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The economic value of innovation: measuring the linkages of pharmaceutical research, use of innovative drugs and productivity gains

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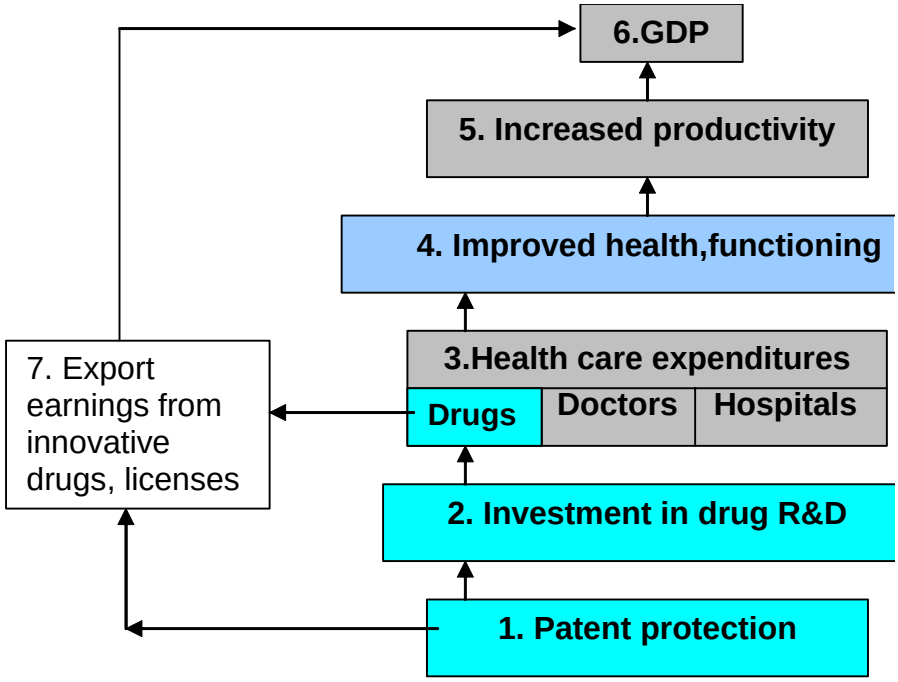
EXECUTIVE SUMMARY

Overview

This paper evaluates some of the empirical evidence about the impacts of patents on medicines, pharmaceutical research and development, the availability of modern medicines, and their effects on health status, worker productivity and gross domestic product.

Our conceptual framework is depicted below.



For simplicity, we summarise available empirical evidence that might answer four questions.

1. Do higher levels of national health expenditures (Box 3) lead to better health outcomes (Box 4)?

2. How do better health outcomes and productivity gains (Boxes 4 and 5) increase gross domestic product (Box 6)?

3. Does higher investment in medical and pharmaceutical research (Box 2) lead to better health outcomes (Box 4)?

4. Does the enforcement of domestic drug patents (Box 1) lead to higher world share of new drug markets (Box 7), and does entry into global markets lead to faster domestic economic growth and GDP (Box 6)?

Major conclusions of this review

Our review suggests that four major conclusions are defensible.

- Higher levels of national health expenditures are associated with better health outcomes.
- Better health outcomes obtained with modern innovative medicines lead to higher gross domestic product (GDP) by increasing both workforce participation and productivity. One recent study concluded that an average new drug reduced worker activity loss by about 1% more than a drug approved one year earlier by the US Food and Drug Administration.
- Higher investment in medical and pharmaceutical research leads to better health outcomes, and the social return on investment in such R&D may be as high as 40%.
- Recent empirical studies reveal the impact of newer drugs on US worker productivity, and confirm that newer drugs were responsible for 40% of the increased life expectancy in 52 nations in the period 1982 to 2001. Older drugs did not have such an impact.
- Enforcement of domestic drug patents leads to higher world share of new drug markets, and entry into global markets probably leads to faster domestic economic growth and GDP in nations that have appropriate, consistent policy frameworks.[1]

Implications for government policy

Innovative medicines have an effect on the health and productivity of individuals, households and nations. They also affect the levels of employment in science-based industries, the development of a local R&D base, export earnings and national income.

The opinion of independent US economists about the likely economic gains from research into particular diseases is worthy of note as governments forecast the budgets that will be needed for a growing population in which chronic illness is more prevalent.

"The economic gains from increasing life expectancy rise over time and the economic returns to improved healthy are greater the larger is the population, the higher are the average lifetime incomes, the greater is the existing level of health, and the closer are the ages of the population to the onset of disease. Growth and aging of the population alone will raise the economic returns to advances against many diseases by almost 50% between 1990 and 2030, (and) projected increases in real income and life expectancy will add at least that much again".

These findings and opinions are relevant to nations such as Australia that have (1) high admission rates to hospitals and (2) poorly treated chronic conditions where the under-use of modern medicines may be causing reduced productivity, unnecessary hospitalisation and limiting future gains in life expectancy.

[1] Some of those policy frameworks are reviewed in a forthcoming paper by Dr. David Webber

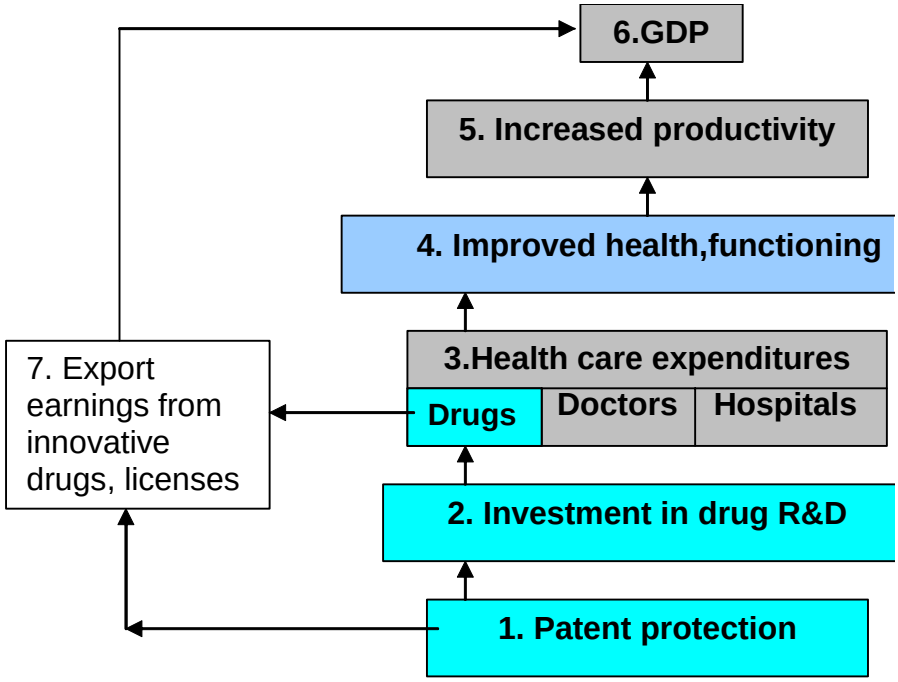
1. PURPOSE OF THIS PAPER

This paper evaluates some of the empirical evidence about the impacts of patents on medicines, pharmaceutical research and development, the availability of modern medicines, their effects on health status and productivity - and thus on gross domestic product.

Some caveats are worth noting on the onset. First, there is no single empirical study that confirms all of these linkages. We therefore attempt to create the linkages by synthesis of a number of empirical studies from different nations.

Second, the focus on patents, a major enabler and facilitator of innovation in any industry, does not mean that we are oblivious to the effects of other government policies on innovation in pharmaceutical R&D, such as tax policies, trade incentives, price regulation, domestic investment or foreign direct investment. An analysis of the impacts of all these enabling policies on innovation is far beyond the scope of this paper. **FIGURE 1** depicts some of the critical policies of government that we do not assess in this paper.

Third, our conceptual framework assumes the following linkages:



We summarise available economic evidence on four questions.

1. Do higher levels of national health expenditures (Box 3) lead to better health outcomes (Box 4)(**Section 2**)?

2. How do better health outcomes and productivity gains (Boxes 4 and 5) increase gross domestic product (Box 6) (**Section 3**)?

3. Does higher investment in medical and pharmaceutical research (Box 2) lead to better health outcomes (Box 4)(**Section 4**)?

4. Does the enforcement of domestic drug patents (Box 1) lead to higher world share of new drug markets (Box 7), and does entry into global markets lead to faster domestic economic growth and GDP (box 1) (**Section 5**)?

2. DO HIGHER EXPENDITURES ON HEALTH CARE LEAD TO BETTER HEALTH?

We summarise first the findings of two studies that used aggregate data[2] to measure the contribution to better health of higher health care expenditures *per se*, regardless of how those expenditures are targeted to primary care, hospitals drugs and other inputs that influence health status.

First, a 1982 study by Jack Hadley[3] used aggregate data from the US Medicare program to measure differences in mortality rates. He concluded that higher Medicare expenditures were associated with lower mortality rates.

A second study[4] of aggregate data from the Canadian health system found that a 10% reduction in health care spending was associated with 0.5% higher infant mortality rate in males and a 0.4% higher infant mortality rate in females.

One question raised by these studies in a single nation is how this relationship might be explained. There are at least two different views of causality that have emerged in studies of the health status-income relationship using cross-sectional data from many nations.[5]

- Pritchett and Summers concluded that 40% of the differential mortality between nations was explainable by differences in their *growth of income*. In this hypothesis, health care plays a peripheral role in the improvement of health status.

- Easterlin concluded that *technological change*[6] (which could include clean water, sanitation, vaccines, modern drugs, surgical techniques and access to primary health care) explained a significant proportion of differential mortality between nations at different stages of economic development. In this hypothesis, access to better health care is one of the major contributing factors to better health.

The hypothesis that the positive relationship of health status and income observed in such cross-national studies was explainable by a causal link from health to income was evaluated by Bloom and Canning.[7] In their view, four plausible mechanisms could explain the relationship:

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[2] Aggregate data include any dataset where the unit of observation is not the individual or the household. Such datasets include measures that represent county, state or national statistics.

[3] J Hadley. *More health care, better health?.* Urban Institute, 1982.

[4] Lewin. Canada, 1999.

[5] DE Bloom and D Canning. The health and poverty of nations. Geneva, WHO Commission on the Macroeconomics of Health, November 2000; and DE Bloom and D Canning." The health and wealth of nations". *Science* 2000; 287(5456): 1207

[6] Easterlin (1998), in an unpublished manuscript quoted in Bloom and Canning 2000 *op. cit*., concludes that the development of antibiotics and antimicrobial drugs, 1n the period 1920-1940, DDT (introduced in 1943),and improvements in safe water and sanitation triggered the decline in infant and child mortality.

[7] DE Bloom and D Canning ." The health and wealth of nations". *Science* 2000; 287(5456): 1207; and WHO *World Health Report 1999*.

- *Productivity*: Workers who are healthier have higher productivity, lose fewer workdays and do not need to care for sick family members- and thus their income was higher.
- *Education*: healthier persons live longer, and thus are willing to invest more in their education, with the higher levels of schooling leading to higher productivity and thus higher income.
- *Investment in human capital*: With increases in longevity, people save more for their retirement, they have better access to capital because of such savings, and their incomes rise. At the same time, a better-educated workforce is likely to attract higher foreign direct investment.
- *The 'demographic dividend*": Lower mortality rates tend to trigger a decline in fertility, leading to greater numbers of persons of working age, and as this happens, income per capita rises. [8]

Bloom and Canning compared two nations, identical in every respect except one has a 5-year advantage in life expectancy They concluded that on the basis of studies in several nations, the healthier nation experienced a growth in per capita income that was 0.3-0.5 per cent faster than in the other nation. Their review of such data led them to a conclusion about the importance of "health-led development".

" *A revolution in economic thinking has taken place over the past few decades, putting human capital, particularly educated workers, on a par with physical capital as an input into production. In addition, long life expectancy may be the fundamental force that creates the demand for education and encourages the domestic saving that is a key determinant of economic growth…The evidence for viewing health as one of the more effective arrows in the development quiver is surely growing stronger".*

Two caveats are appropriate. First, because these studies use aggregated data measuring the average mortality rates of *geographical areas* such as counties and nations, we cannot conclude definitively that higher per capita health expenditures will increase the life span of all *individuals*. Second, higher expenditures on health care will not lead to proportionate improvements in health status unless any existing waste in health care is removed. The extent to which one form of waste (overuse of health care) is present in the health system has been estimated at up to 20- 30%,[9] so improvements in efficiency are a pre-requisite to higher levels of government subsidies for health care in any nation.

These caveats notwithstanding, we conclude that the answer to question 1 is a conditional YES.

[8] A recent review of this linkage is: DE Bloom, D Canning< J Sevilla." *The demographic dividend: a new perspective on the economic consequences of population change*". Santa Monica, RAND Corporation, 2003,107 pages.

[9] J Schuster, EA McGlynn, RH Brook. "How good is the quality of health care in the United States?" *Milbank Quarterly* 1998; 76(4): 517-563, 509.

3. HOW DO BETTER HEALTH AND PRODUCTIVITY GAINS AFFECT GROSS DOMESTIC PRODUCT?

To help answer this question, we have available studies measuring:

(1) the impact of illness on household income in rural China;

(2) the impact of health status and risk factors on the productivity of a sample of US workers; and

(3) the impact of modern vintage drugs on the ability to work and thus on output per capita.

The first two studies rely on a mix of data from household surveys and from aggregated national data, while the last two studies are based on sample surveys of individual workers and households.

The economic impact of illness on households, work loss and GDP in China

As we review the evidence on the impact of better health status on productivity, it is useful to have some estimates of the extent to which illness reduces national productivity. We first turn to studies in Eastern Asia and China.

In China, World Bank researchers[10] estimated the impact of poverty-induced illness on national productivity. They estimated the income loss caused by illness in rural households. The study was based on surveys in 21 poor villages in 2 counties in Shandong province. The data sources were family interviews by village/township doctors, village cadres and accountants.

The estimates of income loss caused by illness were as follows:

Variable	Households	Persons	Per capita income (loss)-yuan	Community total (000)-yuan
1. Villages sampled (21)	4,501	17,807	1,416	25,108
2. Poverty caused by disease[1]	127	232	(737)	(171)
3. Percent - %	2.8	1.3	46.4	0.7

Note 1: Assumed income without disease 1590 yuan and with disease 853 yuan. 1 US dollar is equal to about 8 yuan

The estimates in this study of the losses caused by illness were as follows:

- The percentage of households living in poverty due to illness was 3%.

[10] World Bank. Project appraisal document 17403-CHA, p 66

- The income loss in these families due to the family member's sickness was nearly 50%.
- The mean length of illness was 9.4 years.
- The average cost per household of poverty induced illness was 2,373 yuan, with treatment costs being 1,024 yuan (about 40% of this total) and income loss 1,349 yuan (about 60%).

Based on these data, the World Bank concluded that for Eastern Asian nations, the income elasticity with respect to mortality was –0.5, i.e., a 10% reduction in mortality would be predicted to lead to a 5% increase in per capita GDP. [11]

A second study[12] in China concluded that for every 2 yuan per person (i.e., about US$0.25) invested by the central government in health care, GNP per capita would increase by 30.22 yuan per person. Furthermore, the researchers estimated that if all levels of government in China contributed funding to health care – and including the contributions of individuals, illness would no longer reduce GDP in poor rural areas.

We conclude that the improvement of health status has measurable effects on national income per capita, with the size of that impact in any one nation dependent on its average household income, morbidity and mortality rates, and, as we now suggest, its workforce productivity.

Illness, risk factors and US worker productivity

To this point, we have referred to studies using mainly aggregated data. We need better insights on how illness affects workforce absence, short-term disability and productivity while at work.

In recent years new evidence has emerged on how illness affects individual worker productivity, particularly for disorders where we expect modern medicines, *per se*, to exert a significant impact. In theory, there are at least two levels of impact, one through *illness* and the other through *risk factors* that affect the worker's productivity.

[11] In China, this elasticity was estimated to be closer to –0.9.

[12] IHPP. "The contribution of policy research in improving health care for China's rural poor". Washington DC. International Health Policy Program, April 1999, 57 pp

Illness and productivity: US data[13] from employment surveys in the late 1990's suggest the following impact of specific diseases, mostly chronic diseases, on the worker productivity index (defined in this US study as the percentage of time that a worker is working at full potential):

	Worker productivity	All employees surveyed Average hours lost per week due to			
	index	**Absence**	**STD[1]**	**Productivity**	**Total**
All employees surveyed	89%	0.33	0.28	3.82	4.43
Digestive disease	60%	0.58	5.66	9.72	15.96
Mental health disorders	67%	0.75	8.72	3.72	13.19
Respiratory disease	77%	0.75	2.65	5.85	9.25
Injury	79%	0.48	1.90	6.05	8.43
Musculoskeletal conditions	79%	0.74	6.12	1.38	8.24
Cancer	84%	0.30	5.54	0.74	6.58

NOTE: STD= short term disability

This table suggests that the average US employee in this sample lost 4.43 hours per week, most of it in productive hours lost. Thus illness *per se* causes at least 12% of available work hours to be lost.

While injury leads to the highest absence from work, mental disorders, musculoskeletal disorders have the highest losses in short term disability, digestive diseases have the highest losses in productivity, and in total hours lost, digestive disorders and mental disorders are ranked 1 and 2 and had the lowest worker productivity indices.[14] With the exception of injury, these are all chronic conditions that respond well to modern drugs.

Risk factors and productivity: The same study reveals the impact of specific risk factors on the same worker productivity index. The authors note that:

> *"Diabetes was by far the most debilitating health risk. The workers studied were relatively young, however, and may not have had experienced the full impact of other risks."*

While this conclusion is worthy of emphasis, we can also see that a number of other risk factors exert a toll on the workforce (mental disorders, high blood pressure, raised cholesterol and obesity), and many of these risk factors respond well to modern drugs.

13 WN Burton, DJ Conti. Business and Health 1999, 34.

14 Most of these conditions are responsive to modern drugs.

	Worker productivity	Employees with health risks Average hours lost per week due to			
	index	Absence	STD	Productivity	Total
Smoking	90%	0.36	0.22	3.56	4.14
Physical activity (less than 1 hr week)	92%	0.32	0.29	2.63	3.24
Seatbelt use (less than 90% of the time)	91%	0.35	0.57	2.52	3.44
Exposure to violence	86%	0.24	0.08	5.40	5.72
Psychological distress	87%	0.37	0.31	4.72	5.40
Diabetes	72%	0.49	2.15	8.72	11.36
High blood pressure	87%	0.39	0.75	3.93	5.07
High cholesterol	85%	0.49	0.70	4.94	6.13
Elevated BMI[1]	86%	0.37	0.44	4.98	5.79

NOTE: BMI= body mass index, and is measured as weight in kilograms, divided by the square of height in metres.

We note that these data are derived from individuals and are not based on aggregate data. With these levels of reduced productivity, one can understand why US employers are funding prevention strategies to improve worker productivity by attacking the risk factors.

The prevalence of such programs and the importance of the chronic conditions according to medical directors[15] in US companies in 1999 reflect employer concern with the costs of lost productivity – which we have noted earlier is one of the hidden costs of both chronic diseases and their major risk factors.

	% of firms offering worksite programs for		
Condition	**Current**	**Planning**	**How medical directors rate condition**
Musculoskeletal problems	70	12	8
High blood pressure	65	14	7
Depression/mental health	62	16	7
Heart disease	59	22	7
Obesity	49	18	7
Cancer	46	20	6
Diabetes	37	24	6
Allergies	28	13	6
Asthma	20	15	6
			Scale 1 least important and 10 most important

.

These data also identify the indirect costs of these conditions due to workloss and productivity loss, averaging 11% for the sample population. These losses, amplified to the national level, would reduce the value of GDP by labor's share of GDP if we had full employment and there was no replacement workforce. Modern drugs that reduce these indirect costs confer economic benefits to employees and employers,

[15] Survey by the Benfield Group, *Business and Health*, September 1999, 56

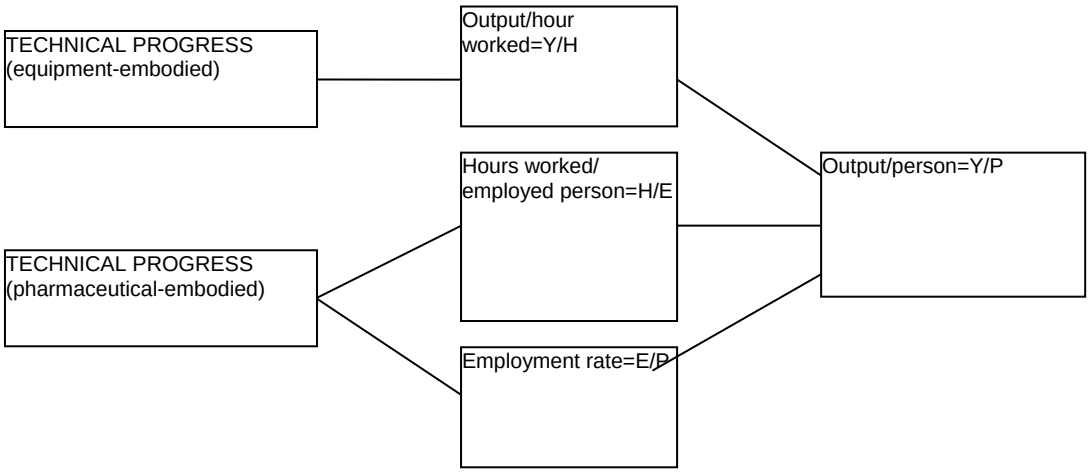
and the next study summarised below provides estimates of the aggregate effects of modern vintage drugs on worker productivity.

Impact of vintage of drugs on ability to work and output per capita

To this point, we have not discussed the possible routes by which national income per capita and GDP are influenced by better health and functional status. Obviously, access to effective health care must be considered as a contributing linkage, and modern drugs represent one important intervention in most health care systems.

In recent years, Frank Lichtenberg has published some pioneering econometric analyses of the relationships of drug expenditures, worker productivity and use of health services. In a new report,[16] he tested the hypothesis that the use of newer drugs increases the ability to work (or reduced the rate of human capital depreciation).

His theoretical model expands the model depicted at the beginning of this chapter to include some new pathways linking boxes 3-6 at the top end of our original model in **Section 1**, as shown below:



In this model, output per person (Y/P) is viewed as the product of three variables: output per hour worked, hours worked per employed person, and the employment rate. Thus

(Y/P)= (Y/H) * (H/E) * (E/P)

Drawing on the work of Robert Solow in his 1956 paper on technical progress,[17] Lichtenberg assumes that two types of technical progress can influence these three variables. *Equipment-embodied technical progress* is assumed to influence only the

[16] F. Lichtenberg. *"The effect of changes in drug utilization on labor supply and per capita output".* Cambridge, National Bureau of Economic Research Working Paper 9139, September 2002, 31 pages plus tables

[17] RM Solow." A contribution to the theory of growth". *Quarterly Journal of Economics* 1956;70 (February): 65-94.

output per hour worked (Y/H). *Pharmaceutical-embodied progress* is assumed to influence the other two variables H/E and E/P.

His hypothesis is simple. "*Pharmaceuticals are about three times as R&D- intensive as other goods and services. We hypothesized that pharmaceutical-embodied technical progress increases per capita output via its effect on labor supply (the employment rate and hours worked per person)".*

Lichtenberg focuses on the effects of modern drugs on an individual's ability to work, hypothesising that innovative drugs increase the ability to work (or reduces the rate of depreciation of human capital).[18]

His data analysis tests two sub-hypotheses in which he evaluates the effect of (1) changes in the average *quantity* of drugs and other medical services; and (2) changes in the average *vintage* of drugs consumed for a given condition, with "vintage" measured by the year the drug was approved by the USFDA. He assumes that higher drug *quality* is embedded in newer vintage drugs.

Quantity of drugs used in treatment: Using individual data from the 1996-1998 waves of the US Medical Expenditure Panel Survey (MEPS), he tested the first hypothesis (viz., the quantity or volume of drugs reduces workloss) by estimating the relationship of the fraction of workers missing one or more workdays with three variables: the number of prescribed medicines, the number of office-based contacts with a doctor, and the average number of hospital stays in a year.

The research question posed here was whether there are *above average reductions* in the rate of missed workdays among conditions with *above average increases* in the use of drugs, medical services or hospital stays.

He found that conditions with above average increases in the utilisation of prescribed drugs tended to have above average reductions in the fraction of persons who had one or more missed workdays.

Using this result, he calculated the value to US employers of averting the missed days of work from a one-unit increase in the drugs used to treat each condition. *He concluded that the dollar value to the employer of these reductions in workloss days exceeded the cost of the extra drug needed to achieve these gains.*

Newness of drugs used in treatment: In his second approach, he estimated whether newer drugs caused larger reductions in worker limitations than older drugs, and whether the costs of using modern drugs was offset by the economic gains to the employer achieved by these drugs.

Using data from about 300,000 records of individuals and medical conditions spanning the period 1985-1996, he found that a switch to the newer more expensive

[18] Lichtenberg notes why ability to work is the appropriate measure: "*At first blush, one might think that employers need only be concerned about work-loss days experienced by currently employed persons. However firms make significant investments in recruitment and training of employees, and if these employees become unable to work, firms are unable to realize returns on these investments. Firms as well as workers incur human capital losses"* (p5).

drugs would increase a person's total drug expenditure by 27% (about US$ 71). Offsetting this increase were the economic benefits of the following improvements in workforce activity:

- Workdays lost per person employed in the workforce: reduced by 21.3%, or about 1 day per year;
- Mean number of restricted activity days for all persons: reduced by 12%, or about 1.74 days per year;
- Probability of having an activity limitation: reduced by 9%.
- Probability of being completely unable to work: reduced by 10.8%. If the average worker compensation per year was US$ 40,000, this reduction alone would be worth US$ 300.

He concluded that activity limitations decline at the rate of about 1% per year of drug "newness". He calculated that if government enacted policies that forced all persons to use only generic drugs, …" *the age of the average drug in use would increase by 31%- and drug costs (viewed in isolation) would almost certainly increase".*[19]

He further concluded that the rate of pharmaceutical-embodied technical progress with respect to *activity limitations* was about 18% per year and that the observed increase in use of modern drugs would be cost-effective even if the earnings of a person enabled to work were a small fraction (10%) of average earnings. The estimated average cost per employee of achieving one less restricted-activity day was US$18-34, versus an average daily employee compensation of US$140. *He concluded that the reduction in restricted-activity days associated with the use of newer drugs appeared to be highly cost-effective.*

This new study thus complements the other studies reviewed in this section by showing how illness affects particular measures of economic activity and growth.

Based on these data, our answer to question 2 (do better health outcomes and productivity affect gross domestic product?) is YES, and innovative drugs have a major impact on productivity by reducing activity limitation in the workforce.[20]

[19] F Lichtenberg." The economic benefits of new drugs" . *Economic Realities in Health Care Policy*. 2002; 2(2):18 (East Brunswick, Pfizer Inc)

[20] They also affect normal activities such as school attendance and housework, but these activities were not the subject of Lichtenberg's study.

4. DOES HIGHER INVESTMENT IN MEDICAL AND PHARMACEUTICAL R&D LEAD TO BETTER HEALTH OUTCOMES?

Some of the studies quoted so far have attempted to link 'better health' and GDP. One of the core problems in such studies is how to value the outputs produced by "better health" and by associated medical research.

In recent years, economists have approached this question by attempting to measure the increases in real income associated with improvements in health and life expectancy.[21] A recent extension of this research has been to estimate the social rate of return on investment in medical research in the USA. On this question, we have available separate studies by Cutler and by Murphy and Topel, both using macro-level data, as well as the summary views of US economists in a new report by the Funding First initiative of the Mary Woodward Lasker Charitable Trust.[22]

In any analysis of the economic benefits of medical research, two steps are involved. First, assumptions must be made about the monetary value of one life saved. Second, the effect of medical research must be isolated from any gains unrelated to R&D.[23]

Investment in medical research: the concept of "health capital"

Cutler defined "health capital" as follows:

"Health capital = the dollar value of health a person will have over the course of their remaining life."

Using aggregate data, he estimated that for a US newborn in 1990, health capital equalled US$3 million, and for the US elderly in 1990, health capital equalled US$1million. He estimated that the increase in health capital per decade was US$40-50,000, and *he concluded that 30% of improvements in health capital in the past 40 years justified all investments in medical research in the same period.*

Nordhaus, using slightly different methods but the same assumed value of one life saved (US $3 million), estimated that in the period 1975-1995, the value of life extension nearly equalled the gains in tangible consumption as measured in national income accounts, as follows:[24]

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[21] See: WD Nordhaus."The health of nations: the contribution of improved health to living standards. Lasker Foundation, 17 November 1999 (accessed on www.fundingfirst@laskerfoundation.org)

[22] Funding First. Exceptional returns: the economic value of America's investment in medical research. May 2000 (accessed at www.fundingfirst@laskerfoundation.org)

[23] *ibid*

[24] Nordhaus, *op cit*

Average annual percentage change	1900-1925	1925-1950	1950-1975	1975-1995
From measured gains in consumption	2.0	1.8	2.4	2.0
From increased longevity[1]	2.3	3.2	1.8	1.6
NOTE 1.Most conservative of four alternative assumptions				

The economic benefits of medical research

Murphy and Topel[25] used a different methodology to estimate the value of extending life. Their method recognised that mortality decreases do not occur uniformly across all age groups, and that the value of a life saved depends on the age and the life expectancy of the person affected. They obtained estimates of the value of a life saved at different ages.

They found that in the period 1970-1990 there was a six-year increase in US life expectancy. Assuming that the value per life saved was US$5 million, they calculated that the economic value of life expectancy gains (in 1992 dollars) was US$57 trillion over the two decades, roughly equal to the gain in national consumption measured in national income accounts, consistent with the Nordhaus estimate for the period 1975-1995.

Recognising that some double-counting would occur if expenditures on health care (which are inputs to the production of a longer life are already included in consumption measures in the national accounts, Murphy and Topel re-ran their calculations assuming that all national health expenditures were inputs to life extension. Their new estimate was only 15% smaller than their first estimate.

They further calculated the benefits of eradicating some major diseases, as follows:

Task	Economic benefit – US $ trillion
1. Eliminate heart disease	48
2. Cure cancer	47
3. Reduce death rate from heart disease or cancer by 20%	10 (equal to the US GDP for one year)

Assuming that US investment in medical research in 1995 was US$36 billion, and further assuming that only 10% of the increased longevity was due to medical research (=US$240 billion/year), *the benefit/cost ratio of investment in US medical research was (240/36=) 7.*

The overall summary of the US economists involved the Funding First study incorporates some of these results, and offers a powerful incentive to governments to create the right policy settings to encourage medical research:[26]

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[25] K Murphy and R Topel., summarised in *"Exceptional returns: the economic value of America's investment in medical research".* Chicago, Lasker Trust, May 2000. Original paper accessible at http:// www.fundingfirst.org/

[26] Funding First, *op cit*

- *"Increases in life expectancy in just the decades of the 1970's and 1980's were worth $57 trillion to Americans- a figure six times larger than the entire output of tangible goods and services last year (i.e., in 1999). The gains associated with the prevention and treatment of cardiovascular disease alone totalled 431 trillion.*
- *Improvements in health account for almost one-half of the actual gain in American living standards in the past 50 years.*
- *Medical research that reduced deaths from cancer by just one-fifth would be worth $10 trillion to Americans-double the national debt.*
- *While it is not always possible to pin down cause and effect, the likely returns from medical research are so extraordinarily high that the payoff from any plausible "portfolio" of investments in research would be enormous."*

Of relevance to Australia, with its population ageing and with chronic illness poorly treated is the following warning about the likely economic losses from limiting research into particular diseases.[27]

"The economic gains from increasing life expectancy rise over time and the economic returns to improved healthy are greater the larger is the population, the higher are the average lifetime incomes, the greater is the existing level of health, and the closer are the ages of the population to the onset of disease. Growth and aging of the population alone will raise the economic returns to advances against many diseases by almost 50% between 1990 and 2030, (and) projected increases in real income and life expectancy will add at least that much again".

Contribution of pharmaceutical research to US health outcomes

The above studies did not attempt to measure the relative contribution of pharmaceutical R&D *per se* to these health outcomes. Three recent studies provide indications of why the US pharmaceutical R&D effort remains a bellwether on the potential economic impact of such research.

One study[28] concluded that one half of the world's most important drugs (i.e., drugs introduced in USA, Europe and Japan) marketed in the period 1975-1994 originated in the USA, with UK distant second at 14%. This result was achieved by spending only 36% of worldwide R&D funding.

A second study by Cutler and Kadiyala,[29] published as part of the Funding First analysis, focused on reductions in heart disease in the USA since 1970. In this period, acute events such as heart attacks and strokes were treated with new technologies, many of which were new drugs. This study concluded that a number of factors contributed to this reduction, as follows:

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[27] Murphy and Topel, *op cit*, p. 96

[28] A Holmer. "Private industry leads drug innovation". *World Health News* 11 October 2000 (http://www.worldhealthnews.harvard.edu/Spotlight/index/html)

[29] D Cutler and S Kadiyala. summarised in *"Exceptional returns: the economic value of America's investment in medical research".* Chicago, Lasker Trust, May 2000. Original paper accessible at http:// www.fundingfirst.org/

Medical technology	33%
- acute	20%
- preventive pharmaceuticals	13%
Public information	65%
Public action	10%

Thus the lower bound on the likely benefits from medical research is assumed to be 20% of the reduction in mortality, with another 13% associated with the use of new drug therapies and treatment protocols that reduced blood pressure and cholesterol. However the authors note that "...some fraction of the other two-thirds also should go to research since gains attributed to changes in public policy and individual behavior depend on research-derived information". This information includes education and patient information supplied by pharmaceutical companies. [30]

Murphy and Topel estimated that the total economic value to Americans of reductions in deaths from heart disease averaged US$ 1.5 trillion in the twenty-year period 1970-1990. So if we assume that only 33% of this gain came from medical research, the return on investment would be US$ 500 billion per year. That estimate is 20 times the value of average annual spending on medical research in the USA.

A third study by Lichtenberg[31] evaluated the relationship of US drug approvals, US rates of hospitalisation, US mortality rates and the social return on investment in pharmaceutical R&D.

He found that a 10% increase in drug expenditures was associated with a 6.6% reduction in hospital expenditures, and for every US$1 increase in drug expenditures there was a US$3.65 reduction in hospital expenditures. He further estimated that the social rate of return on investment in drugs was 40%, and that over 45% of variation across mortality rates in the period 1970-1991 was explained by new drug share.

Contribution of new drugs to life expectancy in 52 countries, 1982-2001

Finally, another recent study by Lichtenberg[32] extended his scope of research into the impact of new drugs beyond the USA. The research question was an extension of his earlier econometric analyses, viz., do new drugs increase life expectancy more than older drugs?

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[30] A new study by Massachusetts General Hospital and Harvard University researchers found that direct-to-consumer (DTC) advertising of prescription drugs led to significant benefits for patients, including lifestyle changes such as cessation of smoking and drinking. The study found that 35% of the 3,000 adults surveyed by Harris Interactive had discussed the advertised drug or other health concerns with their doctor as a result of DTC advertising. While consumers rely on many sources of information, the authors concluded that "…our results suggest that (drug advertising) is a potentially powerful source of consumer health information with effects that include, but also transcend, promoting the use of advertised drugs". See: www.healthaffairs.org/WebExclusives/Pharma_Web_Excl_022603.htm)

[31] F Lichtenberg." Do (more and better) drugs keep people out of hospitals" *American Economic Review* 1996;86: 384-388

[32] F Lichtenberg." The impact of new drug launches on longevity: evidence from longitudinal, disease-level data from 52 countries, 1982-2001". New York, Columbia University and National Bureau of Economic Research, 16 February 2003, 21 pp plus tables and figures.

This study evaluated the impact of launches of new chemical entities (NCE's) on the probability of survival in 52 countries in the period 1982 to 2001. Between 1986 and 2000, he found that average life expectancy in the 52 nations increased 1.96 years. He estimated that new drugs accounted for 40% of that gain, or 0.79 years. Launches of older drugs that were not NCE's, many of which may have been generic drugs already been on the market, did not increase longevity in this large sample of countries at different stages of economic development.

Our conclusion is that Question 3 (does higher investment in R&D – and particularly pharmaceutical R&D – lead to better health outcomes) should be answered YES, and it is clear that new drugs have a high return on investment if judged by their impact on longevity in many nations.

5. DOES ENFORCEMENT OF DOMESTIC DRUG PATENTS LEAD TO WORLD DRUG MARKET SHARE, AND DOES ENTRY TO GLOBAL MARKETS LEAD TO NATIONAL ECONOMIC GROWTH?

We have so far ignored the linkages at the bottom of the schematic in **Section 1** suggesting that patents have an impact on the world market share of manufacturers relying on those patents. We address this gap in this two-part question.

To answer the first part of our question, three very different studies illustrate the economic value of patent protection when price controls apply, the potential effects of effective patent protection and government controls, respectively, on investment in pharmaceutical R&D (Japan) or other spillover effects (India).

The value of patent protection of pharmaceuticals: France

There is a growing literature on the importance of the patent system as a source of economic returns to R&D.[33] A recent study computed the R&D cash subsidy that is equivalent to patent rights in four technology fields in France.[34] The results reflect the particular regulatory regime in France affecting patent approvals in the period 1969-1982 and patent renewals for 1970-1987.

The empirical findings confirm that patent protection creates valuable property rights, and averaged across all four technology fields, they were equivalent to an R&D cash subsidy rate of 25%, varying from 5-10% for pharmaceuticals to 15-35% for mechanical and electronics patents.

The lower value for pharmaceuticals in France, where there is stringent drug price regulation, "… *highlights the important point that R&D incentives are shaped not only by patent law but also by other institutional constraints that affect the appropriability environment".*[35]

Transition to patent protection and effects on FDI in drugs,Japan

Redwood has produced an impressive case study of Japan in the period 1960-2000. He argues that in the 1970's, Japan had a strong chemical industry with good process technology. It pursued product copying in the absence of pharmaceutical product patents and it controlled a pharmaceutical market in a prosperous country in which high drug prices were affordable under national social insurance schemes.

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[33] See for example: R Levin et al." Appropriating the returns from industrial research and development". *Brookings Papers on Economic Activity: Microeconomics* 1987, 783-820; E Mansfield et al." Imitation costs and patents: an empirical study". *Economic Journal* 1981; 91: 907-918; and AS Pakes and M Schankerman. " The rate of obsolescence of patents, research gestation lags, and the private rate of return to research resources". In:Z Griliches (ed*). R&D, patents and productivity*. Chicago, University of Chicago Press, 1984

[34] M Schankerman." How valuable is patent protection? Estimates by technology field". *RAND Journal of Economics* 1998; 29(1): 77-107. The four fields were pharmaceuticals, chemicals, mechanical and electronics.

35 Some of the destructive effects of drug price cpntrols are reviewed in : PF Gross." Seeking a cost-effective mechanism for funding and pricing of new drugs and medical devices". Invited paper, Fifth National Health Summit, Sydney, 18 February 2003.

The effect of a new patent system in Japan on its subsequent percentage share of the world-wide origination of major global drugs was as follows:[36]

Period	Share of major global drugs
1960s	<1.0%
1970s	3.5% [1976]
1980s	13.7%
1990s	21.4%
2000	28.8%

The percentage increase in multinational investment[1] in R&D over the period 1980-2000 was as follows:

1960s	=100%
1970s	46.8% [1976]
1980s	125.8%
1990s	147.4%
2000	187.0%[2]

Notes: 1 Average yearly investment of Top 30 Multinational Pharmaceutical companies only.
2. 2000 value estimated due to incomplete data of year 2000.

Noting the findings of the Redwood study, Webber[37] concludes that the following lessons emerge from Japan in this period:

- Japan demonstrated the transformation from a former copying culture into one that now aims at originality and therapeutic innovation.

- Multinational investment in pharmaceutical R&D in Japan took an upward swing after strong patent protection was introduced.

Impact of government controls on spillover effects: India[38]

The existence of a local R&D capacity created by FDI can in theory create spillover benefits in the form of new knowledge, access to new technology and higher wages[39] to ensure that local research talent does not immigrate.

Studies of the extent of these gains in different industries have not always found such effects,[40] and studies in the pharmaceutical industry are rare.

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36 H Redwood. "Price Regulation & Pharmaceutical Research", JAPM, Novartis, quoted by D Webber, Beijing Roundtable, 26 October 2001.

37 D Webber, Paper presented at Beijing Roundtable with Government of China, 26 October 2001.Beijing, FRPIA, October 2001

38 SE Feinberg and SK Majumbar. "Technology spillovers from foreign direct investment in the indian pharmaceutical industry". *Journal Of International Business Studies* 2001; 32(3): 421-437.

39 M Motta, A Fosfuri, T Ronde. *Foreign direct investment and spillovers through workers' mobility*. Centre for Economic Policy Research Discussion paper 2194, 1999

40 One study in Italian manufacturing industry found that spillovers occurred in industrial clusters For many industries but not for the pharmaceutical industry [M Forni and S Paba." Spillovers and the growth of local

India has ownership restrictions, price controls and weak intellectual property rights A recent study in India found that spillovers of R&D occur mainly between the multinational pharmaceutical companies but not between these companies and local firms.

The authors noted that *government policy on ownership, drug price controls and a weak intellectual property rights system "… may have reduced incentives to import and develop world-class technology in India".*

We conclude that based on these three studies, the answer to the first part of question 4 (does enforcement of domestic drug patents lead to world market share) is PROBABLY YES- but the existence of threats to intellectual property and price controls will reduce the spillovers from foreign direct investment.

In seeking answers to the second part of our question, a recent study by World Bank[41] evaluated the relationship of trade and growth rates in per capita GDP (at purchasing price parity) over the 1990's.

It concluded that the growth rates showed the benefits of trade in global markets. The more globalised poor nations had growth rates of 5%, compared with a decline of 1 % in the less globalised poor nations and 2% growth in the rich nations.[42]

We conclude tentatively that our answer to the second part of our question 4 (does entry to global markets lead to national economic growth) is PROBABLY YES but convincing evidence of sustained growth is not yet available.

industries". *Journal of Industrial Economics* 2002; L (June): 151-171], and a second study found that industry linkages did not benefit the pharmaceutical industry [K Laursen and V Meliciani." The relative importance of international vis-à-vis national technological spillovers for market share dynamics". *Industrial and Corporate Change* 2001; 11(4): 875-894.

[41] World Bank. "*Globalisation, growth and poverty*." December 2001, reported in *The Economist*, 8 December 2001, 71.

[42] The study is not without its critics.

6. SUMMARY

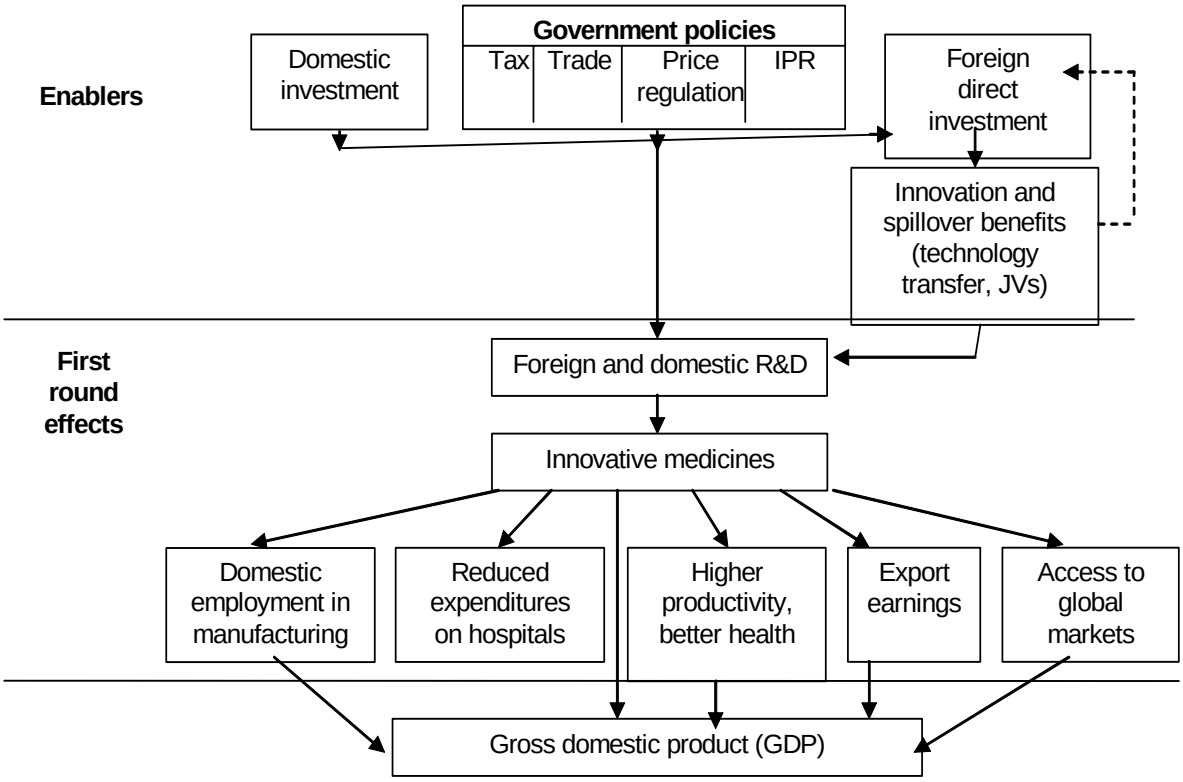
Innovative medicines have an effect on the health and productivity of individuals, households, and the workplace. We have attempted to show some of the economic impacts of this sequence of events. They also affect the levels of employment in science-based industries, the development of a local R&D base, export earnings and national income. These impacts need to be assessed when government policies and future budget estimates are under review.

The most recent empirical studies reveal the impact of recent vintage drugs (i.e., innovative drugs) on worker productivity, and other data clarify the role of new drugs in reducing the use of hospital services and other expensive uses of society's resources. One definitive study suggests that government policies which promote the use of older generic drugs may lead to smaller reductions in days of workloss and restricted activity than would be achieved with newer drugs.

These findings are relevant to any nation such as Australia that has high admission rates to hospitals and poorly treated chronic conditions where under-use of modern medicines remains an issue.

FIGURE 1

Some critical enabling government policies and their effects on the economy



NOTES: IPR = intellectual property rights
JV = joint venture
R&D = research and development

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