Department for International Development United Kingdom

Rates of Return to Research

A Literature Review and Critique

CRDG&L03

Final Report ©

in association with

November 2005

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Abbreviations and Acronyms

CAM	Combined Approach Matrix
CGIAR	Consultative Group on International Agricultural Research
CMH	Commission on Macroeconomics Health
CRD	Central Research Department
DALYs	Disability Adjusted Life Years
DFID	Department for International Development
GDP	Gross Domestic Product
EBM	Evidence-Based Medicine
GEHR	Global Forum on Health Research
HPSR	Health Policy and Systems Research
QALY	Quality Adjusted Life year
MDGs	Millenium Development Goals
NARS	National Agricultural Research Systems
NIH	National Institute of Health
OECD	Organisation for Economic Development and Cooperation
ROR	Rates of Return
R&D	Research and Development
WHO	World Health Organisation
WTP	Willingness to Pay

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Executive Summary

Executive Summary

Objectives of the Study

1 This study investigates what we know about rates of return to research and assesses key evidence that has been presented on agricultural and health research in particular. A specific purpose of the study is to examine in detail the International Food Policy Research Institute (IFPRI) studies that reach the conclusion that additional investments in agricultural research and development increase agricultural productivity more than any other form of public investment in rural areas. The following are the key findings and recommendations.

Key Findings and Recommendations

General

2 There is a robust positive relationship between spending on research and development (R and D) and economic growth – the rate of return on R and D is many times the rate of return on investment in machines and equipment.

3 The social return to R and D is significantly higher than the private return – suggesting that research and development will be under-funded if left to the market. There is a clear role for the public sector in funding research and development.

4 Most studies find that the social rate of return on R and D in advanced market economies in excess of 30 percent. This is in contrast to the social rate of return to education for OECD countries, which has been to be estimated at around 13-14 percent.

5 Though R and D predominantly occurs in advanced market economies, there are significant spillovers from developed countries to developing countries via international trade. Spending on R and D in developed countries can have important positive implications for economic growth and poverty reduction in developing countries.

Agriculture

6 Research and extension in agriculture yields consistently high rates of return – whether for extension and research separately or combined, whether for farm-level (cross-sectional) observations or for aggregated farm production data that varies across districts, states or countries and over time (panel data), and whether for all crops or individual crops.

7 Rates of return to agriculture are significantly higher than comparable rates of return to education in developing countries.

8 There are no comparable estimates for policy-oriented social science research due to the problem of quantification of the benefits of such types of research in terms of output or productivity gains.

The Fan et al. IFPRI studies

9 The Fan et al. papers examine the effectiveness of different types of public investments within one framework, and within a single econometric model. The economic model proposed in the Fan et al. studies can be seen as being more sophisticated both from the point of view of capturing the complex inter-relationships between key economic variables and from a methodological standpoint in the use of more robust econometric methods.

10 The specification of the rural poverty determination equation allows for both direct and indirect impacts of public investments. The disaggregation of public investment into expenditures on research, irrigation, roads, education, power, soil and water conservation, rural development and health allow for separate returns to public investment calculated for each type of expenditure.

11 In the Indian case, the IFPRI study finds that public investment in roads delivers the highest impact with respect to poverty reduction and the second highest with respect to productivity growth. Public investment in research and development has the highest impact on productivity growth, and the second highest on poverty reduction. In contrast, expenditure on power, irrigation and health has minor impacts on poverty reduction and productivity growth. In the Chinese case, public investment in education has the highest marginal impact on rural poverty reduction followed by R and D. Roads are a distant third. With respect to rural income growth, R and D has the highest marginal impact followed by roads and education. Public expenditures in poverty loans do not seem to matter in poverty reduction. The results for the China and India studies suggest that if the government is interested in obtaining the maximum impact on productivity growth and poverty reduction in rural areas for public expenditures, it should primarily allocate these expenditures to agricultural research, education and road construction. The fact that public investment in R and D matters in very different institutional contexts is indeed a surprising result and if found robust, has significant implications for policy.

12 An important omission of the Fan et al. studies is the possibility of intranational spillovers from research both from one state or province to neighbouring states or provinces or international research spillovers from the dissemination of new seed varieties from international agricultural research programs. The omission of such spillovers can lead to a distortion in the estimated rate of return to public investment in research relative to other types of public spending.

13 At the same time, the Fan et al. studies do not control for unobserved ‘fixed effects’ which are time-invariant state or province specific characteristics that may capture institutional differences across states or provinces (such as the quality of governance). The lack of inclusion of these ‘fixed effects’ imply that the estimates may suffer from an omitted variable bias, and thus, may be an *over-estimate* of the rate of returns, including that for research.

14 The Fan et al studies do not conduct standard sensitivity analysis of the different assumptions of the model to see how robust the estimates are. Thus, the results of the Fan et al. studies should be treated with a certain degree of caution – the precise magnitudes can change under different assumptions.

15 The two IFPRI studies on East Africa – Tanzania and Uganda – also find that public investment in R and D has strong positive effects on rural incomes and poverty reduction. In both countries, investment in agricultural research has higher returns to investment as compared to education and health. The poverty reducing impacts of public investment in agricultural research is higher than investments in education, roads and health in the case of Uganda and similar to investments in education (but significantly higher than investment in roads) in the case of Tanzania.

16 However, the studies on East Africa raise serious doubts about data issues and the econometric methodology used. The Tanzania study in particular uses a methodology which is different from that used in the China and India studies, and unlike the latter two studies, does not control for the endogeneity of explanatory variables in the regression model. Thus, the rates of return to research found in the Tanzania study are likely to be seriously biased upwards.

17 Both the Uganda and Tanzania studies also suffer from significant problems of data quality. They also suffer from the restrictiveness of assumptions used to generate the variables required in the econometric implementation of the IFPRI model to the East African context.

18 Given the weaknesses of the current IFPRI studies on East Africa, it is not possible to rank public investments in terms of their effects on economic growth and poverty reduction with any degree of certainty.

19 There is need for further empirical work that re-examines the IFPRI studies with better data, further diagnostic testing, more sensitivity analysis under alternate assumptions, and more improved specification of the equations, including the incorporation of unobserved fixed effects and intranational and international spillovers. This empirical work can provide more solid empirical foundations on which to rank public investments in terms of their impact on economic growth and poverty reduction.

Health

20 WHO has established the central role of health investments in promoting economic growth and poverty reduction worldwide through the recent work of its Commission on Macroeconomics and Health. Estimates of the additional resources required to achieve these ambitious improvements in global health have been made, and economic returns of $3 or more than projected for every health dollar spent, assuming an ideal policy and implementation environment.

21 A recent literature search has identified a number of studies that demonstrate a positive rate of return to spending on basic and applied health research. However, as the authors of the review acknowledge, the methodology for such assessments

needs considerable refinement and major problems of causation and attribution persist.

22 There are no models comparable to the IFPRI model in estimating the rates of return to health research.

23 A global movement to ensure that health interventions and clinical practice are evidence-based and research led means that there is now sufficient knowledge of what interventions work in order to make a major impact upon the health of those in the developing world (notwithstanding the continuing search for more effective treatments for conditions such as AIDS and malaria). Increasingly, the challenge is less to find what health interventions work and more to identify the optimal institutional settings and systems to deliver those interventions and to find ways to pay for them.

24 The Buxton and Hannay model provides a useful aide memoire when thinking about the different types of outputs from research, particular the intermediate and process outputs. It also helps to focus the minds of research funders and researchers on how to ensure maximal stakeholder involvement and ownership, particularly ownership by policy-makers and planners. The CAM and the various other tools produced by WHO and the GFHR are useful in helping to organise data for priority setting.

25 Much also needs to be done to strengthen research capacity in developing countries. A recent study of 176 health policy and systems research institutions in developing countries have found several weaknesses in these institutions in terms of absorptive capacity and performance.

Fragile States

26 There are also doubts whether the win-win situation with respect to investment in research outlined by Fan et al. for China and India (faster growth, stronger poverty declines) can hold for fragile states in Sub-Saharan Africa and other parts of Asia. For investment in research to pay off, the literature on agricultural innovation identifies the following complementary conditions – favourable agro-climactic factors, geographical closeness to markets, stable output prices, access to inputs such as seeds and fertilisers at reasonable costs, viable credit markets, and good access to information and infrastructure. Several of these complementary conditions do not exist in fragile states.

27 There is a stronger argument for investment in health research that is specifically targeted to the poor in fragile states. Most research in health has tended to concentrate on diseases that are prevalent in developed countries.

1 Objectives of the Study

1 Objectives of the Study

1 As DFID's Research Funding Framework, 2005-2007 states, "Research, the process that generates new technologies and ideas, is one of the driving forces behind gains in human development and poverty reduction during the last three decades" (p.5). Investment in research can have strong pay-offs in terms of economic growth and poverty reduction in developing countries. However, research is not the only determinant of economic growth and poverty reduction – for many developing countries, the provision of infrastructure and the acquisition of human capital are equally, if not more, important. For donors and national governments in developing countries, with limited resources to allocate, the crucial questions are two-fold:

- to what extent does the social return from research diverge from its private return that can provide a persuasive case for public sector funding for research; and
- to what extent is the social rate of return to research higher than that for other competing uses of funds for donors and national governments in the achievement of the millennium development goals?

2 This study investigates what we know about rates of return to research and to assess key evidence that has been presented on agricultural and health research in particular. The study is intended primarily for development professionals within DFID and other bilateral donor agencies, and aims to inform debates within policy circles about the optimal allocation of aid to research vis-a-vis other aid instruments. This study does not involve primary research but uses secondary sources to bring together existing information and knowledge on rates of return to research, with emphasis on agriculture and health.

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2 Why Research Matters

2 Why Research Matters

3 Research and development (R and D) has been a key driving force of economic growth in developed countries - the evidence on this is powerful and uncontroversial. Research and development activities of individual firms and governments bring about technological change which is the primary contributing factor for the sustained increases in living standards that have been witnessed in the developed world for the past two centuries. Not only is research and development important, its rate of return is many times the rate of return on investment in machines and equipment – the primary variable of interest in conventional accounts of economic growth.[1/] Moreover, most studies find that the social return to R and D is significantly higher than the private return – suggesting that research and development will be under-funded if left to the market. There is a clear role for the public sector in funding research and development, as the private sector will of its own accord not supply the level of research and development that societies need to grow on a sustained basis.

4 Most studies of the social return to R and D estimate the rate of return to be in excess of 30 percent for OECD countries.[2/] This is in contrast to the social rate of return for education estimated for the same set of countries which is in the range of 13-14 percent.[3/] Thus, the benefit to society for investment in research and development is twice that of an equivalent amount of investment in education.

5 Though most research and development activities whether by the private or public sector take place in developed countries, there is evidence of significant spillovers of the benefits of research and development undertaken in developed countries to developing countries, and that research and development expenditures in developed countries can increase economic growth in developing countries.[4/] This takes place through international trade – traded commodities embody technological know-how and by this mechanism, developing countries can acquire foreign knowledge even though they may not undertake research and development themselves.

6 The strong positive impact that research and development can have on economic growth is because the former affects the latter in two ways – first, via the accumulation of R and D capital stock (since research and development is one additional input to production along with physical and human capital) and second, and more important, by enhancing the rate of total factor productivity growth. In contrast to earlier views on the role of R and D in economic growth, economists have

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1/ Helpman (2004).
2/ Griliches (1992), Hall (1995) and Jones and Williams (1998).
3/ Schutz (1988) and Psacharopoulos (1994).
4/ Grossman and Helpman (1991).

now realised that R and D is different from physical capital in that there are no diminishing returns attached to it, so that an increase in the rate of R and D investment can have a **permanent** effect on economic growth.

3 The Value of Agricultural Research

3 The Value of Agricultural Research

7 The conventional definition of agricultural research includes both applied agricultural research programs and extension programs. Applied agricultural research programs are conducted by both the private and public sector and seek to invent new technology for new crops or market groups. Innovations can either be embodied in capital goods or new products (such as tractors, fertilisers and seeds) or disembodied (for example, integrated pest management schemes). Applied agricultural research has taken place either through the Consultative Group on International Agricultural Research (CGIAR) system, which consists of sixteen autonomous international research centres, or the National Agricultural Research Systems (NARS) of developed and developing countries. Extension programs seek two general objectives. The first is to provide technical education services to farmers through demonstrations, lectures, contact farmers, and other media. The second function in an interactive fashion with the suppliers of new technology, by providing demand feedback to technology suppliers and technical information to farmers to enable them to better provide potentially useful new technology and ultimately to adopt (and adapt) new technology for their production systems.[5/] Research and extension in agriculture has yielded consistently high rates of return – whether for extension and research separately or combined, whether for farm-level (cross-sectional) observations or for aggregated farm production data that varies across districts, states or countries and over time (panel data), and whether for all crops or individual crops.

8 Rates of return for both extension and research studies are summarised in Table A1.1 (see Appendix 1). Two features characterise virtually every category. The first is that mean and median rates of return (RoR) are high. Seventy-four percent of the extension RoRs and 82 percent of the research RoRs exceed 20 percent. The second feature of the RoRs is that the range of estimates is broad. Every category reports both low and high RoRs. Thus, it is difficult to draw strong conclusions on the differences in means across categories. Nevertheless, the following inferences can be drawn. Categories with the greatest proportions exceeding 40 percent are rice and fruits and vegetable research. Research studies have higher proportions exceeding 40 percent than is the case for extension studies. There are important regional differences in RoRs – for both extension and research, Africa reports lower RoRs than other regions. Asian rates of return are especially high.

9 How do the rates of return on agricultural research compare with one other important determinant of agricultural growth and poverty reduction in developing countries – education? Table A1.2 (in Appendix 1) present estimates of the social rate of return for primary, secondary and tertiary education from two different surveys. Firstly, it is clear that primary education offers the highest rate of return as compared to secondary and tertiary education. Secondly, the rates of return to education are consistently lower than the median rate of return for agricultural

5/ Evenson (2001).

research across all regions. This is also true for Africa, where rate of return to primary education is among the highest. If policy-makers had to make a choice between these two categories – agricultural research and extension and primary education, the rates of returns presented in Tables A1.1 and A1.2 unequivocally suggest that the former should be the preferred option.

Rates of Return to Social Science Research

10 A limitation in assessing the evidence on the rate of return to research is that there are no comparable estimates for social science research as there are for applied science research. The reason for this is simple – it is difficult to quantify the benefits of social science research as it is for applied science research – the latter leads to clear benefits in terms of output or productivity gains whether these have occurred due to embodied or disembodied technical change that the research has brought about. Policy-oriented social science research leads to an increase in the stock of knowledge on how social, economic, political and environmental processes can bring about gains in human development, but the precise relationship between the increase in the stock of such knowledge and the actual economic and social changes observed in developing countries is indeterminate and contingent on a whole set of factors that are difficult to quantify. For example, suppose a set of policy reforms were introduced in a particular country that clearly led to economic growth in that country. Suppose these reforms were initiated following the dissemination of a set of research papers that showed that the reforms were necessary for economic growth to occur. Can one attribute the increase in economic growth observed at the end of period of study to the research itself? Clearly not, as the reforms may have been enacted independently of the research – we would not know with any degree of precision that the reforms were a *consequence* of research, rather than being implemented autonomously of the research itself. Such a problem in attributing the economic benefit of a particular research study properly is known as the ‘attribution problem’ in rate of return research and is particularly severe for social science research.[6/] The few studies that have attempted to quantify the rates of return to social science research have used esoteric methods such as Bayesian decision theory and have obtained estimates from these methods using ‘incredible identifying assumptions’ that cannot be robustly defended.[7/] This is an area where further research is needed. There is also need for further work that assesses the combined rates of returns to social science and applied science research, as these two types of research are rarely undertaken in isolation of each other.

6/ Alston and Pardey (2001).
7/ Gardner (1999) and Schimmelpfennig and Norton (2003)

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4 Rates of Return to Public Investment in Research in China and India – the Fan et al. IFPRI Studies

4 Returns to Public Investment in Research in China and India – the Fan et al. IFPRI Studies

11 Two papers lead authored by Shenggen Fan of IFPRI – Fan, Zhang and Zhang (2002) [henceforth, FZZ] and Fan, Hazell and Thorat (2000) [henceforth, FHT] examine the returns to public investments in research as compared to other types of investment in China and India respectively.

The Core Contributions of the Fan et al. Studies

12 While there is a large literature on the determinants of agricultural growth and rural poverty in both China and India, there are few studies that have examined the *effectiveness* of different types of public spending in bringing about economic growth and poverty reduction in rural areas of these two countries. Most of the earlier work has tended to focus on *one* type of policy intervention relating to growth and poverty reduction – for example, public investment in education and health, food for work programmes, price decontrols, and so on (an exception is the use of CGE models for policy simulations done in institutions such as IASSA in Austria, the World Bank and in IFPRI itself – but these models are constructed using calibration techniques rather than econometric methods). The FZZ and FHH papers examine the effectiveness of different types of public investments within one framework, and within a single econometric model. These are the two strengths of the work – a **unifying conceptual framework** for the determinants of agricultural growth and rural poverty that allows for both direct and indirect effects of public investments on growth and poverty, and **a simultaneous equations system approach** to modelling growth and poverty rather than the use of single equation methods, which are open to the standard criticisms of omitted variable bias[8/] and the endogeneity of the independent variables.[9/] Thus, the economic model proposed in the FZZ and FHT papers can be seen as being more sophisticated both from the point of view of capturing the complex inter-relationships between key economic variables and from a methodological standpoint in the use of more robust econometric methods.

The Structure of the Model in the Fan et al. Studies

13 The key relationships modelled are the determination of rural poverty and agricultural productivity. In the Indian case, rural poverty (the head-count ratio) is taken to be a function of agricultural productivity, rural wages, non-agricultural employment, the rural-urban terms of trade, the proportion of rural households that

8/ Omitted variable bias occurs when an important explanatory variable is omitted in the regression model, leading to the coefficients of the variables that are included to be estimated with error.

9/ In the classical regression model, an important assumption to obtain regression coefficients that are not estimated with error is that the explanatory variables cause, but are not themselves caused by the dependent variable – that is, the variable that the regression model is trying to explain. If however a explanatory variable is endogenous (that is, caused by) the dependent variable, the coefficient on that variable is estimated with error.

are landless, and one-year lags of rural population growth and GDP growth. Most of the variables included are self-explanatory, and are common to other econometric models of rural poverty. An increase in the terms of trade can lead to an increase in rural poverty in the short run if most households are net buyers but may have a positive impact on rural poverty reduction if higher food prices leads to increased investment in agriculture, and consequently, higher demand for agricultural labourers in the long term. Rural population growth is expected to increase rural poverty if there is no commensurate increase in rural employment. The lagged GDP growth captures the remaining income effects on poverty. Agricultural productivity growth is defined as total factor productivity growth, not as growth in land or labour productivity as is often the case in the literature. Total factor productivity growth is hypothesised to be a function of current and lagged government spending on agricultural research and extension, the percentage of irrigated cropped area to total cropped area, road density, percentages of villages electrified, the literacy rate of the rural population, and stocks of government expenditures on health, rural development and soil and water conservation. A lagged GDP term is included to control for the effects of overall economic growth on productivity growth. A rainfall index is also included.

14 Rural wages, the proportion of landless households, the terms of trade and non-agricultural employment are all taken to be endogenously determined – the first is a function of total factor productivity, road density, the percentage of irrigated cropped area to total cropped area, and stocks of government expenditures on health, rural development and soil and water conservation. A lagged GDP term is included to control for the effects of overall economic growth on rural wages. Landlessness is modelled as being determined by total factor productivity growth, lagged rural population growth and non-agricultural employment. The terms of trade is modelled in a simple manner as a function of total factor productivity growth both at the national and state levels, and weighted average of the world prices of rice, wheat and corn. In the case of non-agricultural employment growth, the latter is taken as a function of total factor productivity growth, road density, percentages of villages electrified, the literacy rate of the rural population, and stocks of government expenditures on health, rural development and soil and water conservation. A lagged GDP term is included to control for the effects of overall economic growth on non-agricultural employment growth.

15 The next sets of relationships modelled are the determinants of public and private investment, road density, literacy, and village electrification. Public irrigation is modelled as a function of current and past government investments in irrigation, and the degree of electrification (since a higher degree of electrification leads to a higher use of pumps for irrigation); private irrigation as a function of public irrigation and the degree of electrification, road density as a function of current and past government investments in rural roads, rural literacy as a function of current and past government investments in education, and village electrification as a function of current and government investments in power.

16 Finally, government investments in research, roads, irrigation, education, soil conservation, power, development expenditures and health are taken to be endogenously determined as functions of past values of state GDP and the terms of trade.

17 There are 19 equations with 19 endogenous variables. The system of equations is estimated using Full Information Maximum Likelihood methods using data for fourteen major Indian states over the period 1970-1993.[10/]

Results and Key Findings

18 The specification of the rural poverty determination equation allows for both direct and indirect impacts of public investments. Public investments increase total factor productivity growth and hence, reduces poverty. By increasing total factor productivity growth, it also increases agricultural wages and lowers agricultural prices and these both contribute to the poverty reduction impact of public investment. At the same time, by increasing landlessness through the increase in total factor productivity, public investments also contribute to an increase in rural poverty. The net effect of public investment is an empirical issue, though FHT find in the Indian case, the effect is strongly positive. The disaggregation of public investment into expenditures on research, irrigation, roads, education, power, soil and water conservation, rural development and health allow for separate rates of return calculated for each type of expenditure – Table 4.1 summarises the results on the returns for each type of public investment.

Table 4.1 Returns of Public Investments by Type to Productivity and Poverty Reduction, India

Expenditure Variable	Marginal Impact			
	Poverty (no. of poor reduced per million rupees)	Rank	Total Factor Productivity (% point) (per 100 billion rupees at 1993 prices)	Rank
R & D	84.5	2	6.01	1
Irrigation	9.7	7	0.61	4
Road	123.8	1	2.37	2
Education	41.0	3	0.62	3
Power	3.8	8	0.12	8
Soil and Water	22.6	5	0.43	6
Rural Development	25.5	4	0.49	5
Health	17.8	6	0.38	7

Source: FHT; authors' compilation.

19 Public investment in roads delivers the highest impact with respect to poverty reduction and the second highest with respect to productivity growth. Public investment in research and development has the highest impact on productivity growth, and the second highest on poverty reduction. In contrast, expenditure on power has the least impact on poverty reduction and productivity growth. Surprisingly, expenditures on irrigation and health have relatively minor impacts on poverty reduction in this model. The results suggest that if the government is interested in obtaining the maximum impact on productivity growth and poverty reduction in rural areas, it should re-allocate its expenditures from irrigation, health, and power to research and development and road construction.

10/ However, the years 1971, 1974-1976, 1978-1982, 1985-1985 and 1991 were dropped due to missing values.

20 The FZZ model for China is very similar to the FHT model for India with the following differences:

- Government expenditure on poverty alleviation programs (poverty loans) are taken to be an additional factor behind poverty reduction along with the variables already present in the FHT model;
- productivity growth in agriculture is defined to be growth in agricultural labour productivity rather than total factor productivity;
- given the lack of data, no distinction is made between public and private irrigation;
- again, due to lack of data, public investments in health, soil and water conservation and rural development is not modelled; and
- unlike in the case of India, public investment in telephones and its effect on growth is also modelled.

21 There are 11 equations with 11 endogenous variables. The system is modelled using FIML methods using provincial-level data for 1970-1997. Since provincial poverty data are available only for seven years, a two-step procedure is followed. The first step involved estimating all the equations except for the poverty equation using the provincial-level data from 1970-1997. Then the values of agricultural productivity, wages, non-agricultural employment, and the terms of trade were predicted using the estimated parameters. The second step estimated the poverty equation using the predicted values of the independent variables at the provincial level on the available poverty data for 1985-1989, 1991 and 1996.

22 The returns to public investment for China in terms of production increases and poverty reduction are presented in Table 4.2.

Table 4.2 Returns of Public Investments by Type to Production and Poverty Reduction, China

Expenditure Variable	Marginal Impact			
	Poverty (no. of poor reduced per 10,000 yuan expenditure)	Rank	Rural GDP (yuan per yuan expenditure)	Rank
R & D	6.79	2	9.59	1
Irrigation	1.33	6	1.88	5
Road	3.22	3	8.83	2
Education	8.80	1	8.68	3
Power	2.27	4	1.26	6
Telephone	2.21	5	6.98	4
Poverty loan	1.13	7	---	---

Source: FZZ; authors' compilation.

23 Public investment in education has the highest marginal impact on rural poverty reduction followed by R and D. Roads are a distant third. With respect to rural income growth, R and D has the highest marginal impact followed by roads and education. Public expenditures in poverty loans do not seem to matter in poverty reduction – a striking result. Overall, there are important similarities with the Indian

case, and important differences. Public investment in research and development seem to matter in *both* the Chinese and Indian cases, and for *both* growth and poverty reduction. The fact that public investment in R and D matters in very different institutional contexts is indeed a surprising result – and if found robust, has significant implications for policy. Investment in roads also seems to matter in both countries, though not as much in the Chinese case. The relatively low impact of public expenditures in health and poverty alleviation programmes for poverty reduction is a surprising finding and also needs further investigation.

Limitations and Weaknesses

24 There are six important weaknesses of these two studies. Firstly, the data used in the two papers is subject to significant problems. FHT use extrapolation methods for several missing observations in the data – and thus, a large part of the data is constructed 'artificially', while FZZ have very limited data on poverty and use a two step estimation procedure which is known to have significant econometric problems in the use of predicted values of several important variables rather than actual values.

25 Secondly, the estimation method itself – full information maximum likelihood – has advantages over single equation methods in a system of inter-locked equations– but a disadvantage is that it can accentuate measurement bias of the estimated equations if some variables are measured with error (which is highly likely in their case, given the nature of data construction in both the FZZ and FHT studies).

26 Thirdly, the estimated equations have not controlled for individual specific unobserved fixed effects (even though the data has been transformed to first differences, first differencing may not remove these fixed effects if there has been gradual institutional change in Indian states and Chinese provinces that differ across states and regions). Thus, unobserved time-invariant effects relating to differences in institutional contexts of states in India and provinces in China may not have been controlled for, and can potentially bias the effects of the other explanatory variables. This is a particular problem in the Indian case, given the federal nature of the country, where institutional quality and state capacity differs significantly across Indian states.[11/] For example, in a state such as West Bengal where important changes have taken place over time in land tenure institutions, the estimates of rates of return in the FHT model may be biased if it is simply picking up the productivity enhancing and poverty reducing effects of such institutional change. The omission of unobserved fixed effects may lead to an *over-estimate* of the rate of return to public investments, including that for research.

27 Fourthly, a surprising omission of the FZZ and FHT studies is that they do not allow for the possibility that research and development in one state or province may have significant spillovers in neighbouring states, as farmers in other states may adopt new technology introduced in one state (especially if the farmers are located in similar agro-climactic zones that cut across more than one state, so that they find the new technology suitable for their climactic conditions). There is an extensive literature that documents this type of intranational spillovers. There may also be international research and development spillovers, for example, through the

[11/] Besley, Burgess and Esteve-Volart (2004).

availability of international germplasm. As Alston (2002) notes, "studies that ignore interstate and international spillovers are likely to obtain seriously distorted estimates of returns to agricultural research" (p. 317).

28 Fifthly, the explanatory power of the model at least in the FHT study is low - the R-squares are below 0.5 in most cases. Thus, more than half of the variation in the dependent variables are unexplained (the R-squares are considerably higher in FZZ). Most of the equations specified do not seem to originate from a precise theoretical framework, and can subject to criticisms of incorrect specification. For example, the FHT model takes public stocks in irrigation, roads, and electrification to matter for total factor productivity growth, which is a residual in the production function, and not for aggregate agricultural growth itself (most studies take stock of public capital as an additional input in the aggregate production function). Similarly, the specification for the terms of trade assumes that only supply side factors matter in its determination, and not demand side factors – an assumption that does not seem to be in accord with existing empirical studies on the terms of trade in India and other developing countries.

29 Finally, the robustness of the results is open to question – several of the variables which have statistically insignificant coefficients are retained in the policy simulations and can change the results (given the size of the coefficients) if omitted. There has been little attempt to undertake robustness tests of the policy simulations that is common in work of this nature – how sensitive are the results to alternate specifications of the equations where insignificant coefficients are set to zero?

30 For these reasons, the precise estimates of the returns to research that are obtained in the two studies (and the comparison of these returns to other types of public investment) need to be treated with a certain degree of caution. There is need for further empirical work that re-examines the FHT/FZZ studies with better data, further diagnostic testing, more sensitivity analysis under alternate assumptions, and more improved specification of the equations, including the incorporation of unobserved fixed effects and intranational and international spillovers.

31 Notwithstanding these criticisms, if one were to take the broad conclusion of the FZZ and FHT studies to be that research and development matters for agricultural growth, and agricultural growth matters for poverty reduction, then this conclusion is adequately supported by other studies. In the case of China, Jin, Huang, Hu and Rozelle (2002) find that between 1980 and 1995, China's total factor productivity growth in rice, wheat and maize grew rapidly and new technology accounted for most of the productivity growth. Interestingly, this study finds that not only this new technology was not only produced by China's domestic research system but was also imported from abroad as China drew heavily on the international research system for genetic materials. This further reinforces the point made earlier that the rates of return to research in the Fan et al. studies are not the *true* rates of return. In the Indian case, the important role that improved seed varieties played in the Green Revolution of the 1960s in North-West India is clearly documented as is the role of agricultural growth in rural poverty reduction in the country. Palmer-Jones and Sen (2003) establish a robust link between agricultural growth and rural poverty declines using disaggregated data, with agricultural growth over the period 1962-1990 associated with lower end of period poverty.

Extensions of the IFPRI China and India Models to Other Regions, Including Africa

32 A general criticism that can be raised against drawing policy lessons from the Fan et al. studies for other developing counties is that the studies are about two countries – China and India -which have observed the highest rates of economic growth in the 1980s and 1990s and where the institutional quality of the state is much above the average for developing countries. It is not at all clear whether the rates of return to research in terms of economic growth and poverty reduction observed in these two fast growing economies can be similarly observed in countries with weak institutional capacities and with unfavourable agro-climactic factors. Perhaps understanding that their original studies may not be able to shed light for public policy in fragile states, Fan and his co-authors have attempted to address this very important issue in two ways. Firstly, in extensions of their China and India studies, they find that the returns to research in low potential regions were significantly higher than for high potential regions.[12/] In the case of China, the production returns in yuan per yuan invested in low potential Western region was 12.69 as compared to 8.60 in the high potential Coastal region. 33.12 persons were lifted out of poverty in low potential region per 10,000 yuan invested in research as compared to 1.99 for the high potential region. In the case of India, the production return to research in rupees per unit invested was 688 in the low potential rainfed regions as compared to 63 in the irrigated areas and 243 in the high potential rainfall regions. 0.05 of the poor were lifted out of poverty in low potential rainfall regions as compared to 0.02 in the high potential rainfall regions and 0.00 in the irrigated areas. This suggests from a policy perspective, it would be beneficial to target low potential areas for investments in research relative to high potential areas, as the payoffs from investments will be higher in low-potential areas. Thus, the recent Fan-Hazell studies have important implications for the sequencing of investment in research for policy-makers.

33 However, the Indian estimates in particular have been called into question recently in the manner the same poverty data were allocated to regions with different agro-climactic potential. Palmer-Jones (2003) argues that the estimates suffer from an 'ecological fallacy' which could have resulted in the effects on poverty being overestimated in rainfed regions as compared to irrigated regions. While Fan and Hazell (2003) have attempted to defend their estimates from this critique, it does appear that the rates of return to poverty reduction may be biased not only for research but for all types of public investment in agriculture.

34 Secondly, more recently, Fan has undertaken several studies in East Africa that extend his earlier work on China and India to very different institutional contexts in East Africa, and yet find a higher return to research than for education and roads (Fan, Zhang and Rao on Uganda, 2004, and Fan, Nyange and Rao on Tanzania, 2005). However, unlike the case of China and India, the studies find no clear distinction in the returns to research between high and low potential areas. In many high potential areas, returns to investment are still high and there is no sign of any diminishing marginal returns to investment. This suggests that an overall increase in

12/ Fan and Hazell (2000, 2001), Fan, Hazell, and Haque (2000).

the rate of public investment in research can pay large dividends, rather than the targeting of specific regions as in the Chinese and Indian case.

Evaluating the IFPRI Uganda Study

35 We will first examine the Uganda study, which is methodologically very different than that of Tanzania. In the Ugandan study, Fan and co-authors use a simplified version of the China/India model, mostly because of lack of available data. The simplified model, where the four variables of interest are poverty, agricultural productivity, real wages and employment in the non-farm sector, is estimated using district-level data, compiled from the household surveys undertaken in 1992, 1995 and 1999. The study finds that the benefit-cost ratio for agricultural research ad development is 12.38 as compared to 2.72 for education and 7.16 for roads. The number of poor people reduced per million shillings invested in agricultural Rand D is 58.39 as compared to 12.81 for education and 4.6 for health.

36 However, a limitation of the data on agricultural research is that it is only available at the national level and not at the district level. Fan et al. allocate the data on agricultural research at the national level to districts in proportion to district *extension services*. This is a restrictive assumption and the use of it suggests that the Ugandan study is essentially estimating the return to extension services and *not* the return to agricultural research. For this reason, the estimates of the returns to research and other public investments obtained in the Ugandan study (and the rankings generated thereof) cannot be compared to the estimates and rankings provided in the China and India studies.

Evaluating the IFPRI Tanzania Study

37 The econometric methods that Fan and his co-authors have used in the Tanzania study is different from that used in the FZZ and FHT studies (and the Uganda study discussed above). The Tanzania study uses household survey data, unlike the state and province panel data used in the FZZ/FHT studies. In the Tanzania study, household income is modelled as a function of household characteristics along with dummy variables that capture the adoption of HYV seeds, fertiliser use, and access to electricity (1 if the household adopts HYV seeds, uses fertilisers or has access to electricity, 0 otherwise). Poverty is a binary variable, defined as one when the household is below the poverty line, zero otherwise, and its determinants are similar to those for household income. Household income is estimated using least squares and the poverty equation is estimated using a probit model. The estimates can then be to work out how much of an increase in household income will be brought about if the household adopts HYV seeds relative to the household gaining access to electricity or using fertiliser for the first time. The study finds that the return to agricultural research is 12.46 shillings per shilling invested as compared to 9.00 for education and 9.13 for health. The number of poor people reduced per million shillings invested in agricultural research is 40.39 as compared to 43.10 for education and 26.53 for health.

38 It is clear that there are clear differences in the methodology of the Tanzania study from the earlier Fan et al. studies. Firstly, the study does not study the effect of public spending in agricultural research *directly* – rather, they do it indirectly – via the adoption of HYV seeds. Thus, the study estimates the rate of return to *technology*

adoption, rather than to the public investment in agricultural research, so the rates of return in Tanzania study should not be compared with the FZZ/FHT studies, which are about the latter.

39 Secondly, and more importantly, unlike the FZZ/FHT studies, the Tanzania study does not control for the endogeneity of technology adoption in both the household income and poverty equations – a fact acknowledged in the new study by the authors. This is a serious methodological problem – it is expected that richer households will adopt HYV seeds more readily, so that the positive coefficient on HYV seed adoption may be capturing a reverse causality from the income status of the household to the use of technology by this household, rather than the other way around. Thus, estimates of rates of return that do not control for the reverse causality will be significantly biased upwards.

40 Thirdly, while Fan and his co-authors provide estimates of the benefit/cost ratio of investment in research relative to other investments, these are ‘back of the envelope’ calculations, making strong assumptions of the relationship between agricultural research and HYV seed adoption and in the allocation of national research expenditures to the different regions, when no disaggregated data exists. The ad hoc nature of these estimates imply that the latter cannot form the basis of strong policy inferences.

41 In relation to the FZZ/FHT studies on China and India, the Ugandan and Tanzanian studies can be seen to be methodologically inferior, and the results obtained from these studies cannot be robustly defended. However, a problem in replicating the China and India models in the African context is the lack of data at the sub-national level that would have allowed researchers to estimate similar macro-economic models to FZZ/FHT for African countries. There are two possible ways to proceed in this context. One would be to pool the data for several African countries, and estimate returns to research at the country-level. Another would be to use non-parametric methods of estimating returns to investment – that is, modify existing Computable General Equilibrium models that are in existence in the African context to incorporate public investments in research and other activities, and use these models to simulate the effects of investment in research on poverty rates. Both methods would be able to provide a better understanding of the effectiveness of research in bringing about economic growth and poverty reduction than is possible with the current available evidence, drawn mostly from the IFPRI Africa studies.

enterplan

CREATING A NATURAL ADVANTAGE

5 The Value of Health Research

5 The Value of Health Research

42 Recent years have seen a growth in global efforts to promote and strengthen the conduct of health research and it's funding. Since 1998 WHO has been an important advocate of measures to improve the effectiveness, efficiency and equity of health research through its Global Forum on Health Research (GFHR). Whilst arguing for greater spending on health research, the Forum also acknowledges that existing research resources could be used better, not least because of the absence of systematic criteria or formal mechanisms to maximise the payback from health research.

43 The Forum has worked energetically to try and correct the "10/90 gap". This term - coined by the 1990 Commission on Health Research for Development - describes the current situation in which less than 10 percent of the US$ 70 billion spent globally on health research each year is devoted to 90 percent of the world's health problems (when measured in disability adjusted life years DALYs). Global health research funds are almost wholly controlled by a few wealthy countries that prioritise the funding of health research on the basis of their own needs and on issues that are relevant to a small percentage of the global population. Diseases that predominantly affect the poor remain largely ignored, whilst much of the output of research is not easily transferable to poorer countries due to the country-specific nature of the research undertaken and the high costs of the interventions. These imbalances affect both private and public spending on health research. In the private sector, research spending decisions are typically based on shareholder preferences and profit maximisation objectives. This inevitably limits investment in diseases prevalent in low- and middle-income countries where market potential is currently judged to be low. Decisions on public health research priorities often ignore the potential spillover health effects from such factors as: the rapid growth in travel and the potential for international transmission of diseases of poverty; re-emerging diseases such as TB and malaria; the development of drug resistance; and, international migration, all of which have the potential to impact heavily on the health of richer countries.

44 Apart from a misallocation of global health research funds the Forum also argue that health research spending is insufficient. At its November 2004 meeting in Mexico City the Forum called for governments and donor agencies to allocate two percent and five percent respectively of their overall health budgets to health research. Whilst it is difficult to determine how decisions should be made about the appropriate level of spending on health research the target does not seem excessive given the challenges faced by many countries in meeting the Millennium Development Goals, many of which that have a health dimension, and which seem unlikely to be met without significant improvements in the effectiveness, efficiency and equity of health care systems.

45 From a theoretical perspective the relevant question is whether, at the margin, the value of health sector outputs would be increased by a re-allocation of

resources from health services per se to research to improve health services. Even today, many health interventions that are currently funded are of unproven worth or effectiveness with some procedures even being harmful. Well-conducted research can establish the true worth and impact and impact of health spending, and increase the returns to future spending. Amidst the call for more research funding, globally, there is increasing pressure to justify health research expenditures to a greater number of ever more demanding stakeholders (for example, parliament, line ministry, treasury, finance, public, communities, patients). In considering the case for increased funding, the following factors merit consideration:

- Health resources are scarce in all countries but particularly so in developing countries where per total (public and private spending) on health may be less than US$1 per capita per month. Health research spending competes directly with spending on services so that for each cent spent on research there is one cent less for health services that can contribute to better health.

- Much health research is extremely costly and sometimes has significant hidden costs in terms of time and resources of research partners and patients.

46 The remainder of this section of the report explains the challenges faced in measuring payback from health research and outlines how, in spite of these difficulties, donor agencies can do much to increase the returns from their investments in health research.

Distinctive Features of the Health Sector

47 In order to appreciate the challenges faced in determining appropriate levels and patterns of spending on health research, it is necessary to highlight some of the distinctive features of the health sector and the particular challenges these entail, not least the problems of applying input-output analysis to establish payback to health research. These include problems in defining, measuring and - above all - valuing health and health outputs; and problems of establishing causation both in terms of linking health research to practice change, and practice change to health status change. This includes research into the operation of health systems and health seeking behaviour and not merely clinical or epidemiological research.

48 A further problem in the quantification of the payoff to health research is that health research cannot be divorced from health service delivery. It is part of the culture of health service delivery that practitioners do research. Thus, the two processes are intertwined.

49 Health research can be funded by both the private and public sectors, and can be linked to the development of commercial (i.e. marketable) technologies or conducted primarily to add to the global pool of health knowledge. A large proportion of medical research, and the bulk of publicly funded health research is published in peer reviewed journals and is accessible to any party able to access the literature. The output of this research has the two requisite features of a public good: once published, the findings are “non-excludable”; and the product of research is “non-rival in consumption” in that the benefits of knowledge can be enjoyed by any number of parties without diminishing the utility of other users. Since career development in the

medical profession and health sciences depends largely the publication studies in eminent peer reviewed journals, there is a strong impetus to the global sharing of research findings.

50 Of course, not all health research has the attributes of public goods. Much of private health research, and particularly the research funded by pharmaceutical companies and the manufacturers of medical technology is conducted with a view to developing commercial products that can be protected by patents and licensing arrangements for the benefits of the research sponsors. The potential for returns over and above the costs of research and product development has led to the development of treatments for conditions such as hypertension and diabetes. However, the lack of purchasing power amongst the world's poorest is widely accepted as a contributory factor in the failure of international drug companies to develop effective treatments for conditions such as malaria that constitute a major part of premature mortality and morbidity in the developing world.

51 In contrast to agriculture and education, there are major challenges in defining, measuring and valuing outputs in health research. Traditionally, society has conceived of health in negative terms: that is, in terms of the absence of disease, pain and disability, and the avoidance of premature death. The importance of health in earning a living and supporting a household is well understood in developing countries even today where large section of the population rely for their daily livelihoods on being able to sell their labour and where catastrophic health care costs can drive households into poverty and keep them there.

52 In recent years a more positive view of health has emerged, which is well reflected in the widely cited WHO definition of health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". Health is now recognised as a multidimensional entity, valued not just for the sense of general well being it confers but also for the contribution it makes to the enjoyment of other goods and services In line with this changing perception, health services are being re-oriented to emphasize health promotion and disease prevention, rather than focusing solely on the treatment of disease, pain and disability. This reinterpretation of "health" has had consequences in terms of tools and techniques of measurement. Health status and thereby "health output", is now conceived as being the product of both quantity and quality of life (i.e. "years added to life", and "life added to years").

53 Various measurement techniques have been developed from multidimensional profiles, to unified indices that express the utility of different health states relative to each other on a continuum (typically scaled from zero to one). The most widely known of these indices are the Disability Adjusted Life Year (DALY) and Quality Adjusted Life Year (QALY). Although they share many similarities the former ranks alternative health states in terms of different combinations of Disability and Duration, the latter in terms of combinations of Quality of Life and Duration. A range of techniques is used to rank different health states from social consensus methods to individual self-rating methods. However, at the heart of these approaches is the premise that the utility of different health states can be captured in a single value that captures individuals and society's implicit rates of trade off between different dimensions of health. The QALY and DALY represent a significant advance in the economic evaluation of health care spending by allowing economists to rank health

interventions in terms of the relative costs of achieving equivalent units of health gain.

54 Where there has been less progress is in the development of methods for expressing the multiple dimensions of health and health outputs in monetary terms. In the early years of the development of health economics there were numerous attempts to express the outputs of health spending in cost terms so as to assess the net worth of health interventions. However, cost benefit techniques and attempts to translate the value of a life into monetary terms remain highly subjective. Various techniques have been used to place a value on being able to avert death, pain and disability as well as the concomitant loss of economic welfare that ill health or premature brings. However, today many economists avoid the use of cost-benefit techniques preferring instead to use the less subjective methods of cost-effectiveness and cost-utility analysis. The consequence of these methodological challenges effectively preclude the use of input-output analyses for assessing returns to spending on health or more specifically on health research.

55 The problem is further compounded by the problems of establishing the effectiveness of health interventions and attributing causation. Health services are but one of many factors that contribute to good health, and much of the improvement in health that took place in developed countries during the industrial revolution was the product of factors such as improved sanitation, housing, nutrition and education. These same factors are influential today in improvements in the health of developing countries. Maternal education, for example, is well established as an important determinant of infant health. Increasingly, lifestyle factors and health behaviour are seen as being key inputs to the production of good health.

56 In order to measure the returns to health research it is necessary to be able to measure the contribution of research to health innovation and the contribution that such innovations make to better health. Unfortunately, there are major constraints to the accomplishment of this task. Until very recently most medical practice was not informed by any rigorous assessment of the effectiveness of treatments or interventions making assessment of health research payback problematical. The development of Evidence-Based Medicine (EBM) in recent years has helped to inform health sector evaluation and assure clinical effectiveness, through the application of the scientific method to medical practice, including long-established traditions and interventions never subjected to adequate scientific scrutiny. In a short time EBM has helped to produce evidence of clinical effectiveness through research and scientific review; the production and dissemination of evidence based clinical guidelines; the implementation of evidence-based cost-effective practice through education and the management of change; and the evaluation of compliance with agreed practice guidance and patient outcomes (i.e. clinical audit).

57 EBM acknowledges varying levels of rigour in terms of evidence from the "Gold Standard" of at least one systematic review of multiple well-designed randomised controlled trials, to well designed trials such as non-randomised trials, cohort studies, time series or matched case-controlled studies, through to non-experimental studies from more than one centre or research group and the opinions of respected authorities based on clinical evidence, descriptive studies or reports of expert committees.

58 The global EBM movement has helped to ensure there is now sufficient knowledge of what interventions work in order to cost-effectively address the major burden of ill health in the developing world (notwithstanding the continuing search for more effective treatments for conditions such as HIV/AIDS, TB and malaria). Recent decades have seen intensive innovation and experimentation with health sector reform around the world and many countries are experimenting with innovations such as: sector wide approaches; new financing mechanisms; various forms of decentralisation; experiments in public-private partnerships. Increasingly, the challenge is less to determine which health interventions work and more to identify the optimal institutional settings and systems to deliver those interventions; findings ways of paying for those interventions; and better understanding aspects of health seeking behaviour that continue to confound efforts to increase coverage and utilisation. There is now a parallel need to ensure that health policy and practice is also based upon sound and appropriate research.

Literature Review on Health Research Payback

59 Assessing the economic value (i.e. returns or payback) to health research is a complex but necessary step in determining and justifying levels of investment in health research. Various conceptual, methodological and practical problems arise in trying to identify and value the relevant research inputs and to attribute impacts to particular research activities since a single health advance may be attributable to the outputs of many individual research project. Problems also arise in how to define, measure and value research outputs.

60 Buxton M, Hanney S and Jones T (2004) provide a useful recent overview of the conceptual, methodological and practical issues involved in measuring health research payback. Their review is based upon a literature search of relevant online databases using keywords such as: “research” (or “evaluation” or “research and development” or “assessment”); and health (or “biomedical” or “medical”); and “economic re-turn” (or “economic impact” or “rate of return” or “investment” or “payoff” or “payback” or “impact” or “benefit”). Much of the relevant material located during the search was not published in the professional journals but in less-easy-to-access books, monographs and reports (i.e. “grey literature”). Most of the references were from developed countries and particularly the USA, with the developing world under-represented.

61 The Buxton et al review was purposefully selective, omitting studies of the private returns to companies from their internal research; studies addressing less tangible social impacts of research, such as the contribution that an informed society makes to the development of nations; studies assessing the potential benefits from proposed health research; and studies assessing the potential value that would arise from applying existing knowledge.

62 The literature generated by the review suggest that the measurement and valuation and of health research outputs can be captured under four categories that will be familiar to any economist with experience of the health sector. These include:

- direct cost savings to the health-care system,
- benefits to the economy from a healthy workforce,
- benefits to the economy from commercial developments, and

- the intrinsic value to society of health status improvements ("health gain").

Estimates of Rates of Return to Health Research

63 Unlike the IFPRI models that estimate the rates of return to agricultural research as compared to other investments, there is no similar model that compares rates of return to health research with other types of investments. However, a growing body of evidence indicates that investments in health do not merely contribute to development, but that they are essential pre-requisites for economic growth and poverty reduction. The recent report of the WHO Commission on Macroeconomics and Health (CMH) is the most robust and reliable source of evidence on the links between health investment and development. Recognising the high rates of return on investments in health, the CMH called for a doubling of health spending by governments and donor agencies over by the end of the Millennium Development Goals (MDGs) period. Under a conservative set of assumptions the CMH anticipate that every additional $ spent on health would increase the GDP of the relevant countries by $3, and that the returns might be as high as $4 or $5 for every $ invested.

64 The work of Mansfield was commended in a recent review identifying a range of benefits to the economy from publicly funded basic research. Studying large USA corporations covering seven industries (including the pharmaceutical industry), Mansfield identified new products and processes that would have been substantially delayed in the absence of recent academic research. On this basis a worldwide social rate of return of 28 percent was estimated on the sales of research-based products for research conducted in 1975–78. The pharmaceutical industry was ranked as the most dependent on basic academic research.

65 Silverstein et al studied the economic value of research in the medical and life sciences and listed 10 biomedical discoveries that led to industrial applications outside the health sector, and which were worth US$ 92 billion in sales. A report by the USA National Institute of Health (NIH) cites several studies that show the importance of publicly funded research in the pharmaceuticals development. In one study, 15 of the 21 drugs identified as having had most impact on therapeutic practice were shown to have been developed with input from the public sector, but the complex interaction between public and privately funded research prohibited any attempt to calculate a social rate of return.

66 Several recent studies estimate the value of improved health status or "health gain". The "Funding First" report is based upon willingness to pay (WTP) assessments for small reductions in the risk of death, and attach a value of around US$ 3.0 million is to fatality prevention. The authors estimate the value of the increasing longevity of the US population of the can reasonably be attributed to medical research.

67 Lichtenberg estimates that the social rate of return on investment (in terms of the value of additional life years generated) on pharmaceutical research is around 67 percent. For cardiovascular disease, one-third of the decline in mortality attributable to cardiovascular disease is due to invasive treatments, one-third to pharmaceuticals and the remaining one-third to behavioural changes.

68 Although the FF studies employ a common approach in valuing willingness-to-pay for an additional life year there are several concerns about the robustness of the methodology, the assumptions on which the estimates are made, and the ability to generalise the findings beyond the US laboratory. The Funding First methodology has been used to estimate the return on Australian bio-medical research and development on the basis of overall improvements in Australian lifespan, including reductions in specific mortality rates for a range of illnesses. The study uses the USA estimate of the value of a life year, but also factor in the value of reduced morbidity. The base-case assumption is that research and development are responsible for 50 percent of the improvements in healthy lifespan, and that Australian research and development contribute 2.5 percent of the total research and development gains, this being the percentage of global research and development undertaken by Australia.

69 There is very little quantitative evidence on the rate of return to health research in developing countries similar to what exists for agricultural research. While there may be difficult conceptual and measurement problems to surmount in the application of the methodological tools available for the estimation of the rate of return to agricultural research to the health sector, there is a need to develop more innovative methodologies in the quantification of the rate of return to health research, along with the application of these methodologies to developing countries.

Strengthening the Research Prioritisation and Management Process

70 Two tools provide useful support to assist research funders in maximising returns from their investments. Each is briefly summarised below.

The Buxton and Hannay Research Payback Model

71 In a seminal paper Buxton M and Hannay S (1996) present a framework for assessing the payback from health research. The framework comprises two elements. The first element is a multidimensional categorisation of the benefits from health research; the second is a model for assessing and maximising those benefits. The model is based on the notion that there are various interfaces points in the research process between the researcher and the wider political, professional and social environments and that understanding and managing these interfaces can help to improve the returns to research spending.

72 Underpinning the analysis is a recognition that simple models of the health research process fail to capture the complex manner in which research influences practice in the real world. Starting from the simple ***classical knowledge-driven model*** that assumes a simple linear process where research leads to knowledge and then to action, they outline more complex models that better explain how research informs practice and leads to the adoption of new practices in the real world. These other models highlight the importance of external influences and see research as a political tool often used as a means of deferring tough decisions. They note that research findings are seldom used in direct or instrumental way, and that change often occurs only as a result of a gradual accumulation of evidence and weight of opinion. These models help to explain the complexity of the research process and explain why it can be difficult to attribute a change in policy or practice to particular

research processes and outputs. Any funding agency wishing to maximise returns from health research in developing countries needs to acknowledge and account for these factors.

73 Given this complexity the authors look for a range of measures that reflect the diverse nature of research payback. They identify five categories of output including:

- a contribution to knowledge per se,
- benefits to future research and research use,
- political and administrative benefits,
- health benefits ("health gain") and health service benefits, and
- broader economic benefits.

74 Whilst there is some overlap with the output classification used in the literature review cited earlier, the first three indicators are more immediate process indicators whereas the latter two focuses more on measuring the final outputs and impacts of research. The paper considers how best to manage the research process and thereby maximise the aggregate outputs of research, and provide useful direction to research funders on some objectively verifiable indicators of achievement and output.

75 The most obvious output of research is a contribution to knowledge per se. The pool of knowledge can be supplemented in several ways: by producing new knowledge or confirming knowledge; by verifying earlier work or confirming the local relevance and/or applicability of knowledge. Traditionally, this class of output is measured by peer reviews, journal publications, citations, and other bibliometric methods.

76 **Benefits to future research and research use** is another important category of outputs and can be measured in terms such as the development of stronger research capacity (for example, the output of trained postgraduate researchers); the development of research methodologies; and the replication of study methods. Another benefit is in terms of strengthening capacity to make use of existing research; the more effective exploitation of external studies; and the development of research networks and professional contacts.

77 **Real world political and administrative benefits** are no less important. Research can be used by politicians or policy makers to deflect possible attacks by showing that action is being taken to investigate a problem and by providing 'breathing space" by delaying immediate decisions and actions. Politicians can also point to research as a means of demonstrating the rationality of political decisions. In a separate paper Ham (1995) suggests that one way of demonstrating the contribution of research is to have policy documents indicate the research consulted in their preparation to formally link policy-making to the underlying evidence base.

78 A variety of ***health benefits ("health gain") and health service benefits*** can also be identified. These include: cost savings; process improvements in service delivery such as reduced waiting times and greater patient satisfaction; improved health status (for example, more years of life and/or better quality of life); more equitable outcomes.

79 Various ***broader economic benefits*** can also be identified including the commercial exploitation of research products and technology; increased output from a healthier and more productive population (for example, increased human capital).

80 The Buxton and Hannay model has been applied in a number of settings and has proved to be flexible and robust. The key findings from the application of the model are that networks and linkages are very important, and particularly linkages between researchers and various stakeholders. Better dissemination of results is critical including improved targeting of policy makers, practitioners and academics to customise findings to different audiences.

The Combined Assessment Matrix Model

81 As part of its collective initiatives on strengthening health research the Global Forum on Health Research (GFHR) WHO has produced a tool labelled the Combined Approach Matrix (CAM). The CAM incorporates both economic and institutional elements of research prioritisation into a simple two-dimensional matrix. This is then used to help organise, summarise and present all available information on one disease, risk factor, group or condition, and facilitate comparisons between the likely cost-effectiveness of different types of interventions at different levels.

82 This is a tool that:

- brings together in a systematic framework all information (current knowledge) related to a particular disease or risk factor;
- helps to classify, organize and present the large body of information that enters into the priority-setting process;
- identifies gaps in knowledge and future challenges in health research;
- identifies health research priorities, based on a process which should include the main stakeholders in health and health research;
- relates the five-step process in priority setting (economic axis) with the actors and factors (institutional axis) determining the health status of a population;
- permits the identification of “common factors” by looking across the diseases or risk factors;
- is applicable to priority setting in the field of: national, regional or global problems and both diseases and risk factors, and
- permits taking into account the large number of factors outside the health sector that have an important impact on people’s health.

83 The model explicitly addresses the determinants of health problems and the scale of the problem in terms of disease burden. Resource implications are addressed both in term of health financing and the relative cost effectives of different interventions.

6 Rates of Return to Research in Fragile States – What do we know?

6 Rates of Return to Research in Fragile States – What do we Know?

84 To what extent are the findings of the IFPRI and related studies that investment in research has strong payoffs in terms of economic growth and poverty reduction relevant to fragile states, which are characterised by a debilitating combination of weak governance, policies and institutions. There is little doubt that the win-win situation with respect to investment in research outlined by Fan et al. for China and India (faster growth, stronger poverty declines) will not hold for fragile states in Sub-Saharan Africa and other parts of Asia.

85 Taking the case of agricultural research first, for investment in research to pay off, the literature has identified the following complementary conditions – favourable agro-climactic factors, geographical closeness to markets, stable output prices, access to inputs such as seeds and fertilisers at reasonable costs, viable and well-functioning credit markets, and good access to information and infrastructure. Several of these complementary conditions do not exist in fragile states. Previous research on these complementary conditions have shown that price supports, subsidised inputs, credit subsidies for a new technology, and public investment in irrigation, roads and marketing centres have all been instrumental in the adoption of new technologies by farmers in developing countries.[13/]

86 Studies of rates of return to agricultural research for African countries find evidence of very high rates of return, sometimes exceeding 50 percent, for some countries and for some crops, particularly since 1993 (for example, maize in Burkina Faso and Ghana – around 75 percent, rice in Senegal – between 66 and 83 percent, and millet in Mali at 66 percent).[14/] However, the wide variability of the rates of returns reported in these studies cast some doubt on the reliability of the estimates. Macro-accounts of the determinants of poverty reduction in Sub-Saharan Africa find a close positive relationship between poverty declines and agricultural productivity growth and that among the most important determinants of yield increases is investment in agricultural research and development. In fact, the impact of agricultural R and D on agricultural yield in the African case is no different than that for South Asia and much larger than that for East Asia and Latin America.[15/] However, these macro-estimates of the rate of return to research in the African context seems to be contradictory to the evidence on slow agricultural growth and stagnancy or even increases in poverty rates for much of Sub-Saharan Africa, as well being open to methodological criticisms of their own.

87 The conflicting evidence on the rate of return to research, and the concerns that have been expressed on the methodologies of the rates of return research in the African context suggest that one should be careful to draw strong inferences from these studies on the efficacy of public spending in research in fragile states,

13/ Sunding and Zilberman (2001).
14/ Masters, Bedingar and Oehmke (1998).
15/ Thirtle, Lin and Piesse (2003).

particularly in Africa. While there is little doubt that research and extension can be a key driver of pro-poor agricultural growth in fragile states, we need more robust evidence than is currently available on whether the return to research is *higher* than for investments in education, infrastructure, and health – the other critical areas where public funding in the fragile state context is grossly below desired levels. Furthermore, for research and extension to have the maximum possible effect on growth and poverty reduction in fragile states, it is necessary that appropriate complementary conditions of rural infrastructure, easy availability of credit, stable output prices, and access to fertilisers and seeds are also satisfied.

88 There is, however, a stronger case of spending on health research targeted specifically to the poor in fragile states. Globally, the vast majority of health research and development (R&D) funding is spent on issues that are relevant to a small percentage of the global population with diseases affecting mainly the poor largely ignored. Furthermore, the output of much research is not easily transferable to poorer countries due to the high costs of the proposed interventions and/or the country-specific nature of the research undertaken. The population that is excluded from the benefits of health research is predominantly in the developing world, largely poor, and often marginalised from both power and decision-making. There is therefore need for more research in the prevention and treatment of diseases that are particularly common in fragile states.

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7 Key Learning Points and Recommendations

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Key Learning Points

89 There is a robust positive relationship between spending on research and development and economic growth – the rate of return on research is many times the rate of return on other comparable investments.

90 Rates of return to agriculture are significantly higher than comparable rates of return to education in developing countries.

91 The IFPRI studies on China, India and East Africa are important contributions to the understanding of the efficacy of research in increasing economic growth and poverty reduction in the developing country context. However, these studies have limitations of data quality and econometric problems.

92 Thus, the ranking of public investments in terms of their impacts on growth and poverty reduction cannot be considered to be robust, and may change under alternate econometric specifications and with better data.

93 Health investments can play a central role in promoting economic growth and poverty reduction worldwide. The economic returns are estimated to be $3 or more than projected for every health dollar spent, assuming an ideal policy and implementation environment.

94 There are no models comparable to the IFPRI model in estimating the rates of return to health research.

95 The Buxton and Hannay model provides a useful aide memoire when thinking about the different types of outputs from research, particular the intermediate and process outputs. It also helps to focus the minds of research funders and researchers on how to ensure maximal stakeholder involvement and ownership, particularly ownership by policy-makers and planners. The CAM and the various other tools produced by WHO and the GFHR are useful in helping to organise data for priority setting.

96 Investment in agricultural research in the fragile state context research is not expected to have strong payoffs. Several of the complementary conditions needed for investment in agricultural research to payoff do not exist in fragile states. However, there is a stronger argument for investment in health research that is specifically targeted to the poor in fragile states.

Recommendations for Further Research

97 In order to achieve a better understanding of the relative payoff to agricultural research as compared to other types of investment, there is need for further empirical work that re-examines the IFPRI studies with better data, further diagnostic

testing, more sensitivity analysis under alternate assumptions, and more improved specification of the equations, including the incorporation of unobserved fixed effects and intranational and international spillovers.

98 There is also need for further work in the quantification of the benefits of health research in developing countries, similar to the IFPRI and related studies for agricultural research.

Recommendations to National Governments

99 In order to maximise the benefits of agricultural research, it is necessary that national governments ensure that appropriate complementary conditions of rural infrastructure, easy availability of credit, stable output prices, and access to fertilisers and seeds for farmers are also satisfied.

100 With respect to health research, more needs to be done by national governments to strengthen research capacity in their countries. If local research agencies are to attract more funding they will need to increase their absorptive capacity and performance. Networking arrangements with other agencies both in country and overseas may be worth exploring, particularly as a means of accessing larger research contracts, although access to small research grants can help to provide research experience to less experienced researchers.

Recommendations to Donors

101 There is a clear need for donors to support international agricultural and health research, particularly targeted to the poor in low-income developing countries. There is still considerable under-funding of such research, and co-ordinated action on the part of donors and multilateral agencies is required to increase resources for such research, which has been seen to have significant payoffs in terms of poverty reduction.

102 There is a need for donors to invest in research capacities in developing counties in agriculture and health by supporting national agricultural and health research systems. The Commission on Health Research for Development recommends that donors allocate at least 5% of their funding for the health sector to health research and research capacity strengthening in developing countries. A similar case can be made for funding in the agricultural sector in developing countries, where a certain proportion of the funds should be ear-marked for supporting local agricultural research and research capacity strengthening.

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A1 Rates of Return Research (RoR) to Agriculture Research and Extension - A Summary Table

A1 Rates of Return (RoR) to Agriculture Research and Extension – A Summary Table

Table A1.1 Rates of Return to Agricultural Research and Extension – A Summary

	Number of RoRs reported	percent Distribution						Approx. Median RoR
		0-20	21-40	41-60	61-80	81-100	100+	
Extension								
Farm Observations	16	56	0	6	6	25	6	18
Aggregate Observations	29	24	14	7	0	27	27	80
Combined research and extension	36	14	42	28	3	8	16	37
By region								
OECD	19	11	31	16	0	11	16	50
Asia	21	24	19	19	14	9	14	47
Latin America	23	13	26	34	8	8	9	46
Africa	10	40	30	20	10	0	0	27
All extension	81	26	23	16	3	19	13	41
Applied Research								
Commodity Programs								
Wheat	30	30	13	17	10	13	17	51
Rice	48	8	23	19	27	8	14	60
Maize	25	12	28	12	16	8	24	56
Other Cereals	27	26	15	30	11	7	11	47
Fruits and Vegetables	34	18	18	9	15	9	32	67
All Crops	207	19	19	14	16	10	21	58
Livestock	32	21	31	25	9	3	9	36
By region								
OECD	146	15	35	21	10	7	11	40
Asia	120	8	18	21	15	11	26	67
Latin America	80	15	29	29	15	7	6	47
Africa	44	27	27	18	11	11	5	37
All Applied Research	375	18	23	20	14	8	16	49

Source: Evenson (2001).

Table A1.2 Social Rates of Return to Education – Results of Two Surveys

	Primary	Secondary	Tertiary
Psacharopoulos Survey			
Low income countries	23	15	11
Lower middle income countries	18	13	11
Upper middle income countries	14	11	10
High income countries	--	10	8
By Region			
Sub-Saharan Africa	24	18	11
Asia	20	13	12
Europe, Middle East, North Africa	16	11	11
Latin America, Caribbean	18	13	12
OECD countries	14	10	9
Schutz Survey			
Africa	27	19	14
Asia	18	14	12
Latin America	35	19	16
High Income countries	13	10	8

Sources: Psacharpoulos (1994) and Schutz (1988).

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A2 Terms of Reference

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Draft Terms of Reference for a Literature Review and Critique

Purpose

DFID Central Research Department (CRD) want to investigate what we know about the rates of return on research and to assess key evidence that has been presented on agricultural research and health research in particular. This will eventually inform debates within DFID about optimal allocations of aid to research vis a vis other aid instruments. This is preliminary work only to start to assess the effectiveness of research as an aid instrument. We are not looking at this stage to examine the relative effectiveness of different types of research.

Background

Agricultural Research

Two key published papers on agricultural research are;

S. Fan, L., Zhang, and X. Zhang *Growth and Poverty in Rural China: The Role of Public Investment*, Research Report 125 (Washington DC IFPRI 2002)

S. Fan, P. Hazell, and S. Throat, “Government Spending, Growth and Poverty in Rural India”, American Journal of Agricultural Economics 82 (No. 4 2000)

These two macro level case studies modelled Chinese and Rural Indian growth paths in the 1970s and 1980s and isolated and ranked the effects of different types of public investment. For China investments in agricultural R&D, irrigation, roads, education, electricity and telephone were examined. For India investments in agricultural R&D, roads, education, irrigation, power, soil and water, rural development and health were assessed. The broad conclusion reached was that additional investments in agricultural R&D increase agricultural productivity more than any other form of public investment in rural areas. More importantly, agricultural investment was also seen to be a relatively important investment for poverty reduction. The model has been recently applied to a number of African countries with equally dramatic results. (papers to follow)

Health Research

WHO commissioned work in the 1990s on the cost-effectiveness of various potential health research products. WHO may also have more recent work underway. Tim Evans and Tikki Pang at WHO, and who are known to CRD, may be able to advise on such work.

Some work is also believed to have been done across the health product development PPP sector on the rates of return to their kind of research. IAVI, MVI and TDR would be useful reference points.

Prof Martin Buxton at University of Brunel Health Economics Research Group wrote a seminal paper in c 2000, on payback to health research – initially for the UK. He has since done further work for WHO – albeit not specific to developing countries.

Key tasks

General

1. Provide a summary of literature and current work on rates of return/payback for research compared with other investments in developing countries.

Agriculture

2. Undertake a literature review of rates of return to agricultural research and how these may compare to rates of return to other public sector interventions in poor countries.

3. Examine the International Food Policy Research Institute (IFPRI) model and determine the robustness of the IFPRI results; i.e. a peer review of the IFPRI model. In particular is the structure and operation of the model plausible, and is it plausible to lump all types of agricultural research together?

4. On the assumption that the returns to agricultural research must be a joint product with other inputs, assess what assumptions are being made about other inputs that seem essential complements to any rates of return to agricultural research? How robust are the answers to changing those assumptions?

Health

5. Undertake a literature review of rates of return to health research and how these may compare to rates of return to other public sector interventions in poor countries.

6. Determine whether for the health sector there is any equivalent model or work to that of IFPRI for agriculture.

7. For the health sector research work assess what assumptions have made about the linkages in the chain from basic research to clinical trials to access and production. To be effective all three areas need to be funded.

Fragile States

8. Assess what the IFPRI model can tell us about the rates of return to research in fragile states, where other inputs are likely to be ineffective? Initial models of aid allocation (early Collier papers) suggested that in poor policy environments aid would be ineffective but that knowledge transfers were crucial, as a way for states to gradually achieve better policy. This suggests that in fragile states, research could be a relatively good investment. For example, if the health system does not work and

there is no immediate prospect of fixing it, the best health investment might be on a malaria vaccine available 10 years down the line.

Outputs

A summary of the current work on rates of return/payback for research compared with other investments in developing countries. This should comprise a summary of headline results in terms of the relative effectiveness of research and a commentary on the quality and robustness of the analysis.

- in general,
- in agriculture, and
- in health,

and should provide summary evidence and critical commentary on each of the points 1-8 in the Key Tasks section above.

This is preliminary work, so a report of not more than 15 pages is required.

Inputs and Timing

A team of two or possibly three experienced consultants are required;

- an econometrician ideally familiar with the IFPRI model or other similar models
- an economist with specialist knowledge and experience of work on rates of return to research in poor countries, **or**
- a health sector economist **and** an agricultural economist each having experience of returns to research in their sectors and how such returns compare with other public sector interventions.

The work is to be completed by mid August. A total of 20 days is budgeted for the work. A possible allocation is 10 days for the lead consultant and up to five days each for collaborators, though this may be varied depending on the composition of the team.