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The Contribution of the Competitive Process to Productivity Growth The Role of Firm and Plant Turnover

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The Contribution of the Competitive Process to Productivity Growth The Role of Firm and Plant Turnover

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THE CONTRIBUTION OF THE COMPETITIVE PROCESS
TO PRODUCTIVITY GROWTH The Role of Firm and
 Plant Turnover

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DISCUSSION PAPER NO. 769

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Introduction

Technical change has often been described as disembodied -- a type of manna from heaven. While progress has been made in dispelling the image that technical change is bestowed in some ephemeral form, much still remains to bring reality to the exercise. When technical progress is related to a more earthly form, it is generally embedded in such concrete factors as labour and machines. Studies of productivity tend to ignore the contribution that the worldly process of competition makes to growth. Improvements in productivity are rarely related, at least in empirical studies, to the dynamics of firm turnover.

The industrial economics literature contains several tentative steps to measure certain aspects of this relationship; but none tie the various pieces of the puzzle together. One branch has investigated the relationship between changes in concentration and efficiency. Peltzman (1977) examines the relationship between changes in industry unit costs and concentration. Martin (1988) examines the relationship between the share of the top 4 firms and their relative productivity. Neither approach comprehensively measures the amount of firm turnover across all firms nor does it track changes in their productivity.

A separate literature has tried to infer the effect of competition on productivity by examining the relationship between patents, research and development expenditures, or some other proxy for inventive activity, on the one hand, and measures of market structure, on the other hand. This literature suffers in that it rarely measures productivity; nor does it examine the extent of firm turnover directly. Instead of using firm turnover, concentration statistics are relied upon for inferences about the effect of market structure. Elsewhere, we have shown that the usual concentration measures are poor proxies for the process of firm growth and decline which provides the foundation for the competitive process.¹

This paper addresses both deficiencies. It briefly summarizes the importance of the growth and decline of manufacturing firms. Then the proportion of the total increase in

the productivity that is due to the turnover process is calculated.

Growth and Decline of Producers

Market structure, to most industrial economists, is synonymous with measures of concentration.² These measures are relatively stable over time and tend to give a false impression that little change is occurring in the underlying firm size distribution. It is true that some have recognized that underlying change in firm position is not incompatible with a stable measure of concentration. On the theoretical side, Simon and his colleagues have developed models of stochastic firm growth and decline that yield a steady-state distribution of firms that is approximated with a class of skewed distributions that fit most firm size distributions reasonably well.³ On the empirical side, Hymer and Pashigian (1962) have suggested that the turnover of firms should be utilized to measure the extent of competition.

Unfortunately, there have been few systematic attempts to investigate the characteristics of market dynamics across a wide range of industries.⁴ One of the foremost reasons for this has been the paucity of longitudinal data that track firms and establishments over longer periods. The recent development of a longitudinal database that follows establishments and firms in the Canadian Census of Manufactures has overcome this deficiency.⁵ Associated papers use these data (Baldwin and Gorecki, 1990a, 1990c) to outline just how much change is occurring as some firms and establishments grow and others decline as a result of the competitive process.

Change is measured first by separating producers into those whose employment grew and declined. In the short run, there is considerable expansion and contraction in the establishment population (Baldwin and Gorecki, 1990e). On average, over the period from 1971-1981, the rate of annual employment growth due to births and expansion was 9.2 per cent; the rate of employment decline due to exits and contraction was 8.4 per cent.⁶ Most of this was due to expansion and contraction in continuing plants. The annual growth in employment due to entrants was only 1.6 per cent on average; the annual job

loss due to exits was only 1.9 per cent.

Some of short-run change is reversed in the long run. In particular, continuing establishments that grow or decline more or less continuously have much lower annualized long-run rates of growth or decline. Nevertheless, the cumulative effect of growth and decline is substantial. Over the period from 1971 to 1981, plant entrants added 19 per cent to 1971 employment in the manufacturing sector; expansion in continuing plants added 21 per cent. On the exit side, 19 per cent of 1971 employment was lost due to plant closures between 1971 and 1981 and 12 per cent from contraction in the continuing plant sector.

Changes in relative market shares (based on shipments) were also used to provide an alternate measure of the extent to which the growth and decline process causes the relative position of producers to change. In order to investigate the amount of share gain and loss, establishment market shares at the four digit industry level were calculated. Losers were divided into those that exited and those continuing establishments that declined in relative size. Gainers were divided into entrants and continuing establishments that grew in relative size. Figure 1 shows how much market share was shifted on average across 167 4-digit industries between 1970 and 1979.

In 1970, establishments that were to exit over the next decade possessed 22.7 per cent of market share -- 18.1 per cent in plants that would be closed by exiting firms and 4.6 per cent in plants that would be closed by continuing firms. By 1979, new plants would account for 21.3 per cent of market share -- 16.1 per cent in plants associated with entrants and 5.2 per cent in plants opened by continuing firms. The plant entry and exit process then shifted 20 percentage points of market share⁷ from one group of establishments to another.

In 1970, plants that were to continue in the same industry to 1979 but lose share by the latter date possessed 46.4 per cent of total shipments while those that would gain market share accounted for only 30.8 per cent on average. At the end of the decade, these percentages were 32.1 and 46.6 per cent respectively. Contracting plants had lost 14.3 per cent on average; expanding plants had gained 15.8 per cent on average. The amount that

The Components of Establishment Turnover

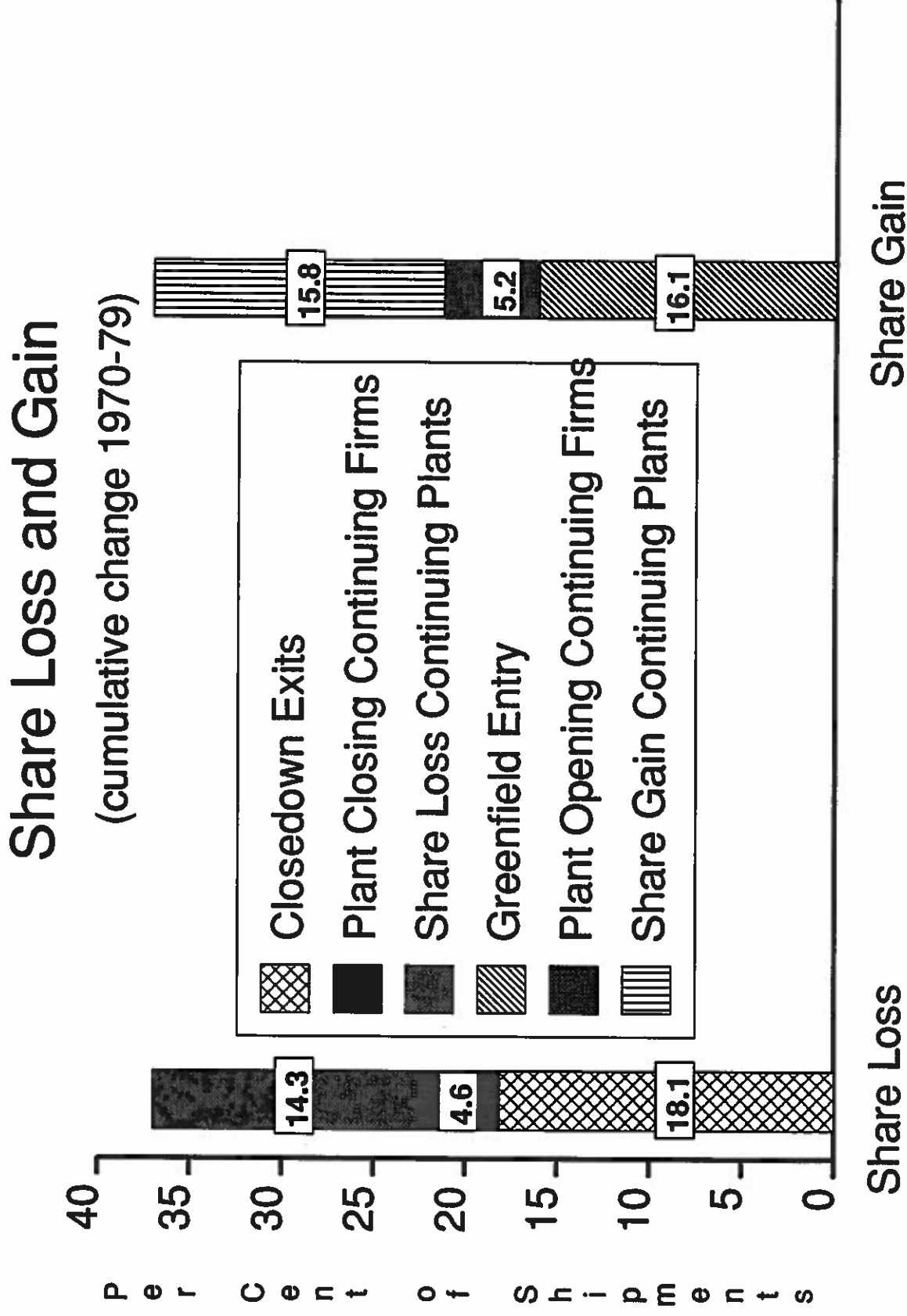


Figure 1

was shifted in this segment was some 15 percentage points on average. This is slightly less than the amount shifted as the result of plant entry and exit. Together, entry and expansion, exit and contraction caused a significant percentage of total market share to be shifted from the relatively unsuccessful to the relatively successful.

Productivity and Firm Turnover

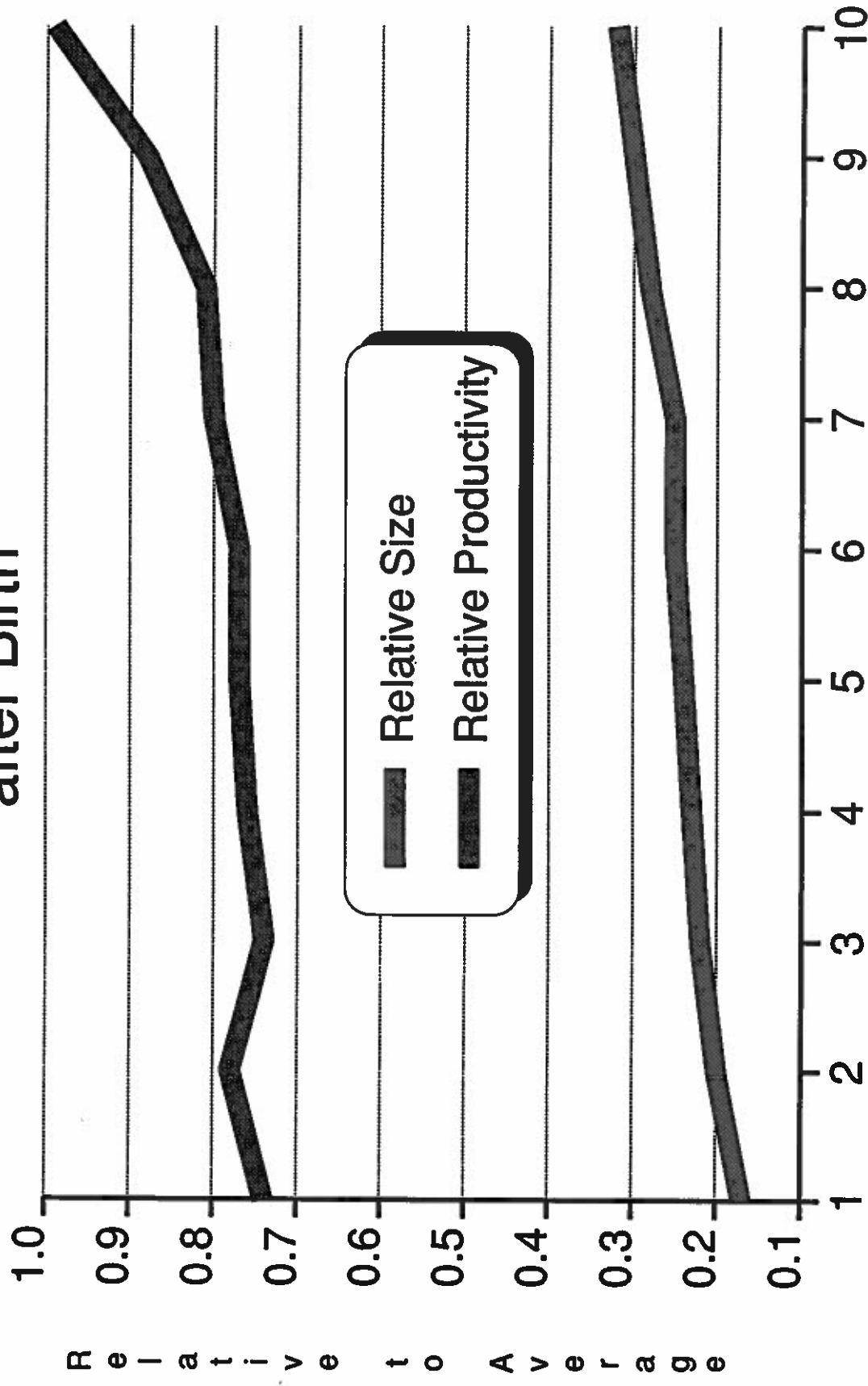
The importance of entry and exit as well as expansion and contraction in the continuing sector must be judged not just by the share of shipments transferred by the turnover process, but also by its effect on a measure of industry performance. The remainder of the paper demonstrates that the turnover process contributed a significant proportion of total productivity growth experienced over the 1970s.

The importance of entry and exit varies in the short and the long run. The course of the post-birth performance of new firms entering the manufacturing sector has already been discussed in Baldwin and Gorecki (1990a). At birth, the share of these entrants is small; greenfield entrants new to the manufacturing sector as a whole accounted annually only for an average of 0.9 per cent of employment between 1970 and 1982. Infant mortality rates in this group are high. Over the same period, the average death rate in the first year after birth was about 10 per cent. Over 50 per cent die within the first decade. Nevertheless, the remaining greenfield entrants in a cohort grow sufficiently rapidly that the total share of the cohort expands over the decade.

While the market share of a cohort of entrants increases, its progress is slow. This is also the case for productivity improvements. Figure 2 depicts the relative progress of greenfield entrants in terms of size and productivity. The graph plots the ratio of mean value of the size (employment) and productivity (value-added per worker) of firm entrants that opened new plants relative to the mean for all firms in the manufacturing sector.⁶ Entry is defined as a firm that is new to the manufacturing sector.

Greenfield entrants commence operations at a relatively small size. At birth, their average plant size is only about 17 per cent that of existing firms. Subsequently, they

Average Relative Productivity and Size of Greenfield Entrants after Birth



Year since Birth

Figure 2

increase their relative size slowly to about 33 per cent by the end of their first decade of life. At birth, the labour productivity of greenfield entrants averages about 73 per cent of incumbents; after a decade, they have become about equally as productive as this group. The effect of entry and exit on overall industry productivity then is likely to emerge more strongly in the longer run and should be measured over a relatively long period.

There is a second reason that a longer period should be used to capture the effects of turnover on productivity. The performance of continuing establishments varies considerably in the short and long run. In the short run, change in this sector contains a large transitory component. It is only in the longer run that structural changes in relative market share begin to clearly emerge in the continuing sector.⁹

In order to evaluate the effect of entry and exit on the productivity of an industry, the period from 1970 to 1979 is chosen and the productivity of plants in the two periods is examined. Productivity is measured as value-added per worker and changes are measured in real terms.¹⁰ More comprehensive (total factor productivity) measures of productivity are not employed for several reasons. The first is that this study is interested in how turnover impacted on output per worker because this measure ultimately is closely associated with well-being. Moreover, since the pioneering work of Salter (1966), it has been shown to be closely correlated with other measures of productivity. Second, more comprehensive measures of productivity have, as one of their goals, the objective of accounting or correcting for other factors that cause output per worker to increase. More complex measures of productivity were not used because the purpose of the paper is to establish the connection between turnover and the success of firms in increasing output per worker. It is not intended to establish the causes of this success. Since labour productivity is being used rather than total productivity, it may be that the paper just measures the effect of capital deepening or some other reason for the success that some firms had in increasing output per worker. If this is so, an alternative interpretation of this paper is that it establishes the importance of firm turnover in facilitating this capital deepening.

The effect of plant and firm turnover on productivity is of interest not only because

of what it can tell us about the importance of the competitive process but also because of what it tells us about the way in which this process functions. Importance will be judged in the next section by the extent to which productivity gains are associated with plant turnover; but first, a broad overview of the relationship between plant turnover and productivity differentials is developed. To do so, two procedures are followed. In the first, all plants are divided equally on the basis of value-added per worker and evidence is sought on the nature of the competitive process by asking such questions as: Did the least productive plant segment contain a higher proportion of exits than the segment with the most productive plants? Did the most productive segment contain a higher proportion of births than the least productive segment? Did those continuing plants that gained market share also gain relative productivity? Answers to these questions serve to provide a picture of the extent to which the competitive process weeds out the least efficient and replaces them with the more efficient.

There are potential shortcomings to the first test procedure that is employed here. First, efficiency is normally considered to incorporate other dimensions than just productivity. Second, productivity involves other dimensions than just output per worker and thus the use of value-added per worker may not even capture differences in productivity. If output per worker is not very closely associated with efficiency differences, the test may find little difference in the tendency of plants to exit. Third, the test uses the relative rankings of firms for only one year -- 1970 or 1979 -- to capture relative position. If there are considerable fluctuations in relative plant productivity due to transitory shifts in output that are not matched by labour reductions, the rankings in any one year may not correspond to long-run efficiency differentials. Despite these shortcomings, the dynamics of the competitive process emerge so clearly that further modifications of the procedure were adjudged to be superfluous.

Although the first section establishes a relationship between the replacement process and relative productivity differences, it has a disadvantage in that, by focusing on probabilities of success and failure, it does not provide measures which are suggestive of the extent to which the turnover process enhances productivity. This is done in the

following section. There the productivity of entrants and exits relative to incumbents is calculated directly. These results are more revealing than those yielded by the procedure that divides all plants on the basis of productivity -- because it allows the relative productivity of the entrant or exiting group to be more clearly delineated.

a) Relative Productivity and Firm Growth and Decline

If turnover is related to productivity gains, then entry, exit, expansion, and contraction should be related to relative productivity differentials. A pattern should emerge that shows exits and contracting establishments to be the least productive, entrants and expanding establishments to be more productive. The relationship between plant turnover and relative productivity differentials is investigated in this section by posing a series of questions. These are:

1) Is exit a purely random process or does it remove the less efficient?

This issue was approached by examining whether plants that were less productive also tended to exit more frequently. The population of plants in each industry as of 1970 was divided equally into two parts on the basis of output per worker. Then the number of closures was calculated for the top and bottom half of each industry. This was done on an industry basis to standardize for industry specific factors. Four different exit categories were used. Exiting plants were divided first into those associated with exiting firms and those made by continuing firms.¹¹ Then, each of these categories was divided into plants that closed (deaths) and those that left an industry and moved to another (switches).¹²

The probability of exit calculated across the whole sample (i.e., all exits for all industries that fall in a segment (bottom or top half) divided by the number of establishments in the segment) is reported in Table 1. The probability of exit by plant closure by exiting firms was significantly higher for the less productive plants. This is not the case for plant closures by continuing firms.

Table 1

The Proportion of Plant Entrants and Exits
in the Canadian Manufacturing Sector
Above and Below the Median Plant Classified
on the Basis of Labour Productivity
(%)

Category	In Bottom 50 %	In Top 50%	Significance of Differences

New Firm New Plant			
1) Plant Birth(23)	18.02	20.42	<.001
2) Plant Switch(23s)	5.20	4.32	.004
Continuing Firm New Plant			
3) Plant Birth(13)	2.87	5.19	<.001
4) Plant Switch(13s)	0.52	0.76	.04
Exiting Firm Exiting Plant			
5) Plant Closure(34)	29.36	21.39	<.001
6) Plant Switch(34s)	4.56	4.36	.47
Continuing Firm Exiting Plant			
7) Plant Closure(14)	3.23	3.80	.028
8) Plant Switch(14s)	0.36	0.54	.040

Note:

1) The plants in each of the 167 industries were divided equally on the basis of labour productivity and the number of entrants in each group was counted. The proportions reported are the sum of all such entrants or exits divided by the sum of all plants above or below the median. Calculating the proportion by industry and taking the mean across all industries yields basically the same results.

2) The minimum significance level required to reject the null hypothesis that the proportions are the same.

2) If initial year productivity determines the probability of exit, does it also influence a different measure of success --the subsequent growth rate over the decade? Is growth and decline conditional on initial productivity?

This question was addressed by examining whether the plants that were more productive in 1970 tended to grow faster over the subsequent decade than plants that were less productive. In order to do so, the output growth rate was calculated for each continuing plant. Plants in each industry as of 1970 were once more divided equally into two parts on the basis of productivity and the proportion in each of the two groups that experienced high growth rates was calculated. High was defined as a rate which increased a plant's relative share of continuing plant sales.

Table 2 contains the proportions of the more and less productive group of plants that experienced an above average rate of output growth. Two samples were used to rank continuing plants as being above or below median productivity. The first excluded exits and thus considered only continuing plants. The second included exits. The conclusions are not affected by the sample chosen.

In 1970, the more productive segment had a significantly lower proportion of plants that subsequently had high growth than did the less productive segment. Thus, if a plant was relatively more productive in 1970, it had a lower chance of exiting but also a lower chance of gaining market share relative to other continuing plants over the subsequent decade.

The same phenomenon can be examined by comparing the median growth rate in output between 1970 and 1979 for the most and least productive plants in 1970 for each of the 167 4-digit manufacturing industries. The mean and the median of the differences in the top and bottom half growth rates were calculated for the entire sample of industries. For the continuing plant sample, the bottom half had significantly higher growth rates than the top half.¹³ But this is the result of using a truncated sample that excludes exits. When the sample that includes exits is used, the top half is no longer the laggard. It grows at least as quickly as the bottom half.¹⁴ The difference in the results of the two samples is illustrative of the care that should be taken when trying to infer the

Table 2

The Proportion of Continuing Plants
in the Canadian Manufacturing Sector
Above and Below the Median Plant Classified
on the Basis of Labour Productivity that
Gained Market Share Between 1970 and 1979
(%)

Year of Comparison	Sample Used to define Median Plant	
	Continuing Plants	All Plants
1979		
Percentage Above Median Gaining Share	59	44
Percentage Below Median Gaining Share	38	31
1970		
Percentage Above Median Gaining Share	47	31
Percentage Below Median Gaining Share	51	35

Note:

- 1) The plants in each of the 167 industries were divided equally on the basis of labour productivity and the number of plants gaining share in each group was counted. The proportions reported are the sum of all such plants divided by the sum of all plants above or below the median. Calculating the proportion by industry and taking the mean across all industries yields basically the same results.
- 2) The differences between the proportions reported here are significant at the 1% level.

behaviour of a population of producers from just the continuing segment.

The more productive plants in 1970 then were less likely to exit over the subsequent decade but gains in market share within the continuing segment were not as likely. Gains in market share within this group then depend on superior performance in more than one year. This accords with those studies that suggest the performance of continuing producers, in other than adjacent years, is not correlated.¹⁶

It is important to note how the differences in the two groups change as the sample changes. When continuing plants are taken alone, being in the high productivity segment means market share will be lost -- relative to the rest of this population. But if exits are included, this is no longer the case. The process is more symmetric when the growth rates of all plants are considered.

3) Is there a connection between a plant's ability to grow and its performance at the end of the period? Are the most productive plants at the end of the period more likely to have gained market share over the decade? Are those plants that grow more rapidly during the decade more productive at the end of the period?

This issue was addressed first by examining whether plants that were more productive in 1979 had grown faster over the decade than the less productive in 1979. Plants, as of 1979, were divided equally on the basis of labour productivity and the proportion of high growth plants above and below the median level of productivity was calculated. Those plants in the most productive half of the 1979 distribution had a much higher proportion that grew more rapidly during the decade. By way of contrast, growth performance over the decade was not related or only weakly related to initial (i.e., 1970) productivity performance. Success then, as measured by gains in market share, was associated with superior productivity performance -- where the latter was measured at the end rather than at the beginning of the decade.

4) Are entrants randomly distributed or do they concentrate in the most productive plants?

This issue was addressed by asking whether the more productive plants in 1979

had a higher proportion of entrants than the less productive segment. The universe of plants in each 4-digit industry as of 1979 was divided on the basis of labour productivity and the number of entrants in the top and bottom half was tabulated. Entrants were broken down first into new plants associated with new firms and then with continuing firms. Then, each of these categories was broken into newly opened plants (births) and plants that were switched from another industry (switches).

Table 1 contains the proportion of plants in each of these entrant categories in the most and least productive set of plants.¹⁶ Plant births for both new and continuing firms made up a larger proportion of the more productive than the less productive segment. The difference is greatest for new plants of continuing firms. As was the case with the exiting categories, switches did not follow the same pattern. Plant switches by continuing firms were more likely to be in the more productive segment in 1970 and end up in the more productive segment in 1979. Plant switches that caused a firm to exit one industry and enter another were equally likely to be in either segment in 1970 but were more likely to end up in the less productive segment in 1979.

In summary, the pattern of entry and exit in the plant population would have contributed to improvements in productivity. First, the less productive plants in 1970 were more likely to exit. Secondly, in 1979 plants born since 1970 made up a greater proportion of the more productive than the less productive plants.

b) The Relative Productivity of Entrants and Exits

The contribution that this process made to total growth in productivity depends on several factors. First, it will be a function of the size of the shares of entrants, exits, and the shift in shares within the continuing segment between those establishments whose relative productivity is growing and those whose relative productivity is declining. Secondly, it will also depend upon the relative productivity of the various components.

i) Exits

A comparison of the productivity of exits relative to the continuing segment at the beginning of the period gives an indication of the potential gains from exits. For the comparative exercise, continuing plants that did not have a change in ownership are chosen.¹⁷ Plant exits are divided into four categories -- the closed and switched plant¹⁸ of exiting firms, the closed and switched plant of continuing firms. Table 3 contains the mean and the standard error (column 1) of the ratio of the median productivity¹⁹ of each of these exit categories to the median productivity of continuing plants²⁰ for 167 4-digit manufacturing industries.²¹ A test of significance for the difference in the two medians is presented in column 2.

Closed plant associated with exiting firms had the lowest relative productivity. On average, they were only 79 per cent as productive as continuing plants in 1970. The difference between the two is significant. Plant switches that led a firm to exit were also less productive than average. *Ceteris paribus*, establishment exits associated with exiting firms would, therefore, improve industry productivity performance as the less efficient are weeded out.

A simple comparison of average productivity differences at the 4-digit industry level may conceal the true significance of exits, especially if they are concentrated in only a portion of all 4-digit industries. Moreover, it does not standardize for other factors.

The primary difference between exiting and continuing plants is size. Generally, smaller plants are less productive than larger ones. Therefore, exiting plants may be less productive only because they are small plants.²² To investigate this issue, a regression of 1970 productivity (PROD) on size (SIZE) as measured by employment, and dummy variables for the various exit categories was estimated for the entire plant sample. Industry dummies and interaction effects with size were also included to allow for different industry effects such as differing capital-output ratios.²³ The results are reported in Table 3, column 3, where the estimated coefficients are the ratio of the productivity of plants in an exit category to the productivity of plant in the continuing category that did not change ownership and the probability value is the significance level required to reject

Table 3
Relative Labour Productivity of Plant Entrants
and Exits Compared to Continuing Plants¹
for 167 4-digit Manufacturing Industries

Category	Mean ¹ (S.E. of Mean) ²	Significance of Sign Rank Test for First Differences ³	Regression Coefficient (Prob value) ⁴

EXITS ¹			
a)Exiting Firms			
1)Closed Plant(34)	0.79 (.02)	<.001	.89 (.009)
2)Plant Switch(34s)	0.96 (.04)	.001	.97 (.018)
b)Continuing Firms			
1)Closed Plant(14)	0.96 (.04)	.003	1.01 (.020)
2)Plant Switch(14s)	0.99 (.07)	.280	1.07 (.054)
ENTRANTS ¹			
c)Entering Firms			
1)Plant Births(23)	1.04 (.03)	.173	1.16 (.010)
2)Plant Switch(23s)	0.95 (.04)	.003	0.98 (.018)
d)Continuing Firms			
1)Plant Births(13)	1.15 (.05)	.006	1.31 (.020)
2)Plant Switch(13s)	0.93 (.06)	.146	1.09 (.048)

Notes:

- 1) Productivity is measured for plant exits as of 1970 and for entrants as of 1979 relative to continuing plants that did not change ownership. The mean is calculated across 167 industries. It is the average of the ratio of the median estimate of the productivity of each class divided by the median estimate of the productivity of the continuing class.
- 2) The standard error of the mean is in brackets below the mean.
- 3) the probability of a greater absolute value of the signed rank statistic for the mean difference in the medians of productivity in each entry class less that of the continuing class under the null hypothesis of no difference.
- 4) The probability value is the minimum level of significance required to reject the null hypothesis that the relative productivity of the category relative to the continuing sector is one.

the null hypothesis that the exit category is no less productive than the establishments of continuing firms that do not change ownership over the decade. The results show that plant closures and plant switches associated with exiting firms were significantly less productive than the continuing segment that did not change ownership over the decade.

It is noteworthy that the productivity disadvantage of plant closures by exiting firms remains even after the size effect has been removed. Plants do not exit just because their smallness causes a productivity disadvantage. Plant exits may on the whole be smaller than the population average; but they suffer even more of a productivity disadvantage than might be expected given their size.

There are two ways of explaining the exit process. The first is that exits occur because of random fluctuations in demand that are more likely to force the output of small plants to zero and cause exits. The second is that competition drives out the inefficient. In actual fact, both explanations probably hold. Random fluctuations may cause smaller firms to suffer a productivity disadvantage if they impact more heavily on this segment. But this effect should be caught by the size variable in the regression analysis. Exit is, therefore, not just a random phenomenon brought about by variations in demand that might affect smaller plants more intensively. In addition to the random effect, there is also a natural selection process at work that drives out the inefficient.

Finally it should be noted that the exiting plant of continuing firms (both closed plant and switched plant) are not found to be less productive than average in the regression analysis. Taken by itself, this would suggest that the continuing sector makes no contribution to productivity growth with plant closures. But that will turn out to be incorrect. Closures are only one-half of the turnover process and the effect of one should not be evaluated in isolation of the other -- unless the opening of new plants is unrelated to the closure of old plants.

ii) Entrants

Table 3 also contains the mean of the ratio of the median productivity in 1979 of plant entrants relative to the median productivity of plants that survived the decade

without a change in ownership for 167 4-digit manufacturing industries. Both plant birth categories were more productive than continuing plants; but, the only significant advantage occurred for plant births of continuing firms. Plant switches in both categories are less productive than continuing plants.

As in the case of exits, these averages take no account of productivity differences that might be expected because of size differences. Despite the progress they had made in terms of relative size since birth, greenfield entrants as of 1979 were considerably smaller than existing plants. A regression of productivity comparable to that done for exits was estimated across the entire plant sample. Productivity in 1979 was regressed against employment (a measure of size), dummy variables for industries and for entry categories. The coefficients from this regression are also reported in Table 3. Once again, they represent the ratio of the productivity of the entry category relative to establishments that were in the same 4-digit industry in both 1970 and 1979 and that did not change ownership. The results show that when corrected for size, productivity in the new firm plant birth categories is now significantly higher than that of continuing plants. Continuing firm new plants are significantly more productive. Plant switches for new firms are significantly less productive than continuing plants. Plant switches for continuing firms are more productive.

An additional regression was estimated for the two plant birth categories alone in an attempt to further detect the selection process at work. Jovanovic (1982) and Pakes (1988) have formulated models of entry that incorporate a learning process. In a world where adaptation and learning occur, entrants that succeed gradually approach the size and productivity of continuing firms.

Figure 2 already was used to depict the annual progress in relative productivity made by each entry cohort as it matured. But the estimates for Figure 2 were calculated at a relatively aggregated level -- for greenfield entrants that were new to the manufacturing sector as a whole. Data at the 4-digit industry level in 1979 for all entrants since 1970 can also be used to track the progress of entrants. Plant entrants as of 1979 can be dated by their year of entry. Therefore, the 1979 size (employment) of all

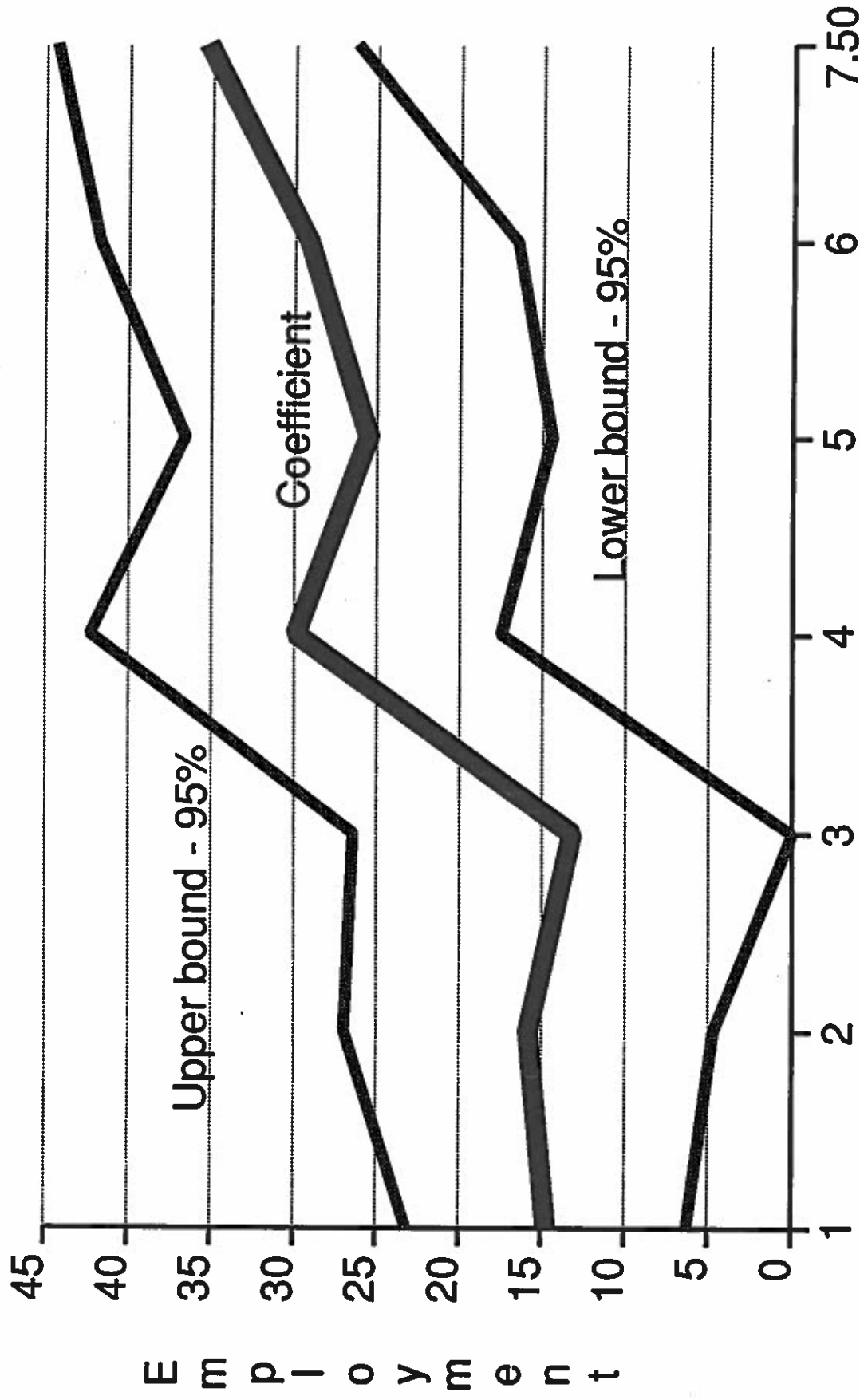
plants that entered between 1970 and 1979 and that were still alive in 1979 was regressed on binary variables for year of birth and industry dummies to test for the learning effect. The estimated coefficients for each of the year of birth variables and a 95 confidence interval for each are plotted in Figure 3. The previous results using aggregate data are confirmed with this micro data. The further away the year of birth is from 1979, the larger is the coefficient on the year of birth. It is evident that the older the plant, the larger it was. Table 4 contains the regression results of a slightly different formulation. The size of entrant was regressed on a trend variable ($T=1,2,\dots,9$) to capture the age of the entrant and industry dummies. Age is highly significant. The results suggest that successful entrants grew at about 8 per cent per year. Entering plants increase their relative size slowly but surely over the decade.

Productivity of 1979 entrants was also regressed on size,³⁴ industry dummies and a time trend to capture age. Two different productivity variables were used -- shipments per worker and value-added per worker. The estimated coefficients for the time variable are reported in Table 4. Even with size of plant controlled, age still had a significantly positive coefficient. The results depicted in Figure 3 and Table 4 are consistent with the adaptive model. Entrants can appear with lower than average size and productivity but the successful ones increase their relative size and productivity over time.

iii) Continuing Plants

The third source of productivity gains comes from the replacement process within the continuing plant sector. It has already been demonstrated that over the decade of the 1970s, almost as much share changed hands as a result of expansion and contraction in continuing establishments as by entry and exit. Accompanying this were substantial changes in relative productivity. In order to measure the extent to which changes in relative productivity were taking place, the continuing plant population was divided into those that increased and those that decreased market share between 1970 and 1979. The mean of the ratio of the productivity of the gainers to the losers, calculated across 167 4-digit industries in 1970 was .98 ³⁵ (standard error of the mean was .02), which was not

The Regression Coefficient of Employment Size on Age for 1979 Entrants



Years Since Birth

Figure 3

Table 4

The Relationship Between Size or
Productivity and Age for 1979 Entrants

Dependent Variable	Regressors			R ²
	Intercept	Log of Employment	Time Since Birth	
Employment	15.05 (1.45) [.148]		3.65 (8.16) [.0001]	.17
Log of Employment	2.63 (20.87) [.0001]		0.083 (15.46) [.0001]	.24
Log of Shipments/ Employee		0.065 (0.752) [0.452]	0.021 (5.71) [.0001]	.48
Log of Value-Added/ Employee		0.074 (0.878) [.380]	0.013 (3.61) [.0003]	.27

Notes: 1) The regression coefficients were estimated from the entire sample of long-form establishments that entered between 1970 and 1979 and were still extant in 1979.

2) The t value is included immediately below the coefficient estimate in round brackets and the associated prob value is included in square brackets.

significantly different from unity. The mean of the relative productivity of the two groups in 1979 was 1.34 (s.e.=.09), which was significantly different from unity. Plants that grew more quickly over the period did not start with an advantage in productivity; but by the end of the decade, they had become 34 per cent more productive on average than those losing market share. The growth and decline process in the continuing plant segment also served to enhance the average level of productivity over the decade.

Taken together, the results on the relative productivity of exiting plant and entering plant demonstrate a pattern. Continuing firms are not closing plant that is relatively unproductive; but they are opening plant that is very much more productive than the average. It is this group that is at the frontier of new knowledge and techniques. A plant does not have to be substandard for it to be closed when the opportunities to make a substantial gain in productivity are known. Exiting firms that close plant and entering firms that open plant show a different pattern but one that has the same effect on productivity. The closed plant of exiting firms is much less productive than the average, even when allowances are made for plant size differences. These firms are the failures. Firms that enter with newly opened plant are initially not more successful than the average continuing plant. A learning process takes place that gradually increases the size and productivity of the successful entrant. To the extent that these entrants replace the exiting firms of below average productivity, industry average productivity will be enhanced by the turnover associated with the entry and exit process.

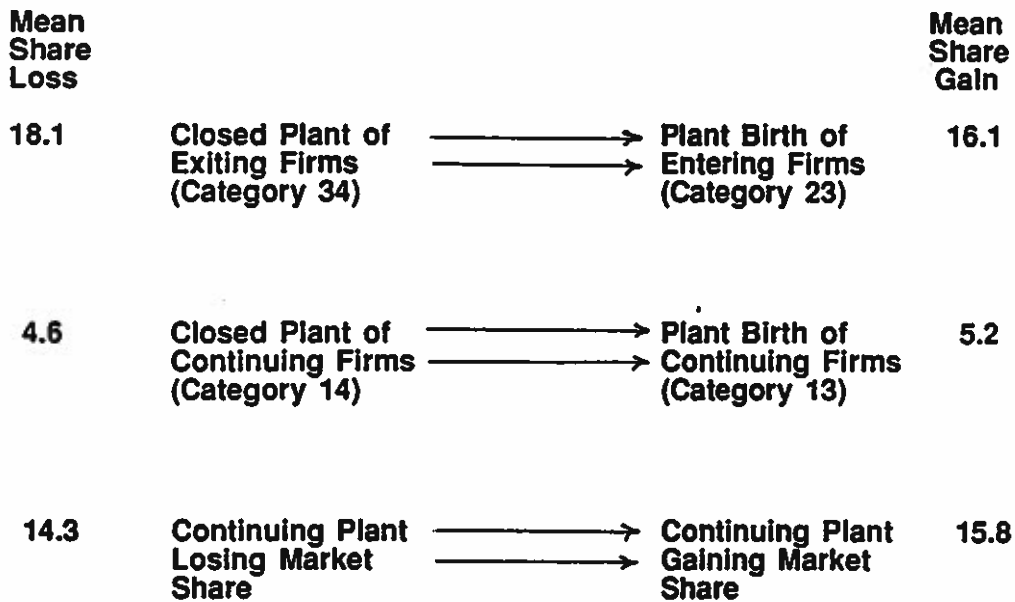
Measuring the Effect of Plant Turnover on Productivity Growth

The data then reject both the view that the turnover of plants is quantitatively unimportant and that this process makes no contribution to overall productivity growth. The size of the contribution is the subject of this section.

In order to measure the effect of each of the entry categories, it is tempting to think of a simple trade-off process akin to that depicted in Figure 4, with each entry category replacing one exit category -- new plant of new firms replacing closed plant of

Figure 4

A SCHEMATIC OF A SIMPLE REPLACEMENT PROCESS



Note: Share change is defined in terms of industry shipments at the 4-digit level.

exiting firms; new plant of continuing firms replacing closed plant of continuing firms; and share increases in continuing plants displacing share decreases in the continuing sector. There are several reasons for postulating this replacement pattern. First, the individual components of each pair are symmetrical in definition. Moreover, they are sufficiently different in concept that inter-group rivalry might not be expected to be very strong. Finally, as Figure 1 demonstrated, the respective losses and gains for each category are similar though not identical.

This characterization of the replacement process generates a straightforward measure of productivity gains that each turnover category contributes. For then the relative performance of each category that gained share can be set against that of one category that lost share. Plant births of entrant firms are much more productive in 1979 relative to continuing plants than the closed plants of exiting firms were in 1970 -- a ratio of 1.04 versus .79 (Table 3, column 1). Plant births of continuing firms are also more productive in 1979 relative to the continuing plant population than are the closed plants of continuing firms in 1970 -- a ratio of 1.15 in 1979 against 0.96 in 1970. Finally, continuing plants that gain share have become 1.34 times as productive on average as those that lost share over the decade. In 1970, there was no significant difference between the two.²⁸

The relative magnitude of the productivity gains that were being generated can be obtained from a comparison of the increase in productivity between 1970 and 1979 within each category relative to the increase that was managed by the losers in the continuing sector -- the plants that lost market share to other continuing plants. The latter provide a convenient standard of comparison in that they continue to exist over the decade but they are not able to maintain market share. Plant turnover associated with entering and exiting firms produced a mean productivity gain (the 1979 productivity of the former minus the 1970 productivity of the latter) equal to 1.43 (s.e. of mean = .09) times that in the contracting sector. Productivity growth in continuing sector plants that gained market share was on average 1.49 (s.e. of mean = .08) times that in the declining sector. Productivity growth associated with plant turnover by continuing firms (the productivity

of new plants in 1979 minus that of closed plants in 1970) was on average 1.56 times (s.e. of mean = .10) that in the declining sector.

a) The Effect of Each Entry Category Considered Independently

Measuring the effect of entry and exit will be approached in two ways. First, total growth in labour productivity is arbitrarily broken into terms that involve entry and exit. Unfortunately, there is more than one way to break total growth down and, thus, more than one way to measure the effect of entry. This is more than just the standard index number problem. Secondly, an explicit simplifying assumption will be made about the way entry affects exits as opposed to the continuing plant population. This will be referred to as the replacement assumption. Then, the formula from the first exercise that corresponds to different replacement assumptions will be identified. In a subsequent section, the appropriateness of each replacement assumption will be empirically tested. The correct one is then used to measure the contribution of each category to total productivity growth.

In this section, only the effects of entry and exit will be considered.³⁷ All plants in the continuing sector are grouped together. No distinction is made between those continuing plants gaining market share and those losing market share. A subsequent section relaxes this restriction and examines the replacement assumption in more detail.

In order to evaluate the contribution that exits and entrants make to changes in average productivity per worker, the change in this variable can be decomposed into components that measure the effect of entry and exit. Total growth in average productivity per worker (TOT) is

$$1) \text{TOT} = (\text{SHE}_0 \cdot \text{APE}_0 + \text{SHC}_0 \cdot \text{APC}_0) - (\text{SHE}_0 \cdot \text{APE}_0 + \text{SHC}_0 \cdot \text{APC}_0)$$

where APE represents output per worker in the entering/exiting sector and APC is the

output per worker for the continuing sector. SHE and SHC are the labour shares for each category and the subscripts 9 and 0 refer to the years 1979 and 1970 respectively. APE_9 , thus, refers to the productivity of entrants in 1979; APE_0 to the productivity of exits in 1970. Total productivity growth is then equal to the difference in productivity in 1979 and 1970 where the productivity in each of these periods is just the weighted average of the productivity in each sector -- entrants and continuing plants in 1979, exits and continuing plants in 1970.

Equation #1 can be rewritten so as to capture the effect of entry in a number of different ways. Perhaps two of the most intuitive, which are derived from an orthogonal transformation of change, are

$$2) \text{ TOT} = SHE_9.(APE_9 - APE_0) + SHC_9.(APC_9 - APC_0) \\ + (SHC_9 - SHC_0).(APC_0 - APE_0)$$

$$3) \text{ TOT} = SHE_0.(APE_9 - APE_0) + SHC_0.(APC_9 - APC_0) \\ + (SHC_9 - SHC_0).(APC_9 - APE_9)$$

These two expressions break the total change into three terms and differ only in the extent to which base or end year shares are used as weights. The first term captures the change that is due to the productivity difference between entrants and exits. It is the entry (exit) share multiplied by the difference in productivity of entrants and exits. The second term represents the growth in productivity due to progress in continuing plants. It is simply the share of continuing plants multiplied by the growth in their average productivity. Both the first and second terms capture that component of total change due to entry or continuing plant progress assuming shares are held constant. The last term captures the effect of share changes.

There are a number of other ways to break the total productivity change from equation #1 down. For example, it can also be written as²⁸

$$4) \text{TOT} = (\text{APC}_9 - \text{APC}_0) + \text{SHE}_9(\text{APE}_9 - \text{APC}_9) + \text{SHE}_0(\text{APC}_0 - \text{APE}_0)$$

In this formulation, the first term measures productivity growth in the continuing sector, the second and third terms measure the difference between productivity in entrants or exits and the continuing sector. The second and the third terms can be interpreted as capturing the effect of entry and exit respectively -- though, as is demonstrated below, in a very different sense than do equations #2 and #3. The differences between equation #4 and either equation #2 or #3 occur because each originates from a different assumption as to whom entrants supplant -- exits or continuing plants.

Instead of arbitrarily breaking down productivity growth into components as is done in equations #2, #3, or #4, an alternate approach can be utilized which starts with explicit assumptions about the effect of entry and exit on the share of the continuing population.²⁹ Suppose that entrants replace exits. This is equivalent to assuming that, in the absence of entry, exiting plants would not have disappeared. It can be written in the same form as equation #1 except that the values of the entrants' share and/or average productivity are replaced with comparable values drawn from the exits. In this case, the increase in productivity that would have occurred in the absence of entry can be written as

$$5) (\text{SHC}_9 \cdot \text{APC}_9 + \text{SHE}_9 \cdot \text{APE}_9) - (\text{SHC}_0 \cdot \text{APC}_0 + \text{SHE}_0 \cdot \text{APE}_0)$$

or

$$6) (\text{SHC}_0 \cdot \text{APC}_9 + \text{SHE}_0 \cdot \text{APE}_9) - (\text{SHC}_0 \cdot \text{APC}_0 + \text{SHE}_0 \cdot \text{APE}_0)$$

Equation #5 is just equation #1 except that the productivity of entrants in 1979 is replaced with that of exits for 1970. Equation #6 is just Equation #5 with the share of entrants in 1979 being replaced with that of exits for 1970. The difference between total growth (equation #1) and growth without entry (equation #5 or #6) is the effect of entry. It is given by the first term in equation #2 for the assumption embedded in equation #5

and the sum of the first and third terms in equation #3 for the assumptions of equation #6.

Alternately, it could be assumed that if there had been no entry, the amount of exits would have been unchanged. This is equivalent to assuming entrants replace continuing plants -- that is, cause continuing plants to lose market share they would otherwise have captured -- since exits are presumed to fail in any case. Then the increase in productivity that would have occurred without entry can be written as

$$7) APC_0 - (SHC_0.APC_0 + SHE_0.APE_0)$$

Similarly, if it is assumed that entrants would have occurred without exits, the amount of total growth not due to exit is

$$8) (SHC_0.APC_0 + SHE_0.APE_0) - APC_0$$

Subtracting each of #7 (the amount of growth not due to entry) and #8 (the amount not due to exit) from the actual growth given by #1 yields the second and third terms of #4 -- the amount due to entry and exit, respectively.

If the effect of entry and exit is to be evaluated then, the conditions for the counterfactual exercise must be clearly stated. The assumptions embodied in equations #5, #6, #7, and #8 are quite different. Which of these formulations is chosen depends on our view of the economic process and ultimately is a matter for empirical investigation. If entrants displace exits, then the formulations in equations #2 or #3 are closer to the truth. Our work suggests that exits are related to entry in the sense that the more entry there has been in the recent past, the higher will exit rates be today. In this sense, entrants and exits are closely associated. However, it is also true that the share of entry does not correspond exactly to the share of exits. Some of the replacement occurs between the continuing sector and that of entrants or exits. If entrants generally replace continuing plants, the formulation in equation #4 is the appropriate one;³⁰ but only if the

continuing plants whose share declined as a result of entry had average levels of productivity.

This last qualification reveals the importance of a second implicit assumption contained in this growth accounting exercise. It is assumed that share changes do not affect average productivity levels. If entrants are assumed to replace continuing plants, it may be inappropriate to measure the effect of no entry with equation #7. This formulation presumes that the level of productivity in the continuing segment with entry is the same as without. Yet if entry eliminated the least productive continuing plants, as seems likely, the average level of productivity of the continuing segment would be lower without entry and the second term of equation #4 would understate the effect of entry.

All three assumptions (#5, #6, and #7) are used to provide a first approximation to the effect of entry and exit. Only new plant creation by new firms and by continuing firms is considered.³¹ The results for equation #5, which presumes that the new plants in a firm category (new firms versus continuing firms) replace closed plants in the same firm category, are reported in Table 5. The contribution is expressed as a percentage of the total change in productivity and the mean estimate is presented for only those 4-digit industries where positive real productivity growth occurred.³²

When plant creation by entrants is presumed to displace plants closed by exiting firms, entry accounts for some 24 per cent, on average, of total productivity growth. When continuing firm plant creation is presumed to replace continuing firm closed plant, this process contributes 5 per cent. Together, all plant openings and closings contributed 29 per cent of productivity growth.³³ Productivity growth in the continuing sector accounts for about 65 per cent of the total growth on average. The residual, some 5 per cent, is due to share shifts (terms comparable to #3 in equation #2).

If the contribution of entry and exit is assumed to occur using the assumptions embedded in equation #8 -- with entrants replacing continuing plants which possess average productivity levels (equation #4) -- then the contribution of entry falls dramatically. The contribution of entry is -5 per cent and, of exit, 14 per cent for a joint contribution of 9 per cent. The fact that entry contributes negatively to productivity

Table 5

The Contribution of Entry, Exit,
Growth and Decline in the Continuing Sector
to Productivity Growth between 1970 and 1979
across 167 4-digit Manufacturing Industries¹
(%)

Source of Productivity Growth	Contribution to Total Productivity Growth

Assumptions ² of Equation #5	
New Firm New Plant Replaces Closed Plant of Exiting Firm	24.0 (3.2)
Continuing Firm New Plant Replaces Closed Plant of Continuing Firms	5.1 (1.8)
Growth in Continuing Plants	64.8 (3.1)

- Notes: 1) The reported ratios are calculated for a sample of 167 4-digit industries where real productivity growth was positive.
- 2) The assumptions contained in the formulation is discussed at greater length in the text.
- 3) The standard error of the mean is in brackets.

growth in the latter case is similar to the results of Hazledine (1985), who used a similar formula but shorter time periods in the mid-1970s.³⁴ But as will be demonstrated, the assumptions implicit in this formulation are the least realistic.

In the case where entrants are treated as replacing exits, the contribution that the two jointly make is not unimportant. How important it is depends on the standard chosen to measure it. It is certainly important enough to eliminate any notion that entry and exit make no contribution, that they are only a fringe phenomenon. But can we say they contribute more than might be expected if they were treated as ongoing firms that would also have experienced productivity growth? To evaluate this issue, the distribution of the share of productivity growth derived from entry using equation #2 was compared to the distribution of the entry category's share of shipments. The ratio of the two will be one if the entry category contributes to growth in the same proportion to its industry share. The median of this ratio was 1.24 for new plants of new firms for industries with positive real productivity growth. It was 1.39 for new plants of continuing firms. A Wilcoxon non-parametric signed rank test was used to test whether the contribution of the entrant was greater than its share. The null hypothesis that they were the same was rejected in each case in favour of the alternate hypothesis that each entry category made a significantly greater contribution to productivity growth than might have been expected in light of its market share.

b) The Effect of Displacement in the Continuing Sector

The exit of some and the entry of others is not the only way in which market share is transferred from the less to the more successful. In the continuing segment, some plants lose market share, and others gain it. The difference between the labour productivity of the two by the end of the period is substantial. The effect of this part of the plant turnover process can be calculated, as it was in the previous section, by considering the replacement process here to be independent of that taking place elsewhere -- in this case, of the amount of entry and exit. Productivity growth in the continuing sector (TOTC) is

$$9) \text{TOTC} = \text{APC}_9 - \text{APC}_0$$

$$= (\text{SHCU}_9 \cdot \text{APCU}_9 + \text{SHCD}_9 \cdot \text{APCD}_9) - (\text{SHCU}_0 \cdot \text{APCU}_0 + \text{SHCD}_0 \cdot \text{APCD}_0)$$

where SH refers to the employment share, AP refers to average labour productivity, the suffixes CU and CD refer to the segment of the continuing sector that increases market share and that decreases market share respectively between 1970 and 1979. The subscripts 9 and 0 refer to the years 1979 and 1970, respectively.

The total productivity growth (TOTC) that originates in the continuing sector can be rewritten in a form comparable to equations #2 and #3 as

$$10) \text{TOTC} = \text{SHCU}_0 \cdot (\text{APCU}_9 - \text{APCU}_0) + \text{SHCD}_0 \cdot (\text{APCD}_9 - \text{APCD}_0) \\ + (\text{SHCU}_9 - \text{SHCU}_0) \cdot \text{APCU}_9 + (\text{SHCD}_9 - \text{SHCD}_0) \cdot \text{APCD}_9$$

or

$$11) \text{TOTC} = \text{SHCU}_9 \cdot (\text{APCU}_9 - \text{APCU}_0) + \text{SHCD}_9 \cdot (\text{APCD}_9 - \text{APCD}_0) \\ + (\text{SHCU}_9 - \text{SHCU}_0) \cdot \text{APCU}_0 + (\text{SHCD}_9 - \text{SHCD}_0) \cdot \text{APCD}_0$$

In each case, the first and second terms capture the productivity growth that comes from growth in the expanding and contracting sectors respectively. The third and fourth terms capture the effect of share displacement -- the effect of the expanding segment displacing the losing segment. The difference between equations #10 and #11 lies in whether base or final year shares are chosen as weights. The mean values of the first, second and the sum of the third and fourth terms expressed as a proportion of total productivity growth in the continuing sector (TOTC) are reported in Table 6, column 1 for equation #10. The means are calculated across those industries where real productivity growth was positive. Some 38 per cent of productivity growth in the continuing sector comes from displacement of declining with growing plants; 43 per cent comes from productivity growth in plants gaining market share; only 19 per cent come from those losing market share.

Table 6

The Contribution of Growth and Decline
in the Continuing Sector
to Productivity Growth between 1970 and 1979
in Canadian Manufacturing Industries¹
(%)

Source of Productivity Growth ¹	Contribution to Productivity Growth in the Continuing Sector	Contribution to Total Productivity Growth
(%)		
Displacement Effect	37.9	26.9
Growth in Plants Gaining Share	43.2	38.9
Growth in Plants Losing Share	18.8	3.0

Notes:

1) The breakdown in column 1 was estimated using equation #10 in the text. Column 2 was estimated from the second term of equation #2.

2) The sample contains only those industries where growth in real output per worker was positive.

Instead of starting with an arbitrary breakdown as in equations #10 and #11, the effect of turnover can be estimated as previously using the counterfactual approach -- by specifying what productivity growth would have been in the absence of a particular event. For instance, if it is assumed that in the absence of productivity growth in the expanding sector, market shares in 1979 would have been the same as in 1970, and only the declining sector would have had productivity growth, then the growth in labour productivity in the continuing sector would have been

$$12) (SHCU_0.APCU_0 + SHCD_0.APCD_0) - (SHCU_0.APCU_0 + SHCD_0.APCD_0)$$

and the difference between actual total productivity growth in the continuing sector (TOTC) and the amount yielded by equation #12 is the amount of productivity growth due to those plants in the continuing sector which gained market share. It is

$$13) TOTC = SHCU_0.(APCU_1 - APCU_0) \\ + (SHCU_1 - SHCU_0).APCU_1 + (SHCD_1 - SHCD_0).APCD_1$$

This is just the first, third and fourth terms of equation #10. It accounts for 81 per cent of productivity growth in the continuing sector (TOTC).

The displacement effect due to share change can be measured by postulating the counterfactual where both sectors manage to achieve their actual productivity growth but where there is no share change -- that is, shares remain in 1979 what they were in 1970. In this case, the displacement effect is just the sum of the third and fourth terms of equation #10. It amounts to 38 per cent of continuing sector productivity growth (TOTC).

The difference between the amount of productivity growth due to those plants in the continuing sector which gained market share and the amount due to displacement is the effect of no growth in the expanding sector extrapolating from the displacement effect -- just term one in equation #10. It is 43 per cent of continuing sector productivity growth.

Finally, the effect of no growth in the declining sector can be estimated by assuming a comparable counterfactual to equation #12. The effect then of growth in the losing segment would be the sum of the second, third and fourth terms in equation #10. It makes up 57 per cent of the total. Once again, it includes the effects of both productivity growth and share change. Subtracting the displacement effect gives just the effect of productivity growth in the losing sector -- 19 per cent.

Dividing total productivity growth in the continuing sector (TOTC) into its components is useful, but it does not by itself tell us how much of total overall growth in productivity comes from each of the continuing sector components. An estimate of this can be derived by substituting the components of equation #10 into the second term of equation #2, multiplying by SHC_{jt} , and calculating each component as a percentage of total productivity growth (TOT). The mean values of these ratios for industries with positive real productivity growth are reported in Table 6, column 2. The sum of the three components just equals the contribution reported in Table 4 for the continuing sector -- some 69 per cent of the total. The contribution of some continuing plants displacing others is 27 per cent. Productivity growth in those plants gaining share contributes 39 per cent of the total. Productivity growth in plants losing share is relatively unimportant -- at only 3 per cent of the total. It is noteworthy that the latter category loses its relative importance when its contribution to total productivity growth, as opposed to just growth in the continuing sector, is calculated. This suggests that where losers are relatively important in the continuing sector, the share of the continuing sector is lower; if losers in the continuing sector are important, the continuing sector is not.

In conclusion, when the continuing sector is treated independently of other sectors, plant turnover, this time via share displacement rather than through openings and closings, accounts for 27 per cent of total productivity growth. Together with the results in Table 5, this suggests that total turnover contributes almost half of productivity growth. But the assumptions made here as to the independence of the processes may be incorrect. Simultaneous measurement of the effect of both new plants and continuing plant share displacement is the subject of the next section.

c) The Contribution of Total Firm Turnover

Separate assessments of the role of entry and exit or of expansion and contraction in the continuing sector, as was done in the two previous sections, is difficult and unsatisfactory for several reasons. The counterfactuals discussed above involved discrete choices between entrants replacing exits or entrants supplanting continuing plants but not both. Reality probably lies somewhere in between. But when continuing plants are treated as a group, the difficulty in treating entrants as replacing continuing plants, which are on average about as productive as entrants, is all too evident.

When the continuing sector is broken into those plants which increased market share (the gainers) and those plants which lost market share (the losers), the direction of the tradeoffs is easier to conjecture. Table 7 contains the ratio of the productivity of new plants in 1979 to continuing plants which gained and which lost market share, respectively.³⁵ New plants are divided into those associated with new firms entering an industry and with continuing firms. Each of these categories in turn is divided into plant births and plant switches. New plants in all four categories were more productive than those continuing plants that lost market share; but, only new plants of continuing firms were more productive than continuing plants that gained market share. The new plants of new firms, both births and switches, were significantly less productive than the gainers.

On the basis of relative productivity differentials, it is reasonable to consider entrants as replacing not only exits but also those continuing plants that lost market share. Continuing plants that gained market share should have done so both at the expense of declining continuing plants and also of exits. The nature of the trade-off was estimated using regression analysis.

The share of entrants (SHE_e) is calculated for two categories -- entering firm new plants (SH23) and continuing firm new plants (SH13).³⁶ The share of exits (SHE_o) is also estimated for two categories -- the closed plant of exiting firms (SH34) and the closed plant of continuing firms (SH14).³⁷ The increase in market share for continuing plants that gained (U) is the difference between the share of this group in 1970 and 1979 (i.e. U

Table 7

Relative Productivity of Plant Entrants
Compared to Continuing Plants that
Gained and Lost Market Share for
167 4-digit Manufacturing Industries

Category	Mean ¹	S.E. Mean	Probability Value of Rank Test for First Differences ²
I)Relative to Continuing Plants Gaining Share			
a)Entering Firms			
1)Plant Births(23)	0.97	.03	<.001
2)Plant Switch(23s)	0.90	.04	<.001
b)Continuing Firms			
1)Plant Births(13)	1.08	.04	.532
2)Plant Switch(13s)	0.86	.05	.004
II)Relative to Continuing Plants Losing Share			
c)Entering Firms			
1)Plant Births(23)	1.24	.07	.015
2)Plant Switch(23s)	1.09	.05	.771
d)Continuing Firms			
1)Plant Births(13)	1.32	.06	<.001
2)Plant Switch(13s)	1.10	.08	.256

1) The mean was calculated across the ratio of the median estimates of the productivity for each class relative to the median estimate of productivity for the declining class for each of the 167 4-digit manufacturing industries.

2) the minimum significance level required to reject the null hypothesis that the productivity of the plant birth categories are the same as for continuing firms.

= $SHCU_0 - SHCU_9$). The decrease in share for losers (D) is the difference between the share of this group in 1970 and 1979 (i.e., $D = SHCD_0 - SHCD_9$). By definition, the sum of the market shares of entrants and those continuing plants gaining share must just offset the share lost by the others.

$$14) \quad SH23 + U + SH13 = SH34 + D + SH14$$

In the previous section, entrants were only considered to replace exits within a given category. Each of three categories was considered separately. As intuitively attractive and as empirically tractable as the assumptions underlying this approach are, they need to be investigated more fully. This is done in Table 8.

Table 8 reports the coefficients estimated by regressing each of the shares of the displaced categories (SH34, D, SH14) on the shares of the entrants and the continuing plant gainers (SH23, U, SH13).²⁸

$$SH34 = a_0 * SH23 + a_1 * U + a_2 * SH13$$

$$15) \quad D = b_0 * SH23 + b_1 * U + b_2 * SH13$$

$$SH14 = c_0 * SH23 + c_1 * U + c_2 * SH13$$

Each of these coefficients indicate the extent to which a one per cent change in a growing category results in the replacement of a declining group. The coefficients sum to one in each column. The estimated coefficients reported in Table 8 indicate that the gainers in each category do not just replace the losers in that category -- the diagonal elements are not the only coefficients significantly different from zero. Nevertheless, some replacement patterns are stronger than others. New plants of new firms (SH23) have a greater effect on the exiting plant of exiting firms (SH34) than on the decliners in the continuing plant population (D). A one percentage point change in SH23 leads to a .67 percentage point change in SH34 but only a .30 percentage point change in D. The effect of an increase of one percentage point in the share of gaining continuing plants (U) is also distributed more heavily on SH34 than on D -- .83 on SH34, 0 on D, and .19 on SH14. These coefficients allow the displacement effects that were only hinted at previously to be more

Table 8

The Relationship Between Share Loss and
Share Gain at the Establishment Level

Regressor	Regression Coefficients			R ²
	SH23	U	SH13	
SH34	.673 (.037) (.0001)	.832 (.053) (.0001)	-.067 (.116) (.5640)	.88
D	.296 (.035) (.0001)	-.026 (.049) (.601)	.718 (.108) (.0001)	.58
SH14	.034 (.024) (.2181)	.193 (.035) (.0001)	.340 (.077) (.0001)	.44

Note:

1) The variables are defined in terms of shipments. The definitions are:

SH34 - the share of exiting plant of exiting firms

SH14 - the share of exiting plant of continuing firms

D - the share loss of continuing plants losing relative share

SH23 - the share of plant births of entering firms

SH13 - the share of plant births of continuing firms

U - the share gain of continuing plants gaining relative share

2) Entrants and exits contain switches.

precisely modeled.³⁹

In order to do so, total productivity growth is broken into its separate components.

Let

SH_j represent the 1979 share of plants in category j -- (SH23, SHCU, SHCD, SH13)

SH_i represent the 1970 share of plants in category i -- (SH34, SHCU, SHCD, SH14)

AP_i, AP_j represent the average productivity of category i and j respectively

and $i=34$ closed plants of exiting firms
=14 closed plants of continuing firms
=CD0 continuing plants as of 1970 that lose share
=CU0 continuing plants as of 1970 that gain market share

and $j=23$ new plants of entering firms
=13 new plants of continuing firms
=CD9 continuing plants as of 1979 that lose share relative to other continuing plants.
=CU9 continuing plants as of 1979 that gain market share

Then the total change in average productivity is written as

$$16) \text{ TOTAL} = \text{Sum}_j(SH_j * AP_j) - \text{Sum}_i(SH_i * AP_i)$$

The relationship between the categories gaining and losing shares, which was presented in Table 8, is represented as:

$$17) SH_i = \text{Sum}_j(a_{ij} * SH_j) \text{ where } SH_j = (SH23, U, SH13) \\ \text{and } SH_i = (SH34, D, SH14)$$

The effect on average productivity of one of the categories j gaining share as a result of displacing plants in a category i losing share is written as:

$$18) \text{ PROD}_{ij} = a_{ij} * SH_j * (AP_j - AP_i)$$

In this formulation, each gainer is allowed to partially affect each loser. The change due to any one entrant then consists of the sum of its effects across all exit components i . The sum of the components ($PROD_{ij}$) across all exit classes i is

$$19) PROD_j = SH_j * [Sum_i(a_{ij} * (AP_j - AP_i))] \quad \cdot$$

that is, the effect of new firms building new plants (category 23) is

$$PROD_{23} = SH_{23}[a_0 * (AP_{23} - AP_{34}) + b_0 * (AP_{23} - AP_{CD0}) + c_0 * (AP_{23} - AP_{14})]$$

Finally, the total effect of all turnover in all "entry" classes j is

$$20) TURN = Sum_j(PROD_j)$$

The sum of the various components derived from equation # 20 (TURN) along with the growth in productivity in the growing and declining segment is equal to the change in estimated change in average productivity (TOTEST).

$$21) TOTEST = TURN + SHCU_0 * (AP_{CU0} - AP_{CU0}) \\ + SHCD_0 * (AP_{CD0} - AP_{CD0})$$

TOTEST equals the change given by equation #16 plus an error term due to the fact that equation #17 is estimated with an error.

$$22) TOTEST = TOTAL + U \text{ where } U \text{ is a stochastic error term}$$

The first term in equation #21 (TURN) represents the productivity growth due to the replacement process associated with competition. It is comparable to the first and

third terms of equations #2 and #3. The second term represents the productivity growth that occurred in the continuing sector that gained share (GU). The third term represents the growth that occurred in the continuing sector that lost share (GD). Each component of equation #21 was estimated for each of the 167 4-digit manufacturing industries where real growth in productivity was positive.⁴⁰

Each component was expressed as a percentage of total growth (TOTEST).⁴¹ The means of these ratios across the reduced sample are reported in Table 9, column 1. The results are robust to the exclusion of outliers. The first three rows of the table correspond to the three terms that make up TURN in equation #18. New plants of entering firms contributed 20 per cent of the total, on average; continuing firm plant births for 7 per cent; the replacement process due to market share growth in continuing plants for 21 percent. In addition, 48 per cent came from productivity growth in market share gainers and 4 per cent from productivity growth in market share losers. The contribution made by each component is presented in Figure 5. Table 9, column 2 also contains the results derived previously using the restrictive assumptions about replacement patterns. The differences between the two sets of results are relatively small.

The contribution that turnover made to growth in output per man can be examined in reverse. Instead of calculating the effect of a particular entry or expansion category, the effect of an exit or contraction category can be estimated in a completely analogous fashion -- except the effects $PROD_j$ in equation #18 are summed across all entry classes j . The results are presented in Table 10. The displacement of plants closed by exiting firms (category 34) accounted for 32 per cent, the closure of continuing firm plants for 8 per cent and the market share loss of continuing plants for 7 per cent, on average, of total productivity growth.

Productivity Growth as Manna from Heaven

Economists, while occasionally accused of being too worldly because of their interest in material matters, often manifest a tendency to rely on the extra-terrestrial.

Table 9

Plant Turnover and the
Proportion of Productivity
Growth Accounted for by Each
Entry Source
(%)

Source of Productivity Growth	Assumption Regarding Replacement	

	Complex ¹	Simple ¹
	(I)	(II)

I) <u>Share Growth Due to New Plant² Entry</u>		
a) By New Firms	19.5 (2.8)	24.0 (3.2)
b) By Continuing Firms	7.0 (1.7)	5.1 (1.8)
II) <u>Share Growth by Growing Continuing Plants</u>	20.9 (2.0)	26.9 (9.7)
III) <u>Productivity Gains in Growing Continuing Sector</u>	48.2 (6.3)	38.9 (4.8)
IV) <u>Productivity Gains in Declining Continuing Sector</u>	4.4 (4.6)	3.0 (5.1)

Notes:

1) The complex replacement assumption uses the trade-offs from equation #17 and the estimates from Table 8. The simple replacement assumptions come from equations #2 and #10 and are presented previously in Tables 5 and 6.

2) New plants include both plant openings and plant switches.

3) The sample includes only those industries where growth in real output per worker was positive.

4) The standard errors of the means are in brackets.

PRODUCTIVITY GROWTH

The Importance of the Components of Plant Turnover

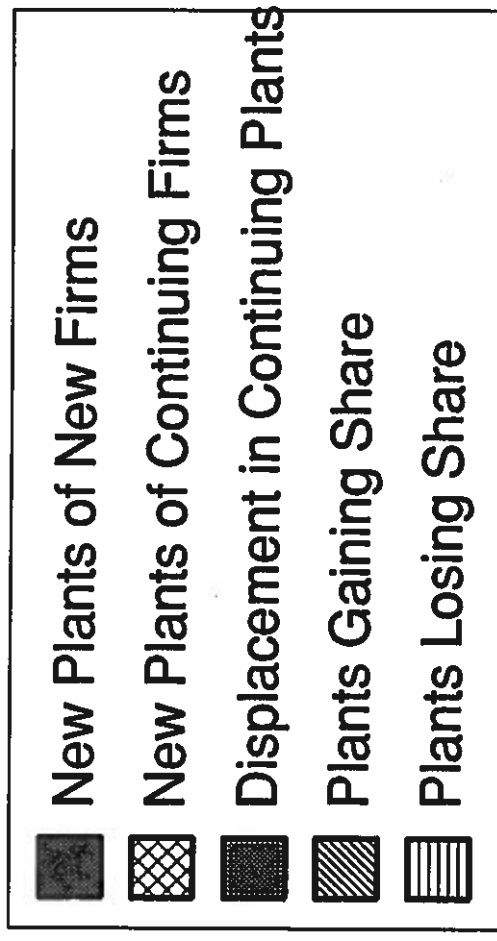
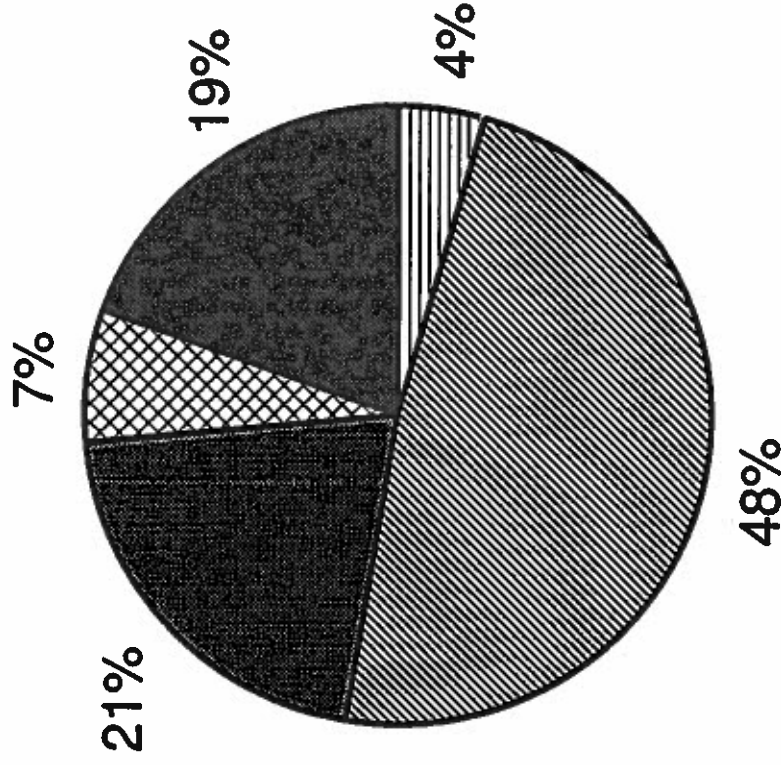


Figure 5

Table 10

Plant Turnover and the
Proportion of Productivity
Growth Accounted for by Each
Exit Source
(%)

Source of Productivity Growth	Components Breakdown ²
<hr/>	
I) <u>Share Growth Due to Plant² Exit</u>	
a) By Exiting Firms	31.8 (2.9)
b) By Continuing Firms	8.1 (2.1)
II) <u>Share Loss Due to Decline in Continuing Plants</u>	7.4 (1.4)
III) <u>Productivity Gains in Growing Continuing Sector</u>	48.2 (6.3)
IV) <u>Productivity Gains in Declining Continuing Sector</u>	4.4 (4.6)

Notes:

- 1) The results use the complex replacement assumptions derived from equation #17 and the estimates from Table 8.
- 2) Plant exits include both plant closings and plant switches.
- 3) The sample includes only those industries where growth in real output per worker was positive.
- 5) The standard errors of the means are in brackets.

Monetary economists, with their helicopter bond drops, have long been infamous in this regard. Research into productivity has not been far behind. The emphasis on disembodied progress is symptomatic of this abstraction from reality. It would be unrealistic to expect this paper to resolve such a theological controversy; but the results depict a world in which the Darwinian-type replacement process matters. Whether the sectors are considered separately or jointly, some 40 to 50 per cent of productivity growth is due to plant turnover. That is not the disembodied image that many studies portray of technological progress.

Can we say anything about the degree to which progress is "exogenous" or naturally endowed on the manufacturing sector. One measure of the amount of "exogenous" technical progress is the proportion of total growth that occurs in those plants whose share declines over time. Continuing plants that lose market share provide a useful benchmark. Progress is made in these plants but not enough to maintain their market share. The losers rate of technical progress then can be used as the rate that is bestowed naturally on the industry -- a type of Rawlesian patrimony. Winners succeed because they improve on what even losers can manage. If this is the definition of "exogenous" technical progress used, then only 4 per cent of total growth is disembodied.

This definition presumes that the technical progress of losers is independent of winners. It may be that losers learn from winners and that there is a spillover effect. While it is possible that there is such a demonstration effect, there is little quantitative support that it was very significant. A regression of the change in productivity of the losers on the gainers produced an insignificant regression coefficient of about .05. Thus, as a first approximation, the progress made by losers will be considered to be exogenously determined.

There is an alternate and more generous way to measure "exogenous" technical change. The estimate presented in the previous section presumes that if exits had not been replaced, the affected plants would have made no gains in productivity. It also presupposes that all growth in the continuing plant sector that gained market share was due to the special efforts of plants in this group. Alternately, it may be assumed that

each of these groups would have had the same rate of productivity growth as the continuing segment that lost market share. In this case, the amount of productivity gain due to exogenous forces can be written as

$$23) \text{ PEXOG} = \text{Sum}_i (SH_i * [AP_i/AP_{cdo}] * AP_{cdo}) \\ - \text{Sum}_i (SH_i * AP_i)$$

In this formulation, all segments also are assumed to maintain their market shares in 1979 at their 1970 level. The mean estimate of the contribution of PEXOG to total productivity gain (TOTAL) for those industries with positive productivity growth is 19 per cent.

The residual can then be divided as before into that which is due to each entry category. This time the formula for the growth for the entry component j is

$$24) \text{ PRODEXOG}_{ij} = a_{ij} * SH_j * [AP_j - ((AP_i/AP_{cdo}) * AP_{cdo})]$$

When this is done for those industries with positive real growth in productivity, new plants of entering firms accounted for 12 per cent, new plants of continuing firms for 8 per cent and the gainers in the continuing segment for 21 per cent of total productivity growth. In addition, growth in the continuing segment that gained market share accounted for 40 per cent of the total. The impression of the importance of turnover to productivity growth is not greatly affected by this alternate assumption about what would have happened in its absence.

To assume that productivity in all plants would have grown at the same rate as the continuing sector that lost market share provides a generous estimate of "exogenous" change. Even so, it indicates that without the turnover process that replaces less productive plants with more productive plants, productivity growth would have been reduced by some eighty per cent on average. The cumulative effects of this type of

difference over long time periods are substantial.

The second counterfactual is, however, quite misleading. In actual fact, the turnover process was associated with much of the productivity growth. What would have happened in the absence of this competitive process is somewhat moot; what did happen is not. Growth came as new and expanding plants supplanted exiting as well as declining plants. Some 45 per cent of the total growth in productivity, on average, came from this displacement process. About 50 per cent came from productivity growth in that sector of the continuing plant population that gained market share. Very little, less than 5 per cent, came as the result of productivity growth in plants that were being supplanted and, of course, none came from those which exited because another more productive plant took its place. In actuality, the turnover process mattered very much.

Conclusion

Entry and exit may be viewed either as the engine of progress or as an interesting but irrelevant curiosity. In the first case, entry is seen to bring new and dynamic firms into the market and exit to eliminate the incompetent. In the second case, entry is portrayed as bringing a group of fringe firms into an industry that leave quickly without having made much impact. Recent references to the entry and exit process as "hit and run" leave the impression of an unstable fringe which makes no contribution to overall progress -- though entry may restrain the market power of existing firms.

In a related vein, the competitive process that leads to the growth and decline of the continuing sector can be viewed as constructive or destructive, stable or unstable. Gort's (1963) work on the stability of the largest U.S firms between 1947 and 1954 suggests that there was little turnover among the largest firms. With such an impression, it is not surprising that there has been little work done on the amount of productivity growth due to changes in relative firm position.

This paper and associated work demonstrate the necessity of careful measurement if the importance of entry and exit is to be fully appreciated. In the short run, the change

associated with entry and exit is dominated by expansion and contraction in the continuing sector. Short-run estimates of entry and exit, therefore, suggest that the process has little importance. Because most studies in the past have had to rely on such estimates, the impression has been left that entry and exit are insignificant. Absent much entry, conclusions to the contrary have had to rely on the threat of entry rather than evidence of actual entry. The development of panel data for the Canadian manufacturing sector (Baldwin and Gorecki, 1989b) has meant that such indirect methods need not provide the sole method of evaluating the effect of entry. These panel data show that over time the importance of entry and exit accumulates inexorably and no longer can be dismissed as either absolutely or relatively unimportant.

This paper extends this analysis by looking directly at the contribution of entry and exit to productivity growth. It does not rely on correlation or regression analysis to examine the relationship between entry intensity and productivity. Rather it looks directly at the relative productivity of entrants and exits and calculates the contribution that both make to productivity growth. It extends the previous analysis from simply delineating the magnitude of entry and exit to measuring one dimension of its importance. Previous work on Canadian data (Hazledine, 1985) had left the impression that the effect of entry on productivity was unimportant, indeed that it was negative. This paper finds this not to be the case. Entry and exit make a healthy contribution to total productivity growth.

In doing so, the paper also shows that industries are not homogeneous -- a point that Marshall stressed but that has been often ignored (Reid, 1987). Entrants arrive in industries at sizes well below the average. While they grow, they still are well below the average plant size by the end of ten years, even though they have moved their labour productivity up to the average by this time. More importantly, the pattern of substitution that is discovered has new plants of entering firms supplanting closed plants of exiting firms, and new plants of continuing firms supplanting closed plants in the same sector. While there is some interaction between the two groups, there is clearly a distinction that means it is useful to think of differences of inter and intra group rivalry (Caves and Porter, 1977). This is important for those attempting to model entry. Most work that is

based on the early research by Orr (1974) has some more or less complicated version of a limit entry model behind it, in which entrants and leading firms are held to interact. The results of this paper suggest that entrants have little effect on incumbents and, instead, basically replace other small firms that exit. Shepherd (1984) was correct when he observed that large existing firms do not generally have to worry about entry. They have to worry about which of the large number of entrants will move out of the fringe and challenge them.

These contributions of the paper shed light on several issues of importance to industrial economists. The findings of the paper also have implications for policy in the area of technical change and manpower policy. Exits and entrants, expansion and contraction of existing firms result in a substantial reallocation of workers. The problem faced by the labour force that emanates from technical change is far different in a world where all firms make about the same degree of progress in productivity improvements than the world depicted here. In the former case, labour displacement, as a result of technical change, occurs at the margin of every firm. This is not what takes place. In actuality, substantial shifts in relative firm position occur because of the rise and fall of firms -- a rise and fall that is very much associated with productivity differences. The problem of adjustment in this world does not arise because a few workers are being let go at the margin of each firm. Wholesale adjustment is required because firms are failing and others are downsizing because of losses in market share. In order to gain the small but cumulatively important gains in productivity that contribute to increases in well-being, the competitive process is continuously shifting a considerable proportion of total input from the less to the more successful.

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NOTES:

1. See Baldwin and Gorecki(1990a).
2. See Scherer(1980) or Jacquemin(1987) for a traditional presentation of market structure that focuses almost exclusively on measures of concentration.
3. See Simon and Bonini(1958), Ijiri and Simon(1977).
4. For a Canadian example of a case study that looks at changes in market shares, see Canada, Report of the Commission of Inquiry on the Pharmaceutical Industry(1985).
5. Dunne, Roberts and Samuelson(1989) have used a comparable American data base to measure a related aspect of change -- job turnover.
6. Entry and exit is measured at the manufacturing sector level -- ie. establishments new to manufacturing in the case of entry. See Baldwin and Gorecki (1990b).
7. This is the average of the entry and exit shares.
8. The data used here are discussed at length in Baldwin and Gorecki (1990b).
9. See Baldwin and Gorecki (1990c).
10. Real productivity was defined as value added per worker divided by an output price index. The theoretical conditions for the use of an output price index were investigated by David (1961). We chose to use this approach more for practical than theoretical reasons in that we felt more confidence in the output price indices than in the implicit value added indices that are available for this time period. In the end, the results were robust to other approaches. Experiments with real shipments per worker rather than with value added per worker yielded the same qualitative conclusions reported below -- that is, turnover accounted for a significant proportion of total productivity growth during the decade of the 1970s.
11. Exiting firms are those which no longer own plant in the 4-digit industry in question. They may continue to own plant in other industries.
12. Switched plant are those plants where the product mix changes sufficiently over the decade that they are reassigned from one 4-digit industry to another by the Census.
13. The distributions were compared using a non-parametric signed rank test.
14. The median of the differences is significantly greater than zero using the non-parametric sign rank test but the mean is not.
15. See Leonard(1987,1988) who shows that while adjacent year performance is correlated, correlations for longer periods of two, three, and four years are not significant.
16. The proportions are taken across all observations in the top and bottom halves of all industries -- as opposed to the mean across all industries of the proportion calculated for each industry.
17. Continuing plants that changed ownership are excluded so as to eliminate the effects of mergers. The latter is the subject of a separate paper. See Baldwin and Gorecki (1990d). Their inclusion does not greatly change the ratios presented in Table 6.
18. Switched plant are those plants where the product mix changes sufficiently over the decade that they are reassigned from one 4-digit industry to another by the Census.

19. Medians are used extensively as measures of central tendency since the raw data on plant characteristics such as value-added per worker may have large outliers --due to incorrect data --that greatly influence means. For example, a plant with positive output but no employees listed would have infinite value-added.
20. These are the continuing plants that exist in the same industry in 1970 and 1979 and that do not experience a change in ownership over the decade. The addition of those that change ownership does not affect the reported ratios to any great extent.
21. Use of medians of the 167 observations rather than means does not change the conclusions that are derived from the analysis.
22. Random fluctuations in demand may partially explain size-related productivity differentials -- if a greater proportion of small than large firms have recently declined below optimum production levels and if such a decline leads to declines in productivity because fixed factors are not being optimally employed.
23. Both linear and log-linear forms were used. The conclusions were not affected by the type of functional form chosen.
24. Alternate functional forms were tried and the results remained qualitatively the same. Age was always significant in explaining the productivity of entrants.
25. The ratio of the median productivity in each group was calculated for each industry before the means were taken across all 167 industries.
26. These estimates are all means of the median estimates of the ratios taken at the individual 4-digit industry level.
27. For this exercise, switches were included in plant openings for both the entering firm and the continuing firm category.
28. This is the formulation used by Hazledine(1985).
29. For the purposes of this exercise, we only ask what effect entry has on shares. We do not ask what effect it has on the absolute size of the industry because of cost-reducing effects.
30. With this formulation, the difference in productivity between entrants and exits can be just the same as the difference in the growth in the continuing segment, but entry and exit will not be ascribed any importance.
31. New plant creation includes both births and switches.
32. Alternate samples had little impact on the estimates provided.
33. If the assumptions of equation #6 are applied instead, then the estimate of the joint effect of all plant openings and closings is 30 per cent.
34. Hazledine uses three year time periods and employs indices of unit costs rather than changes in productivity.
35. Contrary to the results in Table 3, continuing plants here include those which experience a change in ownership.
36. For simplification, plant openings and plant switches are combined in SH23 AND SH13.
37. Plant exits in each category include both plants that were closed and those that were switched to another 4-digit manufacturing industry.
38. OLS was used. Seemingly-unrelated least squares was also employed but made no difference.

39. Second order effects might also be postulated since SH23 and U were correlated. Entrants via new plants compete with and displace some continuing firms that might otherwise have grown at the expense of the same groups that are being displaced by the entrants. But, presumably, the plants in the continuing sector whose share gain is smaller than it would otherwise have been were less productive than the entrants and therefore their contribution is less and not more than that of the entrants who displaced the groups actually losing market share. Therefore, these trade-offs were not pursued further.

40. When the estimations are made, the total predicted share loss using equation #14 is not equal to the actual total share loss. This is because the estimated share equations have statistical error terms. The approximation was quite good on average. Nevertheless, there were some industries where the approximation of the displacement effect yielded by equation #15 was not very good. To handle this problem, the estimation procedure was modified slightly. The ratio of the predicted share for a displaced category relative to the actual share was calculated for each industry and its inverse was used to correct each term a_i in equation #19.

41. Thus, the proportions of total estimated growth and not of actual growth were calculated. This was done so that the proportions would sum to one for the purpose of presentation. Using the actual growth as denominator did not affect the relative size of the various components.