Labor Productivity in Israel Manufacturing Sector, 1990-1994

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1. Introduction

The beginning of the 1990's witnessed a remarkable increase in the rate of growth of employment, capital investment and output in the manufacturing sector (Figure1). Productivity growth, however, did not depart significantly from the pattern exhibited during the 1980's. Indeed, Figure 1 suggests that most of the change in output growth during the first half of the 1990's appears to be the result of increases in the factors of production, and not of increased productivity.

It is generally accepted that the single most important factor contributing to the recent growth experience was the increase in domestic demand. Beginning in 1990 with the massive influx of immigrants from the former Soviet Union, domestic demand for manufacturing and construction goods, as well as for services, expanded considerably. In this context, the slow growth in productivity is surprising for at least two reasons. First, if the short-run response of a firm to a sudden surge in domestic demand is to take advantage of unused capacity, then its *measured* productivity should have risen, at least temporarily. Second, as new capital is put in place, labor productivity should be enhanced further.[1] Moreover, tapping the new immigrants' relatively high level of human capital should also increase productivity in the manufacturing sector.

In order to understand what lies behind the aggregate productivity trends, this paper analyzes *firm-level* data for the manufacturing sector. We seek to characterize the observed patterns of productivity growth at the firm level, rather than to account for the causes of growth (i.e., via the accumulation of physical, human, and R&D capital). For the most part, this is a purely descriptive paper that looks at the contribution of different groups of firms to aggregate growth.

Examining the patterns of productivity growth at the micro-level enhances our understanding of the processes driving aggregate productivity changes. For example, it enable us to quantify the effects that entering and exiting firms have on aggregate manufacturing productivity growth, as well as the effect of shifts in the composition of employment across firms.

[1] If this new capital is technologically more advanced, and this feature is not fully captured by our measurement methods, then we would also expect measured total factor productivity to increase.

More precisely, this paper focuses on the dynamics of *labor* productivity in the manufacturing sector during the 1990-1994 period, the period for which the data are readily available. We analyze labor productivity—and not total factor productivity (TFP)—because of two equally important reasons. First, labor productivity is an important macroeconomic indicator of earning capacity, and a datum closely followed by the public and policy-makers alike. Second, the data on capital stocks required to study TFP are not of the same good quality as the other data and exist for only about a third of the firms in the sample seriously limiting the scope of the analysis.

Our analysis indicates that the entry of new, highly productive firms and the disappearance of low-productivity firms plays an increasingly significant role in accounting for aggregate labor productivity growth. The productivity performance of continuing firms also has a considerable impact, and is responsible for the year-to-year swings in aggregate productivity growth. We found that the reallocation of employment from more productive to less productive continuing firms had a significant *negative* impact on aggregate productivity growth.

The micro data also enable us to assess that downsizing firms experienced productivity gains. However, aggregate productivity growth relied on firms that increased *both* their productivity and employment levels.

We also go beyond the industry-based definition of a "high-tech" sector by grouping firms according to their investments in research and development (R&D) and quality of their labor force—*not* by their industrial classification—and measure the contribution of such high-tech sector to aggregate productivity growth. Doing this delivers the surprising result that the average growth rate in labor productivity is essentially the same in both sectors. However, because the relative size of the high-tech sector declined during the 1990-94 period, its contribution to aggregate productivity growth was nil (or even slightly negative). It is important to remark that the aggregate data do *not* allow for this type of analysis. These and other ways of looking at the data are only possible with firm-level data.

The rest of the paper is organized as follows. Next section describes the aggregate patterns of the Israeli manufacturing sector during the 1990's, while Section 3 defines the labor productivity measure. Section 4 presents the data and our empirical findings. A summary of the main findings appears in Section 5.

2. A Brief Background

Figure1 displays the time-paths of value-added, hours of work, capital investment, labor productivity and TFP from the aggregate data used by the Research department at the Bank of Israel in its Annual Report. Value-added increased at an average annual rate of 8 percent during 1990-1994, several orders of magnitude above the growth rates experienced during the 1980's. Hours of work and capital investment also grew at a pace unseen in the recent past.

The measured growth in productivity did not change in a significant way during the 90's. This feature is common to most broadly-defined industries: examination of the productivity data in seventeen 2-digit industries turns up the same pattern observed in the aggregate manufacturing data. [2]

If growth was mainly driven by the accumulation of capital and labor rather than by productivity gains, as Figure 1 suggests, this has implications towards the growth potential of the manufacturing sector. Although the goal of this paper is not to prove this conjecture it is opportune to recall a widely cited study by Young (1995) that reaches such a conclusion in a detailed analysis of the East Asian growth experience. [3]

Perhaps the major shaping force of the economy during the early 90's has been the massive immigration from the former Soviet Union and their absorption into Israeli society. The consequent increase in domestic demand was a major cause for the surge in output at the beginning of the decade.

[2] As mentioned before, the counter-cyclical nature of measured productivity in the 1990's rules out explanations based on the unmeasured underutilization of inputs along the business cycle. Such models would predict an opposite productivity performance for Israel's manufacturing sector in the 1990's. Indeed, in part because of this line of thinking, we came to expect a recovery in productivity growth that did not materialize.

[3] One significant problem in measuring productivity is the failure of the official price statistics to keep track, in a timely manner, of the rapid quality changes and associated price reductions of goods and services (e.g., drugs, computers, cellular phones, banking services, etc.). This underestimates the growth in output and related productivity measures. Moreover, as the industries undergoing rapid quality change expand, the measurement problems become more severe. We do not deal with this and other measurement problems here, but it is something to keep in the background (see Griliches, 1994).

On the other hand, the process of trade liberalization continued during the 1990's. The reduction in tariffs and the removal of informal trade barriers, as well as the real appreciation of the exchange rate, opened the Israeli market to stronger foreign competition. Cheap imports of consumer goods competed directly with the output of traditional industries such as textiles, clothing, food, etc. Therefore, the growth in domestic demand caused by the absorption of immigrants, mitigated some of these negative effects. Some of these industries are reorganizing themselves, becoming more productive and more export-oriented, a process accompanied by a high rate of firm turnover.

The removal of trade barriers, the overall positive atmosphere generated by the peace process, and the increase in global demand for more sophisticated and high-tech goods, facilitated the penetration of high-tech Israeli products into foreign markets. In addition, there is some evidence pointing to the important role played by the availability of high-skilled immigrants in making possible the rapid growth of high-tech exports.[4]

Table 1 shows the basic aggregate patterns using the Central Bureau of Statistics *firm-level* data for the period 1990-94.[5]

Table 1: Manufacturing Sector, 1990-1994
Growth Rates
(percentages)

Period	Production (1)	Value-added (2)	Capital Investment (3)	Worker-years (4)	Production per Worker-year (5)	Value Added per Worker-year (6)
1990-1991	3.44	1.53	43.87	3.71	-0.26	-2.10
1992-1991	10.55	10.79	20.16	5.03	5.25	5.48
1993-1992	7.49	1.83	12.48	3.60	3.76	-1.71
1994-1993	11.39	9.32	14.12	5.05	6.04	4.07
1990-1994	9.23	6.30	30.47	4.64	3.88	1.41

Notes: For any variable X the *average* growth rate between 1990 and 1994 is $\left(\frac{X_{94}-X_{90}}{X_{90}} \div 4\right)x100$.

[4] The share of high-tech product in total exports has been rising steadily for the last two decades.

[5] The data set is described in the next Section.

This table also reveals that both gross production and value-added grew very rapidly between 1990 and 1994. Capital investment and worker-years also grew at a very fast pace. However, growth in value-added per worker-year has been modest—and quite erratic— during this period, at an average rate of 1.41 percent per year (the annualized growth rate is 1.38 percent per year).[6] But growth in production per worker-year was much stronger, at an average rate of 3.88 percent per year.

3. Definition and Decomposition of Labor Productivity

Labor productivity at firm i in year t is,

(1) $$A_{it} = \frac{Y_{it}}{L_{it}}$$

where Y_{it} is either value-added or gross output of firm i in year t and employment, L_{it}, is the number of worker-years. The number of worker-years is the number of "full-time" employees (i.e., those working 2000 hours a year, see Appendix 1) in the firm. Thus, this measure of employment takes into account the number of hours worked by the employees (and by the firm owners as well).

The use of temporary workers hired via private employment agencies presents a potentially serious problem because these workers are not counted in the standard measure of employment, L_{it}. Given the ongoing sharp increase in the employment of this type of workers, measures of labor productivity, their growth rates in particular, are biased upwards. However, because the wage bill on these workers is included in the business expenses

[6] In all the tables we use the *average* growth rate over 5 years— between 1990 and 1994—defined as $\frac{X_{94}-X_{90}}{X_{90}} \div 4$, for any variable X, rather that the annualized growth rate $\sqrt[4]{\frac{X_{94}}{X_{90}}} - 1$, to ensure that our decompositions (see below) add up properly.

of the firm, the value-added based measure of labor productivity is less sensitive to this measurement problem.

Outsourcing has a similar effect on the measurement of labor productivity, but it works mainly through the numerator, Y_{it}. By including the value of outsourcing activities in the output measure the output-based measure of labor productivity is biased upward. As the frequency of subcontracting activities to outside firms increases, so does the importance of this bias. The value-added based measure of labor productivity is, again, less affected by the increase in subcontracting and therefore reflects more accurately the firm's own productivity.

These considerations lead us to focus our analysis around the value-added measure of labor productivity, a-priori expecting *lower* growth rates than in output per worker. In fact, the positive difference between the growth rates of production and value-added in Table 1 indicates that the use of intermediate inputs has been rising at a faster pace than output. This is consistent with the empirical and anecdotal evidence pointing to a sharp increase in the amount of outsourcing and in the use of temporary workers hired through manpower agencies.

The aggregate level of productivity in year t is calculated as the ratio of aggregate output, $\sum_{i=1}^{N_t} Y_{it}$, to aggregate employment, $\sum_{i=1}^{N_t} L_{it}$, for any level of aggregation. Because we use a sample of firms we need to multiply each firm's value by its sampling factor in order to get population moments. The sampling factor equals the inverse of the probability of being included in the sample and is denoted by λ_{it}.[7] Aggregate labor productivity is, therefore,

(2) $$A_t = \frac{\sum_{i=1}^{N_t} \lambda_{it} Y_{it}}{\sum_{i=1}^{N_t} \lambda_{it} L_{it}}$$

Aggregate labor productivity can be written as a weighted average of the individual firms' productivity levels,

(3) $$A_t = \sum_{i=1}^{N_t} s_{it} A_{it} \quad , \quad s_{it} = \frac{\lambda_{it} L_{it}}{\sum_{i=1}^{N_t} \lambda_{it} L_{it}}$$

where s_{it} is the population-weighted employment share of firm *i* in aggregate employment.

4. The Data and Empirical Results

The Data

We use firm-level data to examine in detail the growth pattern of labor productivity. The data used in this paper contains information on about 2900 industrial firms with 5 or more employees for the years 1990, 1991, 1992, 1993 and 1994. The data base was constructed by Haim Regev and Malkiel Yoha from the Central Bureau of Statistics (CBS). The data were extracted from the annual Industrial and R&D Surveys carried out by the CBS and includes data on production, materials, labor, capital stock, investment, share of exports, R&D expenditures, as well as on firm characteristics. Regev and Yoha assembled the data from the different surveys, cross-validated the information, created adequate price deflators, and, in general, made the data available for academic research through the research facilities of the CBS.[8] A full account of these data can be found in Griliches and Regev (1995) and a list of the variables used in this paper is presented in Appendix 1.

The Distribution of Labor Productivity over Time

Figure 2 provides estimates of the distribution of value-added per worker, A_{it}, for three of the sample years (1990, 1992 and 1994). Clearly, there is a substantial amount of heterogeneity in the level of productivity across firms. As will be seen below, this empirical fact has important implications regarding the evolution of *aggregate* productivity over time.

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[7] All large firms are included in the sample so that, for them, $\lambda = 1$.
[8] To preserve confidentiality, the files we work with do not include information that can make identification of the firm possible.

The cross-sectional distributions are right-skewed, reflecting the presence of a few, highly productive firms. This asymmetry in the distribution is consistent with the implications of dynamic models of industry evolution where the very inefficient firms quit the industry (Jovanovic, 1990).

Figure 2 also suggests that the location and shape of the distributions of labor productivity did not change much over time. This is corroborated by the descriptive statistics in Table 2.

Table 2: Descriptive Statistics of the Distribution of Labor Productivity

Year	25th percentile	Median	75th percentile	Mean	Standard Deviation	Interquartile Range
1990	10.2	16.1	26.4	22.1	23.4	16.2
1991	9.5	15.7	27.1	22.5	24.7	17.6
1992	9.5	16.4	28.3	23.6	26.8	18.8
1993	9.2	16.0	28.4	22.9	28.3	19.2
1994	10.2	17.8	30.4	24.3	31.1	20.2

Notes: in thousands of 1990 dollars.

The only feature of the distribution of labor productivity exhibiting a somewhat significant change over time is the estimate of the 75th percentile. As a consequence, the mean and dispersion measures of the distribution also increased between 1990 and 1994.

The fact that the distribution of A_{it} does not vary much over time does not tell us much about changes in *aggregate* productivity because the latter is a *weighted* average of the A_{it}*'s* (see (3)). Even in the extreme case of a constant A_{it} over time, aggregate productivity can change because the share of employment across firms with different productivity levels may change over time. If more productive firms become larger (in relative terms) then aggregate productivity increases and, conversely, as the share of employment in the less productive firms increases, aggregate productivity decreases.

Note that the existence of heterogeneity in A_{it} is a necessary condition for this mechanism to operate. One of our goals is to quantify this

composition or ***relative size*** effect on the growth of aggregate labor productivity.

A second issue that cross-sectional distributions cannot reveal is what happened to the productivity level of individual firms. Is the stability of the cross-sectional distribution a result of constant productivity levels—firms maintaining their position in the distribution—or is it a result of productivity increases in *low* A_{it} firms canceling declines in *high* A_{it} firms—micro-turbulence due to firms switching places in the distribution?

Again, because aggregate productivity is a weighted average of A_{it}*'s*, changes in the level of productivity at the firm level can affect the aggregate level even though the individual changes may average to zero as suggested by Figure 2.[9] This mechanism is termed the ***own productivity effect***.

Still, a third issue that cannot be addressed by Figure 2 is the impact of firms leaving and entering the manufacturing sector on the growth of aggregate productivity. If firms leaving the sample are less productive than entering (new) firms, then this ***replacement effect*** can push aggregate productivity up even when the productivity level at the firm remains constant over time (i.e., when productivity acts as a vintage effect).

These three effects can be identified when we write down the growth rate of aggregate productivity. From equation (3) the growth rate in aggregate labor productivity between year *t-1* and *t* is,

(4) $$\frac{A_t - A_{t-1}}{A_{t-1}} = \frac{\sum_{i=1}^{N_t} s_{it} A_{it} - \sum_{i=1}^{N_{t-1}} s_{it-1} A_{it-1}}{A_{t-1}}.$$

Equation (4) indicates that aggregate productivity growth is not only affected by changes in the firm's level of productivity but also by the reallocation of employment across firms—changes in s_i. In addition, the productivity level and relative size of firms entering and quitting the sample between periods *t-1* and *t* affects the growth in aggregate productivity.

[9] Provided there is heterogeneity in relative sizes, which is actually quite large.

The aggregate growth rate can be rewritten so as to emphasize the three effects mentioned above. First by grouping observations into continuing, entering and quitting firms we obtain,

(5)
$$\frac{A_t - A_{t-1}}{A_{t-1}} = \frac{\sum_{i\in C}\left(s_{it}A_{it} - s_{it-1}A_{it-1}\right)}{A_{t-1}} + \underbrace{\frac{\sum_{i\in N}\left(s_{it}A_{it}\right)}{A_{t-1}} - \frac{\sum_{i\in X}\left(s_{it-1}A_{it-1}\right)}{A_{t-1}}}_{\text{Replacement Effect}}.$$

where C is the set of firms operating in periods *t-1* and *t* (the *continuing firms*), *N* is the set of firms that entered between year *t-1* and year *t* (the *entrants*), and *X* is the set of firms that quitted between year *t-1* and year *t* (the *quitters*).

Entering firms add to productivity growth (from zero productivity last year to positive productivity), while quitting firms reduce growth (from positive to zero productivity). The net contribution of entrants and quitters reflects the differences in the level of productivity between the two groups as well as any differences in their relative size.

The relative size and own productivity effects are associated with the continuing firms. This can be seen once the contribution of these firms is written as (see Aw et al. (1997)),

(6)
$$\underbrace{\frac{1}{A_{t-1}}\sum_{i\in C}\left(s_{it}A_{it} - s_{it-1}A_{t-1}\right)}_{\text{Continuing Firms}} = \underbrace{\frac{1}{A_{t-1}}\sum_{i\in C}\left(\frac{s_{it}+s_{it-1}}{2}\Delta A_{it}\right)}_{\text{Own Productivity Effect}} + \underbrace{\frac{1}{A_{t-1}}\sum_{i\in C}\left(\frac{A_{it}+A_{it-1}}{2}\Delta s_{it}\right)}_{\text{Relative Size Effect}}.$$

We start our description of the data by examining the characteristics of entering, continuing and quitting firms and their contribution to growth in aggregate productivity (as per (5)). We then focus on the own productivity and size effects among the continuing firms.

Entrants, Continuing and Quitting Firms

Panel A of Table 3 shows the number of firms entering and exiting the sample. Naturally, the bulk of the firms in any given year are firms continuing in operation from the previous year, but a substantial number of firms entered and exited the sample.

Table 3: Firms, Employment and Labor Productivity
All Manufacturing Firms

	Total	Continuing	Entrants	Quitters
A. Number of Firms in Sample				
1990	2122	—	—	—
1991	2186	1973	213	149
1992	2193	2042	151	144
1993	2290	2058	232	135
1994	2352	2118	234	172
	Population Averages			
B. Employment (Worker-years)				
1990	34.16	—	—	—
1991	32.28	37.55	8.33	11.42
1992	33.48	36.46	10.42	9.44
1993	32.39	37.07	10.64	9.11
1994	33.01	37.05	11.00	9.01
C. Value-added per Worker-year (thousands of 1990 dollars)				
1990	28.21	—	—	—
1991	27.62	28.33	12.92	16.01
1992	29.13	29.50	19.28	14.05
1993	28.63	29.21	19.24	17.35
1994	29.80	30.25	21.52	12.26
D. Production per Worker-year (thousands of 1990 dollars)				
1990	86.08	—	—	—
1991	85.86	87.38	54.76	59.49
1992	90.37	91.00	73.22	51.06
1993	93.76	95.20	70.53	79.98
1994	99.43	100.41	81.50	54.89

Notes: In any given year *t*, *continuing* firms are firms that appeared in the sample in years *t* and *t-1*, *entrants* are firms that *first* appeared in the sample in year *t,* while *quitters* are firms that did not appear in the sample in year *t* but did appear in year *t-1*. For the quitting firms, the average in year *t* corresponds to the average of year *t-1* values. Employment, value-added and production per worker are population averages in each cell (i.e., each firm's value is inflated by its sampling factor). The number of firms is the number in the sample, i.e., the firm counts are not inflated by the sampling factor.

In every year, about 10 percent of the firms are newcomers, while about 7 percent of the firms cease to exist, i.e., quit.[10] These turnover figures are a bit above the figure reported by Griliches and Regev (1995) for

[10] There are 1680 firms that appear in every year of the sample period— the balanced panel. There are 31 firms that quitted and reentered the sample. These firms therefore appear as entering (at least) twice. Six firms changed industry, but this was not considered an "exit" or "entry".

the 1979-88 period. Notice also that in every year there are more entrants than quitters, but there is no evidence of a time trend in this difference. Table 4 shows the distribution of entry and exit by industry in every year.

Table 4: Distribution of Entry and Exit by Industry: 1990-1994

Industry	Entry 1991	Entry 1992	Entry 1993	Entry 1994	Exit 1991	Exit 1992	Exit 1993	Exit 1994
Total number of firms	213	145	215	225	149	145	133	168
	Percentages							
Mining and quarrying	0.9	0.7	0.9	0.9	0.0	0.7	0.8	0.6
Food, beverages, and tobacco	14.1	9.0	9.8	8.0	16.1	13.2	7.5	12.5
Textiles	1.4	0.7	1.4	4.0	4.7	2.1	3.0	0.6
Clothing and made-up textiles	10.8	11.0	16.7	14.2	14.8	16.0	16.5	17.9
Leather and its products	6.1	7.6	5.6	4.0	4.7	8.3	7.5	5.4
Wood and its products	8.0	10.3	6.5	8.4	6.7	8.3	10.5	8.9
Paper and its products	3.8	2.1	5.6	0.9	3.4	4.9	0.8	1.8
Printing and publishing	5.6	6.2	7.9	9.3	6.7	6.9	7.5	7.1
Rubber and plastic products	7.0	6.2	5.1	6.2	4.7	7.6	6.0	4.8
Chemical and oil products	1.4	4.1	1.9	3.1	4.0	2.8	0.8	1.2
Non-metallic mineral products	6.1	9.0	2.3	7.1	3.4	5.6	8.3	5.4
Basic metal	0.9	1.4	0.9	1.3	1.3	0.7	3.0	0.0
Metal products	16.9	15.9	17.2	12.0	10.1	10.4	11.3	16.1
Machinery	1.4	4.1	4.2	4.9	6.7	2.8	3.0	3.6
Electrical and electronic equipment	8.0	6.2	7.9	9.8	6.7	4.9	6.0	7.7
Transport equipment	1.4	1.4	0.5	0.4	2.0	0.7	0.8	1.2
Miscellaneous	6.1	4.1	5.6	5.4	4.0	4.2	6.8	5.3

Notes:

Columns may no add-up to 100 because of rounding.

Interestingly, three industries account for 35-45 percent of entry *and* exit in every year: food, beverages and tobacco (SIC 11), clothing and made-up textiles (SIC 14), and metal products (SIC 23). This jives with our prior notion that the first two industries are facing severe competition from abroad as tariffs for their output were significantly reduced during this period, and the latter may be an industry undergoing rapid technical change. Times of structural change give rise to both entry and exit of firms as the changing environment, on the one hand, proves unprofitable to the less productive firms, but on the other hand, generates new opportunities that lead to the creation of new business ventures. Importantly, food and clothing are industries using relative low skilled labor requiring less specific human capital. This, in turn, may lower the costs associated with entering and exiting these industries and consequently generate high turnover rates. This is consistent with theoretical models in which firm turnover is negatively associated with entry costs (e.g., Hopenhayn, 1992).

Table 3 also presents some basic information on the average employment size and labor productivity of continuing, entering and quitting firms. Panel B shows that the average continuing firm is about 4 times larger than the average entering firm. On the other hand, both entrants and quitters are of comparable size: they employ about 10 worker-years at the beginning or at the end of their lifetime, respectively. But entering firms are, on average, more productive than quitters (panels C and D). This is reflected in Figure 3 where the estimated distribution of labor productivity for entering and quitting firms, pooled over the 4 years, is shown. Moreover, the initial productivity level of the new firms appears to increase with the cohort of entry.

Table 5 decomposes the growth in aggregate value-added per worker into the contributions of continuing, entering and quitting firms (the three terms on the right-hand side of equation (5)).

Table 5: Contribution of Continuing, Entering and Quitting Firms To Growth in Aggregate Labor Productivity
(percentages)

Year	All Firms (2) + (3) (1)	Continuing Firms (2)	Entering + Quitting Firms (4) + (5) (3)	Entering Firms (4)	Quitting Firms (5)
1991-90	-2.10	-2.33	0.22	2.12	-1.90
1992-91	5.48	4.46	1.03	2.49	-1.46
1993-92	-1.71	-3.77	2.06	3.85	-1.79
1994-93	4.07	1.72	2.35	3.89	-1.54
Average 1990-94	1.41	-0.38	1.79	3.72	-1.93

Notes: The terms in the decomposition appear in equation (6).

The "Average 1990-94" row shows average growth for the 1990-1994 period for the 1699 firms that appear in the sample in 1990 and 1994 (the set C), for the 646 firms that appear in the sample in 1994 but not in 1990 (the set N), and for the 442 firms that appear in the sample in 1990 but not in 1994 (the set X).

Recall that the net contribution of entrants and quitters reflects the differences in the level of productivity between the two groups as well as any differences in their relative size. We know that the size of the entering and quitting firms is about the same, but that the former group is more productive. And we also know that in every year the number of entrants is larger than the number of quitters (Table 3). We therefore expect the net contribution of entry and exit to aggregate productivity growth to be positive as shown in Column (3) of Table 5.

Remarkably, this contribution is increasing over time and is relatively large. This means that, as a group, entrants are increasingly more productive than quitters, and their net contribution accounts for a significant portion of the aggregate growth in manufacturing. In fact, in 1993 and in 1994 growth would have been measurably lower were it not for the net contribution of the new entrants.[11]

Column (2) indicates that the erratic pattern in the growth of aggregate labor productivity over time reflects the continuing firms' performance.[12]

The last row in the panel decomposes the average growth over the period into the contributions of the 1699 firms operating both in 1990 and 1994, of the 646 firms that entered the sample after 1990, and of the 442 firms that quitted by 1994.[13] Overall, the change in productivity among the continuing firms is quantitatively less important than the positive net effect of entrants and quitters. However, the entry effect maybe overstated in the last row of the table because "entrants" includes also "young" firms, i.e., firms appearing in the sample after 1990.

This finding differs sharply from the growth experience during the 1980's (Griliches and Regev, 1995), and from the experience in the U.S. manufacturing sector during the 1972-1987 period analyzed by Bailey,

[11] This conclusion holds at the within-industry level as well. In all industries, except food, the net effect of entry and exit is positive. This means that in almost every industry entering firms are, as a group, more productive and/or larger than quitting firms. Moreover, the net entry and exit contribution is, in most industries, comparable in magnitude to the contribution of continuing firms, and in some cases it is the main contributor to growth in the industry (e.g., metal products and machinery). Hence, firm turnover also has a measurable effect on productivity growth at the industry-level.

[12] Recall that the entries are contributions to growth in aggregate productivity and not the productivity growth rate of the continuing firms. In fact, the continuing firms grew on average at 1.5 percent per year during the 1990-94 period (see Table 8).

Hulten and Campbell (1992), where the net effects of entry and exit were found to be negligible. But it accords with the growth experience in Taiwan's manufacturing sector during the 1980's where the high rate of firm turnover contributed significantly to output and productivity growth (Aw et al. 1997).

In order to shed some light into the performance of the continuing firms we now decompose their contribution to aggregate productivity change into a part corresponding to changes in their productivity level—changes in A_{it}—and a part corresponding to changes in their relative size—changes in s_{it}, as given by (6). Table 6 presents the result of this decomposition.

Table 6: Contribution of Continuing Firms to Aggregate Growth
(percentages)

Year	Total Contribution (1)	Change in Firms' Productivity (2)	Change in Firms' Relative Size (employment share) (3)
1991-90	-2.33	-0.62	-1.71
1992-91	4.46	5.06	-0.60
1993-92	-3.77	-2.18	-1.59
1994-93	1.72	2.45	-0.73
Average 1990-94	-0.38	1.25	-1.63

Column (2) indicates that productivity growth *within* the continuing firms drives the erratic growth pattern of these firms. The effect of changes in employment shares across firms—the relative size effect—can be positive or negative depending upon whether the firms that were above average productivity level were increasing or decreasing their shares of employment between periods.[14] Column (3) indicates that the relative size term is always negative and quite large in a few years. This suggests that the continuing

[13] These are the 1680 firms that appear in the five years of the sample and 19 firms that quitted and reentered.

[14] Because $\sum_{i\in C}\frac{A_{it}+A_{it-1\tau}}{2}\Delta s_{it} \approx \sum_{i\in C}\left(\frac{A_{it}+A_{it-1}}{2}-\frac{\bar{A}_t+\bar{A}_{t-1}}{2}\right)\Delta s_{it}$. This is only an approximation because the sum of the employment shares over the continuing firms *only* does not add up to one (it adds up to 0.95 approximately). However, the approximation is good because $\sum_{i\in C}\Delta s_{it}$ is very close to zero in every year.

firms that reduced their relative size were, on average, among the more productive firms.[15]

Clearly, the reallocation of employment from more productive to less productive firms had a significant *negative* impact on aggregate productivity growth. However, over the 5-year period, about 80 percent of this depressing effect (-1.63) is compensated by the growth in the firms' *own* labor productivity (1.25) during the period

To sum up, the entry of new, highly productive firms and the disappearance of low-productivity firms play an increasingly significant role in accounting for aggregate productivity growth. In this respect the Israeli manufacturing sector performance accords more with the Taiwanese than with the U.S. experience. The productivity performance of continuing firms also has a considerable impact, and is responsible for the year-to-year swings in aggregate productivity growth.[16] However, their growth performance has been systematically undercut by the reallocation of employment from more to less productive firms.

Downsizing and its Effects on Productivity Growth

Firm downsizing, i.e., a reduction in the size of the firm's labor force, is often rationalized as an integral part of a process of structural change that will eventually result in productivity gains. It is interesting then to try and confront this notion with our data.

First, we regressed the percentage change in labor productivity between 1990 and 1994 on a dummy variable equal to one for firms that increased their number of worker-hours (L) during the period, and zero for those that did not (as well as on industry dummies). Column (1) of Table 7 presents this result.

[15] Of course, this does not imply that higher productivity *causes* a reduction in relative size; both variables are endogenous.

[16] Industry differences are significant. In some industries (e.g., food and textiles), the continuing firms increased their productivity significantly, whereas in others (e.g., clothing, leather, wood and paper), these firms continued to decline and growth was due to the contribution of new firms. In about half the industries, including electronic and transportation equipment, the productivity level of the continuing firms decreased by 1994!

Table 7: Productivity and Labor Change: 1990-1994

Dep. Variable = $\dfrac{A_{i94} - A_{i90} / A_{i90}}{4}$

	(1)	(2)
Dummy (ΔL > 0 =1)	-0.050 (0.041)	—
Dummy (2nd Quartile ΔL)	—	-0.100 (0.056)
Dummy (3nd Quartile ΔL)	—	-0.075 (0.057)
Dummy (4nd Quartile ΔL)	—	-0.138 (0.056)
R^2	0.014	0.017
N	1699	1699

Notes: observations correspond to the 1699 firms that appeared in the sample in 1990 and 1994. Standard errors in parenthesis. Industry dummies were included in each regression.

The estimated coefficient of the dummy variable indicates that, within the same industry, firms that increased their labor force experienced 0.05 percentage point lower productivity growth than firms that decreased their hours of work. This is not much of a quantitative difference, nor is it statistically significant.

Next, we assigned each firm to a quartile in the distribution of ΔL between 1990 and 1994, and used dummies for the last three quartiles in the regression. The estimated coefficients were all negative, larger in absolute value, and mostly significantly different from zero.

These results tell us that firms that increase their labor force are expected to have lower productivity growth rates. This is certainly not surprising given that we have not controlled for changes in the capital stock. In any case, regression results cannot reveal the magnitude of the changes in productivity among those firms that *upsized* or *downsized*.

It is interesting therefore to sort firms by the change in *absolute* size of their labor force and trace their productivity performance. Following Baily, Bartelsman and Haltiwanger (1994), we divide the same sample of 1699 continuing firms into four groups. The first group comprises firms that decreased their workforce and increased their productivity (the successful downsizers). The second group includes firms that downsized but did not increase their productivity (the unsuccessful downsizers). In the third group we have firms that raised both employment and productivity (the successful upsizers), and lastly, the fourth group gathers firms that upsized but reduced their productivity level (the unsuccessful upsizers).

A firm can be found in one such group for a variety of reasons. The downsizers may be facing a fall in demand and fail to completely adjust employment to the new scale of production (unsuccessful downsizers). Or, they may be facing a fall in demand and react by adopting labor-saving techniques, i.e., they engage in “restructuring” the operation of the firm (successful downsizers). Such a fall in demand would be consistent with the opening up of the domestic market to competitive foreign imports.

The successful upsizers are possibly facing increased demand combined with increasing returns to scale in their technology. Alternatively, these firms may have experienced technical change that moved their supply function along an elastic demand. This may well be the case characterizing the high-tech sector in Israel. The unsuccessful upsizers may be firms facing increased demand but having a technology exhibiting decreasing returns to scale, or firms shifting to lower quality employees (which would be observed by falling wages).

Panel A of Table 8 shows that the number of firms *increasing* and *decreasing* their levels of labor productivity between 1990 and 1994 is about the same. However, there are 60 percent more upsizers than downsizers. Note that about half the downsizers and upsizers increased their productivity level between 1990 and 1994.

Table 8: Downsizing and Productivity Growth
All Continuing Firms during 1990-1994

A: Number of Firms

Group	$\Delta A_{ij94} \leq 0$	$\Delta A_{ij94} > 0$	All
$\Delta L_{ij94} \leq 0$	294	362	656
$\Delta L_{ij94} > 0$	523	520	1043
All	817	882	1699

B: Average Growth in Value-Added per Worker-year

Group	$\Delta A_{ij94} \leq 0$	$\Delta A_{ij94} > 0$	All
$\Delta L_{ij94} \leq 0$	-8.03	18.71	2.04
$\Delta L_{ij94} > 0$	-8.10	15.04	1.11
All	-8.17	16.86	1.52

C: Contributions to Aggregate Average Growth in Value-Added per Worker-year

Group	$\Delta A_{ij94} \leq 0$	$\Delta A_{ij94} > 0$	All
$\Delta L_{ij94} \leq 0$	-3.59	0.17	-3.42
$\Delta L_{ij94} > 0$	-1.36	4.40	3.03
All	-4.95	4.57	-0.38

Notes: All entries are in percentages.
Entries in panels B and C refer to the average growth rate and contribution between 1990 and 1994.

Turning now to the marginals in panel B of Table 8, the 656 downsizers increased their labor productivity on average by 2.0 percent per year, while labor productivity among the 1043 upsizers grew on average by only 1.1 percent per year. Thus, the popular notion that downsizing and productivity growth are positively correlated appears to be correct. What is sometimes ignored, however, is that productivity growth also occurred in half of the firms that increased employment over the period.

The contribution of an individual firm to aggregate productivity growth depends also on the changes in its relative size. Because downsizers are getting smaller, the contribution of their increased productivity to aggregate growth is diminished. In fact, the size effects are so large that the downsizers' contribution to aggregate growth is negative (Panel C). Among the downsizers, growth in value-added per worker contributed on average -3.42 percentage points per year to aggregate manufacturing growth, while among the upsizers—which did not increase their productivity as much as the downsizers— it contributed 3.03 percent per year![17]

[17] The difference equals -0.38 percent: the total contribution of the continuing firms to aggregate growth in labor productivity (Table 6).

Thus, growth in aggregate productivity among the continuing firms is due to the upsizing firms, even though the downsizing firms experienced a higher rate of growth in labor productivity. Furthermore, among those continuing firms that experienced positive growth in labor productivity between 1990 and 1994 (882 firms), downsizers (362 firms) grew by 18.7 percent per year but only contributed 0.17 percentage point per year to aggregate growth, while the upsizers (520 firms) grew by 15.0 percent per year, but contributed 4.4 percentage points per year to aggregate growth!

In sum, the data support the argument that downsizing firms experienced productivity gains. However, aggregate productivity growth relied on firms that increased both their productivity and employment levels.[18]

High-tech and Traditional Firms:

The firm-level data allow us to group firms in different ways and compute the productivity contributions of these groups. In general, aggregate productivity is as a weighted average of the productivity level in each group. Thus, its growth rate is affected by the productivity growth in each group and by changes in their relative size (employment share).[19]

One such decomposition is into high-tech and traditional firms. Table 9 shows the contributions of the firms in the high-tech and traditional sectors to aggregate manufacturing growth.

According to one definition of high-tech—those firms having positive R&D expenditures—the contribution of the high-tech firms during 1990-1994 to growth in aggregate value-added per worker was nil! In fact, in every year except 1991, traditional firms contribute more than high-tech firms to aggregate productivity growth.

[18] This was also observed in U.S. manufacturing firms (Baily, Bartelsman and Haltiwanger, 1994).
[19] The algebra for the decomposition of aggregate productivity is presented in Appendix 2.

Table 9: High-tech Contribution to Growth in Aggregate Labor Productivity
(percentages)

Year	All firms (1)	High-tech Firms (2)	Traditional Firms (3)
		High-tech = Positive R&D (No. of firms)	
1991-90	-2.10 (2186)	-0.26 (331)	-1.84 (1855)
1992-91	5.48 (2193)	1.48 (336)	4.00 (1857)
1993-92	-1.71 (2290)	-1.78 (345)	0.07 (1945)
1994-93	4.07 (2352)	0.66 (349)	3.41 (2003)
Average 1990-94	**1.41 (2352)**	**0.00 (349)**	**1.41 (2003)**
		High-tech = Positive R&D and Above Average Labor Quality (No. of firms)	
1991-90	-2.10 (2186)	-0.20 (168)	-1.90 (2018)
1992-91	5.48 (2193)	0.90 (170)	4.58 (2023)
1993-92	-1.71 (2290)	-1.66 (178)	-0.05 (2112)
1994-93	4.07 (2352)	0.16 (179)	3.91 (2173)
Average 1990-94	**1.41 (2352)**	**-0.22 (179)**	**1.63 (2173)**

This surprising result still obtains when a more restrictive definition of high-tech is used. The "Positive R&D" definition of high-tech encompasses about 15 percent of the firms in the sample. Requiring firms to have positive R&D *and* above average labor quality halves the number of high-tech firms.[20] Nevertheless, the bottom panel of Table 9 shows a similar picture when this more restrictive definition is used.

In interpreting these results one must bear in mind that many high-tech firms producing advanced products, e.g., software, are not part of the manufacturing sector. Nevertheless, these results are striking.

In order to shed some light on the forces driving this unexpected result we decompose the total growth in productivity in each sector into the

[20] Labor quality is an index of technical-scientific labor "quality" in which the proportion of engineers, technicians and other workers are weighted according to their relative wages. R&D engineers and technicians are not included in this index; they appear in the R&D expenditures. See Appendix 1.

contributions of continuing, entering and quitting firms.[21] Table 10 presents these results.

Table 10: Labor Productivity Growth Decomposition by Sector

A: High-tech = Positive R&D

	High-tech (No. of firms)				Traditional (No. of firms)			
Year	Total Growth	Cont.	Entr.	Quit.	Total Growth	Cont.	Entr.	Quit.
1991-90	1.00 (331)	0.65 (324)	0.63 (7)	-0.28 (3)	-3.78 (1855)	-3.86 (1643)	3.76 (212)	-3.68 (152)
1992-91	4.41 (336)	3.75 (328)	0.97 (8)	-0.31 (3)	6.64 (1857)	5.65 (1707)	4.03 (150)	-3.05 (148)
1993-92	-2.17 (345)	-3.20 (328)	2.17 (17)	-1.15 (8)	-0.66 (1945)	-3.26 (1714)	6.56 (231)	-3.95 (143)
1994-93	2.80 (349)	0.23 (340)	2.63 (9)	-0.06 (5)	5.34 (2003)	3.06 (1769)	6.55 (234)	-4.28 (176)
Average 1990-94	**1.51** **(349)**	**0.52** **(311)**	**1.65** **(38)**	**-0.66** **(16)**	**1.84** **(2003)**	**-0.76** **(1360)**	**6.07** **(643)**	**-3.47** **(435)**

B: High-tech = Positive R&D and Above Average Labor Quality

	High-tech (No. of firms)				Traditional (No. of firms)			
Year	Total Growth	Cont.	Entr.	Quit.	Total Growth	Cont.	Entr.	Quit.
1991-90	1.32 (168)	1.24 (165)	0.25 (3)	-0.18 (1)	-3.21 (2018)	-3.41 (1805)	3.19 (213)	-2.99 (151)
1992-91	3.41 (170)	2.80 (167)	0.88 (3)	-0.27 (1)	6.61 (2023)	5.37 (1873)	3.40 (150)	-2.16 (145)
1993-92	-2.01 (178)	-3.69 (168)	2.41 (10)	-0.73 (2)	-0.82 (2112)	-3.03 (1881)	5.53 (231)	-3.32 (142)
1994-93	3.83 (179)	2.31 (174)	1.48 (5)	0.04 (4)	4.88 (2173)	2.21 (1939)	5.52 (234)	-2.85 (173)
Average 1990-94	**1.65** **(179)**	**0.79** **(160)**	**1.24** **(19)**	**-0.38** **(6)**	**1.83** **(2173)**	**-0.50** **(1526)**	**5.25** **(647)**	**-2.92** **(430)**

[21] Firms were classified to the high-tech sector on a yearly basis, so that there is entry to and exit from the high-tech sector (as well as to and from the sample). Entrants can be incumbent firms moving from the traditional to the high-tech sector, or new firms altogether. Quitters can be firms abandoning their R&D projects, and moving to the traditional sector, or firms leaving the sample altogether.

Note first that labor productivity in the high-tech sector grew at an average rate of 1.50-1.65 percent per year, while the traditional sector grew at an average rate of 1.85 percent per year. According to either definition of high-tech, both sectors grew at almost the same average pace.[22] Moreover, *continuing* high-tech firms outperform *continuing* traditional firms in terms of productivity growth. This result is more in line with our priors.

In Table 9, however, we saw that the *contribution* of the high-tech sector to aggregate growth was negative. This implies that the employment share—relative size—of the high tech sector declined between 1990 and 1994 and that this effect was strong enough to overcome the positive effect stemming from the growth in its own productivity. In fact, the employment share of the high-tech sector declined almost monotonically during the period, loosing almost 2 percentage points from 1990 to 1994.[23]

Interestingly, productivity growth within each sector is driven by different forces. In the high-tech sector, where the number of new and retiring firms (entrants and quitters) is small—both in absolute and relative terms—the major contributor to growth in the sector is the positive growth performance of the continuing firms. In the traditional sector, however, continuing firms had, on average, a *lower* value-added per worker in 1994 than in 1990, so that the positive productivity growth in this sector is exclusively the result of firms entering and quitting that sector. This reflects, first and foremost, the fact that the relative and absolute number of firms entering and quitting the traditional sector is quite large.

In both sectors the magnitude of the net contribution of entry and exit relative to the contribution of the continuing firms is quite large, emphasizing again the important role these flows of firms play in shaping aggregate productivity growth.

An possible explanation for the lesser importance of *net* entry and exit effects in the high-tech sector is that new high-tech firms have a lower productivity level (relative to the incumbents) because it takes time until their R&D projects bear commercially applicable results. Moreover, because the exit threshold is likely to be higher, firms abandoning the high-tech sector should be more productive as those quitting the traditional sector. On

[22] Even though in every year, except 1991, the traditional sector grew faster.

both accounts, therefore, the *net* effect of entry and exit should be smaller in the high-tech sector.

The data in Table 11, however, do not support this interpretation. The table suggests that there are not significant differences in the productivity levels of entrants and quitters between the two sectors (relative to the incumbents in each sector).[24]

[23] According to the first definition of high-tech—those firms with positive R&D—its share of employment was 27.8 percent in 1990 and 26.2 percent in 1994. Using the second definition, we have 18.7 percent in 1990 and 17.1 percent in 1994.

[24] But, given the small number of observations in the high-tech sector, this issue requires further analysis.

Table 11: Productivity Level of Entrants and Quitters
(Relative to incumbents)

Year		High-tech Firms (1)	Traditional Firms (2)
		High-tech = Positive R&D (No. of firms)	
1991-90	Entering Quitting	0.59 (7) 0.85(3)	0.59(212) 0.75(152)
1992-91	Entering Quitting	0.74(8) 0.85(3)	0.79(150) 0.67(148)
1993-92	Entering Quitting	0.81(17) 0.73(8)	0.83(231) 0.89(143)
1994-93	Entering Quitting	1.02(9) 0.11(5)	0.88(234) 0.72(176)
Average 1990-94	Entering Quitting	**0.81(38)** **0.65(16)**	**0.92(643)** **0.74(435)**
Year		High-tech Firms (1)	Traditional Firms (2)
		High-tech = Positive R&D and Above Average Labor Quality (No. of firms)	
1991-90	Entering Quitting	0.65 (3) 0.78(1)	0.56(213) 0.72(151)
1992-91	Entering Quitting	0.97(3) 1.64(1)	0.75(150) 0.57(145)
1993-92	Entering Quitting	0.81(10) 0.76(2)	0.78(231) 0.82(142)
1994-93	Entering Quitting	0.96(5) -0.08(4)	0.84(234) 0.59(173)
Average 1990-94	Entering Quitting	**0.82(19)** **0.71(6)**	**0.88(647)** **0.70(430)**

Another question of interest that can be addressed with our firm-level data is the correspondence between an industry-based definition of "high-techness" and the firm-based definitions used in this work. Table 12 displays the industry distribution of firms in the high-tech sector according to the two previous definitions.

Table 12: Industry Distribution of High-tech Firms in 1994

(percentages)

Industry	High-tech = Positive R&D	High-tech = Positive R&D and Above Average Labor Quality
Mining and quarrying	0.94	1.35
Food, beverages, and tobacco	9.97	4.38
Textiles	2.65	0.34
Clothing and made-up textiles	0.94	0.00
Leather and its products	0.16	0.00
Wood and its products	0.78	0.00
Paper and its products	0.78	0.67
Printing and publishing	1.56	1.68
Rubber and plastic products	11.05	9.43
Chemical and oil products	13.07	17.85
Non-metallic mineral products	0.94	0.00
Basic metal	0.94	1.01
Metal products	8.26	8.75
Machinery	3.27	3.03
Electrical and electronic equipment	32.70	38.05
Transport equipment	4.52	3.03
Miscellaneous	7.47	10.43
Manufacturing Sector	**100.00 (349 firms)**	**100.00(179 firms)**

Notes: The proportion of firms in each industry are population proportions.

Table 12 indicates that between 33 and 38 percent of the high-tech firms belong, as expected, to the electrical and electronic equipment industry, while another 35 percent belongs to the plastics, chemical and metal products industries combined. The only unexpected result is that the food industry comprises a significant number of high-tech firms.

Table 13 looks into this issue from the other direction: it shows the proportion of firms in each industry belonging to the high-tech sector, the degree of high-tech intensity in each industry.

Table 13: Proportion of High-tech Firms in 1994 by Industry
(percentages)

Industry	High-tech = Positive R&D	High-tech = Positive R&D and Above Average Labor Quality
Mining and quarrying	8.70	5.80
Food, beverages, and tobacco	5.80	1.18
Textiles	4.45	0.26
Clothing and made-up textiles	0.40	0.00
Leather and its products	0.40	0.00
Wood and its products	0.52	0.00
Paper and its products	2.59	1.04
Printing and publishing	1.04	0.52
Rubber and plastic products	13.10	5.17
Chemical and oil products	33.87	21.37
Non-metallic mineral products	1.28	0.00
Basic metal	4.26	2.13
Metal products	2.78	1.36
Machinery	4.5	1.93
Electrical and electronic equipment	28.26	15.21
Transport equipment	13.49	4.19
Miscellaneous	10.67	6.89

Notes: The proportion of firms in each industry are population proportions.

As expected, the highest proportions of high-tech firms are in the electrical and chemical industries. However, a large majority of the firms in *any* industry are not high-tech. Hence, defining the high-tech sector according to industry affiliation can be very misleading.

It is also of interest to ask the following question: to which industries do the firms that increased their labor productivity belong? Table 14 gives the industry distribution of the 882 (see Table 8) firms that increased their productivity between 1990 and 1994.

If one classifies the first six industries in Table 15 as "traditional" industries then a third of the firms experiencing an increase in labor productivity during 1990-94 belong to industries not usually associated with the high-tech sector.

Table 14: Industry Distribution of Firms with $\Delta A > 0$

Industry	Percentage
Mining and quarrying	0.53
Food, beverages, and tobacco	9.74
Textiles	4.88
Clothing and made-up textiles	9.11
Leather and its products	1.71
Wood and its products	9.46
Paper and its products	1.24
Printing and publishing	7.00
Rubber and plastic products	6.25
Chemical and oil products	2.89
Non-metallic mineral products	6.59
Basic metal	1.62
Metal products	21.03
Machinery	6.13
Electrical and electronic equipment	6.47
Transport equipment	2.40
Miscellaneous	2.95
Manufacturing sector	882 firms

In sum, grouping firms according to their own characteristics into a high-tech and traditional sector delivers the surprising result that the average growth rate in labor productivity is essentially the same in both sectors. However, because the relative size of the high-tech sector declined during the 1990-94 period, its contribution to aggregate productivity growth was nil (or even slightly negative).

Labor productivity among continuing high-tech firms grew over the period, while it declined among continuing traditional firms. Thus, the contribution of firm turnover to productivity in the traditional sector was more important than in the high-tech sector.

About 70 percent of the high-tech firms belong to the electronics, plastics, chemicals and metal products. On the other hand, not all firms in these industries are high-tech. Indeed, at the very least 2/3 of the firms in each industry cannot be said to be high-tech (Table 13). Finally, about a third of the firms having positive productivity growth during 1990-94 belong to what are usually considered traditional industries. Thus, the availability of firm-level data allow us to cast strong doubts on the relevance of the mapping between high-techness and industry affiliation.

5. Summary of the Results

Our analysis of firm-level data in the manufacturing sector during the 1990-94 period unearthed the following findings:

- The entry of new, highly productive firms and the disappearance of low-productivity firms played an increasingly significant role in accounting for aggregate productivity growth.
- The increase in the employment share of the less productive firms depressed aggregate growth considerably.
- Downsizing firms experienced productivity gains.
- But aggregate productivity growth relied on firms that increased both their productivity and (absolute) employment levels.
- The decrease in the employment share of the high-tech sector resulted in a nil or slightly negative contribution to aggregate productivity growth.
- A third of the firms experiencing an increase in labor productivity between 1990 and 1994 do *not* belong to the industries usually associated with “high-tech”.

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Appendix 1: List of variables

Identity (N1): 6-digit firm identity number.

Year (YR1): survey year.

Expansion Factor (GN1): expansion factor coefficient, equal the inverse of the probability of being sampled. Almost all large firms have GN1=1.

Branch (BR1): 2-digit industrial branch. See table for codes. The variable used is BR2 which merges some of the industries in BR1.

Sector (SC1): Type of ownership. See table for codes.

Establishment Year (EY1): year in which the firm was established.

Continuity (RPL1): Discrete variable with values 0 to10 describing year in which the firm started and ended reporting to the Survey. See table for code.

Production (PK1): Output per worker-year in thousands of 1990 dollars. The price deflator for output combines price deflators for the local (wholesale price) and for the export market. These deflators are calculated at the 3-digit level for about 100 industries, and each firm weights each deflator according to the share of exports in the firm's output. An alternative variation is that each firm in the same 3-digit industry has the same output price deflator.

Materials (MK1): materials per worker-year in thousands of 1990 dollars. The price of materials is also at the industry level and is obtained from the I0 tables and from import price deflators.

Employees (E1): Number of employees in the firm. Average of the number of employees working in the firm during the reporting months. An employee is a worker that worked for at least one day during the reporting month.

Worker-year (L1): Number of "full-time" employees in the firm. This is calculated as 12 times the monthly average number of hours *worked* by employees divided by 2000 hours. This gives the number of full-time (i.e., working 2000 hours) employees. Hours for each of the owners of the firm are added.

Capital Services (KS1): Per worker-year. Defined as the sum of estimated depreciation on the net stock of capital plus the cost of equipment and building rentals. This variable was could be estimated directly for most large firms for which capital stock data existed (or could be computed). For most small firms, capital service levels were imputed statistically, using information on investment in the sample and its relation to the estimated capital services and other variables in the sub-sample with available capital stock data. See Griliches and Regev (1995) for more details and references.

Appendix 2: Decomposition of Aggregate Productivity

We usually classify firms according to some grouping criteria e.g., high-tech versus traditional, 2-digit SIC code, etc. Naturally, we are interested in the contribution of each group to aggregate productivity.

Aggregate productivity is as a weighted average of the productivity level in each group, and productivity in group *j* is itself a weighted average of the individual firms' productivity levels in the group. Let A_{jt} be the productivity level in group *j*. Then,

$$A_{jt} = \frac{\sum_{i=1}^{N_{jt}} \lambda_{ijt} Y_{ijt}}{\sum_{i=1}^{N_{jt}} \lambda_{ijt} L_{ijt}} = \sum_{i=1}^{N_{jt}} \omega_{ijt} A_{ijt}, \qquad \omega_{ijt} = \frac{\lambda_{ijt} L_{ijt}}{\sum_{i=1}^{N_{jt}} \lambda_{ijt} L_{ijt}}$$

where ω_{ijt} is the population-weighted employment share of firm *i* in group *j*'s employment. Adding up over groups,

$$A_t = \frac{\sum_{j=1}^{J} \sum_{i=1}^{N_{jt}} \lambda_{ijt} Y_{ijt}}{\sum_{j=1}^{J} \sum_{i=1}^{N_{jt}} \lambda_{ijt} L_{ijt}} = \sum_{j=1}^{J} \omega_{jt} A_{jt}, \qquad \omega_{jt} = \frac{\sum_{i=1}^{N_{jt}} \lambda_{ijt} L_{ijt}}{\sum_{j=1}^{J} \sum_{i=1}^{N_{jt}} \lambda_{ijt} L_{ijt}}$$

where ω_{jt} is the population-weighted employment share of group *j* in total manufacturing employment.

Aggregate growth rate in labor productivity is, therefore,

$$\frac{A_t - A_{t-\tau}}{A_{t-\tau}} = \frac{\sum_{j=1}^{J} \left(\omega_{jt} A_{jt} - \omega_{jt-\tau} A_{jt-\tau} \right)}{A_{t-\tau}}.$$

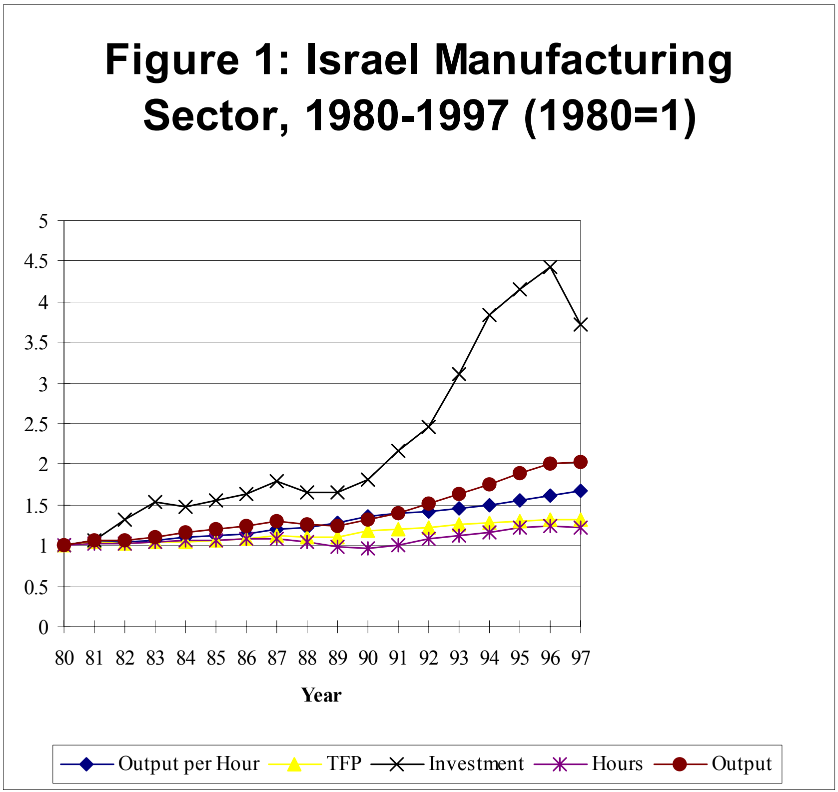

Figure 1: Israel Manufacturing Sector, 1980-1997 (1980=1)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97
Year
Output per Hour
TFP
Investment
Hours
Output