

1.1 Definition of R&D

The official international definition of R&D is currently as follows; ' Research and Experimental Development comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications'¹. Furthermore, R&D is, in principle, generally defined as being the sum of three exhaustive and mutually exclusive activities; basic research, applied research and experimental development, described as follows:

- a) *Basic Research* is defined as theoretical/experimental research conducted to develop hypothesis/theories to acquire new knowledge on phenomena/ observable facts without directly giving consideration to specific application/uses.
- b) *Applied Research* refers to research which aims to ascertain the possibility of practical application by establishing specific goals or that which explores new applications of method which are already in practical application using knowledge discovered through 'basic research'.
- c) *Experimental Development* is the utilisation of knowledge acquired from basic/applied research and actual experience and research designed for introduction of new materials, equipment, system or processes and their improvement.

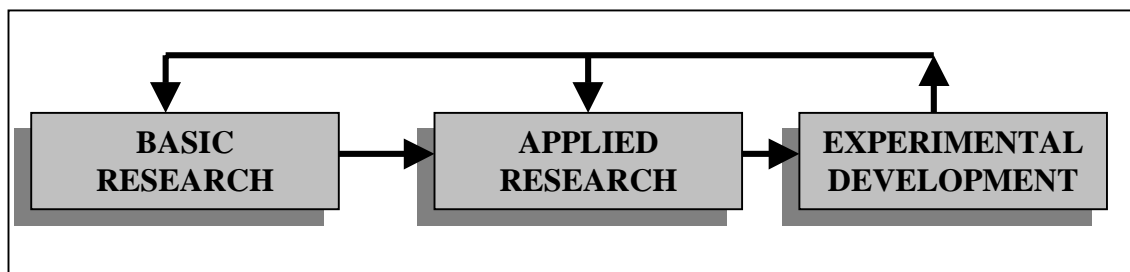


Figure 1: Interrelationships between Basic Research, Applied Research and Experimental Development

¹ *The Measurement of Scientific and Technical Activities. Proposed Standard Practice for Surveys of Research and Experimental Development (Frascati Manual)*, OECD, Paris, 1976.

1.2 Major Elements in R&D Activities

1.2.1 Classification of Field of Research (FOR) and Socio-Economic Objectives (SEO)

The R&D classification system for Field of Research (FOR) and Socio-Economic Objectives (SEO) was first introduced in the “1992 National Survey of Research and Development”. In 1994, it was revised for the first time by taking into account responses and feedback received from various parties to categorise related R&D activities undertaken by GRI, IHL, private sector as well as NPO. The 1998 survey was conducted based on the 3rd Revised Version, which was published in December 1998. This classification was adopted from Organisation for Economic Co-operation and Development (OECD) which proposed Standard Practice for surveys of Research and Experimental Development, 'Frascati Manual', 1993.

(i) Fields of Research (FOR)

The classification of areas of research has been categorised according to the Field of Research to examine the nature of R&D. Among the main areas of research are

(a) Natural Science, Technology and Engineering

- Mathematical Sciences
- Physical Sciences
- Chemical Sciences
- Earth Sciences
- Information, Computer & Communication Technologies
- Applied Sciences and Technologies
- Engineering Sciences
- Biological Sciences
- Agricultural Sciences
- Medical and Health Sciences
- Environmental Sciences
- Material Sciences
- Marine Science

(b) Social Sciences and Humanities

- Social Sciences
- Humanities

(ii) Socio-Economic Objectives (SEO)

This classification allows R&D to be categorised according to the purpose of the R&D as perceived by the data provider (researcher).

(a) Defence

- Defence

(b) Economic Development

- Plant Production and Plant Primary Products
- Animal Production and Animal Primary products
- Mineral Resources (excluding energy)
- Energy supply
- Manufacturing
- Construction
- Transport
- Information and Communication services
- Commercial Services
- Economic Framework
- Natural Resource

(c) Society

- Health
- Education and Training
- Social Development and Community Services

(d) Environment

- Environmental Knowledge
- Environmental Aspects of Development
- Environmental Management and Other Aspects

(e) **Advancement of knowledge**

- Natural Sciences, Technologies and Engineering
- Social Sciences and Humanities

1.2.2 Classification of Ownership

There are four categories of company ownership/control based on their capital structure,

- *Foreign owned* – Foreigners own 100% of the equity
- *Foreign controlled* – Foreigners own more than 50% of the equity
- *Locally owned* – Locals own 100% of the equity
- *Locally controlled* – Locals more than 50% of the equity

1.2.3 Gross Domestic Expenditure on R&D (GERD)

GERD includes capital expenditure (acquisition of fixed tangible assets involved in R&D activities) and current expenditure (manpower costs, and other related operating expenditures). Figures for GERD in each current year are expressed in normal terms and are not adjusted for inflation. The actual GERD figures also do not include outsourced funds given out by organisations carrying out R&D to other institutions. It is a common practice that the R&D performance is measured from the GERD/GDP ratio, i.e., the GERD as a percentage of GDP. In this survey, the GDP at 'constant' price, i.e., 1987 prices was used to compute the ratio. The GDP at 1987 prices was reported as RM 182,331 million².

1.2.4 Types of R&D Expenditure

- (i) **Labour costs** - annual salaries and wages and all associated costs or fringe benefits such as bonus payments, holiday pay, contribution to pension funds and other social security payments, payroll taxes, etc. All these should be 'gross', i.e., before deduction for income tax, insurance etc. Labour cost is calculated using the following formulae

$$\text{Labour cost} = (\text{salary} + \text{emolument}) \times \text{Total FTE}$$

² Key Statistics – Malaysia, Dept. of Statistics, September 1999

- (ii) **Capital Expenditure** - annual gross expenditure on fixed assets used for R&D activities. It includes expenditure on land, buildings, major equipment and instrument acquired for R&D.
- (iii) **Operating Costs** - all consumables, repairs and maintenance, commission work etc. This does not include payment for purchase of technical know-how.

1.2.5 R&D Manpower

Theoretically, manpower for R&D should include all persons i.e., researchers, technicians and support staffs. All the above should be included, regardless of their level of responsibility or of the type or level of education (e.g., PhD, Masters, Bachelor degrees, etc.) they have received. ‘Researchers’ are professionals engaged in the conception or creation of new knowledge, product processes, methods, and system, and in the management of the projects.

‘Technicians’ comprise persons whose main tasks required technical knowledge and experience in one or more fields of engineering, physical and life science and humanities. They participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers.

‘Supporting staff’ includes skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D projects or directly associated with such projects. The breakdown of R&D manpower can be illustrated in a hierarchical order (according to the level of occupation and education) as shown in Figure 2 as follows:

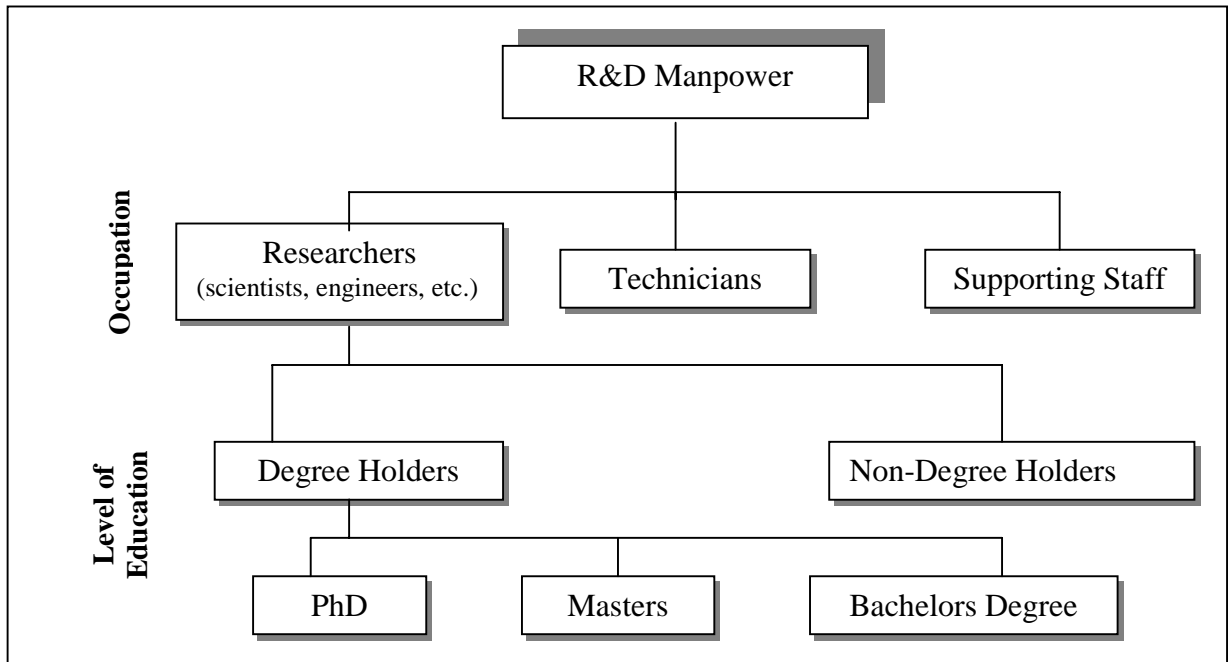


Figure 2: Classification of Manpower for R&D

1.2.6 Full Time Equivalent (FTE)

FTE is an appropriate measure of the proportion of time a researcher, technician or other support staff spent on R&D work during the surveyed year. One FTE may be considered as one person-year. Thus, a person who normally spends 60% of his or her time on R&D and the rest on other activities (e.g., teaching, administrative work, consultancy work, etc.) should be considered as 0.60 FTE. A person can only work at most one person-year per year (i.e., FTE cannot exceed 1).

Basically, FTE is

$$\frac{(\text{Hours or days spent on R \& D in 1998})}{(\text{Total working hours or days in 1998})} \times \frac{(\text{no. of months in 1998 doing R \& D})}{(12 \text{ months})}$$

1.3 Comparison Analysis

In the analysis of survey data, one important aspect is comparison of R&D elements across

- (a) sectors
- (b) organisations or institutions

(c) countries (i.e., international comparison)

Comparison is also made between the R&D elements over time (i.e., trend analysis).

1.3.1 Issues Related to International Comparison

(i) *Exchange rates*

The issue of the exchange rates should be addressed accordingly when making international comparisons. The currency conversion has some influential effects on the calculated ratio of R&D expenditure of the country. However, the classical method of making direct international comparisons is to convert the expenditure of the country concerned into a common currency such as the US dollars.

(ii) *FTE conversion problem -*

The purpose of FTE is to distinguish R&D and other activities and to measure the number of R&D personnel based on time they are engaged in R&D. The FTE conversion recommended to the OECD is needed for making comparisons with the population/labour force statistics and is useful for assessing R&D potentials.