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Productivity, Investment in ICT and Market Experimentation: Micro Evidence from Germany and the U.S

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Productivity, Investment in ICT and Market Experimentation: Micro Evidence from Germany and the U.S.

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ABSTRACT: This paper examines the relationship between the use of advanced technologies such as ICT, and outcomes such as productivity, the skill mix of the workforce and wages using micro data for the U.S. and Germany. We find support to the idea that U.S. businesses engage in experimentation in a variety of ways not matched by their German counterparts. In particular, there is greater experimentation amongst young U.S. businesses and also among those actively changing their technology. This is evidenced in a greater dispersion in productivity and related key business choices. We also find that the mean impact of adopting new technology on productivity and wages is greater the in U.S. than in Germany.

Zusammenfassung: Dieses Papier untersucht die Beziehung zwischen dem Einsatz neuer Technologien, wie von IKT, und betrieblichen Kenngrößen wie der Produktivität, der Qualifikationsstruktur und den Löhnen, wobei Mikrodaten für die USA und Deutschland verwendet wurden. Dabei kann die Hypothese unterstützt werden, dass in den USA Betriebe stärker experimentieren – gemessen anhand der Streuung der Produktivität und anderen betrieblichen Entscheidungsvariablen – als in Deutschland. Dies zeigt sich insbesondere bei jungen Betrieben und bei Betrieben, die ihre Technologie verändern. Wir finden ebenfalls einen größeren durchschnittlichen Einfluss der Einführung neuer Technologien auf die Produktivität und die Löhne in den USA als in Deutschland.

KEYWORDS: ICT, Experimentation, Productivity, Internet Use, U.S., Germany

JEL-CLASSIFICATION: D20, D24, O30

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1. Introduction

In this paper, we examine the relationship between the use of advanced technologies, such as information and communications technologies (ICT), and related business practices and outcomes such as productivity, employment, the skill mix of the workforce and wages using micro data for the U.S. and Germany. Recent empirical work at the industry level (Bartelsman, Scarpetta and Schivardi, 2002, and Bartelsman et al., 2002) suggests that U.S. businesses engage in more market experimentation than do their European counterparts and that selection and learning effects are more important in the U.S. Relative to those in Europe, the typical entrant in the U.S. is much smaller and less productive than more mature firms. Selection and learning effects yield a substantial contribution from the entry and exit of businesses to growth and productivity. In particular, we see a large contribution from the exit of the least productive businesses in the U.S. and the rapid post-entry growth of surviving entrants in the U.S.

We examine the theme of potential differences in experimentation between the U.S. and Germany in two distinctive ways. First, experimentation may be present in the entry and exit process as new businesses adopt new technologies (broadly defined to include the use of advanced technologies but also organisational structure) and concurrently learn whether the technology chosen is suitable and whether the ownership/management team is suitable as well. This form of experimentation is closely linked to the ideas in Jovanovic (1982) where new businesses are uncertain of their type (which can be defined in a variety of ways including managerial ability and/or the appropriate business practices for a specific production unit) and learn about it in the first several periods of operation. Such experimentation suggests that dispersion on a variety of dimensions (productivity, size, wages, skill mix, use of technology) is likely to be especially large for entrants and young businesses. In what follows, we explore this hypothesis by examining the nature of such experimentation across the U.S. and Germany. Again, the working hypothesis is that the market and institutional environment in the U.S. encourages such experimentation so that we should observe a stronger relationship between establishment age and the dispersion of various outcomes in the U.S.

An alternative but related idea is that each time a business (whether new or mature) adopts a new technology the experimentation process begins anew. This idea, that learning is an "active" ongoing process as businesses adopt new technologies, is based on the model of Pakes and Ericson (1995). Under this view, it is at businesses that are most actively changing their technology where we should observe the greatest dispersion in choices and outcomes reflecting the underlying experimentation. Here again, we are interested in exploring whether the patterns that emerge in the data differ between the U.S. and Germany.

We focus on cross-sectional micro data for the years 1999 and 2000 in the U.S., and 2000 and 2001 in Germany (see Box 1). While the data are cross sectional, we know the age of the establishments so that we can explore the differences in investment in ICT and outcomes for different cohorts. The micro data permit us to examine the relationship between investment in computers, employee Internet access, the skill mix of the workforce and outcomes such as productivity and wages. While there have been studies conducted at the micro level on these topics for both the U.S. and European countries, our advantage is that we conduct the study for a virtually identical time period using harmonised measurement and methodology.[1]

The paper proceeds as follows. Section 1 presents the key features of the establishment-level data for the U.S. and Germany. Section 2 presents the results of simple regressions relating labour productivity and wages to measures of use of advanced technology in both countries. Section 3 examines the evidence on "experimentation" across countries – first by looking at the results by establishment age and then exploring the active learning model by examining the differences across businesses depending on how actively they are changing their technology. Section 4 concludes with interpretation of the results.

1 For the U.S. studies using micro data include Doms, Dunne, and Troske (1997), Dunne, Foster, Haltiwanger and Troske (2001), Doms, Jarmin and Klimek (2002), and Stolarick (1999a and 1999b). For Germany the only micro study we know of, which analyses the impact of ICT on productivity, is Hempell (2002). This study, however, is based on the German service sector.

Box 1: Establishment-level data for the United States and Germany

U.S. Data

The U.S. data come from two surveys of U.S. manufacturing establishments: the Computer Network Use Supplement (CNUS) to the 1999 Annual Survey of Manufactures (ASM) and the 2000 ASM. We also draw information on establishment age from the Longitudinal Business Database (see Jarmin and Miranda 2002), a research data file maintained by the Centre for Economic Studies. Since both surveys are based on the ASM sample frame, we first discuss the general features of the ASM.

Both the 1999 ASM (from which the 1999 CNUS is drawn) and 2000 ASM are part of the 1999-2003 ASM panel. The panel is drawn from the 1997 Economic Census with allowances for new establishment births and replacement for sample deaths. The design for the 1999-2003 panel initially contained approximately 52,000 of the over 380,000 U.S. manufacturing establishments with paid employees. Manufacturing companies with more than $1 Billion in manufacturing shipments are selected into the ASM with certainty. There are just over 500 these certainty enterprises, and all of their over 14,000 establishments are included in the 1999-2003 ASM panel.

Also selected with certainty are remaining establishments meeting at least one of the following conditions: have at least 500 paid employees, produce [electronic] computers, or produce in certain "small" industries. The number of certainty cases in the 1999-2003 ASM panel is approximately 16,600. The remaining portion of the sample is chosen randomly from the remaining establishments with 5 of more employees. Selection probabilities are proportional to size, according to a procedure that minimises sample size while satisfying quality constraints within industry and product strata.

For the analysis, we require a number of data items from the ASM and CNUS. Table 1 lists the data items and their source. We also use establishment identifiers and industry codes from the ASM and CNUS files. The CNUS data on e-business processes are available only for reference year 1999. The computer investment data are available for reference years 1992 and 2000. We examine the 2000 cross section only. We match the 1999 CNUS to the 2000 ASM. Since both surveys are drawn from the 1999-2003 ASM panel, differences in the samples are minimal. There will be some difference due to entry and exit. However, the largest difference in the establishment composition of the two files is due to non-response to the 1999 CNUS.[2] The 1999 CNUS contains just fewer than 40,000 establishment observations. After matching the 1999 CNUS, the 2000 ASM and the LBD, we are left with 31,265 establishment observations.

2 . More details on the 1999 CNUS are in U.S. Census Bureau (2001), "*1999 E-business Process Use by Manufacturers: Final Report on Selected Processes",* available at www.census.gov/estats.

German Data

The German data we use are from the IAB Establishment Panel Data Set collected by the Institut für Arbeitsmarkt- und Berufsforschung (IAB), Nuremberg, Germany.[3] This yearly survey has been conducted since 1993 in West Germany, and since 1996 in East Germany. Information is obtained by personal questioning carried out by Infratest Sozialforschung, Munich, with voluntary participation by plants managers. Altogether, the (unbalanced) IAB panel comprises 79000 observations and 26000 plants. Detailed descriptions of the IAB Establishment panel can also be found in Kölling (2000).

The sample is drawn from the employment statistics register of the German Federal Office of Labour, which covers all plants with at least one employee (or trainee) subject to social security.[4] All plants included in the population (i.e. all plants included in the employment statistics register--- are stratified into 400 cells, which are defined over 10 plant sizes, 20 industries and two regions (West vs. East Germany), from each of which the observations of the establishment panel are drawn randomly. Large plants are over-represented in the IAB panel. In the first wave (1993), for example, the probability of being drawn was on average 91 % for plants employing more than 5,000 employees, but only 3% for plants employing between 100 and 200 employees and as small as 0.1% for plants with less than 5 employees. The over sampling of large plants implies that the survey covers about 0.7% of all plants in Germany, but 10% of all employees.[5]

Interviewers ask about 80 questions each year on topics including: detailed information on the decomposition of the work-force (gender, skill, blue-collar vs. white-collar, part-time employees, apprentices, civil servants, owners) and its development through time; business activities (total sales, input materials, investment, exports, profit situation, expectations, whether plant does R&D, product and process innovations, organizational changes, technology of machinery, adopted plant policies/strategies); training and further education; wages; lots of information on working time (standard working time, overtime, percentage of employees working overtime, percentages of employees working on Saturdays, working on Sundays, working on shifts, and working with a flexible working time schedule); and general information about the plant (whether plant is subunit of a firm, ownership, birth year, existence of works council, whether plant applies bargaining agreement, whether plant has been merged with or split from another plant in the last year, three-digit industry affiliation, region). While most questions are asked yearly (or on a two-year/ three-year basis), some topics have been surveyed only once.[6]

This study uses observations from the manufacturing sector of the 2000 and 2001 waves of the IAB panel. The regression analysis, however, is only carried out with the latter wave, since we do not observe information on Internet access in 2000. This leaves approximately 7700 observations for the descriptive statistics and 3500 observations for the regression analysis. Altogether, in 1999 there were 336,000 plants (which employed at least one employee subject to social security) in the German manufacturing sector covered.[7] Our sample accounts for approximately 1% of these plants, but for 12% of its workforce and for 11% of its value added.

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3 . The IAB (in English Institute for employment Research) is the research institute of the Federal Employment Services in Germany.

4 . For 1995, the employment statistics cover about 79of all employed persons in Western Germany and about 86% in Eastern Germany (Bender, Haas and Klose, 2000).

5 . Population weights, which are the inverse of the sample selection probabilities, are available for empirical analysis.

6 . Information on Internet access, for example, is only available for 2001.

7 . Source: IAB-Betriebsdatei, own calculations.

2. Data Description

Table 1 presents the definitions of the key measures used in this study, while Table 2 presents summary statistics for the key variables. As shown in Table 1, for the most part, the measurement methodology has been harmonised so that the measures are comparable across the countries. Moreover, in order to compare value figures between the two countries, we have converted German measures into dollars using an aggregate PPP measure (OECD, *Main Economic Indicators* 2002). There is only one notable exception where comparability between the two countries is problematic: the access of employees to Internet: the German dataset has a categorical variable on the proportion of workers with Internet access (none, some, half, most, all) instead of a measure of the percentage of workers with access to the Internet, as in the U.S. data.

Table 1: Primary U.S. and German Data Items

Panel A: U.S. Data

Variable	***Source***	***Notes***
Shipments (tvs)	ASM	Total value of shipment. We adjust for changes in inventories to get a concept closer to actual production.
Value Added (va)	ASM	Adjusted shipments minus materials, energy and the costs of resales and contract work.
Employment (te)	ASM	Number of full and part time workers at the plant (production and non-production).
Production Workers (pw)	ASM	Number of full and part time production workers.
Payroll (sw)	ASM	Total salaries and wages paid.
Total machinery and equipment investment (nm)	ASM	Total investment in new equipment and machinery, including vehicles.
Computer investment (nmc)	ASM	Total investment in computers and peripheral equipment (software not included).
% of employees with Internet access (emp_access)	CNUS	% of employees at establishment with access of any kind to the Internet.
STAN industry	Derived	Using SIC codes available on ASM
Age	LBD	Categorical age variable taking on values 0 - 10 for plants aged 0-10 and 11 for plants aged 11+.

Panel B: German Data

Variable	***Source***	***Notes***
Shipments	IAB	Total value of shipment in the previous business year. No Adjustment for changes in inventories.
Value Added	IAB	Total Shipments minus materials and services received from other plants.
Employment	IAB	Number of (production and non-production) employees (excluding apprentices) at the plant on June 30 of the current year. Adjusted for part time workers.
Production Workers	IAB	Number of full and part-time workers (as opposed to salaried employees) on June 30 of the current year.
Payroll	IAB	Total salaries and wages paid in June of the current year (excluding social insurance payments by the employer).
Total machinery and equipment investment	IAB	Total investment in the previous business year (buildings, equipment, machinery, vehicles).
Computer investment	IAB	Total investment in information and communication technology in the previous business year.
% of employees with Internet access	IAB	Percentage of (office) jobs at establishment with access of Internet/Intranet (categorical: 1-all, 2-most, 3 half, 4-a few, 5 none). Information for 2001 only.
STAN industry	IAB	13 categories
Age	IAB	Categorical age variable taking on values 1 - 12 (in 2000: takes the value 11 for plants age 11+, in 2001 takes the value 12 for plants aged 12+).

The first item of note that emerges from the data for the two countries is the significant heterogeneity in main characteristics of establishments (see the standard deviations of key variables). These differences reflect both within and between-industry differences (the latter are shown in Appendix Table A.1).[8] Moreover, the average size of U.S. establishments tends to be much higher than in Germany (Table 2). We also find that

8 For example, in the U.S. (Table A.1.a) computer investment per worker is lowest in the non-metallic minerals industry but highest in the computer and office equipment industry. The gap in computer investment between these two industries is about $1600 per worker, which is substantial. However, this gap is relatively small compared to a one standard deviation difference in computer investment per worker reported in Table 2 (which is $5100 per worker).

the share of non-production workers (an indirect measure of skill) is larger in Germany relative to the U.S., but this level comparison may not warrant much attention given the potential differences in how production and non-production workers are defined (e.g., in Germany the distinction is based upon hourly wage workers vs. salaried workers while the U.S. definition refers more to the type of activity).

Table 2: Descriptive Statistics *(*Weighted by Sample Weights*)*

Panel A: U.S. Data – Matched ASM/CNUS sample[9]

Statistic:	Mean	Standard Deviation	10th Percentile	90th Percentile
Age (years)	9.45	3.024	4	11 +
Employment	140.1	402.50	15 (freq=121)	288 (freq=19)
Skill (Proportion of non-production workers)	0.277	0.191	0.071	0.540
Employee Internet Access (percentage)	0.210	0.263	0.000	0.600
Total Equipment Investment per Worker ($1000)	7.927	41.380	0.344	14.938
Total Computer Investment per Worker ($1000)	0.455	5.113	0.000	0.925
Log labor Productivity: VA per Worker	4.325	0.758	3.536	5.173
Log Payroll per worker	3.480	0.402	2.972	3.973

Productivity and payroll per worker are higher in the U.S. but there is greater dispersion in productivity and payroll per worker in Germany (but see cautions below about simple comparisons of dispersion measures across countries). Total equipment investment per worker is higher in the U.S. but computer investment per worker is higher in Germany. However, the U.S. exhibits much greater dispersion for both measures of investment relative to Germany. For the most part, the industry rankings on the various measures

9 Statistics for the matched ASM/CNUS sample differ from population values. First, ASM establishment are on average larger and more productive than the average manufacturing establishment, as measured by the Census of Manufactures – the typical ASM establishment has 81 workers in 2000 and the average establishment employment from the 1997 Census of Manufactures is 44. Second, plants matching to the CNUS data are larger still.

Panel B: German Data

Statistic:	Mean	Standard Deviation	10th Percentile	90th Percentile
Age (years)	9.7	2.99	5	12
Employment	28.95	229.75	2	47
Skill (Proportion of non-production workers)	0.32	0.34	0	1
Employee Internet Access (categorical; 1=all, 5=none)	2.83	1.7	1	5
Total Equipment Investment per Worker ($ 1000)	7.05	23.6	0	14.61
Total Computer Investment per Worker ($ 1000)	0.78	2.71	0	1.97
Log labor Productivity: VA per Worker ($ 1000)	3.63	0.9	2.49	4.59
Log Payroll per Worker ($ 1000)	2.92	0.63	2.05	3.61

are similar across the countries although there are some notable exceptions (see Table A.1 in Appendix).

While these summary statistics are useful, we base our subsequent analysis on a difference in difference approach (e.g., difference between low and high tech businesses in U.S. *vs.* difference between low and high tech in Germany). The level comparisons across the countries may be plagued by a variety of measurement problems (e.g., the appropriate price deflator conversion across the countries) and thus we have much greater confidence in the results that rely on differences in differences. In this regard, we especially note that the differences in dispersion across the countries may reflect differences in the degree of measurement error as well as differences in the size distribution or other factors across countries. Thus, we do not put much emphasis on the differences in the levels of dispersion, in say, productivity between the U.S. and Germany reported in Table 2.

In what follows, we seek to relate the use of advanced technology to outcomes like productivity and wages at the micro level. Given limitations of available data, we rank establishments on the basis of their equipment investment per worker and computer investment per worker. Since both of these measures are only proxies of what we would like (which instead might be a measure of the stock of high tech capital per worker), we use them to create a set of technology groups similar to that used in Doms, Jarmin and Klimek (2002). Specifically, for each measure we create 3 groups: (i) zero investment, (ii) low investment (below the 75th percentile), and high investment (above the 75th percentile).[10] We choose to classify high investment establishments as those to the right of the 75th percentile since the investment distributions are very skewed. In turn, we interact these 3 groups to consider six possible combinations.

One point that is worth emphasizing in this context is that the computer investment, by itself, is likely to be an inadequate measure of the use of advanced technology beyond the obvious problem that we have a flow rather than a stock measure. The computer investment measure only captures the direct spending on computers but does not include the spending on equipment with imbedded advanced technology (e.g., semi-conductors). Prior research using the Survey of Manufacturing Technology (see, e.g., Dunne, 1994) finds that direct spending on computers misses a substantial amount of the investment in high technology equipment. Accordingly, we focus on both total equipment expenditures as well as computer investment expenditures.

Given that our proxies for the intensity of advanced technology usage are imperfect, we check whether our results for so-called advanced technology investment also apply to other equipment investment. Namely, we replicate the analysis for investment in *highway vehicles* (i.e., cars and trucks - which, like computers, are components of equipment investment) by U.S. establishments. Obviously, if similar results also hold for vehicles this would raise substantial questions as to whether our measures of IT investment are capturing advanced technology.[11]

Another limitation worth emphasizing is that using establishment-level data for wages is inadequate along a number of dimensions. Clearly, the relationship between advanced technology and wages should be conducted at the individual worker level. Having said that, a number of micro studies have shown that (i) a large fraction of the dispersion in wages across workers is accounted for by between-establishment differences as

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[10] These non-parametric measures also have the advantage of being more comparable across the two countries.

[11] This experiment is similar to that performed by DiNardo and Pischke (1997).

opposed to within-establishment differences; (ii) the between-plant differences in wages largely reflect differences in the skill mix across workers; (iii) the differences in the skill mix across establishments is closely linked to differences in technology use across businesses.[12] Thus, there is considerable information content in exploiting the cross-plant variation in wages in this context. Moreover, checking the cross-plant variation in wages is a useful robustness check on the results using the cross-plant variation in measured output per worker since there are undoubtedly measurement problems in the latter.

3. THE RELATIONSHIP BETWEEN PRODUCTIVITY, WAGES AND ADVANCED TECHNOLOGY

We begin our micro comparison of the U.S. and Germany by examining the empirical relationship between labour productivity and technology choices at businesses, including investment in advanced technology and in human capital (using the skill mix of the workforce). In a like manner, we examine the relationship between payroll per worker and these same factors.

The left columns of Table 3 present the results from simple descriptive regressions with labour productivity (log value added per worker) as dependent variables, and measures of the use of technology and the skill mix as right hand side variables. As discussed earlier, we define technology groups in a non-parametric fashion using the equipment investment and computer investment per worker measures. We also include the skill mix (share of non-production workers), a measure of Internet access and the interaction of the skill mix and the Internet access variable as right-hand-side variables. Also, all regressions include controls for size, age, multi-unit status (a dummy variable indicating whether or not the establishment is owned by a multi-location company), 2-digit STAN industry dummies, and (for Germany) a dummy indicating that plant is located in East Germany. The regression results reported are weighted estimates, where the weights are constructed by multiplying the appropriate survey sample weight by employment.[13]

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[12] See, e.g., Davis and Haltiwanger (1991), Doms, Dunne and Troske (1997), Dunne, Foster, Haltiwanger and Troske (2001).

[13] We also estimated the regression models unweighted and with survey sample weights alone. The results are broadly similar regardless of the weights used. The employment-weighted results are the most relevant to related studies, so we focus on them here.

Table 3: Cross Sectional Regressions

Panel A: U.S. Results

Variable		Dep. Variable: Log (Value Added Per Worker)	Dep. Variable: Log (Payroll per Worker)
Investment Class Index: Investment in Total Equipment / Investment in ICT 0: No Investment Low: below the 75th Percentile High: above the 75th Percentile (High/High omitted)	0 / 0	-0.669	-0.288
		(0.160)	(0.077)
	Low / 0	-0.461	-0.240
		(0.018)	(0.008)
	High / 0	-0.157	-0.045
		(0.023)	(0.011)
	Low / Low	-0.513	-0.261
		(0.017)	(0.008)
	Low / High	-0.414	-0.165
		(0.019)	(0.009)
	High / Low	-0.074	-0.067
		(0.021)	(0.010)
Employees. with Internet Access		0.524	0.219
(Percentage)		(0.028)	(0.014)
Non-Production Workers		0.154	0.349
(Percentage)		(0.037)	(0.018)
Interaction: Employees. with Internet Access (Percentage)/ Non-Production Workers (Percentage)		-0.451	-0.006
		(0.069)	(0.033)
Number of Observations		22,704	22,947
R^2		0.259	0.408

Source: Authors' calculations using the1999 CNUS and 2000 ASM (Center for Economic Studies).

Notes: All regressions also control for size, age, STAN industry and multi-unit status.

Panel B: German Results

Variable		Dep. Variable: Log (Value Added Per Worker)	Dep. Variable: Log (Payroll per Worker)
Investment Class Index:	0/0	-0.287	-.111
		(0.068)	(.036)
Investment in Total Equipment /	Low/0	-0.434	-.104
		(0.077)	(.035)
Investment in ICT	High/0	-0.176	.018
0: No Investment		(0.096)	(.042)
Low: below the 75th Percentile	Low/Low	-0.393	-.141
		(0.055)	(.031)
High: above the 75th Percentile	Low/High	-0.31	-.032
		(0.058)	(.024)
(High/High omitted)	High/Low	-0.172	-.030
		(0.062)	(.027)
Employees with Internet Access	Most	0.165	.124
		(0.098)	(.056)
(Index)	Half	-0.053	.068
(All omitted)		(0.149)	(.115)
	a few	0.163	.107
		(0.076)	(.061)
	None	0.09	.055
		(0.104)	(.069)
Non-Production Workers (Percentage)		0.978	.582
		(0.133)	(.103)
Interaction:	Most	-0.333	-.17
Non-Production		(0.229)	(.122)
Workers (Percentage) /	Half	0.029	-.173
Employees with		(0.322)	(.231)
Internet Access	a few	-0.585	-.183
(Index)		(0.201)	(.140)
	None	-0.828	-.713
		(0.257)	(.170)
Number of observations		3121	3121
R^2		0.315	0.342

Source: Authors' calculations from the 2001 wave of the IAB Establishment Panel.

Notes: All regressions also control for size, age, STAN industry, multi-unit status and East Germany.

In both countries, the use of advanced technology and the use of more skilled workers are associated with higher labour productivity. Also, in the U.S., the interaction of Internet access and the skill mix is (somewhat surprisingly) negative while the interaction effects in Germany are more difficult to interpret, as the effects are not monotonic and often statistically insignificant.[14] Still, at first glance, it is striking that the overall patterns are so similar across the two countries.

While the patterns across the countries are broadly similar, the quantitative effects are different in some interesting ways. In particular, the use of advanced technology yields a greater increase in labour productivity in the U.S. compared to Germany. We base this inference on the difference between the labour productivity of the highest technology group (High/High) and the lowest technology group (0/0). In the U.S., the productivity premium for being "High/High" is 67 log points, while it is only 29 log points in Germany. In a like manner, the productivity premium for being "High/High" relative to "Low/Low" is 51 log points in the U.S. and 39 points in Germany.

Some of the intermediate comparisons are less clear-cut. For example, conditional on the level of total equipment investment, there is an additional productivity premium for U.S. establishments with high computer investment per worker of approximately 7 to 10 log points. These effects are estimated less precisely for Germany. According to the point estimates, a business with high computer investment per worker has, conditional on the level of total equipment investment, a productivity premium of between 8 to 17 log points. Alternatively, conditional on computer investment, there is a bigger productivity premium from an increase in total equipment per worker in the U.S. relative to Germany. That is, conditional on computer investment per worker, the productivity premium in going from low to high equipment investment is between 41 and 44 log points in the U.S. and 14 and 31 log points in Germany. We think these intermediate/conditional comparisons are interesting but place more emphasis on the comparisons based upon using the combined impact of total equipment and computer investment spending (e.g., High/High vs. 0/0) given the limitations of the measures. Moreover, even though there are less clear-cut patterns for some intermediate comparisons, it is apparent from

14 The surprising negative interaction effect may in part be related to the fact that the non-production worker mix is a poor proxy for the skill mix. For example, the non-production worker mix includes clerical workers. Put differently, the interaction effect may be picking up composition effects within the two broad categories of workers that we measure.

Table 3 that the broad patterns are such that the impact of investment is greater in U.S. than Germany.

Internet access has a slightly larger quantitative effect in the U.S. than Germany. The differences in the measurement of the variables make this a bit difficult to compare. However, consider that in the U.S. moving a plant from the 10^{th} to the 90^{th} percentile of the Internet Access distribution is equivalent to an increase in Internet access from 0 percent to 60 percent of the plant's workforce. Using the coefficients from Table 3 suggests that this is associated with an increase in productivity of approximately 24 log points (this calculation takes into account the negative interaction effect). In Germany, an increase Internet access by a plant's workers from "none" to "half" or "most" (which is roughly equivalent in going from 0 to 60 percent in the U.S.) yields an increase in productivity of between 13 to 23 log points.[15]

Turning to other effects of interest, we see that in both countries an increase in the skill mix is associated with an increase in productivity and, in this case, the quantitative effect is much larger in Germany.[16] Also, as noted the interaction between Internet access and the skill mix is negative[17] in the U.S. while the effect is not monotonic in Germany. Going from "none" to "all" Internet access does yield a positive interaction effect in Germany.

The right columns of Table 3 present analogous results based on payroll per worker for the two countries. Interestingly, the findings suggest that productivity differences are also reflected in wage differences along the same dimensions (i.e. the right-hand-side variables in the regressions) especially in U.S. As is typically the case in these types of regressions, appropriate caution needs to be given to the interpretation. It is likely the case that U.S. high tech firms are especially high skill firms and the production/non-

15 The interaction effects for Germany are imprecisely estimated so appropriate caution required about this comparison. However, we have estimated these specifications without the interaction effects and the quantitative estimated impact is still approximately the same.

16 This measure of skill is quite crude but the only one we have available readily for both countries. For Germany, there are alternative measures of skill and somewhat surprisingly we find that when we include these alternative measures of skill instead of this measure that we find less of an impact of a change in skill on productivity.

17 Interestingly, the negative interaction term for the U.S. implies that the marginal impact of increased skill, as measured by the share of non-production workers, on productivity is negative for a significant number of establishments with high levels of Internet access. Our prior hypothesis was that Internet access and skill would interact positively. This may yet be the case and our finding may be due to imperfections in our measures – especially for skill as noted above. An alternative and somewhat whimsical interpretation is that the web surfing by the non-production workers is decreasing productivity.

production distinction only captures part of the skill differences across firms. Existing studies (e.g., Doms *et al.*, 1997; and Abowd *et al.*, 2001) suggest that this pattern holds in the U.S. Alternatively, it may be that there is some rent sharing of “success” from adopting advanced technology. In looking at the quantitative patterns, the wage gaps tend to be smaller than productivity gap. For example, the wage gap between the 0/0 group and the High/High group is 0.288 for U.S., and only 0.111 for Germany. One possible explanation for the apparent greater compression of wages relative to observables in Germany is that this is due to the wage setting institutions in Germany (and Europe more generally) that reduce the flexibility of relative wages and thus reduces experimentation in Europe.

As stressed above, we checked for the validity of our results concerning the impact of investment in advanced technologies on plants' outcomes by replacing it with investment in “low-tech” equipment – highway vehicles (cars and trucks). Reassuringly, we find no productivity or wage premium at establishments with high investment in highway vehicles. As such, this gives us more confidence that there is information content in the computer investment data we are exploiting in this analysis.

In sum, while the overall patterns in the data reveal striking similarities across the two countries, there are some notable differences in the relationships between outcomes like productivity and payroll per worker and measures of the use of advanced technology such as expenditures on computers and equipment, and Internet access. In both the U.S. and Germany, the high productivity workplaces are the high skill and high tech workplaces. In the U.S., the differences in technology use account for more variation across businesses in productivity and payroll per worker than in Germany. In what follows, we treat these results as a backdrop and investigate whether there is a different degree of market experimentation in the U.S. relative to Germany.

4. Experimentation? Differences across Germany and the U.S.

4.1 The Role of Establishment Age

As discussed in the introduction, a key theme/hypothesis in this paper is that the U.S. exhibits greater market experimentation, which might help explain its stronger growth performance in a period of rapid diffusion of the a new general purpose technology (ICT). Here we look at the nature of experimentation for entrants and young businesses. New businesses are inherently experimenting as they are beginning to produce goods or services at a new location. However, the incentives for experimentation may vary across institutional environments. In environments that especially encourage experimentation, we would expect to see greater dispersion in both choices and outcomes for young and new businesses.

Figure 1 **Average Employment by Age**

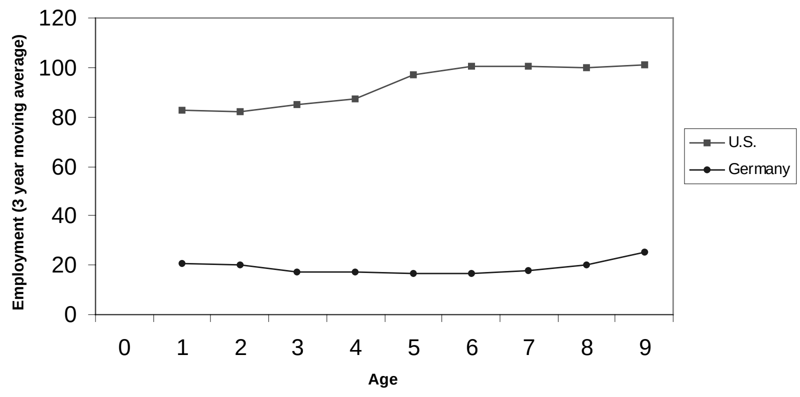


Figure 2 **Productivity Dispersion by Age**

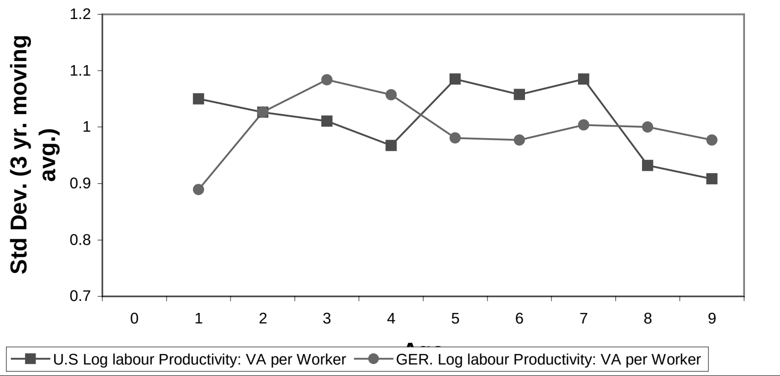
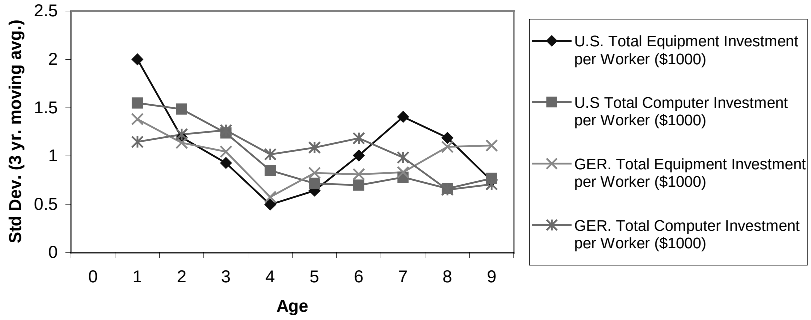


Figure 3 **Investment Dispersion By Age (normalized)**



Figures 1, 2 and 3 show how some of our key indicators vary with plant age.[18] Figure 1 confirms the findings in Bartelsman, Scarpetta and Schivardi (2002) that while the average size of U.S. businesses increases significantly with plant age, no such age effect is found amongst German plants. Note that these results are based on a cross section of existing establishments and not on the size evolution of a given cohort (which is not possible on the basis of available data). Moreover, Figure 2 shows that productivity dispersion falls with age in U.S. but not in Germany.[19] While the decline is not monotonic, the magnitude of the change in dispersion over the entire age range is substantial in U.S. with the within age standard deviation for age 9 establishments 13% below that for age 1 establishments. Finally, Figure 3 shows that both the U.S. and Germany exhibit

18 The figures highlight some of our more interesting results, and additional detailed statistics are available in Appendix Tables A.2 and A.3. The results depicted in Figures 1, 2 and 3 are computed from the Appendix tables using a 3 moving average and excluding the final age categories that include all establishments with age 10 or more.

19 In unreported results, we have calculated similar statistics using industry controls to remove the effect of different industrial structures across the two countries. That is, before calculating the statistics, we deviate each measure from the relevant industry-specific (2-digit STAN mean). We find the same basic patterns in those results. In particular, even controlling for industry, we find that productivity dispersion falls systematically with age in the U.S. but it does not fall in Germany. For example, for the U.S. the standard deviation of log productivity decreases from 0.92 (compare with Appendix tables 2a and 2b) for the youngest plants to 0.67 for the most mature plants while the equivalent statistics for Germany are 0.54 (youngest) and 0.59 (most mature). The patterns for other variables are similar as well. We also repeated the exercise using the employment weighted distribution and found similar patterns.

decreasing dispersion in investment per worker over the age distribution. The decreased dispersion is more marked in the U.S., consistent with the notion that young business in the U.S. experiment with a wider range of strategies than do their counterparts in Germany.

4.2 The Role of Active Learning – Differentiating between businesses actively changing their technology and others

Businesses that are actively changing their technology are also inherently experimenting. There is uncertainty about the best way to implement a new technology and/or whether the business in question is capable of implementing the new technology in a successful manner. Again, different market and institutional environments may provide different incentives for experimentation. If adjustment costs from institutional factors limit flexibility then businesses may choose a lower mean, lower risk strategy of implementation.

For this analysis, we use the technology groups that we used in the simple regression analysis in the previous section. For example, businesses that are most actively engaged in changing their technologies are the “High/High” group – those businesses that are above the 75th percentile in both equipment investment per worker and computer investment per worker, respectively.

We summarise the results of this analysis in Figures 4 and 5 that are based upon the analysis by more detailed technology groups that are in Appendix Tables A.4 and A.5. For illustrative purposes, in Figures 4 and 5 we collapse the six technology groups into two that we designate as active and inactive. The active group consists of groups: “High/High”, “High/Low”, “Low/High” and “High/0”. The inactive group consists of groups: “0/0”, “Low/Low”, and “Low/0”. In other words, the active group has at least one of the investment indicators in the high category (i.e., above 75th percentile in either or both the total or computer investment intensity distributions) and the inactive group has neither investment indicator in the high group.[20]

[20] The appendix tables make clear that these summary patterns are robust to alternative cut offs of the respective groupings. For example, if the “High/0” group is made part of the “low” summary group the patterns in Figures 3-5 remain the same.

Figure 4 **Active vs. Inactive Gap in Mean and Dispersion of Productivity**

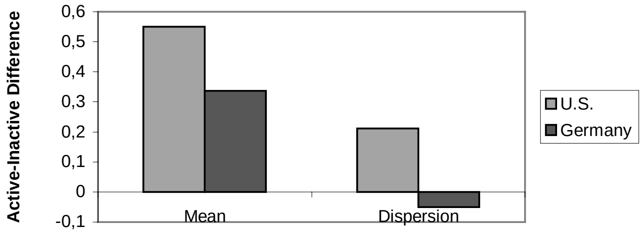


Figure 5 **Active vs. Inactive Gap in Mean and Dispersion of Skill Mix**

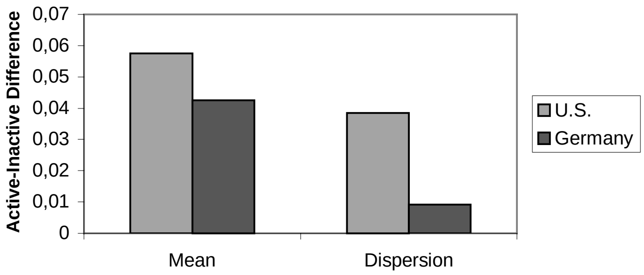
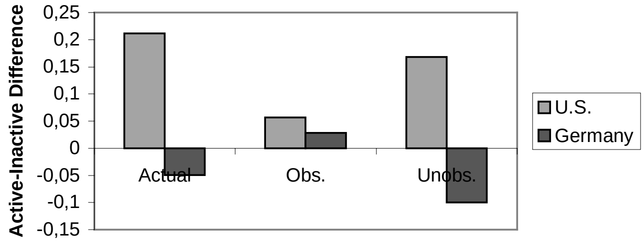


Figure 4 shows the difference in the mean productivity and the dispersion of productivity between the active and inactive groups. Figure 5 shows the analogous statistics for the skill mix. The detailed statistics in Tables A.4 and A.5 show that in terms of means, businesses that are more actively changing their technology in both countries have higher productivity, higher payroll per worker, a higher skill mix, and have more workers with access to the Internet (an alternative technology measure in its own right). These patterns are more pronounced in the U.S. Figures 4 and 5 highlight this finding as they show that the difference in the mean productivity and mean skill across the tech groups is greater in the U.S.

The striking difference between the U.S. and Germany is in the dispersion across the technology groups. In the U.S., Tables A.4 and A.5 show that businesses most actively changing their technology have greater dispersion in productivity, payroll per worker, the skill mix of workers, computer and equipment investment per worker, and the internet access relative to those businesses less actively changing their technology. The differences in dispersion are substantially larger and more systematic in the U.S. relative to Germany as illustrated in Figures 4 and 5. For example, figure 4 shows that the increase in productivity dispersion from the inactive to the active tech groups is more than 20 log points. Figure 5 shows that the increase in dispersion in the skill mix from the inactive to active tech is about 4 log points. These patterns are less pronounced and less systematic for Germany. For example, Figure 4 shows that there is slightly lower dispersion in productivity in the active tech group and the detailed statistics in the Appendix tables show that this reflects the lack of a systematic relationship between productivity dispersion and technology groups in Germany.

To explore these findings further, we use the results from section 3 above that relate the characteristics of the business to the productivity differences. In particular, we use the regression results in Table 3 to examine how much of the changes in productivity dispersion across technology groups can be accounted for by changes in the dispersion of characteristics across businesses (e.g., skill mix, internet access, computer investment and equipment investment per worker) and how much is accounted for by unobservable factors. Figure 6 presents the results of this exercise (and results by detailed technology group are in Appendix Table A.6). Interestingly, both observable and unobservable factors help account for the greater productivity dispersion associated with the pace of technological change in the U.S. These results are consistent with the view that experimentation occurs over both observable and unobservable dimensions. That is, the contribution of observables may reflect the role of experimentation as businesses try different ways of conducting business. Alternatively, the role of the unobservables might be interpreted as suggesting that those businesses most actively changing their technology face considerable uncertainty about how best to change the technology and whether they have the “ability” to change the technology successfully. Apparently, both observable and unobservable factors are important in the U.S. For Germany, given that there is not a large or systematic relationship between the pace of technology changes and dispersion, it is harder to interpret the results.

Figure 6 **Active-Inactive Gap in Productivity Dispersion: Observable and Unobservable Factors**



5. SUMMARY AND INTERPRETATION

The evidence presented in this paper provides further support to the idea that U.S. businesses engage in experimentation in a variety of ways not matched by their German counterparts. In particular, there is greater experimentation amongst young U.S. businesses and there is greater experimentation among those actively changing their technology. This experimentation is evidenced in a greater dispersion in productivity and in related key business choices, like the skill mix and Internet access for workers. We also find that the mean impact of adopting new technology is greater in U.S. than in Germany. Putting the pieces together suggests that U.S. businesses choose a higher mean, higher variance strategy in adopting new technology.

There are many caveats and cautions that must be noted for interpreting the results in this fashion. Our measures of technology as well as our measures of outcomes like productivity and wages at the micro level are imperfect and likely subject to both classical and non-classical measurement errors. Moreover, the comparison is only for the manufacturing sectors in the U.S. and Germany, and largely reflects within country cross-sectional differences across businesses in each country. In a related matter, the causal link between use of advanced technology and productivity is difficult to determine without longitudinal data and, thus, our results on the relationship between technology and productivity (and wages) should be interpreted as simple correlations between the variables of interest. Bearing these caveats in mind, the covariance structure between productivity and measures of changing technology differ systematically at the micro level across the U.S. and Germany in a manner that is clearly suggestive of the U.S. exhibiting a greater degree of experimentation in the adoption of new technologies.

There are many areas of research that we have only touched upon that deserve further exploration. For one, our micro based results on experimentation seem to line up well in broad terms with the micro as well as aggregate based analyses in Bartelsman, Scarpetta and Schivardi (2002) and Bartelsman et. al. (2002). However, full micro and macro reconciliation of the statistics and analysis is beyond the scope of this study but should be an objective for analysis and development of such statistics in the future. In addition, we have only touched on the many different sources of heterogeneity across businesses in this analysis that may underlie the role of experimentation. One of the most policy-relevant is the differences in the demand for skills and the associated differences in internal labour market and human resource practices across businesses. The type of experimentation we stress in this study obviously has implications for labour market dynamics given the implied reallocation of labour. However, beyond these obvious implications, there may be even more far-reaching implications. Relevant open questions include: Is market experimentation across businesses closely linked to the demand for skills and human resource practices? Are the successful businesses those that not only adopt advanced technologies on the “hard” side of technology (i.e., IT) but also on the “soft” side of technology? Analysis by Bresnahan et al. (2002) suggests, for example, that successful adoption of IT is closely related to the human resource and organizational practices of businesses. To explore such ideas, the micro data that we have used in this analysis must be augmented with richer data on the mix of workers at businesses as well as richer measures of the hard and soft sides of technology. Developing the micro datasets that permit such analysis should be another priority for the future.

APPENDIX

In this Appendix we provide the detailed tables that either lie behind the figures or analysis discussed in the main body of the paper. Tables A.1.a and A.1.b list summary statistics by STAN industry codes. Tables A.2.a through A.3.b list the results underlying the Figures 1 through 3. Tables A.4.a through A.5.b list the results underlying figures 4 through 6.

Table A.1a: U.S. Means by STAN Industry; Weighted by Sample Weights

Stan Industry	ISIC Rev. 3	Age	Number of Establish-ments	Em-ploy-ment	Skill (percen-tage)	Internet Access (percen-tage)	Equipment Investment per Worker	Computer Investment per Worker	Labour Productivity	Log Payroll per Worker
Food and Beverages	15-16	9.7	2788	192.1	0.292	0.139	9.106	0.289	4.545	3.358
Textiles, Leather, Footwear	17-19	9.2	1656	148.0	0.206	0.128	3.816	0.263	3.880	3.125
Wood Products	20	9.2	1539	87.1	0.177	0.089	6.773	0.327	4.054	3.281
Pulp, Paper, Publishing	21-22	9.7	3028	100.9	0.288	0.275	7.276	0.559	4.296	3.538
Petroleum & Other Fuels	23	10.4	163	219.8	0.400	0.450	29.010	0.772	5.570	3.965
Chemicals	24	9.3	2211	135.3	0.384	0.352	23.362	0.782	4.949	3.694
Rubber and Plastics Products	25	9.3	2251	120.4	0.222	0.163	7.515	0.263	4.218	3.373
Non-Metallic Minerals	26	9.2	2080	73.3	0.228	0.131	16.896	0.236	4.546	3.495
Basic Metals	27	9.4	1282	234.9	0.223	0.183	8.741	0.338	4.395	3.526
Fabricated Metals Products	28	9.7	3547	84.5	0.244	0.156	4.712	0.300	4.256	3.503
Machinery & Equipm., N.E.C.	29	9.0	3584	113.4	0.303	0.240	5.642	0.722	4.340	3.623
Computer and Office Equipment	30	8.2	155	350.7	0.551	0.632	7.154	1.995	4.623	3.750
Electrical Machinery	31	9.6	930	201.9	0.359	0.339	5.626	0.821	4.383	3.545
Radio & Telecommunications Equipment	32	8.9	655	240.6	0.338	0.362	10.259	0.750	4.371	3.545
Medical and Optical Instruments	33	9.3	933	172.8	0.456	0.437	4.505	0.867	4.439	3.605
Motor Vehicles	34	9.3	973	368.1	0.230	0.172	6.459	0.302	4.373	3.527
Shipbuilding	35.1	8.5	119	353.7	0.153	0.137	1.887	0.251	4.004	3.439
Air & Spacecraft	35.3	9.8	242	731.7	0.376	0.378	4.954	0.552	4.576	3.753
Manufacturing N.E.C.	36-37	9.2	2035	90.3	0.277	0.168	3.992	0.239	4.042	3.341

Source: Authors calculations from 1999 CNUS and 2000 ASM, Center for Economic Studies.

Table A.1b: German Means by STAN Industry; Weighted by Sample Weights

Stan Industry	ISIC Rev. 3	Age	Number of Establish-ments	Em-ploy-ment	Skill (percen-tage)	Internet Access (index)	Equipment Investment per Worker	Computer Investment per Worker	Labour Productivity	Log Payroll per Worker
Food and Beverages	15-16	10.2	858	17.4	0.319	3.061	5.572	0.334	3.281	2.645
Textiles, Leather, Footwear	17-19	10.2	307	19	0.353	3.56	2.616	0.419	3.504	2.656
Wood Products	20	9.9	505	12.6	0.146	2.876	4.33	0.262	3.482	2.773
Pulp, Paper, Publishing	21-22	9.8	470	26.8	0.49	2.468	7.831	1.86	3.801	3.144
Petroleum & Other Fuels; Nuclear Fuel; Chemicals	23-24	9.6	497	73.3	0.526	2.319	10.1	1.806	4.288	3.192
Rubber and Plastics Products	25	9.8	425	48.7	0.192	2.393	6.784	0.721	3.703	3.069
Non-Metallic Minerals	26	9.5	453	20.6	0.354	3.101	9.405	0.958	3.635	2.815
Basic Metals	27	9.6	548	59.7	0.211	2.606	10.072	0.631	3.688	3.044
Fabricated Metal Products	28	10	965	24	0.208	3.116	9.447	0.478	3.742	3.105
Machinery & Equipm., N.E.C.	29	8.8	991	42	0.39	2.757	12.389	1.418	3.921	3.155
Electrical Euipment excluding Medical and Optical Instruments	30-32	9.1	602	47.1	0.402	2.338	5.174	1.443	3.839	3.135
Medical and Optical Instruments.	33	9.6	448	13.5	0.444	2.621	2.993	0.594	3.591	2.95
Motor Vehicles	34	8.5	362	161.1	0.208	3.099	8.753	0.546	3.725	2.95
Other Transport Equipment	35	10.2	169	46	0.21	2.687	8.067	1.064	3.87	2.957
Manufacturing N.E.C.	36-37	9.5	454	15.3	0.186	2.704	5.885	0.462	3.311	2.669

Source: Authors calculations from the 2000 and 2001 waves of the IAB Establishment Panel.

Table A.2: Means by Establishment Age; Weighted by Sample Weights

Table A.2a: U.S. Data

Age (years)	0	1	2	3	4	5	6	7	8	9	10	11	12
Number of Establishments	843	1297	751	588	561	547	518	520	629	620	634	23694	
Employment	86.9	80.6	80.5	84.4	89.8	88.3	113.5	99.2	88.8	111.5	102.6	157.2	
Skill (percentage of non-production workers)	0.24	0.27	0.26	0.26	0.28	0.25	0.24	0.30	0.28	0.28	0.27	0.28	
Employee Internet Access (percentage)	NA	0.26	0.21	0.19	0.22	0.21	0.23	0.26	0.24	0.22	0.23	0.21	
Total Equipment Investment ($1000)	1162.3	845.3	1242.8	890.2	948.0	846.2	952.2	647.2	641.7	819.7	910.0	1400.6	
Total Computer Investment ($1000)	55.4	44.6	48.2	62.9	47.0	63.3	52.9	55.2	45.9	68.5	64.9	85.8	
Total Equipment Investment per Worker ($1000)	36.47	15.38	17.12	11.60	7.19	7.78	9.07	9.70	9.43	6.40	7.03	6.52	
Total Computer Investment per Worker ($1000)	0.85	0.61	0.64	1.02	0.37	0.48	0.41	0.44	0.41	0.38	0.58	0.42	
Log labor Productivity: VA per Worker	4.34	4.29	4.37	4.33	4.35	4.26	4.12	4.27	4.17	4.25	4.30	4.35	
Log Payroll per Worker	3.38	3.32	3.34	3.37	3.38	3.35	3.37	3.45	3.42	3.37	3.38	3.52	

Source: Authors calculations from 1999 CNUS and 2000 ASM, Center for Economic Studies.

Table A.2b: German Data

Age (years)	0	1	2	3	4	5	6	7	8	9	10	11	12
Number of Establishments		92	197	250	231	250	292	337	447	581	621	2465	2256
Employment		20.34	22.5	18.35	18.79	15.27	18.45	15.65	15.91	22.02	21.64	32.78	35.65
Skill (percentage of non-production workers)		0.23	0.32	0.26	0.38	0.25	0.31	0.38	0.34	0.31	0.34	0.32	0.33
Employee Internet Access (index: 1-5)		2.96	2.85	2.43	2.32	3.16	2.55	2.73	2.54	2.46	2.91	3.12	2.88
Total Equipment Investment ($1000)		694.2	350.4	394.1	293.3	117.2	309.9	148.4	159.6	190.7	226.0	283.2	375.3
Total Computer Investment ($1000)		32.2	28.0	93.1	69.8	14.4	20.6	16.0	16.8	17.5	17.9	37.6	35.8
Total Equipment Investment per Worker ($1000)		17.09	8.23	15.01	6.93	7.07	5.45	10.47	7.27	5.52	13.53	6.21	5.78
Total Computer Investment per Worker ($1000)		1.09	0.65	0.56	0.89	0.46	1.21	1.43	1.27	0.51	0.67	0.84	0.59
Log labor Productivity: VA per Worker ($ 1000)		3.3	3.36	3.42	3.47	3.77	3.55	3.77	3.77	3.58	3.48	3.66	3.65
Log Payroll per Worker ($ 1000)		2.82	2.72	2.66	2.62	2.82	2.83	2.95	2.92	2.87	2.74	2.92	3.03

Source: Authors calculations from the 2000 and 2001 waves of the IAB Establishment Panel.

Table A.3: Standard Deviations by Establishment Age; Weighted by Sample Weights

Table A.3a: U.S. Data

Age (years)	0	1	2	3	4	5	6	7	8	9	10	11	12
Number of Establishments	843	1297	751	588	561	547	518	520	629	620	634	23694	
Employment	277.7	140.4	176.0	140.3	203.7	172.0	400.4	624.8	366.3	304.6	199.7	432.5	
Skill (percentage of non-production workers)	0.20	0.21	0.20	0.20	0.22	0.18	0.19	0.24	0.22	0.20	0.20	0.18	
Employee Internet Access (percentage)	NA	0.29	0.29	0.26	0.27	0.26	0.28	0.33	0.29	0.27	0.28	0.26	
Total Equipment Investment ($1000)	5588	4733	9680	6102	9336	3962	5616	3438	3130	3784	4214	11589	
Total Computer Investment ($1000)	469.8	269.2	327.3	448.4	284.5	416.4	346.3	686.7	484.5	656.2	442.2	1054.7	
Total Equipment Investment per Worker ($1000)	151.8	72.80	85.28	26.77	31.89	18.38	49.29	88.11	80.50	15.81	18.70	27.16	
Total Computer Investment per Worker ($1000)	4.16	3.18	4.40	3.67	1.31	1.47	2.66	1.16	2.10	1.76	1.97	5.75	
Log labor Productivity: VA per Worker ($1000)	0.94	0.89	0.84	0.88	0.85	0.73	1.18	0.78	0.80	0.79	0.72	0.72	
Log Payroll per Worker ($1000)	0.50	0.51	0.48	0.46	0.46	0.37	0.44	0.47	0.38	0.39	0.41	0.38	

Source: Authors calculations from 1999 CNUS and 2000 ASM, Center for Economic Studies.

Table A.3b: German Data

Age (years)	0	1	2	3	4	5	6	7	8	9	10	11	12
Number of Establishments		92	197	250	231	250	292	337	447	581	621	2465	2256
Employment		99.73	148.08	117.03	178.06	71.54	100.07	49.46	46.71	59.25	67.83	237.12	309.48
Skill (percentage of non-production workers)		0.25	0.36	0.33	0.40	0.34	0.36	0.41	0.39	0.34	0.38	0.32	0.34
Employee Internet Access (index: 1-5)		1.83	1.81	1.68	1.65	1.70	1.66	1.64	1.53	1.65	1.63	1.71	1.70
Total Equipment Investment ($1000)		21636	3438	6559	8679	764	13690	1024	955	1600	2047	3232	21852
Total Computer Investment ($1000)		321	314	5482	3321	130	203	130	78	166	145	785	1017
Total Equipment Investment per Worker ($1000)		33.64	25.94	48.15	14.70	18.72	11.57	34.03	17.65	13.11	54.68	18.64	19.37
Total Computer Investment per Worker ($1000)		3.19	1.39	5.24	3.86	1.75	3.10	4.46	2.57	1.40	1.60	3.05	1.60
Log labor Productivity: VA per Worker ($ 1000)		0.67	0.83	0.83	1.03	0.98	0.76	0.83	0.97	0.83	0.82	0.91	0.90
Log Payroll per Worker ($ 1000)		0.53	0.78	0.70	0.74	0.67	0.65	0.58	0.62	0.57	0.56	0.62	0.59

Source: Authors calculations from the 2000 and 2001 waves of the IAB Establishment Panel.

Table A.4: Means by IT and Total Equipment Investment Categories;

Weighted by Sample Weights; High Category Defined as Investment Exceeding the 75th Percentile

Table A.4a: U.S. Data

Investment class: Equip / IT	0 / 0	Low / 0	High / 0	Low / Low	Low / High	High / Low	High / High
Number of Establishments	40	9047	2872	10163	4401	2284	2395
Age	9.54	9.41	8.84	9.71	9.53	9.51	8.78
Employment	34.4	101.0	136.7	148.7	149.9	209.1	228.0
Skill: (Proportion of non-production workers)	0.20	0.25	0.24	0.27	0.37	0.25	0.33
Employee Internet Access (Fraction)	0.07	0.16	0.21	0.19	0.34	0.22	0.34
Total Equipment Investment ($1000)	0	282.6	4332.6	396.1	604.5	4322.6	6586.7
Total Computer Investment ($1000)	0	0	0	22.29	195.17	38.81	668.30
Total Equipment Investment per Worker ($1000)	0	2.47	33.32	2.23	3.44	22.34	36.58
Total Computer Investment per Worker ($1000)	0	0	0	0.16	1.44	0.20	3.04
Log labor Productivity: VA per Worker	3.94	4.19	4.73	4.19	4.42	4.65	4.83
Log Payroll per Worker	3.33	3.39	3.56	3.43	3.62	3.60	3.73

Source: Authors calculations from 1999 CNUS and 2000 ASM, Center for Economic Studies.

Table A.4b: German Data

Investment class: Equip / IT	0 / 0	Low / 0	High / 0	Low / Low	Low / High	High / Low	High / High
Number of Establishments	1579	793	450	1727	1057	524	1543
Employment	9.15	14.45	16.54	44.43	34.05	76.33	58.5
Skill: (Proportion of non-production workers)	0.34	0.25	0.24	0.25	0.4	0.26	0.39
Employee Internet Access (Fraction)	3.23	2.94	3.03	2.71	2.2	2.2	2.44
Total Equipment Investment ($1000)	0	36.16	420.16	112.54	119.43	962.77	1467.63
Total Computer Investment ($1000)	0	0	0	12.27	47.35	25.59	209.36
Total Equipment Investment per Worker ($1000)	0	2.69	32.91	2.11	3.1	13.05	25.45
Total Computer Investment per Worker ($1000)	0	0	0	0.29	1.66	0.35	4.15
Establishment Age	9.94	9.53	8.49	9.96	9.85	10.23	9.25
Log labor Productivity: VA per Worker ($1000)	3.45	3.46	3.73	3.57	3.81	3.75	4.03
Log Payroll per Worker ($ 1000)	2.77	2.74	2.93	3.05	3.09	3.13	3.13

Source: Authors calculations from the 2000 and 2001 waves of the IAB Establishment Panel.

Table A.5: Standard Deviations by IT and Total Equipment Investment Categories;

Weighted by Sample Weights; High Category Defined as Investment Exceeding the 75th Percentile

Table A.5a: U.S. Data

Investment class: Equip / IT	0 / 0	Low / 0	High / 0	Low / Low	Low / High	High / Low	High / High
Number of Establishments	40	9047	2872	10163	4401	2284	2395
Establishment Age	2.935	3.023	3.522	2.781	2.933	2.978	3.561
Employment	33.66	291.45	422.19	396.27	457.50	422.18	669.98
Skill: (Proportion of non-production workers)	0.109	0.179	0.190	0.178	0.213	0.159	0.213
Employee Internet Access (Fraction)	0.153	0.223	0.281	0.235	0.313	0.264	0.321
Total Equipment Investment per Worker ($1000)	0	2.181	103.60	2.065	2.143	64.612	96.252
Total Computer Investment per Worker ($1000)	0	0	0	0.117	12.679	0.125	6.656
Log labor Productivity: VA per Worker ($1000)	0.572	0.744	0.922	0.606	0.652	0.891	0.944
Log Payroll per Worker ($1000)	0.239	0.405	0.441	0.356	0.380	0.361	0.414

Source: Authors calculations from 1999 CNUS and 2000 ASM, Center for Economic Studies.

Table A.5b: German Data

Investment class: Equip / IT	0 / 0	Low / 0	High / 0	Low / Low	Low / High	High / Low	High / High
Number of Establishments	1579	793	450	1727	1057	524	1543
Employment	28.07	39.56	81.64	169.32	118.44	313.96	409.87
Skill: (Proportion of non-production workers)	0.38	0.31	0.33	0.25	0.34	0.28	0.34
Employee Internet Access (Fraction)	1.81	1.72	1.7	1.54	1.44	1.34	1.54
Total Equipment Investment ($1000)	0	141.99	1963.85	588.83	573.66	4841.08	34957.82
Total Computer Investment ($1000)	0	0	0	45.41	278.73	101.55	3735.69
Total Equipment Investment per Worker ($1000)	0	1.7	60.61	1.67	1.6	9.94	37.35
Total Computer Investment per Worker ($1000)	0	0	0	0.17	1.1	0.14	6.46
Establishment Age	2.77	3.04	3.71	2.9	2.79	2.7	3.27
Log labor Productivity: VA per Worker ($1000)	0.93	0.8	0.85	0.84	0.8	0.66	0.94
Log Payroll per Worker ($ 1000)	0.64	0.66	0.55	0.52	0.65	0.49	0.56

Source: Authors calculations from the 2000 and 2001 waves of the IAB Establishment Panel.

Table A.6: Standard Deviations of Predicted Values and Residuals by IT and Total Equipment Investment Categories

Based on Regressions in Middle Column of Table 3; High Category Defined as Investment Exceeding the 75th Percentile

Table A.6a: U.S. Estimates

Based on Regression in Middle Column of Table 3a

Investment class: Equip / IT	0 / 0	Low / 0	High / 0	Low / Low	Low / High	High / Low	High / High
Standard Deviation of Predicted values	0.210	0.267	0.321	0.250	0.253	0.298	0.325
Standard Deviation of Residuals	0.448	0.682	0.783	0.555	0.607	0.780	0.750

Source: Authors calculations from 1999 CNUS and 2000 ASM, Center for Economic Studies.

Table A.6b: German Estimates

Based on Regression in Middle Column of Table 3b

Investment class: Equip / IT	0 / 0	Low / 0	High / 0	Low / Low	Low / High	High / Low	High / High
Standard Deviation of Predicted Values	0.285	0.277	0.309	0.325	0.351	0.293	0.341
Standard Deviation of Residuals	0.856	0.751	0.641	0.804	0.704	0.651	0.818

Source: Authors calculations from the 2000 and 2001 waves of the IAB Establishment Panel.

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