Productivity Growth and Firm Size Distribution

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Productivity Growth and Firm Size Distribution

A fundamental issue in economics is how to achieve productivity growth. Given limited resources, productivity growth is the only way to sustain and increase standards of living. In this paper, we ask an empirical question: Is productivity growth related to market share distribution by firm size ? Suppose we sort every establishment by its industry classification and by the range of its parent corporation's size. We record also the establishment's number of employees. We then have a distribution of share of establishments and employment by firm size in each industry. Are industries with greater productivity growth associated with a greater market share to small firms or with a greater market share to large firms?

It is surprising that the empirical question has never been raised before. There are good reasons to expect that productivity growth is related to the distribution of market share by firm size. Small and large firms have different capabilities in introducing innovations and in adopting and commercializing innovations. They also make different contributions to productivity growth. We therefore would like to verify that market share distribution by firm size is indeed related to productivity growth and to identify which class of firms makes more contribution to productivity growth, small or large firms? Answers to these questions shed light on the relative importance of large and small firms in promoting productive growth. Hopefully, they will also improve our understanding of the innovation process, from advancing radical innovation to its implementation in production.

We carry out our empirical investigation using U.S. cross-sectional industry data. We find that industries in which larger firms have a greater market share have greater productivity growth; market share is defined either as the share of employment or as the share of establishments. Moreover, total factor productivity growth also increases with growth in larger firms' market share. We check the possibility that our results are spurious because of variable measurement errors and missing variables and find that our results appear to be robust.

In the next section, we discuss the motivation of our empirical question. We present our data in Section III and results in Section IV. Section V reports our robustness check, followed by conclusions in Section VI.

II Motivation

There has not been a debate on whether small or large firms are more important in generating productivity growth and there should be. Productivity growth comes from using new ways to use inputs to generate better output. It involves both the generation of new ideas and successful implementation of them. Small and large firms carry out these activities differently.

There is a popular perception that small firms are the engine of innovation. Recent experiences in emerging markets are startling: upstart small firms serve as an engine of growth while large state-owned firms drag growth. Although these observations are extreme and there are good explanations for them, smaller firms make undeniable contribution to productivity growth in these economies. Similarly, in many fast growing economies, e.g., Hong Kong, which have experienced phenomenal productivity growth, small firms have considerable market shares and are often alleged to be the generator of productivity growth. These observations suggest that smaller firms play an important role in generating productivity growth.

At the same time, it is well known that larger companies invest substantially more in creating and adopting innovation. Private R&D spending is in the main undertaken by large corporations. Also, large scale adoption and commercialization of innovation is usually undertaken by established large corporations. These efforts generate results. While smaller companies initiated the PC and Micro-Chip revolution, the larger IBM made major contributions to these industries' productivity growth via its investment in

R&D, manufacturing and marketing. It is possibly the case that the current Intel and Microsoft are contributing more to productivity growth in their respective industries now than when they were younger and smaller.

It is convenient to assess the contribution of small and large firms to productivity growth via a Schumpeterian lens (Schumpeter, 1934 and 1942). In a Schumpeterian world, individuals and firms driven by profit incentives come up with new products and more efficient production processes to displace old firms falling behind in efficiency and innovations. In the presence of competitive pressures, indigenous firms must adopt innovations and improve their overall efficiency in order to survive. Thus, productivity growth follows from the creation and commercialization of ideas and their resultant competitive pressures. We can assess the relative contribution of smaller and larger firms to productivity growth in these terms.

Arguments in Favor of Smaller Firms

Innovation is about having new ideas. It is motivated individuals, not firms, which are merely legal entities, who create ideas. We argue, as in Acs et al (1996), that individuals in smaller firms have more incentives to innovate. Large corporations have agency problems and blurred property rights which reduce employees' incentive and frustrate their effort to innovate.

In large organizations employees often only have limited intellectual property rights. They have to share returns to their innovation with many other employees, even if their names are distinctly associated with an innovation, say in the form of patent ownership. In some corporations, employees have to sign explicit agreements to surrender property rights to their invention to the firm. The justification is that it is the corporation's investment and general resources that stimulate and facilitate the development of innovations[1].

The stipulation to share the fruit of innovation with other employees also causes a free-riding problem: less motivated individuals can free ride on other people's innovative effort and results. Worse yet, individuals in a large corporation can improve their economic well-being via bureaucratic politics to capture more rents from another's innovation. The limited intellectual property rights, the partial reward to innovations, and the possibility of free-riding on another's effort reduce employees' incentive to innovate.

Incentive contracts may mitigate the agency-incentive problem, but they create other problems. To mitigate the agency problem, incentive contracts aim to provide a direct linkage between employment earnings and cashflow due to innovation results. These contracts therefore must link job compensation to earnings from old innovations. Such contracts, however, will first lead to inevitable bickering over who has made what contribution; that is, dispute on defining and sharing innovation results.

In addition, these incentive contracts lead to bureaucratic inertia and distortions which also discourage innovation efforts. These stem from employees' interest to protect cashflow generated by their old innovations. Past innovators in an organization push for refinement of their old ideas, rather than the pursuance of new ideas, because doing so will enhance their value within the corporation. Corporate leaders promoted to their positions due to their past innovations will explicitly direct corporate resources towards the refinement of their old ideas under the pretense of investing in ideas with a proven record. Other employees will also stifle the pursuit of new ideas that threaten the value of existing knowledge and routines which benefit them. Employees who cannot benefit considerably from a new change may also impose pressure to retard the change if they have to make substantial efforts to adopt to the change. Bureaucratic inertia and distortions can cause delay and may even stop the implementation of innovation.

In summary, larger corporations will tend not to be innovative and are slow to adopt radically new ideas.

Unattached individuals do not face the aforementioned distortions. In a social environment where individual property rights are reasonably well protected, unattached individuals would normally be able to reap the full benefit of their innovation. Individuals who possess an innovation and have enough financial means would enter the market whenever the expected benefits exceed the expected costs. They become small firm owners. Their small firms provide the innovations which stimulate productivity growth.

Note that our argument is not that individuals in existing smaller firms have better property rights protection than their counterparts in larger organizations. Rather, our argument is that unattached individuals are more innovative because they do not have the property rights and incentives problems that individuals in larger organizations face. Unattached individuals equipped with an innovation start a business, usually much smaller in scale than indigenous firms, to implement their innovation and their smaller firms stimulate productivity growth.

Arguments in Favor of Larger Firms

While the property rights consideration suggests that smaller firms are more important contributors to productivity growth, there are several arguments which favor the opposite: (i) larger firms have a resource advantage, (ii) larger firms have an advantage in entering markets, and (iii) and larger firms reap more immediate benefits from innovations because of their larger scale and scope of operation.

Innovation is by definition information based; there is information asymmetry between an innovator and outsiders. Commercializing an innovation requires innovator's effort and intrinsic skills which are not fully observable to outsiders. Thus, adverse-selection and moral-hazard problems make outside financing options both costly and limited. Internal financing is a necessity. However, individuals and small firms face a more severe financial constraint than large corporations which have more internal financial resources and more collateral assets to raise external funds. In particular, large firms with established market power can build up wealth to finance further innovations. This is an integral argument in Schumpeter (1942).

Adopting and commercializing innovations involves breaking down market entry barriers. Larger firms are more capable in breaking down entry barriers than individuals and smaller firms. They have more internal financial resources to construct large production capacity. This is often a credible signal for determined entry, necessary for breaking down entry barriers. They also have more resources to persevere in market share battles which entail expensive marketing, price cutting, and bidding for key personnels, suppliers, and distributors. Consequently, incumbent firms are more ready to yield market share to large entrants with abundant resources than to small entrants with only limited resources. This in turn implies that it is less costly for larger entrants than it is for smaller entrants to penetrate a market.

The third consideration is based on the well known internalization argument popular in the foreign direct investment literature (e.g. Morck and Yeung, 1991). Larger firms have secured larger scale and scope of operations. Thus, their innovation will have a greater scale and scope of immediate application, which should translate to higher and less risky financial rewards. There is then the possibility that the larger scale and scope of larger firms induce these firms to be more active in creating and adopting innovations (e.g. Mitchell, Morck, Shaver, and Yeung, 1996).

In summary, there are arguments in favor of smaller firms being main contributors to productivity growth -- smaller firms are more likely to be equipped with innovative ideas while larger corporations have a more bureaucratic environment not conducive to creating and adopting innovations. There are also arguments in favor of larger firms being main contributors to productivity growth -- larger firms have a resource advantage, are more capable and likely to break entry barriers, and they can capture more immediate returns to innovations. We therefore seek answer to the following empirical questions:

(a) Is productivity growth significant related to the share of larger and smaller firms?

(b) If yes, is greater productivity growth associated with greater presence of smaller firms or with greater presence of larger firms?

III Data

The empirical questions call for relating productivity growth to firm size distribution, say by regressing productivity growth on market share of large and small firms. There are several ways to do so: (i) use cross-sectional industry level data within a country, (ii) use cross-sectional country level data, and (iii) use multiple country multiple industry level data, (iv) use cross-sectional time series panel data of the above varieties. This study is based on U.S. cross-sectional industry level data.

Extensive multiple country time series data are not readily available to us. We are able to find industry level measures of productivity and firm size distribution only for the U.S. However, the data limitation is not necessary undesirable. Productivity growth is influenced by institutional environment (Olson, 1996) which in turn influences firm size distribution. There are no simple ways to capture the effect of institutional environment; such an attempt would be by itself a major theoretical and empirical undertaking. Regressing industry level productivity growth on the industry level firm size distribution using a single country's data, we suppress variations in macro institutional (e.g., political, governmental, legal) environment and thus identify in a conservative manner whether firm size distribution matters given the data-country's institutional environment. After similar regression analyses for other countries are conducted, we shall have a set of results which shed light on how the institutional environment and firm size distribution interactively affect productivity growth.

We are unfortunately not able to obtain time series data. Our regression results are based on only one year's worth of U.S. cross-sectional industry data. In Section V, we shall discuss the implication of this data limitation on our research.

We draw on two data sources to form our data set. The first is the *NBER Manufacturing Productivity Database*, which is itself compiled by pooling various government data sources, e.g. *Census Bureau's Annual Survey of Manufactures* and *Census of Manufactures*. The data set contains information on inputs, output, and total factor productivity for 450 manufacturing industries (based on the 1972 4-digit level SIC classification codes 2000 - 3999). The *NBER* constructs this data by aggregating establishment observations by industry. From the database we retrieve our main dependent variable, "total factor productivity" (tfp) to measure productivity growth. This variable is defined as follows:

$$tfp = dy/y - (s_1 * dx_1/x_1 + .. + s_5 * dx_5/x_5)$$

where dy/y = percent growth in output (real shipments),

dx_i/x_i = percent growth in factor input i,

s_i = expenditures for each input / average of t and t-1 industry shipments, and

$x_1, .., x_5$ = raw materials, production worker hours, number of non-production employees, energy, capital

The second data set is the *New Census Based Small Business Data Base* which is based on the annually updated *Company Organization Survey*. The data in the file are classified by industries (based on the 1972 4-digit level SIC classification). It is our understanding that the data are compiled in the following way. First, all establishments are surveyed[2]. Second, establishments are then sorted into industries according to their own declared industry classification and into "size" classes according to their parent firms' number of employees. The size classes are coded 2, 3, 4, 5, 6, and 7; representing parent firm employment ranges of 1-4, 5-9, 10-19, 20-99, 100-499 and above 500, respectively. (Size class 1 represents "industry total.") Establishments whose parents cannot be identified are sorted into size class 2, which assumes the parent firm employs less then five persons[3]. Third, establishment level data are then summed within size class. The variables most useful to us are: beginning of the year (which is defined as in March) "employment" and "number of establishments" in each parent firm size class. Based on these variables, we can obtain for each industry the "establishment share" and "employment share" of each parent firm size class. As well, we can use these shares to formulate a composite index for firm size distribution. We also retrieve from the data set "total establishment birth" (establishments newly put into operation) and "total establishment death" (establishments closed down) in each industry.[4]

We examine the consistency of the second set of data by checking that for each variable the industry total is equal to the sum by size class and that the end of the year data minus the beginning of the year data is equal to the reported annual change. For example, we check whether reported annual change in total industry employment is equal to the sum of reported change in employment by parent firm size classes. The data consistency check reveals that the 1990 and 1991 beginning of the year data and the reported annual changes in 1990 are reliable. (The data set has data from 1989 to 1991. We did not use data other than the 1990 and 1991 beginning of the year data due to concerns about data consistency).

Combining the two data sources, we have the required variables to examine how a U.S. industry's total factor productivity in 1991 is related to the 1990 employment and establishment share of large and small firms in the industry. A stylized representation of our empirical question is as follows:

$$TFP_{1991} = a + b_1\text{*(small firms' share)}_{1990} + b_2\text{*(large firms' share)}_{1990}$$

$$TFP_{1991} = a + b_1\text{*(change in small firms' share)}_{1990} + b_2\text{*(change in large firms' share)}_{1990}$$

The research questions: "Are b_1 and b_2 significant?" and "What are their signs ?"

IV Results

Background changes

It is useful to have a glimpse of the background changes in productivity and industry characteristics in U.S. manufacturing in 1991 before we start our main statistical analyses. We should also bear in mind from the out-set that the second half of 1991 was the beginning of a recession in the U.S.

Table 1A and 1B report descriptive statistics for "total factor productivity (tfp)", "employment," and "establishment count." In both tables, the top row of numbers are statistics for tfp. The second block of rows of numbers represent shares by parent firm size class. In Table 1A, share is defined as employment in a firm size class divided by industry total. In Table 1B, share is defined as establishment counts in a firm size class divided by industry total. The firm size classes are defined according to the range of parent firm employment: 1-4, 5-9, 10-19, 20-99, 100-499 and above 500. The third block of rows of numbers represent change in the shares.

[Table 1A and 1B about here]

Table 1A and 1B first reveal that U.S. manufacturing industry on average experienced a decline in total factor productivity in 1991 by 1.07%; that is, average industry real shipments dropped by 1.07% after accounting for changes in factor inputs. (The median is -1.46%.) That is not unexpected given that 1991 was the beginning of a recession.

In addition, Tables 1A and 1B show that larger firms, whose parent firms have more than 500 employees, accounted for 57% of employment but only 22% of establishments (row 7 of both Table 1A and 1B), which is inevitable given that larger firms usually have more large scale establishments. The larger firms in general experienced a decline in both employment and establishment share while the opposite is true for smaller firms (the third block of rows in both Table 1A and 1B). The observation appears to be consistent with the conventional wisdom that small firm start-up is counter-cyclical. We do need to be cautious. Because of missing industry observations, certain biases may have been introduced into the data. Nevertheless, further results reported in the next two tables suggest that variations in employment and establishment share by firm classes are not driven purely by the 1991 recession.

[Table 1C about here]

We next examine the actual change in number of establishments by parent firm size class. The top panel in Table 1C reports statistics from the full sample. The middle and the bottom panels report, respectively, statistics from industries losing and gaining establishments. The table reveals that in 1991 the U.S. manufacturing experienced a net increase in establishments; 119 industries lost establishments and 274 gained establishments. In the middle panel, we observe that larger firms accounted for about 20% of establishment shut-downs, roughly the same proportion as their share of establishments. However, the lower panel shows that in industries with a net creation of establishments, larger firms still on average closed down establishments while the smaller firms (size class 2 to 4) accounted for more than 100% of establishment creation. Hence, the results suggest that larger firms were on average closing down establishments, perhaps driven to do so by the up-coming recession, while smaller firms were the driving force in establishment creation.

[Table 1D about here]

Table 1D reports actual changes in employment in the data year. In the top panel, we report numbers from the full sample. Again, not unexpectedly, US manufacturing lost employment: the second row of the first panel shows that total job loss was 626,706, which was about 4.29% of total manufacturing employment at the beginning of 1991.

The numbers in the top panel suggest that larger firms were cutting jobs while smaller firms were creating jobs.

A closer look reveals a more complicated picture. We divide the sample into industries registering net job gains and net job losses; about 80% of industries experienced net job losses and 20% experienced net job gains. The statistics for the two sub-sample are reported in the middle and bottom panel of Table 1C. The two panels reveal that larger firms in the main accounted for 70% of the job losses in the job-losing industries and 71% of the job gains in the job-gaining industries (from the "sum" column, the entry in row-x7 divided by the entry in row-x1, in both the middle and the bottom panel). In both sub-samples, larger firms accounted for about 57% of employment. Hence, larger firms actually showed more employment volatility than smaller firms. They were certainly not cutting jobs across all industries as a response to recession.

Average tfp for job-gaining and job-losing industries and for establishment-gaining and establishment-losing industries are reported in the first row of the middle and bottom panels of both Tables 1C and 1D. These average tfp's are not statistically significantly different from one another; they actually have very similar magnitude.

Therefore, the emerged picture is as follows. In our data year (1991) the U.S. manufacturing sector on average experienced negative total productivity growth, net job loss, and net closing down of establishments. There were no discernible differences between the tfp of expanding and contracting industries when expansion and contraction was measured in terms of employment and establishment counts. Larger firms generally lost both employment and establishment share. However, while the trend was that larger firms were closing down establishments, they were even more of the driving force behind industry variations in employment -- they accounted for more than their share of job creation in job-gaining industries and more than their share of job losses in job-losing industries.

Results

We now turn to the relationship between total factor productivity and distribution of employment and establishments by parent firm size class. We shall first report some simple correlations between total factor productivity and share of employment and establishment by parent firm size class.

In anticipation of subsequent regression analysis, we transform the total factor productivity measure from the NBER database in the following way:

$$ttfp = \log \{(tfp + 0.5)/[1 - (tfp + 0.5)]\}$$

The transformation is done to preserve the sign of the original tfp measure and to allow the transformed variable to span a greater domain than the original tfp.[5] The original tfp is roughly bounded within -0.25 and 0.25. In our regression, we do not want the independent variable to be bounded within such a narrow range.

Table 2A reports the simple correlation between ttfp (in 1991) and the employment shares of the six parent firm size classes (as indicated by beginning of 1991 data) and also between ttfp and the changes in these employment shares (defined as beginning of 1991 data - beginning of 1990 data). Table 2B reports the same simple correlation between ttfp and establishment shares and between ttfp and the changes in the establishment shares.

The top row in both tables shows that ttfp is positively correlated with larger firms' share (x7) and with changes in larger firms' share (dx7). While the correlations are not highly significant, they are significant at the 1-tail 10% level. The top row in both tables also shows that ttfp is negatively correlated with smaller firms' shares (x2, .. x6) and also with changes in these smaller firms' shares (dx2, .. , dx6). The correlations are often significant at the 2-tail 5 % level. Hence, the correlations suggest that industries dominated by smaller firms have lower total factor productivity.

To improve on the preliminary results, we regress ttfp on the employment share (establishment share) of the parent firm size classes. We run a separate regression for the share of every class of parent size. Due to multicollinearity, we cannot enter the shares for all classes simultaneously.

Three independent variables are introduced in the multiple regressions. First, we include a lagged value of ttfp ($ttfp_{t-1}$). Productivity growth may be serially correlated because it often takes time to fully adopt productivity improving technology.

Second, we include the log of value-added in t-1 as another control variable ($\log(\text{real value-added})_{t-1}$, where real value-added = real shipment - real expenditures on raw materials). Larger industries are typically "older" and older industries' productivity expectedly grows slower. Also, it is generally the case that in macroeconomic studies large economies grow slower. An analogous treatment here is to introduce the lagged value of value-added into our regression.

Our third control variable is a capital intensity measure, K/L_{t-1} [(plant & equipment) / direct production worker-hours]$_{t-1}$. We introduce K/L_{t-1} as a control variable for several reasons. First, productivity growth may be capital-biased, which is likely the case in the U.S. Second, we are concerned that the total factor productivity measure may have a "rent" element. The tfp measure we use is calculated as the change in real value of shipments minus the sum of the product of the change in each factor input and its cost share (where the cost shares of inputs sum to one). Part of this tfp measure may reflect "market power."[6] To capture the potential rent component in the tfp measure, we introduce K/L_{t-1}, since high capital intensity can serve as an entry barrier.

[Tables 3A and 3B about here]

Table 3A reports the regression results when ttfp is regressed on employment shares and changes in employment shares by parent firm size classes. Table 3B reports the results when ttfp is regressed on establishment shares and on changes in establishment shares by parent firm size classes. Notice again that we run a separate regression for the share of every class of parent size. Due to multicollinearity, we cannot enter the shares for all classes simultaneously. Thus, each column in both Tables 3A and 3B represents an independent set of regressions. Columns with heading X2 to X7 represent, respectively, that the prime independent variable is the market share of parent firms whose employment is within 1-4, 5-9, 10-19, 20-99, 100-499, and above 500. Columns with heading dX2 to dX7, respectively, represent that the prime independent variable is the change in the share of parent firms whose employment is within 1-4, 5-9, 10-19, 20-99, 100-499, and above 500. For example, the first column in Table 3A marked X2 represents the regression of ttfp on the employment share of parent firms having only 1 to 4 employees; the seventh column marked dX2 represents the regression of ttfp on the change in the employment of share of parent firms having only 1 to 4 employees. In the top panel, ttfp is regressed on only the share variable. In the second panel, we add the lagged value of ttfp as another independent variable. In the third panel, we add the lagged value of K/L, and in the bottom we further include the lagged value of log(real value-added) in the regressions.

The results suggest that tfp is higher the greater the larger firms' share. The results in both tables 3A and 3B show that smaller firms' shares attract negative and often significant coefficients. The changes in smaller firms' shares also attract negative coefficients but they are less significant. Larger firms' shares and the change in their share both attract positive coefficient. They are occasionally significant at the 10% 1-tail level.

To save space, we do not report the coefficient of the control variables in Table 3A and 3B. Two of the control variables, K/L_{t-1} and $ttfp_{t-1}$, are both positive as expected, but they are utterly insignificant. The remaining control variable, $\log(\text{value added})_{-1}$, is negative and occasionally marginally significant at the 10% level.

The preliminary results in Tables 2A, 2B, 3A and 3B highlight that factor productivity is indeed related to the distribution of market share to firm size classes.

They suggest that industries whose larger firms capture a greater share of employment and establishments have greater total factor productivity.

We need to improve on the preliminary results. We obtain the relationship between tfp and small and large firms' market share individually – there is an obvious "missing variable" problem as other firm size classes' shares are not represented. As we have stated earlier, it is not sensible to do a multiple regression incorporating all firm size classes' shares because they are very highly correlated (e.g., see the simple correlations in Table 2). One reasonable approach is to find a continuous variable that is a composition of all the firm size classes' shares. A candidate is "employment / establishment" in each industry. The variable can be expressed as:

$$s_2*(L/est)_2 + .. + s_7*(L/est)_7$$

where $(L/est)_i$ = employment / number of establishments in parent firm size class i,

i = 2, ..., 7 representing, respectively, that parent firm employment is within 1-4, 5-9, 10-19, 20-99, 100-499 and above 500,

s_i = number of establishments in parent firm size class i / total number of establishments in the industry.

Hence, "employment / establishment" of an industry is an "establishment-share-weighted" average of each firm class' average employment per establishment. Note that larger parent firms typically have more employment per establishment[7]. Thus, the greater the establishment share of larger firms the higher the variable. The "employment / establishment" variable we actually use is the log of the ratio based on the beginning of 1991 data. We also use the first difference of the variable (the beginning of 1991 data minus the beginning of 1990 data). We call the two variables L/est and CHL/est.

L/est is by construction correlated with larger firms' establishment share and CHL/est is correlated with changes in larger firms' establishment share. We need to verify that L/est is an acceptable composite variable of all firm size classes' employment shares. We find that L/est is positively and very significantly correlated with the employment share of firm size class 7 (parent firm employment exceeds 500) and is negatively and very significantly correlated with other firm size classes' employment shares. Similarly, CHL/est is positively and very significantly correlated with the change in the employment share of firm size class 7 while negatively and very significantly correlated with the changes in the employment share of firm size classes 2 to 5.

Our empirical question is: How does tfp relate to L/est and CHL/est? We regress ttfp on the two variables with and without the control variables, $ttfp_{t-1}$, K/L_{t-1}, and log(real value-added)$_{t-1}$. The results are reported in Table 4. The "employment / establishment" variable (L/est) has a positive coefficient significant at the 1% level in all specifications. Similarly, the change in "employment / establishment" (CHL/est) has a positive coefficient significant at the 5% level. Again, the control variables result in regression coefficients of the expected sign, but only the lagged value of value-added attains a marginal level of significance.

[Table 4 about here]

In summary, our empirical results suggest that total factor productivity varies with the market share distribution by firm size: the greater the market share of larger firms, the higher the industry's total factor productivity.

V Robustness Check

In this section, we report some robustness checks of the results. Our first concern is whether L/est and CHL/est are picking up "rents" or are indeed indicating that industries with a greater market share to larger firms have higher total factor productivity. Recall that when we introduce the control variables, we point out that our total factor productive measure may capture "rents" -- industries with more market power may register a higher tfp not because they experience higher total factor productivity, but because the tfp calculation may include market power of the existing firms in the industry. The point then is that our dependent variable potentially is measured with error. Larger firms in industries with concentrated market power ought to have a large market share. L/est and CHL/est may then be capturing the measurement error in the above regressions.

There is a way to examine the possibility. The basic format of our regression is:

(1) $ttfp_t = b * L/est_{t-1}$ (or $b * CHL/est_{t-1}$)

Suppose that "rent" exists in our tfp variable and that in regression equation (1) L/est and CHL/est are indeed picking up the "rent" element. L/est and CHL/est should attract a more positive regression coefficient in industries with more "rent." We can test whether L/est and CHL/est are merely picking up "rent" by changing the regression specification as follows:

(2) $ttfp_t = (b_0 + b_1 * rent_{t-1}) * L/est_{t-1}$ [or $(b_0 + b_1 * rent_{t-1}) * CHL/est_{t-1}$]

where "rent" is a proxy capturing the presence of measurement error in tfp due to market power.

When the presence of "rent" is the only explanation of our previous results, b_0 should be zero and b_1 should be positive. We can reject a "rent" measurement error explanation when b_0 is statistically significantly positive.

We find two proxies for "rent". The first one is "sum of establishment birth and death / original number of establishment" $[(B+D)/est]_{t-1}$. In our data set, establishment birth represents a greenfield start-up while establishment death represents the closing down of an establishment. Thus, $[(B+D)/est]_{t-1}$ captures the extent an industry is contested and indicates low fixed costs in the industry. In other words, the higher $[(B+D)/est]_{t-1}$, the lower the "rent." We expect that if L/est and ChL/est are merely picking up rents, the cross-terms between $[(B+D)/est]_{t-1}$ and them (i.e. b_1) will be negative and significant while L/est and CHL/est themselves (i.e. b_0) will be insignificant.[8]

Another plausible variable to capture "rent" is capital intensity, K/L_{t-1}. Industries with higher capital intensity are likely to have a greater fixed cost component and thus more "rent." We expect that if L/est and ChL/est are merely picking up rents, the cross-terms between K/L_{t-1} and them (i.e. b_1) will be positive and significant while L/est and CHL/est themselves (i.e. b_0) will be insignificant.

[Table 5 about here]

The regression test results are reported in Table 5. We regress ttfp on L/est and its cross-terms with $[(B+D)/est]_{t-1}$ and with K/L_{t-1} (Cols. 1 and 2, respectively), on CHL/est and its cross-terms with $[(B+D)/est]_{t-1}$ and with K/L_{t-1} (Cols. 3 and 4, respectively), and then on both L/est and CHL/est and their cross-terms with $[(B+D)/est]_{t-1}$ and with K/L_{t-1} (Cols. 5 and 6, respectively). In the top panel we report regressions without any control variables and in the bottom panel we report regressions with all the control variables we used in Table 4 (i.e., $ttfp_{t-1}$, K/L_{t-1}, and $\log(\text{value-added})_{t-1}$). It turns out that the regression coefficients for the stand-alone L/est and CHL/est are always positive and significant, just like they are in Table 4. The regression coefficients for the cross-terms are never significant and sometimes they have a sign opposite to that expected by the "pure rent" hypothesis (e.g. the fourth entry in column five in the lower panel). In other words, we find that b_0 in equation 2 is positive and significant while b_1 is insignificantly different from zero. These results contradict the hypothesis that our L/est and CHL/est are picking up merely a measurement error due to the presence of “rents” in tfp.

We were told that our results would be "cleaner" if computer related industries were taken out from our sample because these industries were known to have productivity trends very different from other industries. The industry classifications in our sample are reconciled with the classifications in 1972. We therefore match the 1972 SIC classifications and the latest SIC classifications to identify industries in our sample that may include computer related industries.[9] We exclude these industries from our sample and re-run the regressions as in Table 4. We indeed obtain more significant regression coefficients for L/est and CHL/est, which remain positive.

There is another potential problem in our main regression results reported in Table 4. Our data year is 1991, the beginning of a recession. We were advised that during the beginning of a recession, larger firms typically allowed a greater build up of inventory than smaller firms. Larger firms might then seem to maintain their productivity while smaller firms did not. Our L/est and CHL/est may be picking up the phenomenon. To mitigate the problem, we include "change in real inventory" as another control variable in the regressions in Table 4. We indeed find that "change in real inventory" is positive and significant in the regression. However, the behavior of L/est and CHL/est remains the same as in Table 4 (i.e. they attract positive and significant regression coefficients).

We question further how the data year, 1991, affects our results. We believe that by accident we might have picked a desirable year for our experiment. The recession in the early nineties began in 1991. Large and small firms react differently to a recession: the former usually contract by laying off workers while the latter are more prompt to close out small establishments. Hence, larger firms may have more idle capital than smaller firms during a recession. Thus industries with more large firms may be more likely to register LOWER total factor productivity than industries with more small firms. Our choice of data year biases against finding that industries with more large firms have a greater total factor productivity. Our results are then particularly noteworthy.

Finally, we are concerned with a survival bias problem. Firms grow larger because they are better (Jovanovic, 1982). Industries with a greater share of larger firms may be industries with a greater share of better firms. Our results then suggest that better firms generate more productivity growth. The point, in our opinion, is not an objection to our finding. Rather, it addresses what the proper interpretation should be. We discuss our interpretation in the next section.

VI Discussion and Conclusion

In this paper, we examine the relationship between productivity growth and market share distribution by firm size. Our results are based on a cross-sectional study of the U.S. manufacturing industry data in 1991. In the data year, the U.S. manufacturing sector on average experienced negative total factor productivity growth, job losses, and a net decline in the number of establishments. Against this background, we find that industry total factor productivity is associated with market share distribution by firm size, where market share is defined as employment share and or establishment share. Industries in which larger firms have a greater market share have a higher total factor productivity growth.

Concerned with our data limitation, we examine the robustness of our result. We are first concerned whether our observation is spurious. We examine and eliminate one plausible explanation of our observation – our total factor productivity measure has a rent component and it is captured by our proxy for large firms' market share. Second, we are concerned whether our result is driven by macroeconomics. Our data year was the beginning of a recession. We introduce an additional independent variable, the change in inventory, in our regressions to check the possibility that larger firms are hoarding inventory at the beginning of a recession and thus register less decline in their productivity. We find that our results are unaffected. We also question how the choice of the first year of a recession cycle affects our results and conclude that it will actually bias against the possibility of finding our observation. While we are optimistic about the robustness of our observation, we still advocate caution and welcome closer scrutiny.

We should be very cautious in interpreting our results. Our results suggest that larger firms contribute more to productivity growth than smaller firms. Why? Would that be due to the Schumpetarian reason (Schumpeter, 1942): larger firms have more resources to adopt and implement innovations? Would that be a reflection of survival bias: larger firms are larger because they are better in the Jovanovic (1982) sense and better firms contribute more to productivity growth? Note that the second explanation obviously offers absolutely no room for policy activism. Even the first explanation does not readily suggest any policy actions: firms are very capable in wasting subsidized resources instead of using them to increase productivity.

Our results also do not suggest that smaller firms do not make substantial contribution to productivity growth. Many radical and yet fruitful innovations are brought onto the market place by small firms. However, many more other small firms are trivial start-ups which will eventually wither. Thence, the average contribution of smaller firms to productivity growth can appear trivial. Moreover, the contribution of radical innovations brought by truly innovative small firms will take time to manifest their influence on productivity.

In our opinion, there is likely a Schumpeterian transition story: small firms introduce radical innovations and large firms magnify the impact of the innovations. The large firms may be the formerly small and yet successful firms, or they are agile large firms successful in acquiring and adopting the innovations brought by small firms. The Schumpeterian transition story suggests that productivity growth is positively associated with the current market share of larger firms but is positively associated with the market share of smaller firms in the past. We therefore urge a follow-up of this study using cross-sectional time series data.

Footnotes:

[1] Often, employees also have to sign explicit agreement that they will refrain from being in a position that directly compete with their current employer within a certain time period after their departure. Hence, they cannot easily conceal an idea, resign from their job, and then use the idea to compete with their old employer.

[2] Still, it is possible that the survey may miss very small establishments, especially the single establishment enterprises. The possible survey bias means that our sample may give larger firms and larger establishments a more complete representation than smaller firms and smaller establishments.

[3] We were told that these establishments inevitable had very "small" parents who even failed to file corporate income tax returns.

[4] Other variables are of limited use because of too many missing values.

[5] It can be easily verified that ttfp and tfp have the same sign and that ttfp stretches from positive infinity to negative infinity as tfp varies from 0.5 to -0.5. The transformation is done to make our regressions conform more to the statistical assumptions in OLS. Regression results using the original tfp as the dependent variable are qualitatively identical to what we are going to report here.

[6] It is easy to understand the formulae in the case of perfect competition and a homogeneous degree 1 production function. For simplicity, consider a two factor homogeneous degree 1 production function, $Q = f(x_1, x_2)$, where Q is output and x_1 and

x_2 are factor inputs. With f_i's defined as partial derivatives, Q can be expressed as follows:

$$Q = f_1 * x_1 + f_2 * x_2$$

Taking total derivative, we obtain:

$$dQ/Q = f_1*dx_1/Q + f_2*dx_2/Q + (df_1*x_1 + df_2*x_2)/Q$$

Assuming perfect competition, we obtain $p*f_1 = W_1$ and $p*f_2 = W_2$, where p is Q's price and W_i's are factor prices of x_i's. By substitution,

$$dQ/Q = (W_1*x_1/P*Q)*dx_1/x_1 + (W_2*x_2/P*Q)*dx_2/x_2 + (df_1*x_1 + df_2*x_2)/Q$$

$$= (s_1*dx_1/x_1 + s_2*dx_2/x_2) + (df_1*x_1 + df_2*x_2)/Q$$

where s_i's = $W_i*x_i/P*Q$, and the sum of all $s_i = 1$.

In the context of the above, tfp is $[dQ/Q - (s_1*dx_1/x_1 + s_2*dx_2/x_2)]$, which is exactly how tfp in the NBER tape is obtained.

However, if there is market power, $MR*f_1 = W_1$ and $MR*f_2 = W_2$, where MR is marginal revenue. Profit maximization implies that MR = MC (marginal cost). By substitutions, $[dQ/Q - (s_1*dx_1/x_1 + s_2*dx_2/x_2)]$ is as follows:

$$(P/MC - 1) * (s_1*dx_1/x_1 + s_2*dx_2/x_2) + (df_1*x_1 + df_2*x_2)/Q$$

Hence, a simple tfp calculation may have a "rent" component which is $(P/MC - 1) * (s_1*dx_1/x_1 + s_2*dx_2/x_2)$. While it is possible to obtain tfp given the presence of market power and in the context of a general production function, we do not have the required data to do so.

7 Indeed, the average employment per establishment increases monotonically with the size of parent firms. The average is, respectively, 1.90, 6.77, 13.76, 40.65, 120.53, and 320.25 (persons) for parent firm employment equal to 1-4, 5-9, 10-19, 20-99, 100-499, and above 500.

8 The $[(B+D)/est]_{t-1}$ measure has its problems. A high establishment death rate may mean not just low exit costs but that an industry is declining. A high establishment birth rate may mean not just low entry costs but also that an industry is expanding. We therefore try several versions: we use $[(B+D)/est]_{t-1}$, B/est_{t-1}, and D/est_{t-1}. They all lead to results qualitatively similar results. We opt to focus on using $[(B+D)/est]_{t-1}$ because the variable mitigate the problem of measuring industry expansion and decline.

9 We find eight such industries: 3574, 3579, 3629, 3661, 3663, 3674, 3679, and 3699.

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Table 1A -- Simple Statistics of Total Factor Productivity, Employment Distribution, and the change in Employment Distribution by Firm Size Class Data, 1991

xi = *employment in firm size class i / industry's total employment (beginning of the year)*

dxi = *xi(t) - xi(t-1)*

class i = 2 3 4 5 6 7 1

parent empl. = 0-4, 5-9, 10-19, 20-99, 100-499, >500, total

Variable	N	Mean	Std Dev	Sum	Minimum	Q1	Q2	Q3	Maximum
TFP	450	-0.0107[a]	0.0537	-4.8221	-0.2075	-0.0401	-0.0146[a]	0.0148	0.2624
X2	298	0.0139	0.0221	4.1490	0	0.0031	0.0074	0.0165	0.2540
X3	301	0.0253	0.0284	7.6263	0.0007	0.0080	0.0163	0.0331	0.2225
X4	322	0.0451	0.0433	14.5102	0.0019	0.0158	0.0316	0.0577	0.2416
X5	338	0.1771	0.1158	59.8667	0.0054	0.0827	0.1606	0.2488	0.5393
X6	345	0.2045	0.0934	70.5432	0.0072	0.1392	0.2013	0.2628	0.5749
X7	361	0.5678	0.2393	204.9704	0.0000	0.3951	0.5907	0.7555	0.9928
DX2	259	0.0013[a]	0.0027	0.3353	-0.0161	0.0001	0.0007[a]	0.0021	0.0136
DX3	262	0.0022[a]	0.0048	0.5775	-0.0273	-0.0000	0.0013[a]	0.0040	0.0293
DX4	298	0.0030[a]	0.0071	0.8845	-0.0253	-0.0007	0.0022[a]	0.0052	0.0337
DX5	323	0.0026[a]	0.0175	0.8557	-0.0643	-0.0070	0.0014[c]	0.0096	0.0919
DX6	326	-0.0008	0.0327	-0.2755	-0.1683	-0.0146	-0.0014	0.0132	0.2008
DX7	346	-0.0068[a]	0.0286	-2.3384	-0.2030	-0.0186	-0.0037[a]	0.0055	0.1063

[a], [b], and [c] represent significance in 2-tail test at 1, 5, and 10% level, respectively.

Table 1B -- Simple Statistics of Total Factor Productivity, Establishment Count Distribution, and the Change in Establishment Count Distribution by Firm Size Class Data, 1991

Xi = *number of establishments in firm size class i / total number of establishments in the industry (beginning of the year)*

dXi = *xi(t) - xi(t-1)*

class i = 2 3 4 5 6 7 1

parent empl. = 0-4, 5-9, 10-19, 20-99, 100-499, >500, total

Variable	N	Mean	Std Dev	Sum	Minimum	Q1	Q2	Q3	Maximum
TFP	450	-0.0107[a]	0.0537	-4.8221	-0.2075	-0.0401	-0.0146[a]	0.0148	0.2624
X2	393	0.2291	0.1179	90.020310	0	0.1414	0.2516	0.2916	0.7185
X3	388	0.1224	0.0498	47.496632	0	0.0839	0.1238	0.1590	0.2453
X4	386	0.1226	0.0441	47.340002	0.0088	0.0909	0.1280	0.1546	0.2609
X5	391	0.2029	0.0728	79.324687	0	0.1556	0.2000	0.2509	0.4348
X6	389	0.1085	0.0547	42.201792	0	0.0686	0.1026	0.1376	0.3243
X7	392	0.2210	0.1807	86.616576	0	0.0862	0.1672	0.3162	0.8919
DX2	392	0.0119[a]	0.0295	4.669175	-0.1167	-0.0007	0.0117[a]	0.0256	0.1920
DX3	386	0.0035[a]	0.0253	1.343226	-0.1118	-0.0089	0.0034[a]	0.0175	0.1429
DX4	386	0.0015	0.0236	0.588044	-0.1424	-0.0085	0.0023[b]	0.0131	0.0967
DX5	391	-0.0054[a]	0.0238	-2.109785	-0.1103	-0.0179	-0.0074[a]	0.0048	0.1231
DX6	388	-0.0040[a]	0.0194	-1.553497	-0.1098	-0.0132	-0.0044[a]	0.0032	0.0978
DX7	392	-0.0071[a]	0.0237	-2.801724	-0.1846	-0.0137	-0.0044[a]	0.0011	0.0968

[a], [b], and [c] represent significance in 2-tail test at 1, 5, and 10% level, respectively.

Table 1C -- Change in # of Establishments by Firm Size Class, 1990 to 1991

Yi = beginning # of establishments in firm size class i: 1991 - 1990

class i = 2 3 4 5 6 7 1

parent empl. = 0-4, 5-9, 10-19, 20-99, 100-499, >500, total

Var.	N	Mean	Std Dev	Sum	Min.	Median	Max.
Full sample							
TFP	450	-0.0107[a]	0.0537	-4.822	-0.208	-0.015[a]	0.262
Y1	393	15.178[a]	86.549	5965	-250	4[a]	1057
Y2	392	14.337[a]	62.222	5620	-37	4[a]	972
Y3	386	4.749[a]	22.013	1833	-87	2[a]	258
Y4	386	2.632[a]	19.633	1016	-134	1[a]	288
Y5	391	-3.325[a]	20.417	-1300	-111	-1[a]	289
Y6	388	-1.722[a]	6.914	-668	-63	-1[a]	27
Y7	392	-1.357[a]	9.097	-532	-35	-1[a]	116
Net change in industry establishment count < 0							
TFP	119	-0.012[b]	0.057	-1.368	-0.191	-0.014[a]	0.197
Y1	119	-15.908[a]	33.013	-1893	-250	-5[a]	-1
Y2	119	0.185	12.380	22	-37	-1	57
Y3	117	-1.299	12.846	-152	-87	0	41
Y4	116	-3.086[b]	15.041	-358	-134	-1[c]	19
Y5	118	-6.034[a]	15.359	-712	-80	-1.5[a]	12
Y6	116	-2.690[a]	6.152	-312	-25	-1.5[a]	12
Y7	118	-3.212[a]	6.453	-379	-34	-1[a]	11
Net change in industry establishment count > 0							
TFP	274	-0.013[a]	0.049	-3.606	-0.208	-0.017[a]	0.262
Y1	274	28.679[a]	98.390	7858	0	8[a]	1057
Y2	273	20.505[a]	73.302	5598	-9	7[a]	972
Y3	269	7.379[a]	24.531	1985	-24	3[a]	258
Y4	270	5.089[a]	20.851	1374	-47	2[a]	288
Y5	273	-2.154	22.173	-588	-111	-1[c]	289
Y6	272	-1.309[a]	7.185	-356	-63	-0.5[a]	27
Y7	274	-0.558	9.928	-153	-35	-1[a]	116

[a], [b], and [c] represent significance in 2-tail test at 1, 5, and 10% level, respectively.

Table 1D - Change in Employment by Firm Size Class, 1990 to 1991

Xi = beginning employment in firm size class i: 1991 - 1990

class i =	2	3	4	5	6	7	1
parent empl. =	0-4,	5-9,	10-19,	20-99,	100-499,	>500,	total

Var.	N	Mean	Std Dev	Sum	Min.	Median	Max.
Full sample							
TFP	450	-0.0107[a]	0.0537	-4.822	-0.208	-0.015[a]	0.262
X1	376	-1666.77[c]	4065.5	-626706	-38028	-793[a]	17578
X2	259	38.290[a]	157.138	9917	-114	13[a]	2012
X3	267	39.603[a]	166.505	10574	-779	19[a]	1406
X4	303	35.297[b]	295.419	10695	-1915	17[b]	3820
X5	327	-227.636[a]	898.742	-74437	-4383	-92[a]	11130
X6	332	-362.087[a]	906.75	-120213	-6105	-196[a]	3152
X7	352	-1252.849[a]	3784.926	-441003	-38282	-535[a]	8304
Net industry level job change < 0							
TFP	302	-0.0143[a]	0.051	-4.318	-0.208	-0.175[a]	0.262
X1	302	-2352.04[a]	4104.689	-710316	-38028	-1199[a]	-8
X2	210	41.876[a]	170.679	8794	-114	14[a]	2012
X3	218	42.849[a]	168.898	9341	-779	22[a]	1406
X4	243	19.288	212.592	4687	-1915	17[b]	827
X5	263	-322.300[a]	694.300	-84765	-4383	-134[a]	1439
X6	267	-466.356[a]	930.361	-124517	-6105	-282[a]	3152
X7	277	-1801.256[a]	4032.980	-498948	-38282	-846[a]	1282
Net industry level job change > 0							
TFP	74	-0.0100[c]	0.049	-0.74	-0.145	-0.013	0.163
X1	74	1129.865[a]	2359.32	83610	10	478[a]	17578
X2	49	22.918[b]	74.711	1123	-31	9[a]	495
X3	44	25.455	164.706	1120	-162	3	1012
X4	55	105.491	528.189	5802	-341	15	3820
X5	60	170.350	1454.56	10221	-481	-18	11130
X6	59	76.763	673.4	4529	-2312	34	2828
X7	69	866.435[a]	1410.45	59784	-796	438[a]	8304

[a], [b], and [c] represent significance in 2-tail test at 1, 5, and 10% level, respectively.

Table 2A -- Simple Correlation between Total Factor Productivity and Employment Share, and the Change in Employment Share, by Firm Size Class , 1991

	TTFP	X2	X3	X4	X5	X6	X7	DX2	DX3	DX4	DX5	DX6	DX7
TTFP	1.0000	-0.1326	-0.1429	-0.0885	-0.0972	0.0635	0.0696	-0.1403	-0.0544	-0.0317	0.0302	0.0179	0.0723
Prob	0.0	0.022	0.013	0.113	0.074	0.239	0.187	0.024	0.381	0.586	0.589	0.748	0.180
n	450	298	301	322	338	345	361	259	262	298	323	326	346
X2		1.0000	0.9307	0.7951	0.4569	0.0234	-0.6310	0.3018	0.3547	0.1976	-0.1617	-0.0290	-0.0065
		0.00	0.000	0.000	0.000	0.692	0.000	0.000	0.000	0.001	0.007	0.631	0.912
		298	286	284	287	289	292	259	254	269	278	277	286
X3			1.0000	0.9278	0.6467	0.0658	-0.7288	0.4045	0.3458	0.2350	-0.1353	-0.0494	-0.0136
			0.000	0.000	0.000	0.260	0.000	0.000	0.000	0.000	0.023	0.410	0.818
			301	288	293	295	293	256	262	274	284	281	288
X4				1.0000	0.7942	0.1550	-0.8152	0.3802	0.2247	0.3606	-0.1294	-0.0963	-0.0177
				0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.025	0.099	0.758
				322	310	311	313	254	255	298	299	295	305
X5					1.0000	0.4899	-0.9458	0.3194	0.4133	0.2708	0.0926	-0.1106	-0.0875
					0.000	0.000	0.000	0.000	0.000	0.000	0.097	0.052	0.117
					338	325	332	257	257	292	323	309	323
X6						1.0000	-0.6757	0.0844	0.0967	0.1534	0.1185	0.1396	-0.2792
						0.000	0.000	0.178	0.121	0.009	0.036	0.012	0.000
						345	336	257	259	291	314	326	325
X7							1.0000	-0.4051	-0.3893	-0.3034	-0.0311	0.0073	0.1556
							0.000	0.000	0.000	0.000	0.580	0.897	0.004
							361	257	255	291	319	317	346
DX2								1.0000	0.2475	0.1891	0.0459	0.0119	-0.1716
								0.000	0.000	0.003	0.468	0.851	0.006
								259	247	247	252	252	253
DX3									1.0000	0.0153	0.0682	-0.0914	-0.1688
									0.000	0.809	0.280	0.148	0.007
									262	251	252	252	254
DX4										1.0000	-0.0040	-0.0044	-0.2438
										0.000	0.947	0.942	0.000
										298	285	282	286
DX5											1.0000	-0.2502	-0.3797
											0.000	0.000	0.000
											323	303	312
DX6												1.0000	-0.8006
												0.000	0.000
												326	308
DX7													1.0000

0.000
346

Table 2B -- Simple Correlation between Total Factor Productivity and Establishment Share, and the Change in Establishment Share, by Firm Size Class , 1991

	TTFP	X2	X3	X4	X5	X6	X7	DX2	DX3	DX4	DX5	DX6	DX7
TTFP	1.0000	-0.1292	-0.1136	-0.1570	0.0377	0.1618	0.0776	-0.0493	0.0739	-0.0946	0.0292	0.0477	0.0097
Prob	0.000	0.010	0.025	0.002	0.457	0.001	0.125	0.330	0.148	0.063	0.564	0.349	0.848
n	450	393	388	386	391	389	392	392	386	386	391	388	392
X2		1.0000	0.6611	0.3136	-0.2123	-0.5897	-0.6852	0.2183	-0.1238	-0.0785	-0.1739	0.0179	0.0711
		0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.124	0.001	0.725	0.160
		393	388	386	391	389	392	392	386	386	391	388	392
X3			1.0000	0.5613	0.0185	-0.5712	-0.7205	-0.0491	0.2350	-0.1832	-0.1132	-0.0083	0.0956
			0.000	0.000	0.717	0.000	0.000	0.335	0.000	0.000	0.026	0.871	0.060
			388	385	386	385	387	387	386	385	386	384	387
X4				1.0000	0.3997	-0.3872	-0.7016	0.0230	-0.1117	0.2610	-0.2531	-0.0071	0.0804
				0.000	0.000	0.000	0.000	0.653	0.029	0.000	0.000	0.890	0.115
				386	386	384	385	385	384	386	386	383	385
X5					1.0000	0.2916	-0.4877	0.0384	0.0727	-0.0003	-0.0099	-0.1031	-0.0230
					0.000	0.000	0.000	0.450	0.155	0.995	0.845	0.043	0.651
					391	388	390	390	385	386	391	387	390
X6						1.0000	0.2049	-0.0019	0.0971	-0.0176	0.0144	0.0869	-0.1660
						0.000	0.000	0.970	0.057	0.731	0.778	0.087	0.001
						389	389	388	384	384	388	388	389
X7							1.0000	-0.1521	-0.0161	0.0473	0.2364	0.0043	-0.0138
							0.000	0.003	0.753	0.355	0.000	0.932	0.785
							392	391	385	385	390	388	392
DX2								1.0000	-0.5243	-0.0834	-0.2685	-0.0676	-0.3074
								0.000	0.000	0.102	0.000	0.184	0.000
								392	386	385	390	388	391
DX3									1.0000	-0.4165	0.0936	-0.0544	-0.0607
									0.000	0.000	0.067	0.288	0.235
									386	384	385	384	385
DX4										1.0000	-0.3170	-0.1378	-0.0577
										0.000	0.000	0.007	0.259
										386	386	383	385
DX5											1.0000	-0.2448	-0.2444
											0.000	0.000	0.000
											391	387	390
DX6												1.0000	-0.3272
												0.000	0.000
												388	388
DX7													1.0000
													0.000
													392

Table 3A -- Regressing Total Factor Productivity on Employment Proportion, and on the Change in Employment Proportion, by Firm Size Class , 1991

Y: *TTFP = log{(tfp + 0.5) / [1 - (tfp + 0.5)]}*

X: *xi = employment in firm size class i / industry's total employment (beginning of the year)*

dxi = xi(t) - xi(t-1)

K/L(t-1) = plant & equipment in millions of 1987 dollar / millions of actual production worker hours (in year t-1)

lnvadd(t-1) = log(value added) in t-1

	X2	X3	X4	x5	X6	X7	dX2	dX3	dX4	dX5	dX6	dX7
No Control												
Coeff.	-1.102[b]	-0.880[b]	-0.376	-0.154[c]	0.135	0.056	-9.041[b]	-1.913	-0.811	0.319	0.108	0.482
t	(2.30)	(2.50)	(1.59)	(1.79)	(1.18)	(1.32)	(2.27)	(0.88)	(0.55)	(0.54)	(0.32)	(1.35)
d.f.	296	299	320	336	343	359	257	260	296	321	324	344
R-square	.0176	.020	.0078	.0095	.004	.0048	.0197	.003	.0010	.0009	.0003	.0052
Control = TTFP(t-1)												
Coeff.	-1.109[b]	-0.879[b]	-0.371	-0.146[c]	0.137	0.052	-9.025[b]	-1.956	-0.858	0.399	0.097	0.472
t	(2.31)	(2.48)	(1.56)	(1.68)	(1.19)	(1.24)	(2.26)	(0.89)	(0.58)	(0.67)	(0.29)	(1.32)
d.f.	295	298	319	335	342	358	256	259	295	320	323	343
R-square	.0179	.0204	.0095	.0114	.0042	.0073	.0198	.0034	.0024	.0047	.0018	.0078
Control = TTFP(t-1), K/L(t-1)												
Coeff.	-0.990[b]	-0.828[b]	-0.378	-0.143	0.176	0.037	-8.862[b]	-1.612	-0.833	0.391	0.097	0.448
t	(2.03)	(2.27)	(1.53)	(1.52)	(1.45)	(0.79)	(2.17)	(0.72)	(0.55)	(0.66)	(0.29)	(1.25)
d.f.	294	297	318	334	341	357	255	258	294	319	322	342
R-square	.0233	.0216	.0095	.0114	.0071	.0089	.0199	.0056	.0024	.0049	.0020	.0101
Control = TTFP(t-1), K/L(t-1), lnvadd(t-1)												
Coeff.	-1.036[b]	-0.872[b]	-0.395	-0.177[c]	0.106	0.057	-8.744[b]	-1.736	-0.955	0.272	0.091	0.500
t	(2.10)	(2.38)	(1.60)	(1.85)	(0.80)	(1.17)	(2.14)	(0.77)	(0.63)	(0.45)	(0.27)	(1.38)
d.f.	293	296	317	333	340	356	254	257	293	318	321	341
R-square	.0251	.0265	.0124	.0199	.0119	.0166	.0238	.0083	.0087	.0089	.0120	.0135

[a], [b], and [c] represent significance in 2-tail test at 1, 5, and 10% level, respectively.

Table 3B -- Regressing Total Factor Productivity on Establishment Proportion, on the Change in Establishment Proportion, by Firm Size Class , 1991

Y: *TTFP = log{(tfp + 0.5) / [1 - (tfp + 0.5)]}*

X: *xi = establishment in firm size class i / industry's total establishment (beginning of the year)*

dxi = xi(t) - xi(t-1)

K/L(t-1) = plant & equipment in millions of 1987 dollar / millions of actual production worker hours (in year t-1)

lnvadd(t-1) = log(value added) in t-1

	X2	X3	X4	x5	X6	X7	dX2	dX3	dX4	dX5	dX6	dX7
No Control												
Coeff.	-0.2307[b]	-0.4824[b]	-0.7514[a]	0.1088	0.6211[a]	0.0904	-0.3519	0.6160	-0.8452[c]	0.2586	0.5156	0.0862
t	(2.575)	(2.246)	(3.115)	(0.744)	(3.226)	(1.538)	(0.975)	(1.451)	(1.862)	(0.577)	(0.937)	(0.192)
d.f.	391	386	384	389	387	390	390	384	384	389	386	390
R-square	.0167	.0129	.0246	.0014	.0262	.006	.0024	.0055	.0089	.0009	.0023	.0001
Control = TTFP(t-1)												
Coeff.	-0.2327[a]	-0.4825[b]	-0.7582[a]	0.1089	0.6215[a]	0.0913	-0.3852	0.6260	-0.8479[c]	0.2658	0.5150	0.0867
t	(2.588)	(2.244)	(3.126)	(0.743)	(3.221)	(1.547)	(1.038)	(1.460)	(1.863)	(0.584)	(0.934)	(0.193)
d.f.	390	385	383	388	386	389	389	383	383	388	385	389
R-square	.0169	.0129	.0249	.0014	.0262	.0061	.0028	.0055	.0090	.0009	.0023	.0001
Control = TTFP(t-1), K/L(t-1)												
Coeff.	-0.2046[b]	-0.4030[c]	-0.6732[b]	0.2440	0.6273[a]	0.0545	-0.3187	0.6694	-0.8398[c]	0.1923	0.4964	0.0041
t	(2.179)	(1.787)	(2.566)	(1.563)	(3.264)	(0.783)	(0.856)	(1.567)	(1.852)	(0.423)	(0.904)	(0.009)
d.f.	389	384	382	387	385	388	388	382	382	387	384	388
R-square	.0197	.0164	.0267	.0162	.0371	.0087	.0102	.0178	.0188	.0104	.0133	.0071
Control = TTFP(t-1), K/L(t-1), lnvadd(t-1)												
Coeff.	-0.2107[b]	-0.3831[c]	-0.6613[b]	0.2268	0.5920[a]	0.0638	-0.3723	0.7083[c]	-0.8295[c]	0.1802	0.5406	0.0085
t	(2.247)	(1.694)	(2.524)	(1.452)	(3.039)	(0.915)	(0.998)	(1.658)	(1.832)	(0.397)	(0.986)	(0.019)
d.f.	388	383	381	386	384	387	387	381	381	386	383	387
R-square	.0254	.0196	.0324	.0218	.0400	.0153	.0163	.0239	.0248	.0169	.0207	.0132

[a], [b], and [c] represent significance in 2-tail test at 1, 5, and 10% level, respectively.

Table 4 -- Regressing Total Factor Productivity on Industry Employment / Establishment, and on the Change in Industry Employment / Establishment, in 1991

	4.1	4.2	4.3	4.4	4.5	4.6
constant	-0.1911[a]	-0.1077	-0.0305[b]	0.0218	-0.1657[a]	-0.0734
	(3.667)	(1.450)	(2.111)	(0.328)	(3.129)	(0.978)
L/EST	0.0330[a]	0.0338[a]	-	-	0.0325[a]	0.0349[a]
	(2.691)	(2.592)			(2.652)	(2.662)
$L/EST_t - L/EST_{t-1}$	-	-	0.3894[b]	0.3520[b]	0.3907[b]	0.3797[b]
			(2.405)	(2.117)	(2.433)	(2.298)
Control Variables						
$TTFP_{t-1}$	-	-0.0259	-	-0.0392	-	-0.0260
		(0.530)		(0.802)		(0.533)
K/L_{t-1}	-	0.0002	-	0.0003	-	0.0002
		(1.154)		(1.562)		(0.937)
$\log(\text{Value-added})_{t-1}$	-	-0.0137	-	-0.0098	-	-0.0156[c]
		(1.500)		(1.088)		(1.695)
R-square	0.0188	0.0272	0.0152	0.0242	0.0335	0.0426
d.f.	379	376	374	371	373	370

t-statistics in parentheses

[a], [b], and [c] represent significance in 2-tail test at 1, 5, and 10% level, respectively.

Table 5 -- Regressing Total Factor Productivity on Industry Employment / Establishment, on the Change in Industry Employment / Establishment, and on their cross-terms with K/L_{t-1} and with $[(\text{\# of establishment birth + death})/\text{ original \# of establishments}]_{t-1}$, 1991

	5.1	5.2	5.3	5.4	5.5	5.6
with no control variables						
L/EST	0.0296[b] (2.267)	0.0301[b] (2.250)	-	-	0.0331[b] (2.260)	0.0307[b] (2.271)
x $[(B + D)/est]_{t-1}$	0.0354 (0.755)	-	-	-	0.0103 (0.145)	-
x K/L_{t-1}	-	0.0001 (0.544)	-	-	-	0.0001 (0.328)
$L/EST_t - L/EST_{t-1}$	-	-	0.7442[b] (1.938)	0.4631[b] (2.264)	0.8066[c] (1.663)	0.3784[c] (1.757)
x $[(B + D)/est]_{t-1}$	-	-	-2.0610 (1.018)	-	-2.3642 (0.815)	-
x K/L_{t-1}	-	-	-	-0.0014 (0.590)	-	0.0001 (0.005)
R-square	0.0202	0.0195	0.0180	0.0162	0.0380	0.0338
d.f.	378	378	373	373	371	371

	5.1	5.2	5.3	5.4	5.5	5.6
with control variables as in Table 4						
L/EST	0.0302[b] (2.171)	0.0515[a] (3.016)	-	-	0.0372[b] (2.371)	0.0511[a] (2.938)
x $[(B + D)/est]_{t-1}$	0.0369 (0.782)	-	-	-	0.0015 (0.021)	-
x K/L_{t-1}	-	-0.0003 (1.600)	-	-	-	-0.0003 (1.424)
$L/EST_t - L/EST_{t-1}$	-	-	0.6998[c] (1.804)	0.3931[c] (1.785)	0.8562[c] (1.725)	0.3264 (1.478)
x $[(B + D)/est]_{t-1}$	-	-	-2.0101 (0.992)	-	2.7355 (0.932)	-
x K/L_{t-1}	-	-	-	-0.0007 (0.285)	-	0.0006 (0.236)
R-square	0.0288	0.0338	0.0268	0.0244	0.0474	0.0478
d.f.	375	375	370	370	368	368

t-statistics in parentheses

[a], [b], and [c] represent significance in 2-tail test at 1, 5, and 10% level, respectively.