Biotechnology Indicators for Public Policy

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The key issue is why one should be interested in biotechnology indicators and why we are interested in collecting them. From the OECD point of view, we are largely interested in them from a policy perspective. There are also two other reasons for collecting indicators. One is because they are very much of interest to academics who can use indicators to develop a long-term or deeper understanding of how economies are structured and how economies can change. Second, indicators are of interest to private investors who can use the information to guide their investment decisions in one particular technology or another. But many of the indicators for investors come too late. This has always been a problem for us because the investment community really wants to know what is happening right now and by the time our indicators are published we are usually several years too late.

From a public policy perspective, we are still really in the world of expectations when we talk about biotechnology, particularly modern biotechnology. I think we are all familiar with these type of expectations, and variations of them show up in many different reports from all around the world. The problem with biotech is that many of these expectations have not yet been realized except in very small ways.

Challenges in Measuring Biotechnology

Partly because of the slow development of biotechnology applications, policy support for biotech is still very much dependent on high expectations. Governments are investing money in biotech because they still expect enormous benefits to come in the future. We can partly measure these expectations through input data such as business investment in R&D or the number of biotech firms.

The number of biotech firms is the most widely available indicator but it can be very misleading. Even though the OECD publishes such data, we discourage its use. In biotech you are almost in a situation where the more commonly available the indicator, the less useful it is. This is one of them.

A simple example can illustrate why the number of biotech firms is a poor indicator. Think of a country which has a hundred biotech firms with five employees

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each, for a total of 500 employees, and another country which has two firms with 2000 employees active in biotech, with a total of 4000 employees. In many cases biotechnology is likely to be more developed and applied in the latter country with two firms. Consequently, counts of the number of biotech firms does not really tell us much about the economic viability of biotech.

One of the main functions of metrics is to justify long-term targeted policy support for biotechnology. The most useful indicators for this are on the actual economic, environmental and social costs and benefits of biotech. These show high positive expectations for biotech, such as the large private and public sector investments in biotechnology, although they are largely in health applications.

There are three main policy options when faced with biotechnology or any other technology. The first is a positive intervention to support biotechnology. This is the most common policy option today, with large public financial investments to encourage the development, adoption, and diffusion of biotechnology. Many of these programmes are targeted, meaning that biotechnology is actually selected and favoured over other options, with specific programmes that only fund biotechnology. Examples include funding for collaboration, public sector spin-offs of biotech, and policy interventions to improve public acceptance of biotechnology and market conditions for biotechnology. These policies are always based on the assumption that there are large economic or social benefits from biotech.

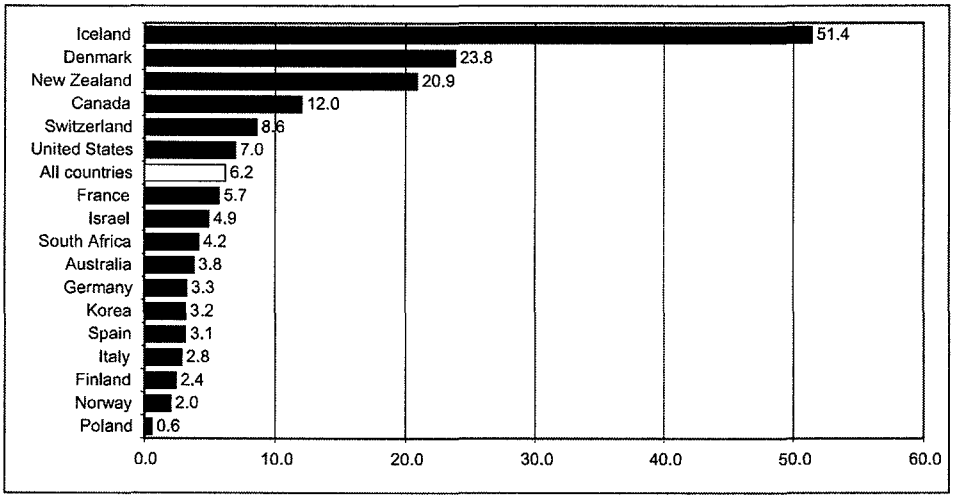
The second option is to adopt a technology neutral stance, where funding is based on competitive bidding. An example is when there are many other competitive alternative technologies to solve a problem. In this case, one can leave investment decisions either to the market or to the quality of the research funding proposal. As an example, is there a public interest in targeting biotechnology research into nutriceuticals and functional foods? If not, then research in this area should not be targeted. Another example concerns animal feed. Should policy target funding to develop genetically modified crops that include phytase enzymes to reduce water pollution from certain types of animal production? The alternative is to add phytase enzyme supplements to the animal feed. In these cases with clear technological alternatives, it might be better to simply let the market decide.

Of course, the third policy option is negative, in the sense of constraining or putting limits on investments, although the results might be positive. Many things such as regulations can actually be positive in the sense that they push or help guide public investments and private investments into areas that are socially beneficial. But there are certainly areas where regulation is required for technologies with potentially harmful effects. Gene therapy is a current example.

Biotechnology in OECD countries

Figure 1 gives biotechnology R&D by businesses as a share of total business sector expenditures on R&D. On average, approximately 6 per cent of OECD private R&D spending is in biotech, with enormous variations from almost half of all business expenditures on R&D in Iceland to two per cent in Norway and 2.4 per cent in Finland. Of course, a lot of the differences in the intensity of business

Figure 1: Biotechnology R&D by businesses as a share of total business



investment in biotechnology are based on differences in the underlying industrial structure. You can see that Denmark is way up there with about 24 per cent of business sector R&D going into biotechnology and this is because the structure of the Danish economy is based on pharmaceuticals and agriculture.

Figure 2 gives the distribution of business R&D in biotechnology by application. Almost all R&D in the business sector in OECD countries is for health. Aside from all of the fuss over Monsanto and herbicide tolerant crops, very little goes into agricultural biotechnology and even less is invested in industrial and environmental applications.

Results from 12 countries: Australia, Canada, China, France, Germany, Iceland, Israel, Norway, Switzerland, UK, and US.

Figure 2: Percent distribution of total business R&D in biotechnology by application

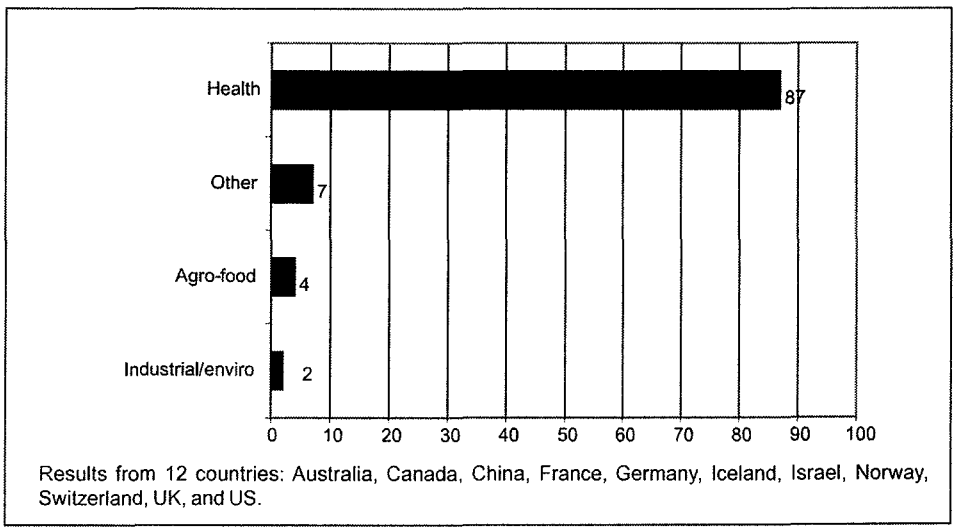


Figure 3: Public R&D expenditures on biotechnology as a percentage of total public expenditures on R&D, 2003 or nearest year

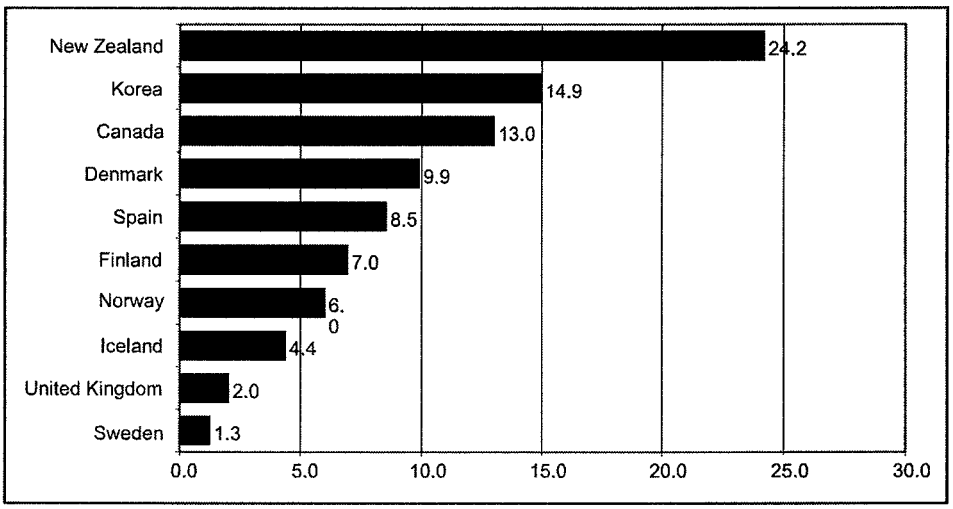
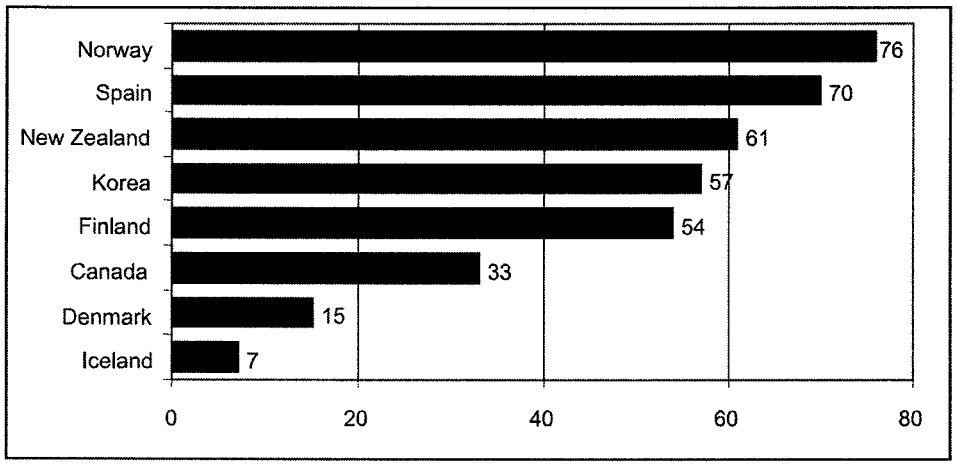


Figure 3 gives public R&D expenditures in biotech as a percentage of total public expenditures on R&D, which gives us an idea of how much targeting might be going on. In New Zealand almost one quarter of all public investment on R&D is flowing into biotech. Again this is due to the structure of the New Zealand economy, which is essentially based on resources. There is a lot of potential there for biotech applications in forestry, animal husbandry and in crops. In Korea the high public expenditure share for biotechnology is partly due to a strategic decision by the Korean Government to invest in biotech.

Figure 4 gives the percentage of all biotech R&D that is due to the public sector, which accounts for over 70 per cent of all R&D in Norway and Spain. This share is suggestive of policy targeting, particularly when public investment is greater than private investment. In Norway and Spain there is actually very little interest in biotech on the part of the business sector. Denmark is not a case of targeting because the Danish public share is less than the private share. But from Canada up you could say there are signs of policy targeting to favour biotech.

Output indicators measure the actual use or economic impact of biotechnology and are consequently very useful for assessing the results of investment in biotechnology R&D. There has been a tremendous amount of focus in the last twenty years on publications and patents as output indicators. However, publications and patents are not output indicators, even though they are widely discussed as such. They are actually intermediate outputs at best. They measure research, but you could easily imagine that you can have thousands of patents and thousands of publications but nothing on the market. From the policy perspective, it is not the publications you are interested in, but the actual use of biotechnology. We would be happier having one patent and a firm with a billion dollars of sales based on that patent than 500 patents and not a single product on the market. I think you can even go so far as to say that patents and publications can

Figure 4: Public biotech R&D as a share of all biotech R&D (public and private combined), 2003

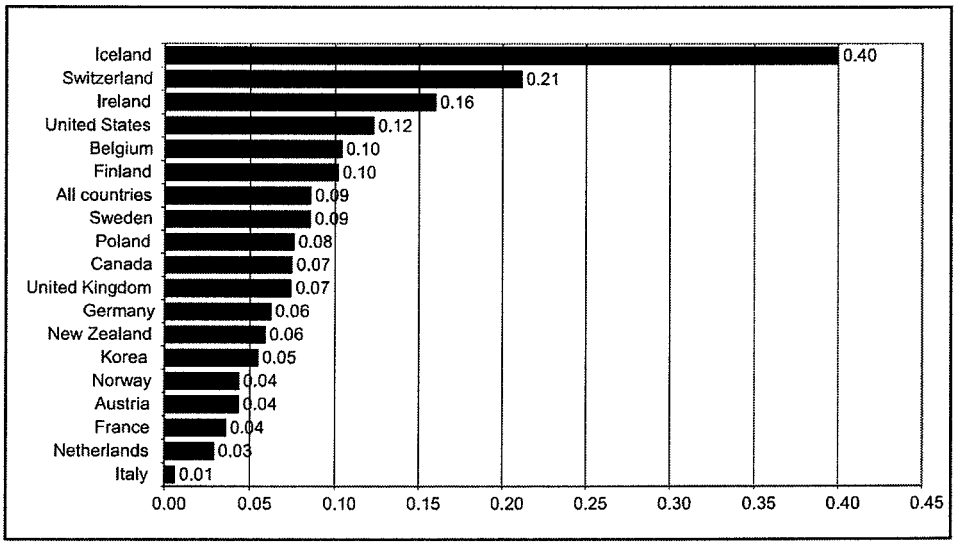


become a fetish. They can disorient and distract us from what really matters.

To give an example of what we have currently available as an output indicator, Figure 5 gives total bioactive employment as a percentage of total employment. By bioactive, we mean employees whose job description involves biotechnology in some way. You can see that in total over all of these countries, about 0.1 per cent of all employees are active in biotech. This is a very small percentage of total employment. I put this in perspective below.

We can supplement the sparse availability of post- commercialization output indicators that we have to date, which is employment and sales, with forecasting and developing leading indicators to improve predictions. This is possible using things such as field trial data

Figure 5: Total bio-active employment as a percentage of total employment, 2003



of GM crops, which are similar to patents except that they are much closer to the market. Another option is to analyze trends in clinical trials. Recent OECD work under *the Bioeconomy to 2030* project has been using both of these types of data to predict the types of biotechnology products that should reach the market by 2015.

Comparison with ICT

An interesting comparison of relevance to the assessment of the economic and social impacts of biotechnology is to compare the growth of biotechnology with ICT. Manufacturing ICT employment reached a peak in 2002 when it accounted for three per cent of total employment in OECD countries. Of course, this rate of three percent employment has had an enormous social and economic impact, such that most people are surprised when they hear that ICT accounted for only 3% of employment. In comparison, biotech only accounted for 0.1 per cent of total employment in 2001. This can appear to be negligible. Yet, if biotech reaches even one per cent of total employment, its effect will be enormous, although not as large as the effect of ICT.

When we look at ICT, we also see that in 2002 ICT accounted for 40 per cent of total business R&D in the OECD, whereas biotech accounted for six per cent. So, we can still see that as far as business investment goes, ICT has attracted far more investment than biotech. This is partly because we are still in the early days of biotech. We have now had 33 years of biotech since the crucial Cohen and Boyer patent in 1974. If you think about 33 years after the start of the ICT age, which is commonly taken as the ENIAC computer in 1946, we reach 1979. ICT was widely diffused in 1979 as mainframes, but the real explosion did not come until later. This shows how long the lead times can be for major new technologies like ICT or biotech.

In OECD countries, positive policies that target biotechnology are actually difficult to justify based on our current economic outputs, say 0.1 per cent of

Table 1. Therapeutic value of biopharmaceuticals and all other drugs (Jan 1986 – April 2007)

	Biopharmaceuticals		All other pharmaceuticals	
	N	%	N	%
Major advance	0	0.0%	7	0.4%
Important advance	8	6.6%	56	3.1%
Some advance	21	17.4%	185	10.3%
Minimal advance	39	32.2%	425	23.8%
No advance (me too)	28	23.1%	898	50.2%
Not acceptable	12	9.9%	107	6.0%
Judgment reserved	13	10.7%	111	6.2%
Total	*121*	*100%*	*1,789*	*100%*

Source: Based on data from *Prescrire* issues between January 1986 and April 2007. All other drugs: 1986 –2000 data on page 59, *Prescrire* Jan 2001, 2000 – 2006 data on page 142, *Prescrire*, Feb 2007; data for2007 from individual *Prescrire* issues. The evaluations for biopharmaceuticals were subtracted from thetotals for all drugs.

employment. However, the main impacts of biotechnology are not likely to be economic in strict terms, but environmental and social. Of course, as there are many economists who are capable of turning everything into dollars and cents, we could get economic indicators for these effects. But I think for general policy and public purposes we would actually be perfectly happy to have indicators of environmental and social impacts without any attempt to try and transfer these into economic terms.

Table 1 gives an example of a very powerful indicator of some of the benefits of biotechnology. This is the additional therapeutic value of pharmaceuticals that entered the market between 1986 and April 2007. Additional therapeutic value is the extra benefit compared to drugs that were already on the market to treat a certain condition – such as psoriasis or cancer. In total about 24 per cent of the biopharmaceuticals made 'some' or higher advance over existing therapies compared to only about 14.4 per cent of all other pharmaceuticals coming on to the market. Only 23% of biopharmaceuticals made no advance (me too drugs) compared to 50% of all other drugs.

Concluding Remarks

Biotechnology has global applications, but these will differ substantially across countries. As mentioned above, in some of the OECD countries investment in biotechnology is strongly related to the underlying industrial structure. Countries that heavily invest in agriculture or pharmaceuticals have a much bigger investment in biotech.

As a first step, we need consistent and internationally comparable metrics across countries for biotechnology inputs, which are often the easiest thing to measure. We are increasingly trying to encourage countries to take the second step, which is to measure outputs, such as employment and sales. We very much need data for Asia. We suspect that Asia is probably the biggest growth area for biotech in the future, with more potential applications than Europe or the United States. This is because of the number of potential agricultural and health applications of relevance to Asian countries and the size of the future Asian market.

The next point is that we need biotechnology metrics by application. Comparisons about biotechnology in general can muddy the picture because many of the benefits are application-specific. The benefits from agricultural biotech are very different from the benefits of health biotechnology.

Another requirement is for better information on social and environmental impacts in a global context. These include both metrics and indicators, leading indicators, and metrics that can help predict the future, such as analyzing clinical trials and developing long-term forecasts. Long-term here can mean anywhere from eight years to twenty years. Again, these forecasts are needed by application.

At the OECD, we are trying to meet the needs of policy analysts by first improving national coverage within the member countries for basic indicators on biotechnology inputs. We very much would like to have more such data from non-OECD countries.

Second, we want to develop current and leading impact indicators by application. Much of the OECD work on

indicators occurs at the national level - we have national R&D expenditures etc. - but many of these impact indicators are not needed at the national level. For example, we can estimate them using international data for clinical trials or for therapeutic value.

Finally, the OECD *Bioeconomy to 2030* project is using scenarios to look farther into the future. The project contains two parts. The first part uses a range of data to estimate trends in applications up to 2015, while the second part develops 'plausible' scenarios for up to 2030 in each of the three main applications areas for biotechnology. Both sets of results can help assist long term policy development.