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Entry, Exit and Productivity
Empirical Results for German Manufacturing Industries [1]

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Using panel data from Spain Farinas and Ruano (IJIO 2005) test three hypotheses from a model by Hopenhayn (Econometrica 1992): (H1) Firms that exit in year t were in t-1 less productive than firms that continue to produce in t. (H2) Firms that enter in year t are less productive than incumbent firms in year t. (H3) Surviving firms from an entry cohort were more productive than non-surviving firms from this cohort in the start year. Results for Spain support all three hypotheses. This paper replicates the study using a unique newly available panel data sets for all manufacturing plants from Germany (1995 – 2002). Again, all three hypotheses are supported empirically.

Keywords: Entry, exit, productivity

JEL classification: L11, L60

[1] All computations for this paper were done inside the Research Data Centre of the Statistical Office of Berlin. Many thanks to Ramona Pohl for running my Stata do-files, and for carefully checking the log-files for violations of privacy.

1. Motivation

In his Nobel lecture James Heckman (2001, p. 674) named “the evidence on the pervasiveness of heterogeneity and diversity in economic life“ the most important empirical discovery from econometric analyses using micro data. Everybody who ever worked with plant or enterprise level data will agree – there is no such thing as a representative firm, not even in 4-digit industries where growing and shrinking, entering and exiting firms can be found in each period. Productivity differentials are a case in point as regards firm heterogeneity inside industries. „Of the basic findings related to productivity and productivity growth uncovered by recent research using micro-data, perhaps most significant is the degree of heterogeneity across establishments and firms in productivity in nearly all industries examined.” (Bartelsman and Doms 2000, p. 578).

The empirical facts uncovered in micro-econometric studies motivated formal models for the dynamics of industries with heterogeneous firms, including Jovanovic (1982), Hopenhayn (1992), and Ericson and Pakes (1995). In these models productivity differentials play a central role for entry, growth, and exit of firms. In equilibrium growing and shrinking, exiting and entering firms that have different productivities are found in an industry.

These models lead to hypotheses that can be tested empirically. Hopenhayn (1992) considers a long run equilibrium in an industry with many price-taking firms producing a homogeneous good. Output is a function of inputs and a random variable that models a firm specific productivity shock. These shocks are independent between firms, and are the reason for the heterogeneity of firms. There are sunk costs to be paid at entry, and entrants do not know their specific shock in advance. Incumbents can choose between exiting or staying in the market. When firms realized their productivity shock they decide about the profit maximizing volume of production. The model assumes that a higher shock in t+1 has a higher probability the higher the shock is in t. In equilibrium firms will exit if for given prices of output and inputs the productivity shock is smaller than a critical value, and production is no longer profitable.

Farinas und Ruano (2005, p. 507f.) argue that this model leads to the following testable hypotheses:

(H1) Firms that exit in year t were in t-1 less productive than firms that continue to produce in t. Given that firms with a low productivity have a higher probability of exit at a point in time, exiting firms will be concentrated among the least productive units. “Less productive” means that the productivity distribution of exits is stochastically dominated by the productivity distribution of the continuing firms.

(H2) Firms that enter the market in year t are less productive than incumbent firms in year t. This follows from the selection process described above that leads to an improvement of the productivity distribution of incumbents over time because in each period the less productive firms have the highest probability to fall below the critical level and, therefore, to exit. Here, “less productive” means that the productivity distribution of entries is stochastically dominated by the productivity distribution of incumbents.

(H3) Surviving firms from an entry cohort were more productive than non-surviving firms from this cohort in the start year. In the model there is persistence with regard to the productivity shock. Therefore, a firm that starts with a low productivity will have a greater chance to experience a low productivity in the future, and a higher chance of failure. Contrary to that, a firm starting with a high productivity will tend to continue to have a high productivity, and a high chance to survive. “More productive” means that the productivity distribution of surviving firms from a cohort stochastically dominates the productivity distribution of exiting firms from the same cohort at the time of start.

Farinas and Ruano (2005) test these hypotheses using panel data for Spanish firms. All three hypotheses are supported by the data. This paper replicates the study by Farinas and Ruano with panel data for German firms, having in mind that “the credibility of a new finding that is based on carefully analyzing two data sets is far more than twice that of a result based only on one.“ (Hamermesh 2000, p. 376)

The rest of the paper is organized as follows: Section 2 describes the data used and discusses measurement issues. Section 4 presents the results of the empirical investigation. Section 4 concludes.

2. Data and measurement issues

This study uses panel data for all German manufacturing firms that produced in at least one year between 1995 (when a new industry classification was introduced) and 2002 (the last year small firms with less than 20 employees had to report to the census). By firm a plant, or establishment, is meant. While panel data of this type, constructed from the cross section data collected in monthly or annual surveys performed by the Statistical Offices, were available for some German federal states for some periods in the past, only recently the data for all federal states were matched and made available for researchers via the newly created research data centres of the system of official statistics. Using these data it is possible to produce results using firm level micro data for Germany as a whole for the first time.[2]

To test the hypotheses (H1) – (H3) the productivity of a firm has to be measured, and three groups of firms have to be defined, namely entries, exits, and incumbents.

The productivity of a firm is measured as the amount of annual total sales per employee, divided by the average amount of total sales per employee in the 4-digit industry of the firm, and multiplied by 100 to get a percentage value. Note that all firms that reported to less than twelve monthly surveys in a year (and, therefore, did not exist during the whole year) are excluded from all computations. Furthermore, for some firms extremely high or extremely low sales in some years are reported in the data set, and this leads to extreme values of productivity computed as sales per head. While some of these extreme values might be errors, others are the consequence of rare events like selling a huge machine that was produced to a large part in year t in the next year, so that no or only low sales are reported for t and high sales for t+1. Given that, on the one hand, extreme values for a small number of observations can have a high impact on empirical results, and that, on the other hand, it is not possible to check all these outliers due to data protection laws, the firms from the top and bottom one percent of the productivity distribution were dropped. Due to missing information on value added and the capital stock used it is not possible to compute value added per employee, or total factor productivity.

[2] For details regarding the type of data used here see Wagner (2000). The data set of this study is confidential but not exclusive. Zühlke et al. (2004) describe how to work with confidential data from German official statistics via the research data centres.

However, the standardization of the productivity measured at the firm level by the mean value of productivity at the 4-digit level should take care of much of the inter-industry differences in capital intensity and the degree of vertical integration.[3]

A fims is considered as an exit in year t if this firm reported a positive number of employees (including the owners of the firm) in t-1 but not in t. This might be wrong because a firm can fulfil this condition if it relocated to a foreign country, or to the service sector, too. Again, it is not possible to check this for all cases labelled as exits.

A firm is considered as an entry in year t if it did not report a positive number of employees (including the owners) in t-2, did not report more than 20 employees in year t-1, is a single-establishment enterprise, and produces in year t. This means that the year t is the first full year in business for this firm (if it did not exist in a foreign country, or outside the industry sector, in the past, and if it has not been founded in January in year t-1). Considering only single-establishment enterprises with a maximum of 20 employees should prevent that a firm which has been part of another firm in the past is considered as an entry.

Incumbents in year t are firms that report a positive number of employees in the years t-1 and t (and that are not classified as entries).

Given that there use to be more or less pronounced differences in firm behaviour and performance between West Germany and the former communist East Germany in the years after re-unification in 1990, all computations are done for both parts of Germany separately.

3. Results of the empirical investigation

The hypotheses (H1) – (H3) derived from the model by Hopenhayn (1992) and tested with Spanish firm panel data by Farinas and Ruano (2005) are investigated with firm panel data for all manufacturing firms from West and East Germany, respectively, by two methods. In a first step, the mean values of productivity for the two groups of firms (continuing and exiting firms; continuing and entering firms; and surviving and

[3] Note that Bartelsman and Doms (2000, p. 575) point to the fact that heterogeneity in labor productivity has been found to be accompanied by similar heterogeneity in total factor productivity in the reviewed research where both concepts are measured. Furthermore, Foster, Haltiwanger and Syverson (2005) show that productivity measures that use sales (i.e. quantities multiplied by prices) and measures that use quantities only are highly positively correlated.

failing members of an entry cohort) are compared using a t-test that does not assume equality of variance for the two groups. If one looks at differences in the mean value for both groups only, however, one focuses on just one moment of the productivity distribution. A stricter test used by Farinas and Ruano (2005) that considers all moments is a test for stochastic dominance of the productivity distribution for one group over the productivity distribution for the other group. More formally, let F and G denote the cumulative distribution functions of productivity for the two groups under consideration. Then first order stochastic dominance of F relative to G means that F(z) – G(z) must be less or equal zero for all values of z, with strict inequality for some z. Whether this holds or not is tested non-parametrically by adopting the Kolmogorov-Smirnov test (Conover 1999, p. 456ff.).[4]

- **Continuing vs. exiting firms**

According to (H1) firms that exit in year t were in t-1 less productive than firms that continue to produce in t. With the German firm panel data at hand this can be tested for the cohorts of exit from 1997 to 2002. Results are reported in table 1-W and table 1-E for West Germany and East Germany, respectively. In line with the results for Spain found be Farinas and Ruano (2005) the hypothesis is supported by the data. In every year the t-test rejects the null hypothesis of equal means of productivity for exiting and continuing firms in favour of the alternative hypothesis that exiting firms in t had a smaller value in t-1 than continuing firms at an error level of less than 0.001. And for both West Germany and East Germany in each year between 1997 and 2002 the prob-value for the Kolmogorov-Smirnov test of the null-hypothesis that the distributions of labor productivity for exiting and continuing firms are identical against the alternative hypothesis that the distribution for continuing firms first-order stochastically dominates the distribution for exits is 0.000, indicating that the null-hypothesis can be rejected in favour of the alternative hypothesis at any usual error level.

[4] All computations used Stata 9.2 .

Table 1-W: Productivity differences between continuing and exiting firms: West Germany*

Cohort	[1] Exiting firms [No. of cases]	[2] Continuing firms [No. of cases]	[3] t-test for differences in means [1] < [2] (prob-value)	[4] Kolmogorov-Smirnov-test for stochastic dominance [1] < [2] (prob-value)
1997	74.99 [4108]	94.09 [73149]	0.000	0.000
1998	75.37 [3909]	94.42 [73284]	0.000	0.000
1999	70.45 [4472]	95.31 [71520]	0.000	0.000
2000	73.42 [4042]	93.59 [72002]	0.000	0.000
2001	70.89 [4680]	93.88 [71133]	0.000	0.000
2002	72.10 [6477]	94.44 [68336]	0.000	0.000

* For a definition of exiting and continuing firms see text. Columns [1] and [2] report mean values of percentage deviations of labor productivity from the respective mean values of the industries (4-digit classification]; see text. Column [3] reports the result of a test of the null hypothesis of equal means in column [1] and column [2] against the alternative hypothesis of a smaller mean value in column [1]; a prob-value of 0.05 (or smaller) indicates that the null hypothesis can be rejected in favour of the alternative hypothesis at an error level of 5 percent (or less). Column [4] reports the result of a test of the null hypothesis of identical distributions of labor productivity in both groups of firms against the alternative hypothesis that the distribution for exiting firms is first-order stochastically dominated by the distribution for continuing firms; a prob-value of 0.05 (or smaller) indicates that the null hypothesis can be rejected at an error level of 5 percent (or smaller).

Table 1-E: Productivity differences between continuing and exiting firms: East Germany*

Cohort	[1] Exiting firms [No. of cases]	[2] Continuing firms [No. of cases]	[3] t-test for differences in means [1] < [2] (prob-value)	[4] Kolmogorov-Smirnov-test for stochastic dominance [1] < [2] (prob-value)
1997	80.99 [808]	95.53 [10865]	0.000	0.000
1998	74.87 [809]	96.31 [11611]	0.000	0.000
1999	77.86 [1003]	96.16 [12233]	0.000	0.000
2000	76.02 [1200]	95.71 [13008]	0.000	0.000
2001	73.46 [1327]	95.65 [13768]	0.000	0.000
2002	79.99 [1529]	95.41 [14333]	0.000	0.000

* For a definition of exiting and continuing firms see text. Columns [1] and [2] report mean values of percentage deviations of labor productivity from the respective mean values of the industries (4-digit classification]; see text. Column [3] reports the result of a test of the null hypothesis of equal means in column [1] and column [2] against the alternative hypothesis of a smaller mean value in column [1]; a prob-value of 0.05 (or smaller) indicates that the null hypothesis can be rejected in favour of the alternative hypothesis at an error level of 5 percent (or less). Column [4] reports the result of a test of the null hypothesis of identical distributions of labor productivity in both groups of firms against the alternative hypothesis that the distribution for exiting firms is first-order stochastically dominated by the distribution for continuing firms; a prob-value of 0.05 (or smaller) indicates that the null hypothesis can be rejected at an error level of 5 percent (or smaller).

- **Incumbents versus entries**

The second hypthesis (H2) states that firms that enter in year t are less productive than incumbent firms in year t. This is tested for entry cohorts into German manufacturing industries from the years 1997 to 2002. Results are reported in table 2-W and table 2-E for West Germany and East Germany, respectively. Again in line with the results for Spain reported by Farinas and Ruano (2005) the hypothesis is strongly supported by the data according to both the t-test and the Kolmogorov-Smirnov test.

Table 2-W: Productivity differences between continuing and entering firms: West Germany*

Cohort	[1] Entering firms [No. of cases]	[2] Continuing firms [No. of cases]	[3] t-test for differences in means [1] < [2] (prob-value)	[4] Kolmogorov-Smirnov-test for stochastic dominance [1] < [2] (prob-value)
1997	70.04 [1976]	94.44 [72323]	0.000	0.000
1998	71.92 [1465]	94.84 [72745]	0.000	0.000
1999	66.61 [3558]	94.17 [70644]	0.000	0.000
2000	72.77 [2988]	93.41 [71710]	0.000	0.000
2001	78.38 [1646]	93.13 [70417]	0.000	0.000
2002	83.92 [5817]	93.50 [67113]	0.000	0.000

* For a definition of entering and continuing firms see text. Columns [1] and [2] report mean values of percentage deviations of labor productivity from the respective mean values of the industries (4-digit classification]; see text. Column [3] reports the result of a test of the null hypothesis of equal means in column [1] and column [2] against the alternative hypothesis of a smaller mean value in column [1]; a prob-value of 0.05 (or smaller) indicates that the null hypothesis can be rejected in favour of the alternative hypothesis at an error level of 5 percent (or less). Column [4] reports the result of a test of the null hypothesis of identical distributions of labor productivity in both groups of firms against the alternative hypothesis that the distribution for entering firms is first-order stochastically dominated by the distribution for continuing firms; a prob-value of 0.05 (or smaller) indicates that the null hypothesis can be rejected at an error level of 5 percent (or smaller).

Table 2-E: Productivity differences between continuing and entering firms: East Germany*

Cohort	[1] Entering firms [No. of cases]	[2] Continuing firms [No. of cases]	[3] t-test for differences in means [1] < [2] (prob-value)	[4] Kolmogorov-Smirnov-test for stochastic dominance [1] < [2] (prob-value)
1997	83.34 [830]	96.54 [11058]	0.000	0.000
1998	76.62 [1031]	96.53 [11656]	0.000	0.000
1999	79.01 [1196]	96.05 [12343]	0.000	0.000
2000	81.61 [1308]	95.63 [13122]	0.000	0.000
2001	77.81 [1307]	95.62 [13686]	0.000	0.000
2002	83.24 [2061]	93.79 [14280]	0.000	0.000

* For a definition of entering and continuing firms see text. Columns [1] and [2] report mean values of percentage deviations of labor productivity from the respective mean values of the industries (4-digit classification]; see text. Column [3] reports the result of a test of the null hypothesis of equal means in column [1] and column [2] against the alternative hypothesis of a smaller mean value in column [1]; a prob-value of 0.05 (or smaller) indicates that the null hypothesis can be rejected in favour of the alternative hypothesis at an error level of 5 percent (or less). Column [4] reports the result of a test of the null hypothesis of identical distributions of labor productivity in both groups of firms against the alternative hypothesis that the distribution for entering firms is first-order stochastically dominated by the distribution for continuing firms; a prob-value of 0.05 (or smaller) indicates that the null hypothesis can be rejected at an error level of 5 percent (or smaller).

- **Surviving and failing entries**

The last hypothesis (H3) to be considered here is that surviving firms from an entry cohort were more productive than non-surviving firms from this cohort in the start year. Here, surviving firms are firms that are still active in 2002, the last year we have information for in the data set used, and the hypothesis can be tested for entry cohorts from 1997 to 2001 (although the time span considered is rather short for the more recent cohorts). The results for West Germany reported in table 3-W are again closely in line with the findings of Farinas and Ruano (2005) for Spain, and in support of the hypothesis. The picture for East Germany is somewhat different. While for four out of five cohorts failing entries do have on average smaller values of productivity than surviving entries in their first year (and slightly higher in one cohort), results of the t-test are in favour of the hypothesis at the usual five percent level for two cohorts only, and the test for first order stochastic dominance does not support (H3) at the usual level for the entry cohort 2000 (where, however, the time span under consideration is very short). The big picture, however, is in line with both the hypothesis (H3) and the findings for Spain.

Table 3-W: Productivity differences between surviving and failing members of various entry cohorts: West Germany*

Cohort	[1] Failing firms [No. of cases]	[2] Surviving firms [No. of cases]	[3] t-test for differences in means [1] < [2] (prob-value)	[4] Kolmogorov-Smirnov-test for stochastic dominance [1] < [2] (prob-value)
1997	62.38 [951]	77.13 [1025]	0.000	0.000
1998	66.07 [597]	75.95 [868]	0.004	0.000
1999	59.05 [1402]	71.53 [2156]	0.000	0.000
2000	64.83 [953]	76.49 [2035]	0.000	0.000
2001	67.11 [308]	80.97 [1383]	0.001	0.005

* For a definition of failing and surviving firms see text. Columns [1] and [2] report mean values of percentage deviations of labor productivity from the respective mean values of the industries (4-digit classification]; see text. Column [3] reports the result of a test of the null hypothesis of equal means in column [1] and column [2] against the alternative hypothesis of a smaller mean value in column [1]; a prob-value of 0.05 (or smaller) indicates that the null hypothesis can be rejected in favour of the alternative hypothesis at an error level of 5 percent (or less). Column [4] reports the result of a test of the null hypothesis of identical distributions of labor productivity in both groups of firms against the alternative hypothesis that the distribution for failing firms is first-order stochastically dominated by the distribution for surviving firms; a prob-value of 0.05 (or smaller) indicates that the null hypothesis can be rejected at an error level of 5 percent (or smaller).

Table 3-E: Productivity differences between surviving and failing members of various entry cohorts: East Germany*

Cohort	[1] Failing firms [No. of cases]	[2] Surviving firms [No. of cases]	[3] t-test for differences in means [1] < [2] (prob-value)	[4] Kolmogorov-Smirnov-test for stochastic dominance [1] < [2] (prob-value)
1997	75.35 [330]	88.61 [500]	0.003	0.016
1998	73.76 [364]	81.28 [667]	0.055	0.008
1999	79.52 [437]	78.71 [759]	0.573	0.039
2000	76.40 [370]	83.66 [938]	0.061	0.071
2001	67.48 [202]	79.69 [1105]	0.009	0.022

* For a definition of failing and surviving firms see text. Columns [1] and [2] report mean values of percentage deviations of labor productivity from the respective mean values of the industries (4-digit classification]; see text. Column [3] reports the result of a test of the null hypothesis of equal means in column [1] and column [2] against the alternative hypothesis of a smaller mean value in column [1]; a prob-value of 0.05 (or smaller) indicates that the null hypothesis can be rejected in favour of the alternative hypothesis at an error level of 5 percent (or less). Column [4] reports the result of a test of the null hypothesis of identical distributions of labor productivity in both groups of firms against the alternative hypothesis that the distribution for failing firms is first-order stochastically dominated by the distribution for surviving firms; a prob-value of 0.05 (or smaller) indicates that the null hypothesis can be rejected at an error level of 5 percent (or smaller).

4. Concluding remarks

To repeat, the motivation for this empirical investigation was to test whether the results reported by Farinas and Ruano (2005) based on panel data for Spanish firms can be replicated with a newly available set of panel data for German firms, having in mind that "the credibility of a new finding that is based on carefully analyzing two data sets is far more than twice that of a result based only on one." (Hamermesh 2000, p. 376).

The findings of this study are in line with the results from Farinas and Ruano (2005) and with findings from the international literature on productivity and selection (cf. Bartelsman and Doms 2000, p. 581). This again demonstrates the relevance of processes of creative destruction in the Schumpeterian sense for industry dynamics.

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