ROOM DOCUMENT 2

A PROPOSED METHODOLOGY TO IDENTIFY BIOTECHNOLOGY'S CONTRIBUTION TO THE AUSTRALIAN ECONOMY

Workshop on Biotechnology Impacts and Outputs

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This document is submitted by Kate Le Strange, Department of Industry, Tourism and Resources, Australia and is presented for information and discussion under item 5.1 of the Agenda.

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A proposed methodology to identify biotechnology's contribution to the Australian economy

Overview of Consultation Draft For Discussion

Final Report prepared for the Department of Industry, Tourism and Resources by ACIL Tasman and Innovation Dynamics

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Overview

Background

This project was commissioned by the Department of Industry, Tourism and Resources (DITR) with the aim of developing and testing a methodology for identifying and measuring biotechnology's contribution to the Australian economy. Biotechnology's contribution was considered broadly and covered both biotechnology related research and development (R&D) including commercialisation, and biotechnology production and use.

The definition of biotechnology used for this study was that adopted by the Organisation for Economic Cooperation and Development (OECD) in recent work on understanding modern biotechnology and its range of applications. This definition essentially covers 'modern' biotechnology, which uses techniques such as genomics, engineering of proteins, proteomics, cellular fusion, embryo/stem cell manipulation, fermentation using bioreactors, bioleaching, gene therapy, bioinformatics and nanobiotechnology.

In order to be able 'to capture biotechnology activities by organisations that utilise biotechnologies, even those that may not consider themselves to be a "biotechnology" organisation', a three-tier framework to allow for different levels of involvement in biotechnology was adopted, namely:

- R&D and commercialisation
- production of biotechnology goods/services by businesses and organisations
- use of biotechnology as an enabling technology and/or intermediate input by production businesses as well as by other *non-cor*e businesses and organisations.

Project structure

The consultants adopted a multi-stage methodology designed to meet DITR's requirements. In summary, the project was structured along the following stages:

- an initiation workshop to review current measures of biotechnology used in Australia
- a methodology workshop to review methods used to evaluate the contribution of biotechnology overseas and in Australia, and agree on a top-level methodology
- piloting of those components that could be implemented immediately
- production of an interim report containing the proposed methodology in more detail
- production of a final report, containing the review of the pilot and final recommended methodology.

Information for policy needs

It is intended that the methodology, if implemented, will generate information for use in policy development. This information may also feed into broader government initiatives such as Biotechnology Australia's marketing and the national approach to biotechnology work programs. Contributions to the economy have therefore been defined broadly to include the myriad of ways in which biotechnology can enhance society's generation of wealth and wellbeing, including through the replacement of existing technologies with cheaper, improved or more sustainable biotechnologies.

For longer-term policy development and research, it will be important to have the capacity, at activity-specific and economy-wide levels, to understand the scope, pervasiveness and value of biotechnology activity to the Australian economy. Also, it would be useful to be able to identify, understand and work toward addressing impediments to the full realisation of biotechnology's contribution.

The methodology has been developed with these policy needs in mind.

Developing a methodology for Australia

The consultants' review of the literature on previous studies into the impacts and/or contribution of biotechnology and information and communications technology (ICT) reveals that the research falls into four broad types as follows:

• *Indicators,* which rely on the collection and analysis of data that have often been published for other purposes. These are used, often as a time series, to infer changes to the structure and characteristics of an industry sector.

• *Surveys,* which have targeted biotechnology researchers, producers and/or users and whose aggregated data are used to provide characteristic and economic data on the nature and level of biotechnology activity and outputs from that activity.

• *Company-specific economic analyses,* including partial equilibrium analyses, which can supply detailed information about the impact of a particular use of biotechnology at the product, technology, firm or industry level.

• Industry- and economy-wide modelling using:

  – *input–output models and multipliers* (which measure both the source of inputs for a sector and the endpoint of the outputs)

  – *econometric analysis,* including growth accounting methodologies (which examine the extent of causal relationships between biotechnology activity and industry- or economy-wide growth)

  – *computable general equilibrium* (CGE) modelling (which uses existing economic models to assess the impact of biotechnology uptake or use on particular industry sectors or the economy in general).

A detailed discussion of these methodologies is presented in Chapter 3.

Approach

After reviewing the literature and considering the current state of play in Australia in respect of data collection, the consultants developed a methodology which involves five facets:

1. Continued collection of biotechnology indicators, taking care to ensure consistency of the biotechnology definition used across collections

2. Benefiting from valuable national statistics resources

3. Development and piloting of a biotechnology survey questionnaire suitable for broad application, which will assist in identifying biotechnology's footprint, its impacts and the impediments to its uptake

4. Development of a generic framework for company- or technology specific microeconomic analysis, to assist in the identification of externalities, social and environmental effects which cannot necessarily be identified through survey techniques

5. Development of a modelling methodology that can be used to identify the overall impacts of biotechnology on the Australian economy.

Australian Bureau of Statistics resources and biotechnology statistics

The Australian Bureau of Statistics (ABS) is Australia's national statistical agency. It manages an extensive register of organisations that are active in the Australian economy. Through access to administrative data in the Australian Business Register, the ABS frame includes virtually all Australian business units. Using these resources, the ABS collects statistics which are either a census or a sample from the population under consideration. The ABS is in the process of developing a large database, known as the Input Data Warehouse (IDW), which will incorporate a range of administrative data and ABS survey data in a confidential environment. This enhances the possibility for combining and analysing ABS and administrative data, and rationalising the reporting load on business.

Only a small proportion of the organisations on the ABS business register is currently involved in biotechnology activity. However, given that biotechnology is an enabling and emerging technology, it is anticipated that, over the longer term, a significantly larger number of organisations on the register may become involved in some form of biotechnology activity. If those organisations on the ABS database (and IDW) which are involved in biotechnology R&D, production and/or use can be flagged as 'biotechnology' organisations, numerous opportunities are opened up for the analysis of biotechnology's contribution and impacts. With this in mind, this report makes a number of recommendations to capitalise on this valuable ABS resource.

• Biotechnology questions should be included in existing ABS surveys, as follows:

  – Ideally, a biotechnology 'flag' [Yes/No] question and the associated biotechnology definition, as outlined in this report in Chapter 4, should be included in all the ABS Economic Activity Survey instruments in order to identify targets for a regular biotechnology census using the questionnaire developed in this

study.

– The Yes/No biotechnology question should be supplemented with a further question, also proposed in Chapter 4, that probes the types of biotechnology activities being undertaken. Note, however, that the need for this supplementary question is dependent on whether the ABS is able to conduct the more extensive biotechnology census. If the ABS is unable to proceed with a regular biotechnology questionnaire, then the inclusion of the two questions proposed in Chapter 4 has a high priority.

– As a matter of priority, the two questions proposed above should be included in the new Business Characteristics Survey (BCS), adopting the full definition of biotechnology recommended by the OECD. If it is considered that the two questions and the definition will take up too much space, then options such as shortening the definition and/or reducing the number of questions could be considered. It is crucial that, at the very least, a 'flag' biotechnology question be included in the BCS.

– Biotechnology questions should be included in all R&D surveys. Action should be taken quickly on the business R&D (BERD) Survey and the Australian Government R&D (GovERD) Survey.

• Progress in the implementation of the ABS IDW should be monitored, and regular liaison maintained to ensure that relevant surveys stay high on the agenda for data migration.

• Once a sufficient number of biotechnology units has been flagged, or relevant surveys migrated onto the database, consideration should be given to funding of a data-mining exercise to identify the types of records that can be linked across the IDW in the context of biotechnology.

With some planning, the proposed methodology outlined in these recommendations should enable:

• identification of the characteristics of organisations involved in biotechnology activity, including *users* of biotechnology

• identification of the type and quantum of biotechnology activity

• leveraging of the existing ABS collections and the IDW to develop a longitudinal dataset which provides long-term indicators of biotechnology related economic activity

• increased understanding (through econometric analysis and modelling) of the more pervasive role biotechnology has played in changing Australia's productivity and gross domestic product (GDP).

The biotechnology survey methodology

At this stage, Australia's knowledge of the role and impact of biotechnology on the economy is limited. A survey instrument, aimed at all forms of biotechnology activity—R&D and its commercialisation, production and intermediate use—will go some way to better understanding these impacts.

Survey and questionnaire design

Ideally, the biotechnology survey should be:

• a *census* of all organisations which have been identified as undertaking biotechnology R&D, and/or *producing* biotechnology goods or services, and/or *using* biotechnology-related goods or services as an input—the 'flag' questions proposed for inclusion in the ABS surveys discussed above can be used to identify this population

• conducted regularly—every two years, for example.

Alternatively, the population could be identified through accessing a privately held database of biotechnology businesses. This option is less attractive as these databases do not currently cover all biotechnology users. If a private database is used to select the population frame, considerable and ongoing effort will be needed to ensure that the database adequately covers users of biotechnology. Further, if the census is conducted by a private-sector agency it runs the risk of achieving very low response rates, which makes assessment of biotechnology's full contribution more difficult.

The biotechnology questionnaire

The biotechnology questionnaire developed for this study has been designed to capture both qualitative and quantitative information (see Chapter 5). In addition to collecting basic data to identify individual organisations (such as their Australian Business Number (ABN)), the questionnaire is designed to collect information on:

• the magnitude of biotechnology's footprint in the economy

• the impact of biotechnology on prices and productivity

• impediments to the take-up or use of biotechnology.

Thus, the questionnaire seeks a wide range of other information about an organisation's characteristics, its biotechnology activities and the impacts of biotechnology. The questions cover the following areas:

• The type of organisation and the main area of activity from which it earns income

  – types of biotechnology activity R&D including commercialisation, production and/or use) and biotechnology's role in the organisation

  – applications of biotechnology that are important to the organisation for each type of biotechnology activity

  – strategic importance of biotechnology to the organisation

  – financial and employment data to help identify biotechnology's footprint.

• The economic impact of biotechnology is explored through a range of questions which examine:

  – if biotechnology activity has changed the organisation's productivity/efficiency, profitability and prices of goods and services produced (if applicable)

  – if biotechnology activity has affected a range of other variables (e.g. changes in the quality of inputs and outputs) and environmental

outcomes (e.g. waste levels and impurities)

– reasons for the organisation choosing biotechnology as an input.

• Impediments to the organisation's uptake of biotechnology in R&D, production and/or use are identified.

• Time take to complete the questionnaire and any other comments.

Piloting the proposed survey

The proposed biotechnology questionnaire was piloted and revised in light of the lessons learned. The target group for the pilot survey included R&D, producers and users involved in 'industrial biotechnology'. It was agreed that this group should be defined according to the OECD's publication *A Framework for Biotechnology Statistics*[1]. Under this framework, industrial processing applications include:

• bioreactors to produce new products such as chemicals, food, ethanol, plastics.

• biotechnologies such as biobleaching and biopulping, which are used to transform inputs.

The population frame for the pilot survey was therefore all organisations (businesses, universities, other research organisations and the like), which undertake R&D, production of, and/or use biotechnology for industrial processing. The full size of the frame in Australia is currently unknown. Because the population frame has not been fully identified, the pilot relied on the industrial processing organisations listed on the Innovation Dynamics database (which comprises core biotechnology firms, biotechnology R&D interests and a range of biotechnology users). The questionnaire was dispatched to 207 organisations on this database on 20 May 2005.

Analysing the pilot

Forty-eight questionnaires were returned (23%)[2], of which 27 answered 'yes' to the biotechnology activity question[3]. These responses were used to assess and validate the clarity and relevance of the questions posed in the pilot questionnaire. Lessons learned have been incorporated in the revised questionnaire (see Appendix J), which we recommend be used to conduct the proposed census of identified biotechnology organisations.

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1 OECD 2005 *A Framework for Biotechnology Statistics* DSTI/EAS/STP/WESTI (2005)8/Final http://www.oecd.org/document/3/0,2340,en_2649_201185_34962243_1_1_1_1,00.html

2 Response rates of around 6% are common for written non-compulsory surveys conducted by the private sector.

3 Many of those who answered 'no' did, in fact, fall within the definition. This is discussed in more detail in the main report in Section 5.5.1.

To illustrate how key results from the proposed survey questionnaire can be reported, section 5.6 summarises some of the main findings of the pilot survey and includes an analysis of the results by type of organisation and by the Australian and New Zealand Standard Industry Classification (ANZSIC). These results should not be considered as representative of the biotechnology component of the industrial processing sector, given the method used to select the pilot sample organisations and the low response rate.

In-depth company- or technology-specific microeconomic analyses

While there are some published technology- or company-specific microeconomic analyses which help build the picture of the contribution of biotechnology to the economy, they draw on different sets of underlying assumptions and are usually not specific to Australian conditions. For this reason, the report proposes a targeted program of specific in-depth case studies with consistent assumptions in the Australian context.
The overarching objective of the technology- or company-specific microeconomic analysis methodology is to seek information which is not readily available from a survey methodology including:

• qualitative or detailed considerations relating to adoption and implementation of biotechnology solutions (e.g. barriers to entry, intrafirm resource use, transaction costs.)

• an indication of the difference between private and social costs and benefits (i.e. the value of spillovers/externalities).

The proposed methodology involves engaging in a program of detailed company-specific microeconomic analyses following a protocol to:

• identify areas of application that should be investigated

• carry out a technology- or company-specific economic analysis

• report in consistent format and add findings to a database

• review and document progress.

These analyses should focus on the impact of biotechnology by comparing the biotechnology process/product/application with its nearest substitute. In other words, two states of the world need to be considered:

• the situation *with* the biotechnology innovation (e.g. using the biotechnology technique or treatment)

• the situation *without* the biotechnology innovation (e.g. continuing with the nearest substitute to the biotechnology technique or treatment, which may be no alternative treatment or use).

With regard to selecting the areas to be covered for the microeconomic analyses, the consultants consider that the following list of biotechnology applications and processes provides a useful starting point:

• health (because of the non-financial impacts of biotechnology)

• waste management (because of the general lack of information, potential exhibited internationally and the non-financial impacts of biotechnology)

• industrial processing (because of the lack of information on this sector to date, and the flow-on environmental impacts of changes to manufacturing processes).

The contribution of biotechnology to the economy: synthesising the evidence

From an economist's point of view, the impact of a major technological change, such as biotechnology, can be multi-layered. The eventual impacts of such changes in an economy will depend on a variety of shifts and responses by businesses, consumers and others. Capturing the detailed evidence and implications of all of these impacts is virtually impossible using surveys or case studies on their own. The approach put forward in Chapter 7 is therefore to use data collected through the proposed surveys and case studies in conjunction with one or more of the following quantitative techniques:

• econometric modelling using
  - time series regression analysis
  - cross-sectional analysis

• CGE modelling.

Time-series analysis

A simple regression model might test the statistical relationship between the level of biotechnology activity and economic growth. To the best of our knowledge, this work has not been undertaken. An econometric exercise of this nature would certainly become a possibility in Australia in the future if the proposed biotechnology 'flag' questions are included the ABS surveys and if the biotechnology survey is implemented. However, as a long time series (30 annual data points) is required to undertake this analysis, it would be a number of years before this methodology can be considered.

Cross-sectional analysis

A more fruitful approach in the short term can be the collection and analysis of cross-sectional data; that is, the analysis of data of individual organisations. This will also be made possible by including the biotechnology identifier question in a wide range of ABS instruments. This approach expands upon the growth accounting methodology used in the analysis of the economic contribution of ICT to economic growth. The approach could be used with data from the BCS once a number of years of data have been collected.

CGE modelling

CGE models recognise that households provide a source of labour to industry and also consume goods and services supplied by industry. Thus, it is possible to identify the impact on the economy of, say, a change in consumers' demand for health services, or of an improvement in the productivity of labour which is attributable to improved health outcomes due to the development of new biotechnology drugs.

Importantly, these analyses can be undertaken using CGE modelling without separately identifying the biotechnology activity as an industry. This feature of CGE modelling is particularly attractive given that biotechnology permeates many industries and the breadth of its reach is expected to grow as the scope of biotechnology applications widens and use of these

technologies increases. Section 7.3 illustrates this technique using data from the pilot survey.

Once the uptake of biotechnology 'settles down' it may also possible to use the 'footprint' information collected through the biotechnology survey and other ABS data to develop an industry in the input–output table that underlies general equilibrium models. However, in the short to medium term, modelling should focus on:

• analysis of the impact of biotechnology on the economy using data from the proposed biotechnology census and case studies

• 'what if' analysis, testing possible scenarios of the impact of biotechnology at the industry level.

Gaps

Despite the development of a comprehensive methodology, there remain some gaps in this approach:

• coverage of organisations which import biotechnology goods and determining the quantum of these imports

• obtaining information about the economic contribution of the significant number of one-person consultancies that provide scientific research and business advice to biotechnology firms.

Another gap in coverage relates to those biotechnology users who are not aware that biotechnology is associated with their inputs. (For example, farmers and other producers using diagnostic kits that have been developed using biotechnology could potentially fall into this category). This gap is particularly relevant for the survey questionnaire component of the methodology. However, the impact of biotechnology on these users should be identifiable through cases studies that focus on biotechnology suppliers as a starting point. These issues are discussed further in section 5.7 of the full report, as is the full set of recommendations relating to the proposed methodology.