Session Number: 6A

Session Title: The Valuation of R&D Expenditure and Output in International Comparisons

Paper Number: 4

Session Organizer: Bart van Ark and Robert McGuckin

Discussant:

Paper Prepared for the 28th General Conference of
The International Association for Research in Income and Wealth
Cork, Ireland, August 22 – 28, 2004

Satellite accounts on R&D expenditure under rapidly growing globalisation and changing industry structure

Soli Peleg

For additional information please contact:

Soli Peleg
Macro Economics Department
Central Bureau of Statistics
Kanfey Nesharim 66, Corner Bachi st.,
Jerusalem 95464
Israel

E-Mail: soli@cbs.gov.il
Fax: +972 2 6592 603
Telephone: +972 2 6592 601
This paper is placed on the following web sites: **www.iariw.org**
www.econ.nyu.edu/iariw
www.cso.ie

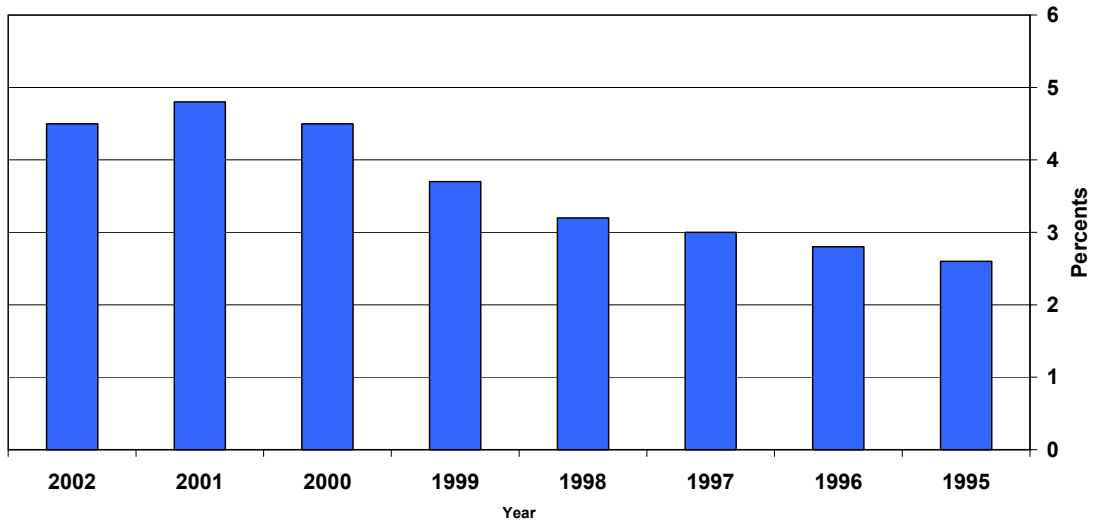
Introduction

Satellite accounts on R&D expenditure at current and constant prices have been prepared in Israel since the late 1970's. In the first years estimates of domestic expenditure on R&D were prepared by the Ministry of Science, but growing problems with the reliability of the series, mostly connected to difficulties of eliminating double counting, led the Ministry to discontinue the series in 1985 and seek the advice of the Central Bureau of Statistics (ICBS). The national accounts division within the ICBS developed a more comprehensive accounting methodology and from 1989 annual satellite accounts on R&D expenditure were prepared using the national accounts methodology. From these accounts the R&D statistics according to the Frascati manual have also been derived, and the expenditure data have been linked to employment data and other statistics on R&D collected in surveys.

The national expenditure in Israel on R&D is exceptionally high (over 4% of GDP – see the diagram below) and has been growing relatively quickly in recent years due to a change in the industry structure with expansion of the high-tech industries and contraction of low-tech industries.

Diagram 1. Expenditure on Civilian R&D in Israel

percents of GDP



External trade and other transactions with abroad have also grown rapidly in recent years. The high-tech industries in Israel are almost wholly export-oriented, and a growing part of exports is high-tech goods or services. International companies have increased their investments in Israel

and many have opened affiliates in Israel that perform R&D for the parent companies. At the same time many Israeli R&D enterprises have opened branches abroad and divide the activities between a number of countries.

The rapid change in industry structure has created large wage differentials and differences in the development of prices between industries.

As a result of these developments, on the one hand the measurement of R&D activities has grown in importance, and on the other hand many difficulties of measurement and analysis of the R&D data have appeared.

Among the measurement problems that have appeared: lack of classifications to meet the demand of new technologies, difficulties with the measurement of activities of start-ups and their financing, difficulties with the evaluation of transactions in the connection with takeovers of start-ups, difficulties with the measurement of cross-border activities such as FAB-less production, activities of affiliates of large multi-national hi-tech firms, problems of price measurement due to changes in the industry structure that affected the wage levels, etc. The analytical problems are of a more fundamental character, since the growing globalization has lead to difficulties of linking R&D with production and income, and to overcome such problems changes to the system of R&D accounts should be considered.

The paper is composed of 2 parts: the first part presents the main measurement problems and their proposed solutions. The measurement problems have caused concern for a number of years, and tentative proposals have been presented separately in previous papers, some of the proposals presented below are based on these papers. The second part presents the analytical problems and some proposals of changes in the system of R&D accounts.

1. Measurement problems

Most of the measurement problems in connection with R&D were initially discovered and solved during the compilation of the core national accounts or the balance of payments. However, the implications are much more important for the R&D satellite accounts, and often the solutions for the satellite accounts have to be different, since more details are needed for the satellite accounts.

Problems with the measurement of activities of affiliates of multi-national hi-tech firms.

Since the 1990's there has been a fast growth of R&D centers that are subsidiaries of foreign corporations and are producing R&D to be used by the foreign parent corporation. In recent years such R&D centers have also begun to sub-contract part of the services involved in producing the

R&D to abroad – a quite common pattern is that an R&D center in Israel is a subsidiary of a US firm and is in turn sub-contracting some of the tasks to for example India or Taiwan.

The transfer of output of R&D to abroad from these centers may not be registered as exports, due to its intangible nature. Even if the transferred output is reported as sales from the subsidiary to the parent corporation, it may be valued at cost and not at the market value of the produced R&D. On the other hand imports of R&D services from sub-contractors may also not be registered, so that the domestic activities are overvalued.

In Israel the source of information for such transactions until recently in most cases has been banking data, and often the only transaction covered in practice in the Balance of Payments has been the transfer of money from the parent enterprise to the R&D center to finance compensation of employees – this transaction has been registered as factor income and not as a sale of R&D, and also does not include full costs and mark-up.

In order to improve the measurement, the use of banking data has gradually been replaced by collection of data from financial reports or surveys in recent years. Due to the complicated nature of the transactions the collection of data is not always straightforward and often involves visits at the R&D center or personal interviews. Data collected so far indicate that R&D centers include at least a minimum percentage of mark-up, dictated by the tax authorities, in the value of their production in their financial reports. However, it seems possible to improve the estimates by comparing data collected in Israel to data collected abroad on such centers.

Problems with measurement of R&D in connection with so-called FAB-less enterprises

In recent years the growing globalization has also lead to the establishment of many so-called FAB-less enterprises. A FAB-less enterprise is an enterprise that engages in R&D, but out-sources the production of the developed products, and then markets the final product, which is sent directly from the sub-contractor to customers. In Israel such enterprises are mainly engaging in computer chip-design (hence the word FAB-less, coming from US computer enterprises having FABs). One of these FAB-less enterprises for example designs and markets finished computer chips worth about a quarter of a billion $, which are produced in an Asian country. The R&D and marketing account for about 35% of the value of the production, which means that the Israeli share in the combined added value is quite high. While it is possible to measure the cost of R&D performed in such enterprises, and this cost will be included in the R&D surveys, there is a problem of measuring the market value of the R&D, of registering the international transactions of such R&D, and of linking between the R&D and the production. Often the parent enterprise will register the whole value of the sales of the final production as domestic income, so that in order to evaluate the

value of the R&D that is used jointly with other production factors abroad, one has to collect data on the transactions taking place between the parent enterprise, the producers abroad, and the customers, and estimate the part to be attributed to R&D. The ICBS has only recently become aware of the problems with statistics on FAB-less enterprises. Such problems affect the series of business indicators, the national accounts, and the balance of payments, in addition to the R&D satellite accounts, and currently a special collection of data on these enterprises has started in the framework of business surveys. As in the case of the R&D centers the transactions are complicated, and the collection of data involves visits to the enterprises and personal interviews. Until detailed data are available, rough estimates of value of the R&D and marketing activities to be attributed to the domestic enterprise are prepared as the difference between gross exports data reported by the firms to the VAT authorities and banking data on the payments to the foreign producer.

Problems with measurement of joint cross-border R&D activities

As bi-national and multilateral international cooperation expands and professional international contacts in general increase due to growing easiness of communication, the problems of measurement of joint cross-border activities are becoming more and more important. These problems affect both the measurement of business R&D and R&D performed by non-market producers.

Israel cooperates with a number of countries on R&D activities, and also participates in some bi-national funds financing joint R&D. Until now the satellite accounts have only included the costs of R&D activities, financed by the joint funds and taking place within the country. While it is relatively easy to account for costs incurred, the market value of each part of the joint effort is not easy to establish. One possibility of measurement would be to work in cooperation with statisticians in other countries, and to jointly decide how to divide the value of the joint R&D according to information available from both countries.

Measurement of international transactions over the internet or in other ways that are not registered at borders.

Even when the R&D producers are domestic and the R&D is produced within the country, there still may be measurement problems with international transactions, since the transfer of R&D often takes place over the internet or in other ways that are not registered at borders. As restrictions on international transactions and foreign currency have been gradually lifted, it also is not possible to identify such transactions through other administrational data sources. Consequently, the use of administrational data (banking data, customs data) is being replaced by collection of data from financial reports or surveys.

R&D in start-ups and their financing

The importance of activities in hi-tech start-ups, which almost all of them engage in R&D, in Israel has grown rapidly since the 1990's. The number of start-ups reached about 4000 in year 2000, and the value added of activities was estimated to 3% of GDP. In the years 2001-2003 the value added decreased to 1-2% and the number of active start-ups decreased sharply, but hi-tech start-ups still contribute more than some traditional industries such as the agricultural industry to Israel's GDP. In the early 2004 a renewed rapid expansion of start-up activities has started.

It is perhaps worthwhile mentioning the factors influencing the growth in hi-tech start-ups in Israel, since it illustrates the relevance of statistics on finance and human resources in R&D to assist policy makers:

In the beginning of the 1990's the government established a technologies incubator unit, intended to meet infrastructure and technological needs of small start-ups and also assist them in search for finance. In addition government venture-capital funds were established, which in turn participated in the establishment of private venture-capital funds that attracted additional private capital. The establishment of a local venture-capital fund sector attracted other investors from abroad and altogether there was an impressive acceleration in financing by venture capital funds: In year 2000 the venture capital funds invested 3.3 billion dollars in Israel compared to 50 million dollars in 1991.

Table 1 Capital Raised by Investor 1991-2001 ($ millions)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Private technology VC funds	49	27	162	112	145	264	589	468	1,567	3,299	1,344
Public & Other Funds	0	54	42	0	0	0	27	8	44	35	6
Other Private Equity Funds	0	45	128	242	6	110	66	99	108	131	11
All Funds	49	126	332	354	151	374	682	575	1,719	3,465	1,361
Investment Companies	9	34	40	20	5	23	47	131	132	236	28
All Capital Sources	58	160	372	374	156	397	729	706	1,851	3,701	1,389

Source : The Israel Venture Capital Industry Review, Annual Report 2002 , IVC

Another factor was the change in the political environment, which led to a reduction in resources spent on defense during the 90's, a flow of scientists to the private sector and in many cases adaptation of R&D developed in the military to civilian uses.

In addition, a large influx of highly skilled immigrants from the former Soviet Union during the early 90's added to the already relatively high proportion of scientists in the population, so that human resources were available and enabled the fast growth in the number of start-ups.

The major part of production of the start-ups in Israel can be characterized as R&D, and the products developed are mainly intended for the software, electronics, and telecommunication industries.

Since start-ups do not have any sales at the early stages, they often are not included in the business survey samples and they even may not be included from the beginning in the business registers. Due to the many investments from abroad in start-ups and the sales of start-ups to abroad, the assessment of the impact of start-ups on the national accounts and balance of payments also is quite complicated, and may not be adequately reflected.

Given the importance of hi-tech start-ups, it was decided not to ignore the start-ups, assuming that their activities would be covered later, when they have matured into enterprises selling products. Economists from the academia or the private sector were consulted and a number of steps were taken to improve estimates of the activities of start-ups.
Since 2000 special information on start-ups has been gathered through scanning of newspapers, tax registers and other sources, and a database with such information has been established.
For the core national accounts the quarterly estimates on production costs in start-ups have been based on data on investments of venture capital funds available from the Israeli Venture Association, since partial information gathered indicates that a major part of start-ups in Israel are financed by venture capital funds. The full value of start-up activities at market prices is obtained by adding a mark-up to the production costs of all the start-ups - the mark-up is estimated using data on returns to venture-capital funds invested in start-ups to obtain the average percentage of operating surplus. This means that production costs of all start-ups are seen as the costs of the few that succeed. One obstacle to this solution has been that venture capital funds in Israel seem to be very anxious about leaks of business information, and are not willing to report data on the rate of return. Assuming that the international financial markets are relatively well developed, data on rate of return abroad were used. First the mark-up was estimated using trend data on NASDAQ revenues. It is now estimated using trend data on revenue of venture capital funds in US.

However, for the R&D statistics the start-up activities have a greater importance, and the database described above was used to expand the survey frames for the R&D surveys so that they include start-ups identified through the special collection of data. The more complete data from R&D surveys on expenditure and sources of finance indicate that the estimates included in the core

national accounts may be underestimates, since additional financing sources ("angels" and other sources) are important. On the other hand, the data on current investment of venture capital in start-ups may not be a good indicator for the expenditure in the short run – the start-up may receive an injection of capital, which is not immediately spent on R&D activity – the expenditure may be spread over time. Currently, a method of combining the partial quarterly indicators with annual delayed data from R&D surveys is examined.

Evaluation of R&D transactions in the connection with takeovers of high-tech companies.
Many start-ups or young high-tech companies have been sold or merged with companies abroad at high prices (see table 2 below), which have no apparent relation to their recorded production costs, operating surplus or sales – some of them at prices of over a billion US$ - when the total GDP of Israel is a little over 100 billion US $.

Table 2: Selected List of Acquisitions/Mergers involving Israeli Technology Companies and Foreign Strategic Partners (1996-2004)[1]

Israeli Company	Acquiring Company	Year	Estimated value of acquisition in millions US$
Riverhead Networks	Cisco	2004	39
Business Layers	Netegrity	2004	44
Envara	Intel	2004	40-60
X-technologies	Guidant	2003	200
Galior	Memscap	2003	16
Predix Pharmaceuticals	Physiome Sciences	2003	20
Radlan	Marvell	2003	150
Precise	VRTS	2003	537
MeetU	Policom	2002	9
Quiver	Inktomi	2002	12
Midbartech	Macrovision	2002	25
Maximal	Microsoft	2001	20
Oramir	Applied Materials	2001	27
Floware	Breezecom	2001	145
Mobilee	Natural Microsystems	2001	13
TopTier	SAP	2001	400
NomadIQ	Omnisky	2001	26
VisionTech	Broadcom	2000	780
Galileo	Marvell	2000	2700
Hynex	Cisco	2000	135
Chromatis	Lucent	2000	4800
Tradeum	VerticalNet	2000	480
Infogear	Cisco	2000	301
ExaLink	Comverse	2000	550
Accord	Polycom	2000	340
DSP Communications	Intel	2000	1600
Telegate	Terayon	1999	100
Libit	Texas Instruments	1999	357
New Dimension	BMC	1999	650
Oshap	Sungard Data Systems	1999	210
Butterfly	Texas Instruments	1999	50
WaveAccess	Lucent	1998	56
Teledata	ADC Telecom	1998	200
Memco	Platinum	1998	412

Lannet	Lucent	1998	117
Class Data Systems	Cisco	1998	50
Mirabilis	AOL	1998	407
Algorithmic Research	Cylink	1997	82.7
Laser Industries	ESC Medical Systems	1997	280
Biosense	Johnson &Johnson	1997	400
RADNet	Siemens +Newbridge	1997	75
Armon Networking	Bay Networks	1996	36
Instent	Medtronic	1996	200
Scorpio	U.S.Robotics	1996	72
Orbot Instruments	Applied Materials	1996	110
Opal	Applied Materials	1996	175

[1] Source: IVA Yearbooks – 2001 and 2002, A Survey of Venture Capital and Private Equity in Israel, Edited and published by IVC Research Center in association with The Israel Venture Association, and newspaper articles for years 2002 to 2004.

In most of the cases the high transaction price reflects the value of the R&D developed within the company - this R&D is sold or handed over to abroad in a merger together with the whole enterprise. In practice, the transfer of R&D in connection with sales of enterprises is often neglected by compilers of data, due to the intangible nature of R&D, so that only a financial transaction is recorded. As a result exports or imports of R&D are undervalued, and the amount of R&D available to the country will be overvalued or undervalued according to the size of its net exports of R&D.

In Israel the problem has only been solved partially. News on sales of high-tech companies to abroad are collected at the ICBS on a daily basis and entered in a database. Ideally these sales data should be compared with banking data, which are currently the source for estimates of financial transactions in the Balance of Payments estimates, to check how the transactions are registered. In each case it would be necessary to examine the transaction in detail in order to define what has been sold to abroad. There are however, a number of obstacles to overcome before a full solution can be implemented. Detailed banking data are collected at the central bank, but not all of the sales data are easily identified. If the sale is identified, it may not be easy to estimate the amount paid for the R&D, even after the agents involved in the transaction are consulted. The agents involved often tend to report an underestimate of the value of the R&D for reasons related to taxation.

Classifications

In 1993 an Israeli classification of industries based on ISIC Rev. 3 was published, and in 1994 a classification of occupations based on the ISCO 88 classification were published. During the late 1990's these classifications proved very unsatisfactory due to the appearance of many new types of high-tech enterprises and new occupations, so that large number of enterprises and employees

were classified under one or two headings although they had very diverse activities. The lack of appropriate classification affected the quality of the R&D accounts, due to the aggregation of diverse activities with varying use of inputs, wage differentials and output prices.
A committee at the ICBS initiated revised classifications and in 2003 a revised classification of industries was published. A revision of the classification of occupations was also proposed in 2002, but has not yet (April 2004) been published.
The main changes to the classification of industries were additions at the third level (groups) and the fourth level (classes) in the "Telecommunications" and "Computer and related services" industries, which enabled and improved analysis of information and communication technology (ICT) industries. To improve the analysis, the classifications of industries by technological intensity and ICT industries were also published separately.
The revision of the classification of occupations proposed includes mainly additions of a large number of details for the occupations: engineers, technicians, designers, managers connected to the developments in high-tech industries.

The lack of adequate classifications in the Balance of Payments also seems to have contributed to the problems with measurement of R&D. The new international detailed classification of trade in services, published in 2001, is currently being introduced in the Balance of Payments of Israel (2004), and will hopefully gradually lead to more detailed measurement of exports and imports of R&D.

Measurement of value and prices: changes in the industry structure that affected the wage levels and created problems measurement, problems of price measurement.
The industry structure in Israel has changed rapidly since the 1990's with expansion of the high-tech industries and contraction of low-tech industries. This rapid change has created large wage differentials (see table 3 below) and differences in the development of prices between industries, which are important for the measurement of prices and values at constant prices.

Israeli R&D statistics are reported to OECD, and in line with the OECD countries, until a few years ago R&D at constant prices was obtained using the implicit GDP deflator.

The latest Frascati Manual, published by OECD in 2002, continues to recommend the use of a general price deflator – the implicit GDP price index, in the absence of R&D deflators. In the discussion of the methods in the Annex 9 of the Frascati Manual, some of the problems with the use of the implicit GDP price index are recognized (Frascati Manual Annex 9, par. 4):
"R&D deflators are justified if it is believed that the cost of R&D has moved in a way that is significantly different from general costs and/or if trends in the cost of R&D have varied

considerably among sectors or industries. In general, over the long term, it is reasonable to suppose that the implicit GDP (output) deflator would tend to increase less rapidly than a "true" R&D (input) deflator because of productivity increases."

The problem of productivity changes is an important one in the long run, and there does not seem to be any easy solutions to the measurement of productivity in the case of R&D - it is almost impossible to quantify changes in the outcome of R&D since each "product" is unique. In this respect the problems with measurement of prices and quantity changes for R&D are similar to problems encountered for part of the general government consumption expenditure.

In the short run, the problems of differential changes in wages of employees engaged in R&D will in most cases have a larger importance than the productivity changes.

TABLE 3.- Employee posts and average wages per employee post in the High-Tech industry

	1995	1996	1997	1998	1999	(1) 2000	(1) 2001
	Thousands						
Employee posts - total	**2,039.0**	**2,145.8**	**2,188.4**	**2,218.7**	**2,274.5**	**2,361.6**	**2,415.5**
High-Tech industy - total	**108.4**	**116.9**	**126.8**	**135.9**	**153.2**	**185.0**	**197.5**
Thereof:							
Manufacturing in High-Tech	59.3	62.0	65.1	67.3	70.0	77.5	78.7
Communications	14.4	15.3	16.2	17.2	19.9	24.0	29.8
Computer and related services and R&D	34.7	39.6	45.5	51.4	63.4	83.5	89.0
Other industries	**1,930.6**	**2,028.9**	**2,061.6**	**2,082.8**	**2,121.3**	**2,176.6**	**2,218.0**
	NIS						
Average wages per employee post (at current prices) - total	**4,355**	**4,915**	**5,493**	**5,914**	**6,377**	**6,835**	**7,079**
High-Tech industry - total	**7,723**	**9,918**	**10,406**	**11,746**	**13,366**	**14,480**	**14,681**
Thereof:							
Manufacturing in High-Tech	8,043	9,990	10,943	12,242	13,875	14,157	14,491
Communications	7,852	9,233	10,104	10,883	10,627	10,684	10,100
Computer and related services and R&D	7,121	10,069	9,745	11,387	13,663	15,871	16,383
Other industries	**4,166**	**4,627**	**5,191**	**5,534**	**5,872**	**6,185**	**6,402**

Source: Feldman, Mark, and Michal Abouganem, "Development of the High-Tech Industry in Israel, 1995-1999: Labour Force and Wages (incl. some updates till 2001)", ICBS, Jerusalem, 2003.
(1) Incl. All of the 35 industry, and not only 355 as in a previous years.

The weight of compensation of employees in the cost of R&D is very large and consequently price changes in this component are important. Compensation of employees also tends to have a differential change over time as structural changes in the economy develop. In Israel, wages in the R&D industry (ISIC category 73) grew 59.3% more that average wages of the entire economy, and 76.4% more than prices of GDP in the years from 1996 to 2000 – years where the importance of R&D grew, and ITC and other high tech industries grew rapidly. In 2001 and 2002, when the ITC and other high tech industries experienced a sharp drop in activities, the wages in the R&D industry contracted 7.8% while average wages grew by 3.3% and GDP prices by 6.7%. The

compensation of R&D personnel is 50%-60% of all expenditure on R&D in Israel, so that the impact of using a general price index instead of a specific one will be quite large.

Another fact to be taken into account is that the composition of other costs in R&D usually is quite different from expenditure on intermediate consumption in other production, and the weighted price change of these components will often be found to be different as well.

Due to the large price differentials the use of general price indices lead to very problematic results, and efforts were made to replace the implicit GDP price deflator with more specific price indices, or at least proxy price statistics for cost components.

National accounts are compiled at market prices, and a first choice for deflation would be a price index based on the measurement of actual market prices of R&D. At first glance the situation for R&D seemed to be better that for many public goods, since a part of R&D – a part that even seems to be growing - is traded in the market. However, the special nature of R&D that makes each outcome of R&D unique, means that the construction of price indices based on collection of data on market prices of R&D is not feasible in most cases. For the relatively large part of R&D that is own-account production or production of non-market producers, measurement of market prices of output is not a possibility.

A second choice would be the construction of price indices for the cost components under the assumption that the prices of the mark-up change proportionally to the cost components. The methods for constructing weighted indices for the expenditure, using specific or proxy price indices for the various cost components, are well known, and have been described in the Frascati Manual and in manuals on national accounting at constant prices. Use of relatively large levels of disaggregation for the construction of weighted price indices and use of data on hours worked should overcome the problems mentioned above with differential changes in wages by sector or industry.

For other current R&D expenditure, input-output tables prepared in the framework of the national accounts may provide valuable information on the composition of intermediate consumption in R&D production that could be used for weighting and choosing the appropriate proxy price indices.

For capital expenditure, detailed price indices appropriate for the equipment used in R&D could probably be used instead of the general GFCF price indices.

In Israel the following procedure was followed:

For the non-market producers of R&D the estimates at constant prices were prepared within the framework of the core national accounts using specific deflators for the cost components. The compensation of employees was deflated using specific data on wages collected from National Insurance Institute data for the non-market producers engaged in R&D. The changes in work hours per employee were taken into account, using data from labour force surveys. The other current expenditures were deflated using weighted proxy indices – the weights were based on the results from the latest input-output table for non-market producers (NPI's, central government and local government are prepared separately) and detailed by industry of origin at a 3-digit ISIC level.

However, the series on R&D expenditure for market producers are in most cases prepared separately on the basis of annual surveys. Series on R&D expenditure in the manufacturing industry have been prepared in Israel since 1970, and for many years the constant price estimates for these series was made using a general index - the Consumer Price Index (CPI). Two years ago the method of deflation for these series was changed, and the results of the change illustrate the impact of using specific price indices instead of using a general index. According to the new method, compensation of employees is deflated using wage indices for the relevant industries at a 3-digit level. Other expenditure excluding overhead (administrational expenses) is deflated using weighted proxy indices – the weights are obtained from data on the relevant industries (3-digit level) from the latest input-output table. Overhead (Administrational expenses) is deflated by the wage index for the relevant industry.

The impact of the change is shown in tables 4 and 5 below. The accumulated change in the estimates at constant prices according to the new method in the period 1990 to 1999 was 14% lower than the change in the estimates obtained using the CPI. As mentioned above, compensation of employees is 50-60% of total expenditure on R&D and the differential change in wages is the main reason for the difference between the two methods. In the first years the specific price indices grew less than the CPI, but in the years 1996 to 1999 wages in R&D intensive industries rose rapidly and consequently the R&D specific indices increased more than the CPI.

Table 4. R&D in Manufacturing in Israel - percent change in prices of cost components on previous year

Year	CPI	Compensation of employees	Goods for intermediate consumption	Payments for services	Overhead
1991	19.0	15.8	13.2	14.2	15.2
1992	11.9	18.0	7.7	13.5	15.6
1993	11.0	2.5	9.7	5.3	4.2
1994	12.4	15.8	6.9	11.8	13.6
1995	10.0	9.3	8.9	9.7	8.8
1996	11.3	3.8	4.8	4.6	4.2
1997	9.0	40.0	4.7	25.2	32.1
1998	5.5	9.4	5.3	7.9	8.6
1999	5.2	15.1	4.2	12.0	13.5

Source: Ety Yaacov, Alexander Stein: ”Development and Continuity in Performance of R&D in the Years 1990-1999 and the Impact of R&D Activity on Sales” (Hebrew only), ICBS, Jerusalem, 2002.

Table 5. Expenditure on R&D in Manufacturing in Israel at 1990 prices

Year	A Constant price estimates obtained using CPI Million NIS	Percent change in A on previous year	B Constant price estimates obtained using specific price indices Million NIS	Percent change in B on previous year	Ratio: B/A
1990	999.5		999.5		1.000
1991	1013.1	1.4	1047.1	4.8	1.034
1992	1097.6	8.3	1099.6	5.0	1.002
1993	1167.7	6.4	1247.1	13.4	1.068
1994	1280.2	9.6	1354.5	8.6	1.058
1995	1283.7	0.3	1366.4	0.9	1.064
1996	1341.7	4.5	1525.3	11.6	1.137
1997	1607.3	19.8	1519.5	-0.4	0.945
1998	1827.3	13.7	1678.7	10.5	0.924
1999	2181.3	19.4	1867.6	11.3	0.856

Source: Ety Yaacov, Alexander Stein: ”Development and Continuity in Performance of R&D in the Years 1990-1999 and the Impact of R&D Activity on Sales” (Hebrew only), ICBS, Jerusalem, 2002

II. Problems of analysis

The R&D statistics, and also the R&D satellite accounts recommended in the SNA93 focus on the expenditure on R&D. The links to the Rest of the World shown in R&D satellite accounts are only shown through the financing of national expenditure on R&D by the Rest of the World.

The central table in the R&D satellite accounts in Israel includes a presentation of R&D expenditure and funding in a matrix form that enables the analysis of flow of finance to performers of R&D – see table 6 below. In addition, time series on R&D, and detailed tables on produced R&D are given (see table 7).

TABLE 6.- NATIONAL EXPENDITURE ON CIVILIAN R&D, BY FINANCING SECTOR AND OPERATING SECTOR

2000

Financing sector	Operating Sector				
	Private non-profit institutions	Higher education(1)	Government	Business	Total
	NIS million				
TOTAL	**757**	**3,463**	**1,212**	**16,685**	**22,117**
Business	98	128	91	15,083	15,400
Government - total	504	2,344	1,020	1,602	5,470
Thereof: through G.U.F. (2)	151	1,558	178	0	1,887
Higher education	8	450	1	0	459
Private non-profit institutions	17	97	50	0	164
Rest of the world	130	444	50	0	624
	Percent				
TOTAL	**3.4**	**15.7**	**5.5**	**75.4**	**100.0**
Business	**0.4**	**0.6**	**0.4**	**68.2**	**69.6**
Government - total	**2.3**	**10.6**	**4.6**	**7.2**	**24.7**
Thereof: through G.U.F. (2)	**0.7**	**7.0**	**0.8**	**0.0**	**8.5**
Higher education	**0.0**	**2.0**	**0.0**	**0.0**	**2.1**
Private non-profit institutions	**0.1**	**0.4**	**0.2**	**0.0**	**0.7**
Rest of the world	**0.6**	**2.0**	**0.2**	**0.0**	**2.8**

(1) Includes Universities and Weizmann Institute of Science .

(2) General University Funds.

However, due to the growing globalization and the changes in R&D production patterns, such tables lack important parts of the information on R&D produced.

TABLE 7.- NATIONAL EXPENDITURE ON CIVILIAN R&D IN ISRAEL, BY OPERATING SECTOR

Year	Operating sector				
	Total	Business	Government	Higher education(1)	Private non-profit institutions
	NIS million, at current prices				
1989	2,269	1,206	260	639	164
1990	2,744	1,455	293	798	198
1991	3,417	1,903	368	909	237
1992	4,231	2,421	459	1,084	267
1993	5,110	2,964	539	1,270	337
1994	6,248	3,668	634	1,551	395
1995	7,422	4,357	736	1,900	429
1996	9,201	5,571	917	2,223	490
1997	11,222	7,155	972	2,539	556
1998	13,091	8,705	1,015	2,772	599
1999	16,436	11,433	1,106	3,209	688
2000	22,117	16,685	1,212	3,463	757
2001*	23,856	17,951	1,248	3,837	820
2002*	23,181	16,905	1,337	4,049	890
	NIS million, at 2000 prices				
1989	9,293	4,872	1,037	2,910	474
1990	9,448	4,946	977	3,025	500
1991	10,215	5,613	1,057	3,036	509
1992	10,920	6,113	1,165	3,121	521
1993	11,592	6,641	1,165	3,193	593
1994	12,429	7,473	1,123	3,255	578
1995	12,862	7,830	1,103	3,282	648
1996	14,015	8,849	1,199	3,320	646
1997	15,116	9,940	1,175	3,335	666
1998	16,166	10,929	1,178	3,370	689
1999	17,712	12,421	1,159	3,412	720
2000	22,117	16,685	1,212	3,463	757
2001*	23,087	17,577	1,211	3,502	797
2002*	22,300	16,610	1,265	3,562	863
	Percent change(2), on previous year				
1990	1.7	1.5	-5.8	4.0	5.4
1991	8.1	13.5	8.2	0.4	1.8
1992	6.9	8.9	10.2	2.8	2.4
1993	6.2	8.6	0.0	2.3	13.9
1994	7.2	12.5	-3.6	1.9	-2.5
1995	3.5	4.8	-1.8	0.8	12.0
1996	9.0	13.0	8.8	1.2	-0.3
1997	7.9	12.3	-2.0	0.5	3.1
1998	6.9	10.0	0.2	1.0	3.5
1999	9.6	13.7	-1.6	1.2	4.5
2000	24.9	34.3	4.6	1.5	5.0
2001*	4.4	5.3	-0.1	1.1	5.3
2002*	-3.4	-5.5	4.4	1.7	8.3

(1) Including universities and the Weizmann Institute of science.
(2) Percent change was calculated before rounding.
* Provisional data.

In the Israeli satellite accounts, the implications of classification of expenditure on R&D as capital formation on the core national accounts also have not yet been examined. The implicit assumption was that all expenditure on R&D adds to the stock of R&D available to the domestic economy and results in benefits over a number of years to domestic production, and that interested researchers could use the R&D statistics published to estimate the impact of R&D on growth etc.

Currently an analysis of the capitalization of R&D on the core national accounts has been undertaken, ways of accounting for stocks of R&D have been considered, and detailed constant price series of R&D production have been prepared. However, in order to analyze the impact, it is important to solve the analytical problems that have emerged due to the increasing globalization and changes in industry structure.

Below the main analytical problems – assuming that measurement problems have been overcome - are outlined and proposals for alternative presentations are also given.

Analyzing R&D activities in R&D centers of multinational companies

As explained above a number of large international companies have opened affiliates in Israel that perform R&D for the parent companies – to mention a few: IBM, Motorola, Intel, National Semiconductor, Analog Devices. The R&D performed at such centers is included as part of R&D produced in Israel (GERD), but in almost all cases the R&D is transferred to the parent enterprise once it has been successfully completed, and does not benefit the domestic economy except for any spillovers that may result from the fact that domestic employees produced the R&D. It would be important to show such R&D separately in the satellite accounts. Tables with supply and use of R&D would give a partial solution, since the R&D eventually transferred to abroad will be shown as exports. However, R&D is produced over a number of years before the production is finalized, and in the first stages of production the use shown would be work in progress, with no indication of the different nature of such R&D. One solution could be to show R&D produced by ownership of the enterprises, one could use the classifications recommended in the new OECD globalization manual.

Analyzing R&D activities of FAB-less enterprises

As explained above, in recent years there has been a fast growth in the number of FAB-less enterprises in Israel. Since such enterprises in fact engage in joint production with non-affiliated enterprises abroad, the analytical problems are quite complicated. The R&D is domestically produced and also stays within the borders of the country. However, the R&D is also used abroad as a basis for production, and the major part of the benefits probably are reaped by the enterprise in Israel.

An added complication for the analysis of such data is that the current balance of payments manual does not take these kinds of transactions into account. According to the latest Balance of Payments manual, whenever an enterprise markets exports of products leaving another country, as is the case of a FAB-less, it is recommended to register the net income from the transaction as exports of merchant services, and the possibility of joint production, with the R&D taking place in one country has not been envisaged.

It is proposed to show supply of such R&D separately as a separate category.

Analyzing joint cross-border activities of non-market institutions or activities in international institutions.

As explained above the international cooperation in R&D production has grown and involves all sectors. First of all, it would be important to separate such R&D, and for analytical purposes it would be important to register the full value of joint R&D production available to the cooperating producers in all countries, at least in memorandum items.

An additional problem, long recognized by the R&D statisticians, is that R&D performed in international institutions is made available to all the member countries of such institutions. Such R&D is not included in the member countries' statistics, and also not in Israel's R&D satellite accounts. One could choose to register proportions of the international R&D in the satellite accounts of the individual countries, and to show all international joint R&D available to the country as a memorandum item.

Analyzing R&D activities of start-ups

A very common situation for start-ups in Israel is that the start-up is financed and owned by foreign residents, and that the production of R&D is later sold or transferred to abroad, as described above. In such a situation the main benefit to the resident economy is the compensation of resident employees and any spillover of R&D conducted at the start-up. The most important problem in such cases will be that although the R&D produced is indeed domestic, and should be included in the gross domestic production of R&D (and in GERD in the Frascati Manual), the benefits for the domestic economy are smaller or at least different from benefits from R&D used within the economy. Since the production period extends over a number of years, it seems important to separate the data on supply of R&D produced in such start-ups.

Proposed changes to the R&D satellite accounts

In order to fully reflect the differences between the various types of R&D produced and used, it is proposed to prepare an extended supply and use tables for R&D, using criteria for classification recommended in the draft OECD globalization manual (2003).

The supply side would detail the following types of R&D:

I. Domestically produced R&D:
- I.1 R&D produced by nationally controlled institutional units, except by start-ups, or by FAB-less enterprises
  - I.1.1 R&D produced entirely by the domestic institutional units
  - I.1.2 R&D produced jointly with units abroad - The part of the joint R&D produced by the domestic unit
- I.2 R&D produced by start-ups
- I.3 R&D produced by FAB-less enterprises
- I.4 R&D produced by foreign controlled affiliates
- I.5 R&D produced by nationally controlled parent companies having affiliates abroad

II. Imported R&D
- II.1 Intra-firm imports
- II.2 Imports in connection with purchase of an enterprise
- II.3 Other imports

III. R&D produced by international institutions

IV. The part of the joint R&D produced by the foreign institutional units

Assuming that R&D is defined as an asset, the uses side of the table would detail the following types of R&D:

V. Intermediate consumption of R&D

VI. Fixed capital formation
- VI.1 R&D used only within the economy
- VI.2 R&D used by FAB-less enterprises for production abroad
- VI.3 Joint R&D with abroad (both parts given above – I.1.2 and IV)
- VI.4 R&D in international institutions

VII. Exports of R&D
- VII.1 Intra-firm exports
- VII.2 Exports in connection with sale of an enterprise
- VII.3 Other exports

VIII. Increase in stocks of work in progress.

The necessary information required for such detailed supply and use tables is currently only partially available, but more complete data is expected to be collected in the near future. A subdivision of production between market production and non-market production, and a division of the increase in stock of work in progress between work in start-ups and work in other units would probably also be useful.

Conclusion

The increasing globalization and the rapid development of the high tech industry in Israel have resulted in a number of difficulties in the preparation of R&D data in recent years.

The many measurement problems have gradually been tackled to improve the reliability of the R&D satellite accounts. Some of the solutions to the problems are only partial and will have to be improved in the future.

A more fundamental problem is that, due to the growing globalization and the changes in industry structure, the analytical framework of the accounts is becoming less and less useful, and does not provide a satisfactory basis for the analysis of the impact of R&D on growth.

A tentative proposal for an extended supply and use framework, which uses the classification of activities of multinational activities recommended in the draft Globalisation Manual prepared by the OECD, and also adds some sub-classifications of the uses has been presented. Such a table allows a separate analysis of R&D produced by multi-national enterprises and start-ups destined for exports, and also takes into account R&D produced jointly in a number of countries. With the implementation of the recommendations of the new OECD Globalisation manual in the next few years, most of the necessary details will be available.

The statistical offices of the international organizations are currently considering the capitalization of R&D in the national accounts in the framework of the first revision of the System of National Accounts (SNA). If R&D were capitalized in the national accounts, the need for reliable measurement of R&D would increase, and the need for proper analysis of the various uses of R&D would also become even more urgent.

References:

Draft Manual on Economic Globalisation Indicators, OECD, Paris, 2003

Dougherty, Sean M., Robert Inklaar, Robert H. McGuckin, Bart Van Ark: “Performing Research and Development Abroad, International Comparisons of Costs and Value”, The Conference Board, August 2002

Feldman, Mark, and Michal Abouganem, "Development of the High-Tech Industry in Israel, 1995-1999: Labour Force and Wages (incl. some updates till 2001)", Central Bureau of Statistics, Jerusalem, Israel, 2003.

Israel Venture Association (IVA)(2002),Israel Venture Association Yearbooks, 2001-2002.

Mandler, Pablo, "Exports and Imports of R&D", Paper presented at the 1. meeting of the Group on Measurement of Non-financial Assets (Canberra group II), Voorburg, Netherlands 2003

"National Expenditure on Civilian Research and Development 1989-2002", Special Publication No. 1212, Central Bureau of Statistics, Jerusalem, Israel, 2003

Peleg Soli, and Pablo Mandler, "Progress made in the measurement of activities of start-ups", Paper presented at the OECD National accounts meeting, Paris, 2000, STD/NA/RD(2000)05

Peleg, Soli, "Measuring R&D Prices", Paper presented at the 1. meeting of the Group on Measurement of Non-financial Assets (Canberra group II), Voorburg, Netherlands 2003

Standard Industrial Classification of All Economic Activities, 1993 - Second Edition (Technical Pub. No. 63) (briefing), Central Bureau of Statistics, Jerusalem, Israel, 2003.

System of National Accounts 1993, Commission of the European Communities, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, World Bank, Series F, No. 2, Rev. 4, Brussels/Luxembourg, New York, Paris, Washington D.C., 1993.

"The Measurement of Scientific and Technological Activities. Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development", OECD, Paris, 2002

Yaacov, Ety, Alexander Stein: "Development and Continuity in Performance of R&D in the Years 1990-1999 and the Impact of R&D Activity on Sales" (Hebrew only), Central Bureau of Statistics, Jerusalem, Israel, 2002.