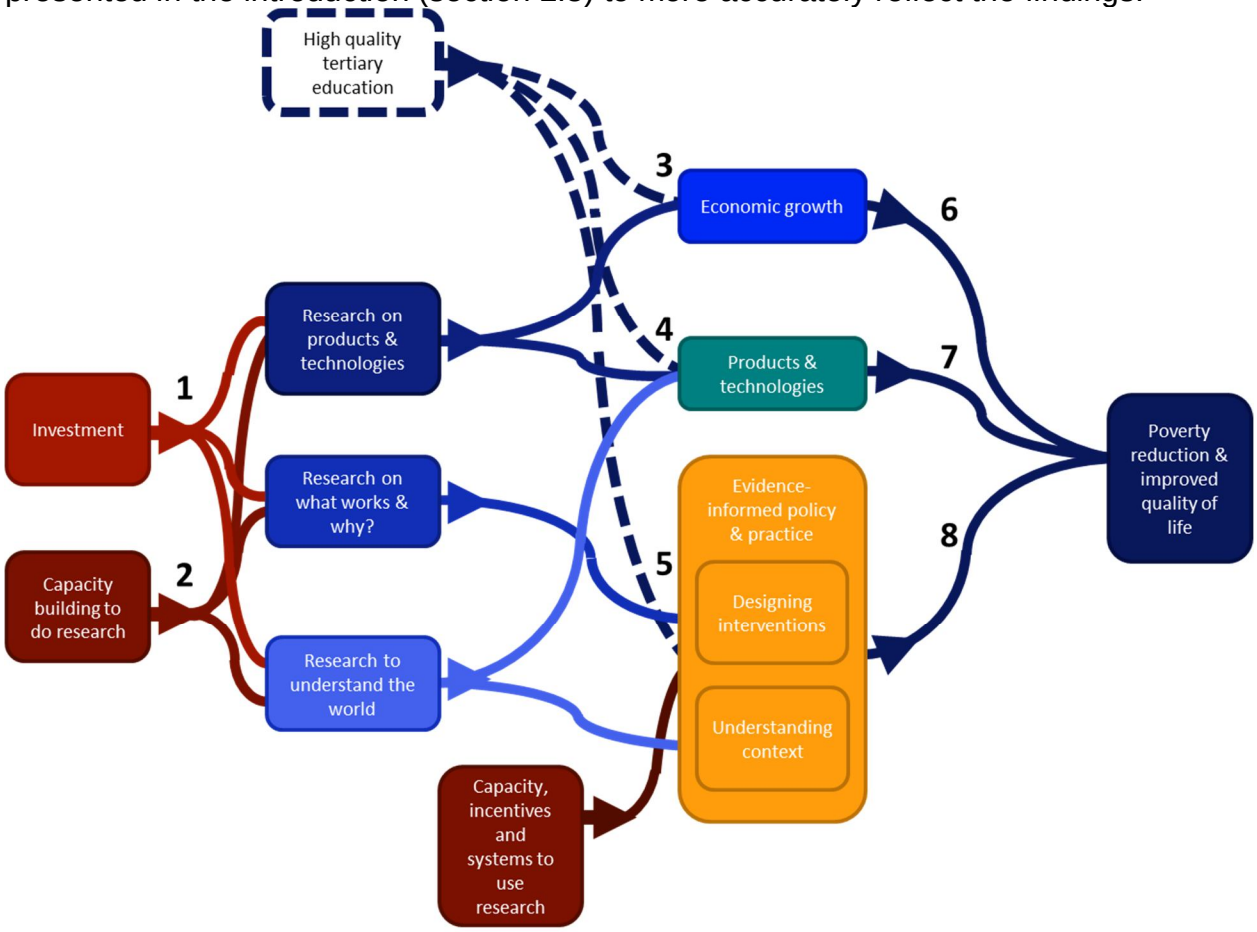

Figure 3: Revised Theory of Change. The numbered points 1-8 are expanded in the text.

The pathway of 'Human capital' has been removed completely and instead a new 'input' of Tertiary Education has been added. This is because the evidence suggests that tertiary education is a major contributor to human capital but that investment in research is relatively unrelated to this. Some human capital is built through research investment, in particular the expertise built up in researchers. However this type of human capital leads to impact via the 'evidence-informed policy and practice' pathway and is therefore captured there.

The notes below give further details of the numbered links shown in the diagram.

1. Investment is needed in a variety of types of research covering a range of thematic areas. Public funding will be needed to fund research which will not be attractive to private funders. In some cases, public funding can be used to overcome 'market failures' and thereby enable private funding (for example in product-development partnerships).
2. Effective research capacity building is required to enable high quality research to be carried out. Research capacity needs vary according to sector and geographical location. Research capacity building efforts have had mixed impacts in the past and it will be important that future capacity building programmes learn from the experience of past attempts.
3. Stimulation of economic growth requires research to develop new products and technologies. In the short to medium term the research capacity to generate products and technologies is likely to be found in developed and emerging economies while research capacity to adapt technologies to local contexts will be required in low-income countries. In addition, firms in low-income countries need to build their absorptive capacity to enable them to benefit fully from new products and technologies. Tertiary education will play a key role in building this absorptive capacity for the future.
4. Developing products and technologies which directly benefit poor people will require research to fully understand the needs and demands of potential users of new products and technologies. In addition, there needs to be research to develop products/technologies to respond to those needs. Tertiary education will play a key role in developing the capacity of future generations to make use of emerging products and technologies.
5. Two types of policy/practice decision can be informed by research. Firstly decisions on a theory of change can be informed by research which aims to provide information on the context in question and/or individuals who have developed thematic expertise through involvement in research. Once decisions have been made about what outcomes should be pursued, research on what works and why can be used to inform decisions on specific interventions. It is crucial that decision makers have the capacity, incentives and processes which enable them to make use of evidence to inform their decisions. Evidence suggests that capacity is lacking in many decision making organisations and therefore capacity building and/or continued professional development will be required to ensure sufficient capacity is built up and maintained. In addition, tertiary education will play a key role in developing the next generation of evidence-literate policy and practice decision makers.
6. Evidence suggests that economic growth is necessary, but not sufficient, to drive socioeconomic development.
7. There is evidence that some products and technologies have direct positive socioeconomic impacts.
8. There is strong evidence that using research evidence to inform policy and practice leads to benefits which contribute to socioeconomic development.

8. Methodology

There is a substantial body of research which is relevant to the theory of change. Some research exists within the 'development research' sector. However, there are also relevant bodies of research in diverse fields from economics to pedagogy. This paper is not intended to be a comprehensive review of the research evidence. Instead it aims to make links between the assumptions implicit in the theory of change and relevant bodies of evidence.

Figure 2: Bodies of research of relevance to theory of change.

Figure 2 provides an overview of some of the main bodies of evidence of relevance to the different links in the theory of change.

A pragmatic approach to searching was taken which aimed to find literature from as diverse sources as possible. Synthesised evidence and evidence from low-income countries were prioritised. Primary research papers were considered where they were of particular relevance or where high quality syntheses were not available. The literature review aimed to synthesise empirical evidence which contributes to our understanding of the links between research and international development. In addition to empirical research, there is a large body of *theoretical* academic work considering links between research and international development. This body of evidence was not explicitly included in this literature review, however it is did influence the authors' conceptual framing of the issues. A wide variety of research evidence was considered including evidence gathered using a variety of research methods and evidence from peer reviewed journals, books and grey literature.

Search strategy

The search strategy for identifying relevant research was as follows:

1. The theory of change shown in section 2.3 was developed and the eight assumptions underlying it were used as a framework for categorising relevant evidence.
2. A hand-search of the following were carried out and relevant papers assigned to the one or more assumption:

    - All systematic reviews listed in the 3ie Systematic Review Database [229]
    - All ESRC Impact Case Studies [52]
    - All papers categorised as 'research to policy' in the Eldis database [597]
    - All World Development Reports since 2000 [14]
    - All outputs listed related to the Research and Policy programme on the Overseas Development Institute website [405]

3. Scopus searches were carried out using the keywords listed below and the titles searched for relevance. Abstracts of any potentially relevant articles were read and if deemed to be relevant were assigned to one or more of the assumptions. Articles for which no English abstract was available in Scopus were discarded. Where a paper was chosen for inclusion, the 'other similar papers' identified by Scopus were also reviewed and included if relevant.

    - TITLE(research AND ("Economic growth" OR return OR investment)) AND DOCTYPE(re) AND PUBYEAR > 1999 [62 results]
    - TITLE("endogenous growth" AND (development OR developing OR low-income OR africa OR asia)) AND PUBYEAR > 1999 [13 results]
    - TITLE("science park") AND PUBYEAR > 1999 [171 results]
    - TITLE("absorptive capacity" AND (developing OR development OR africa OR asia OR "low-income")) AND DOCTYPE(re) AND PUBYEAR > 1999 [87 results]
    - TITLE("Human capital" AND (developing OR development OR africa OR asia OR "low-income")) AND DOCTYPE(re) AND PUBYEAR > 1999 [16 results]

- TITLE("Human capital" AND ("public research" OR "research investment" OR "research capacity building")) AND DOCTYPE(re) AND PUBYEAR > 1999 [0 results]
- TITLE("adult learning" OR "pedagogy") AND DOCTYPE(re) AND PUBYEAR > 1999 [463 results]
- TITLE((evidence-informed OR evidence-based) AND (policy OR practice)) AND DOCTYPE(re) AND PUBYEAR > 1999 [produced 1258 results]
- TITLE(research OR science OR technology OR innovation OR (operational research) AND "economic growth" OR return OR investment) AND DOCTYPE(re) AND PUBYEAR > 1999 [157 results]
- KEY("human capital" OR "capacity building" AND africa OR asia OR development) AND DOCTYPE(re) AND PUBYEAR > 1999 AND (EXCLUDE(EXACTKEYWORD, "Humans") OR EXCLUDE(EXACTKEYWORD, "Human")) [105 results]
- TITLE("higher education" OR "tertiary education" AND development OR africa OR asia OR research OR invest*) AND DOCTYPE(re) AND PUBYEAR > 1999 [101 results]

4. The Scopus results were complimented by Google Scholar Searches using combinations of the key words mentioned above.
5. In addition, relevant sources known to the author were included.
6. Full text of all included papers which were available in an open source format or were available in the DFID elibrary were examined. Where full text was not available, one attempt was made to request a copy of the article from the corresponding author.
7. An initial draft of the paper was prepared on the basis of the included sources.
8. This draft was shared with the expert reviewers listed below who critiqued the paper and suggested addition sources.
9. The final draft incorporates these inputs.

Expert reviewers

Name	Position and organisation	Area of expertise			
		Economic Growth	Human Capital	Products and Technology	Evidence-informed policy/practice
Chris Whitty	Chief Scientific Advisor, DFID		■	■	■
Stefan Dercon	Chief Economist, DFID	■	■		■
Jacqueline Barnett	Director of Innovation Support and Technology Transfer, Nelson Mandela Metropolitan University	■			
Kunal Sen	Professor of Development Economics and Policy, University of Manchester	■		■	
Peilei Fan	Associate Professor of Innovation, Michigan State University	■		■	
Ian Thornton	Deputy Director, UK Collaborative of Development Science	■			■
Alex Ademokun	Senior Programme Manager, Evidence-Informed Policy, International Network for the Availability of Scientific Publications		■		■
Abbi Hobbs	Social Science Advisor, UK Parliamentary Office of Science and Technology				■
Annette Boaz	Reader in Health Care Research, Kingston University				■

Limitations

There are some clear limitations to the methodology used for this review. In particular:

- Only papers published in English and which were either open access, included in the DFID e-library or provided by the author following an email were included and thus much relevant research will have been overlooked.
- For sub-topics where no systematic review was available, the search is likely to have been incomplete. There is a risk that both the search terms used and the decision on whether or not to include studies will have been biased. The extensive pre-publication expert review process attempted to mitigate, at least partially, against this risk.
- The relative quantity and quality of evidence differed greatly between different themes and overall assessments of the strength of evidence are subjective and context specific.
- The subsections in the results chapters were driven in part by the literature uncovered by the search. This means there is some asymmetry between chapters – for example the chapter on Innovation included a consideration or different funding models for innovative research while funding mechanisms are not considered in other chapters.
- While the original list of invited reviewers reflected a balance of northern and southern experts, relatively few southern reviewers were able to provide comments.

Appendix I: Questions for funders of development research

This paper does not seek to make concrete recommendations regarding what research activities funders should and should not fund. Instead, it is hoped that the evidence presented here will help funders to consider their own theories of change for supporting research and to test them against the evidence. In particular, it will be important for funders to consider which outcome(s) they are seeking to achieve through funding research and then to consider what evidence underlies their assumptions.

Below we present each of the four outcomes from our original theory of change and offer some questions for funders to consider.

Economic growth

1. If seeking to drive economic growth through investment in research, is the existing research and technology transfer environment capable of supporting technology development and transfer? Remember that the evidence suggests that in low income contexts, it is very unlikely that publicly funded research will lead to the development of commercially viable technologies or products in the short to medium term.
2. If considering other types of academic-industry linkages, does the academic sector genuinely have the capacity and is there genuine industry demand?
3. Do firms have sufficient absorptive capacity to benefit from new technologies (whether developed locally or globally)? If no, are there mechanisms for supporting tertiary education to develop this?

Human capital

1. If seeking to improve quality of tertiary education through investment in research, could alternative investment lead to greater improvement? Be aware that current research (albeit all from high-income countries) does not support a link between investment in research and quality of tertiary education.
2. If seeking to develop thematic expertise, what areas of policy and practice are expected to be priorities in the future?
3. For capacity building programmes, to what extent have lessons from past capacity building efforts been considered in the design of the new programme? For example, have efforts been made to ensure effective pedagogical techniques are used? Does the programme attempt to work with and through existing structures (rather than creating new ones)? Have effective monitoring and evaluation strategies been built in from the outset?

Pro-poor products and technologies

1. Is there compelling evidence of need amongst potential users of proposed new product/technology?

2. Is lack of a product/technology a key problem or are there deeper problems which will not be solved even if a product/technology is developed?
3. Have potential barriers to uptake and use been investigated?
4. What funding mechanism is most appropriate to drive the necessary innovation? Could public funding be used to overcome market failure and drive private investment?

Evidence-informed policy/practice

1. Does the research aim to provide specific answers on what works and why? If so, have policy makers been involved at design stage to ensure that the results from the research will be most useful for them?
2. Does the research aim to broadly inform theories of change? If so, is the topic area an area of policy/practice priority and/or is it expected to become a priority in the future?
3. What has been done to ensure the research will be appropriately packaged and shared (without incentivising researchers to lobby for specific policy outcomes)?
4. What will be done to synthesise results of research with other relevant research?
5. Do policy and practice decision makers have the capacity, incentives and processes to enable them to make use of research findings?

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[10] Meeting with DFID's Higher Education Taskforce secretariat, 4th February 2014

[11] Personal correspondence from Ian Thornton, Deputy Director of UK Collaborative for Development Sciences and Chair of the UK's Research Capacity Building Group

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[14] Gates Foundation website accessed on 16th January 2014 http://www.gatesfoundation.org/what-we-do

[15] Wellcome Trust International Strategy accessed on 16th January 2014 http://www.wellcome.ac.uk/Funding/International/International-strategy/index.htm

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