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## The Impact of New Technologies on the Demand for Heterogenous Labour: Empirical Evidence from the German Business-Related Services Sector

ZEW Discussion Papers, No. 98-26

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*Suggested Citation:* Kaiser, Ulrich (1998) : The Impact of New Technologies on the Demand for Heterogenous Labour: Empirical Evidence from the German Business-Related Services Sector, ZEW Discussion Papers, No. 98-26, Zentrum für Europäische Wirtschaftsforschung (ZEW), Mannheim

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**The Impact of New Technologies on the  
Demand for Heterogenous Labour:**

Empirical Evidence from the  
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Ulrich Kaiser

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## Non-technical summary

Does technology have an impact on the labor market? In what direction do new technologies influence the demand for differing qualities in labor? Do the results found for the manufacturing industries also hold for services? These are the questions addressed in this paper. Various studies for a large number of countries have shown that new technology favors high skilled labor and acts substitutive to low skilled labor, a phenomenon called *skill biased technological change*. Recent empirical evidence has shown skill biased technological change to be the main reason for the steady decline in relative demand for low skilled labor in most OECD countries. Since existing studies mostly focus on manufacturing industries, not much is known for the service sector. Given the worldwide dynamic growth in service sector employment figures, it is desirable to learn more about the way new technology might affect labor demand.

One of the most challenging economic problems of our times consists of the high unemployment rate amongst low skilled labor. Many policy makers and economists hoped the fast growing service sector could mitigate these problems. In fact, the service sector has grown considerably in terms of employment during the last ten years. One of the driving forces behind these employment gains which make up the focus of these studies were business-related services. Services in general and especially business-related services are not well researched due to some severe data constraints.

This paper aims to shed light on the effect of new technology on the demand for heterogeneous labor in business-related services. Starting from a dynamic factor demand model, it shows that investment in information and communication technologies acts substitutive to workers with a completed vocational training and complementary to university graduates. Further, traditional investment acts substitutive to unskilled labor. Thus, skill-biased technological change is also present in business-related services.

Other findings are that labor costs do not play an important role in the demand for university graduates, in the demand for workers with completed vocational training and additional technical training and in the demand for unskilled workers. They rather turn out to be highly significant for workers with completed vocational training. Also, expected foreign competition has a significantly positive effect on the demand for both university graduates and unskilled labor alike while present foreign competition is only significant and positive in the demand for university graduates.

# The Impact of New Technologies on the Demand for Heterogenous Labor:

Empirical Evidence from the German Business-Related Services Sector

by

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July 1998

**Abstract:** The impact of technology on the demand for heterogeneous labor is controversially discussed throughout the literature. New technology which is said to favor high skilled labor and to substitute low skilled labor is often considered as the main reason for the decline in relative demand for low skilled labor. While most analyses focus on manufacturing industries, this paper presents empirical evidence that technological skill bias is also present for business related services, an increasingly important sector in the German economy.

Cross-sectional data from an innovation survey and panel data from a quarterly business survey in the service sector are used in the empirical investigation. The data allow to directly distinguish among five different skill groups. The micro-level data also allow the analysis of shifting employment patterns for a single economic unit. Ordered probit models are utilized to study the determinants of skill shifts in business related services. It turns out that investment in information and communication technologies is a complement of university graduates and a substitute for workers with completed vocational training. New capital goods are substitutive to low unskilled labor whereas the demand for technically skilled labor remains unaffected by investment decisions. A puzzling finding is that labor costs do not play an important role in the demand for university graduates, technically skilled and unskilled labor but turn out to be highly significant for skilled labor. Also, expected foreign competition has a significantly positive effect on the demand for both university graduates and unskilled labor alike while present foreign competition is only positively significant in the demand for university graduates.

**Keywords:** skill-biased technological change, capital-skill complementarity, panel data, service sector, ordered probit model

**JEL classification:** J23, C21, C23

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\*Helpful comments from the participants of the XIth CREST-NBER *Séminaire Franco-Américain* on "Information and Communications Technologies, Employment and Earnings" at the University of Nice-Sophia Antipolis, June 22-23, 1998 and the VIIIth workshop on "Quality Management in Services" at the University of Ingolstadt, April 20-21, 1998 are gratefully acknowledged. This paper benefited much from invaluable comments by Bertrand Koebel, François Laisney, Georg Licht and Viktor Steiner. I am grateful to Günther Ebling, Norbert Janz and Hiltrud Niggemann for setting up the dataset. I also wish to thank Semka Thorvaldsen for proof-reading.

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# 1 Introduction

Many developed economies have witnessed a steady decline in the demand for low skilled workers over the last few years. This decline was even steeper for Germany than many other OECD countries.<sup>1</sup> Changes in the demand for skills affect the distribution of incomes and the level of unemployment attributable to technological changes. Moreover, skill shortages may lead to a decreased international competitiveness (Capelli, 1993). The issue of shifting employment patterns is thus of great political interest.

The most challenging problem in German economic policy at present is the high unemployment rate. Especially less qualified workers are affected by unemployment as becomes apparent from Figure 1.<sup>2</sup> In 1995, unemployment figures for unskilled workers were three times higher than for workers with a completed vocational training (skilled workers, *Berufsschulabsolventen*) and workers having completed a vocational and an additional technical training (technically skilled workers, *Fachschulabsolventen*) and roughly four times higher than for technical colleges (*Fachhochschule*) and university graduates. Further, the gap between unemployment levels of low and high skilled labor has steadily widened since the German unification in 1990.

Many politicians and economists hoped that the fast growing service sector could mitigate the unemployment problem of the less educated. Indeed, total employment in services has increased by 23.7 percent in West Germany between 1987 and 1995. However, employment gains were unequally distributed across skill groups, even in services. While the number of employees in business related services – which make up for roughly a third of all employees in the service sector – has increased by 41.6 percent, the increase was considerably lower for social services (18.8 percent), personal services (9.4 percent) and distributive services (14 percent). Employment in manufacturing decreased by 8.9 percentage points in the same period.<sup>3</sup> The strong increase in total employment in the business related services sector did not have a positive impact on employment prospects of the less qualified. An analysis of Mikrozensus<sup>4</sup> data for the years 1991, 1993 and

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<sup>1</sup>See OECD (1996) and Papaconstantinou (1997).

<sup>2</sup>Source: Mikrozensus and *Institut für Arbeitsmarkt- und Berufsforschung (IAB)*, Nuremberg, various issues.

<sup>3</sup>Source: IAB and ZEW (Mannheim Regions Monitor).

<sup>4</sup>The Mikrozensus is a household sample collected by the Federal Statistical Office. A one percent sample of the German population is examined annually on questions of employment, income and household status annually. A detailed description is given in Falk and Pfeiffer (1997).

1995 reveals that the share of university and technical college graduates in the sector "business related services" increased by roughly 1.5 percentage points while the share of unskilled workers decreased by 2.2 percentage points. Similar patterns can be detected for the entire German economy where the share of unskilled labor dropped by 2 percent and the share of technical college and university graduates increased by 1.2 percent.<sup>5</sup>

**insert Figure 1 about here**

The decreasing demand for low-skilled workers is well documented in the existing literature, at least for manufacturing industries. While there is no consensus between labor economists, most researchers believe that *skill-biased technological change* (Bound and Johnson, 1992) is the main reason for the decline in the demand for unskilled labor. That skill-biased technological change is the main explanation for deterioration in the demand for low skilled workers has been shown for many developed countries.<sup>6</sup> Most of these studies are concerned with manufacturing industries. Some studies additionally investigate a very broadly defined service sector, often simply defined as "non-manufacturing". Such a broad definition of services is clearly inappropriate given the heterogeneity of this sector.

In this paper, I concentrate on business related services, an increasingly important and, due to very limited data availability, a not well researched part of the service sector.<sup>7</sup>

By using a German panel data set, this paper shows that a shift toward high skilled labor is also present for business related services. The effect is permanent rather than, due to cyclical fluctuations, transitory. Since the data set allows explicit distinguishing of varying skill levels, major criticisms related to the construction of human capital proxy variables put forward by Leamer (1994) can therefore be overcome.<sup>8</sup>

Another novel feature of this paper is that it uses micro-level data to un-

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<sup>5</sup>Source: ZEW-70 percent sample of the Mikrozensus. The Mikrozensus as well as both the IAB and the Mannheim Regions Monitor data use a broader definition of business related services than I do in the proceeding part of this paper. Specifically, I use four-digit classifications for industry while the IAB and the Mannheim Regions Monitor data use three-digit classifications for industry. More disaggregated data are not available at the moment.

<sup>6</sup>See OECD (1996) and Papaconstantinou (1997).

<sup>7</sup>The inappropriate provision with data on the service sector in Germany has recently been criticized by the Council of Economic Advisors (Sachverständigenrat, 1997) and Hax (1998). Waller (1997) describes that a lack of data for the service sector is also present for most European countries.

<sup>8</sup>Leamer (1994) points out that separation of workers into "production" and "non-production" is not appropriate for studying income inequality.

cover the determinants of employment shifts. A weakness of most existing studies which use aggregated data is that the distinction between "within" and "between" industry shifts of employment patterns is not always clear-cut. The micro-level data used here allow a thorough investigation of changes within a single firm. A central finding of this paper concerns the impact of investment in "traditional" capital as well as information and communication technology (IT) on the demand for heterogeneous labor. The microeconomic evidence presented here supports the skill-biased technological change hypothesis. It turns out that total investment per capita has a significantly negative effect on the demand for unskilled labor and a significantly positive impact on the demand for technically skilled labor. The share of IT-investment in total investment has a significantly positive impact on the demand for university graduates and a significantly negative impact on the demand for workers with completed vocational training.

Labor costs, differentiated by skill groups, do not affect the demand for university graduates, technically skilled labor and, somewhat surprisingly, for unskilled labor. However, labor costs significantly and negatively influence the demand for skilled labor. Financial distress variables turn out to have a significant and negative effect only on the demand for unskilled labor giving evidence of labor hoarding effects for the better educated. Import pressure does not turn out to have a significant impact on the demand for heterogeneous labor.

The paper proceeds as follows: Section 2 briefly reviews existing studies on technological skill bias and capital-skill complementarities, section 3 describes the data sets, section 4 presents evidence for shifting employment patterns, section 5 introduces a simple theoretical model of the demand for heterogeneous labor, section 6 discusses estimation results, and section 7 concludes with a summary and some suggestions for further research.

## **2 A brief overview of previous studies**

The decline in relative demand for low skilled labor has given rise to an increasing amount of literature. Four main explanations can be found: (1) skill-biased technological change, (2) Stolper-Samuelson effects of increased exposures from trade with developing countries, (3) decreasing



demand for goods where a large amount of low skilled labor is needed (between–industry shifts) and (4) a relative increase in the supply of high skilled labor.

Berman et al. (1994) point out that skill–biased, or low skilled labor–saving, technological change is the driving force behind the decline in relative demand for low skilled workers in the US since 1979. Skill–biased technological change means that it is the increased use of new technology, such as information and communication technologies, which has caused wages and employment prospects of low skilled labor to deteriorate.

Bound and Johnson (1992) find that skill–biased technological change plays a major role in explaining the phenomenon that during the 80’s wages for the more educated workers increased while wages for the less educated decreased, leaving the average wage level constant. Also, Bound and Johnson (1992) give evidence for within rather than for between industry shifts. Support for their findings comes from Berman et al. (1994), who show that the impact of technological skill bias outweighs Stolper–Samuelson effects of increased exposures to trade from developing countries. Wolff (1996), who uses data from the US dictionary of occupational titles, comes to the conclusion that due to technological change the need for an ability to display more complex and interactive skills was growing increasingly between 1950 and 1990, pushing up the relative demand for more educated labor.

For ten OECD countries, Berman et al. (1997) show that it is skill–biased technological change rather than increased trade with developing countries which has caused the decline in relative demand for low skilled labor. Conflicting evidence for skill–biased technological change comes from Goux (1996) for France and Robinson and Manacorda (1997) for Great Britain. Goux (1996) finds that the main reasons for the decline in relative demand for low skilled labor between 1970 and 1993 consist of the decreased demand for goods which require low skilled labor as input and the increased supply – and an associated decline of their relative earnings – of high skilled labor. Robinson and Manacorda (1997) also stress the impact of labor supply conditions on skill shifts for the period 1984–1994.<sup>9</sup>

While no general agreement on the main reasons for the decline in relative demand for low skilled labor exists, the validity of Griliches’ (1969) capital–skill–complementarity hypothesis remains unchallenged. Using Swedish data, Bergström and Panas (1992) show that the capital–skill complementarity hypothesis is valid for alternative specifications of the production

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<sup>9</sup>Acemoglu (1997) presents a theoretical framework which focuses on the impact of supply of different skills on the direction of technological change.

function.

Specifically, the impact of modern IT technology has gained much attention in recent contributions. According to Autor et al. (1997), the industries upgrading their workforce are those with a higher computer usage. They conclude that since the 1970s 30–50 percent of skill changes in the US since the 1970s can be accounted for by computers. The estimations of Berndt et al. (1992) give evidence for complementarity of capital and both high tech capital and skill. Bartel and Lichtenberg (1987) show that with a growing plant and equipment age the demand for educated workers declines. In a case study concentrating on the banking industry, Levy and Murnane (1996) conclude that computers have increased the demand for skilled labor but the reason for the increase is foremost the way PCs changed the scope of banking activities and to a lesser extent changing skill requirements.

Machin (1996), using British panel data, shows that within–industry and within–establishment shifts in labor demand are related to technological change indicators. In a comparison between Great Britain, Sweden, Denmark and the US, Machin et al. (1996) find evidence for high skilled labor and new technology complementarities.

Skill-biased technological change as well as capital–skill complementarities are also well documented for Germany. Fitzenberger et al. (1995), investigating the wage structure, give evidence consistent with the skill-biased technological change hypothesis. A recent contribution by Steiner and Mohr (1998) finds no evidence for effects of international trade on the demand for heterogeneous labor but empirical results point at skill biased technological change. Falk and Koebel (1997) in a study for 5 sectors of the German economy find strong evidence for technological skill bias. FitzRoy and Funke (1995) show capital and white collar labor complementarities. Very few studies on the relationship between new technology and labor demand at the firm level exist. Amongst them are the papers including those by Machin (1996), already mentioned above, Entorf and Pohlmeier (1991) for Germany and Brouwer et al. (1993) for the Netherlands. Entorf and Pohlmeier (1991) show that product innovation has a positive effect on labor demand while process innovation does not have a significant effect on employment figures. Brouwer et al. (1993) do not find significant effects of R&D intensity but a significantly negative effect of the growth rate of R&D intensity on labor demand. However, both studies do not differentiate between different skill levels so that they do not provide evidence for skill biased technological change.

Almost all of the studies mentioned above use aggregated data which do not account for differences within a single sector. This paper adds to the existing literature in that it focuses on business services. Utilization of micro-level data makes it possible to reveal determinants of shifting labor demand within individual firms. Also, many studies use very broad categorizations of skill levels. Earlier studies simply differentiate between blue collar and white collar labor, more recent ones differentiate between occupations. Neither of them give precise information on whether an individual is skilled, semi-skilled or unskilled. The dataset used in the empirical investigation makes direct distinguishing of different skill groups possible.

### 3 Data

The lack of data on the service sector has recently been criticized by various authors [Bullinger (1997), Sachverständigenrat (1997), Waller (1997), Hax (1998)]. In reaction to earlier criticism, the ZEW began conducting a business survey in ten business related service sectors in cooperation with Germany's largest credit rating agency, CREDITREFORM. This survey, which started in 1994, is called the Service Sector Business Survey (SSBS). The SSBS is a stratified random sample, stratified with respect to sector, three employment classes and region (East/West Germany). Data provided by CREDITREFORM served as the sampling frame.<sup>10</sup>

The panel information from the SSBS is useful for the analysis of the direction of changes in the demand for heterogeneous labor. However, for an investigation of the determinants of skill shifts, it does not contain enough information. Therefore, the first — and up to now only available — wave of the Mannheim Innovation Survey in the Service Sector (MIP-S) is used in the second part of the empirical investigation.

#### **The Service Sector Business Survey**

To date the discussion of defining business related services is rather controversial in the literature.<sup>11</sup> To the author's knowledge, no definite and broadly accepted definition exists. Some authors, e.g. Hass (1995) and Strambach (1995), define business related services by a simple enumera-

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<sup>10</sup>Details on the SSBS can be found in Kaiser and Buscher (1998).

<sup>11</sup>See Homburg and Garbe (1996) for a survey.

tion of sectors. Since a debate on the definition would seem futile at the moment, I will follow this convention. The sectors defined as business related services are: (1) software consultancy and supply, data processing and data base activities (72.20, 72.30, 72.40), (2) accounting, book-keeping, auditing, tax consultancy (74.12) (3) business and management consultancy activities (74.14), (4) architectural and engineering activities (74.20), (5) technical testing and analysis (74.30) (6) advertising (74.40), (7) renting of automobiles, renting of other transport equipment (71.10, 71.20), (8) renting of machinery and equipment (71.30), (9) cargo handling and storing, activities of other transport agencies (63.10, 63.4) (10) sewage and refuse disposal (90.00).

By and large, these are "knowledge-based services" [Alic (1997)]. The firms participating in the SSBS are interviewed quarterly since June 1994. The one page SSBS-questionnaire consists of two parts. In the first part, the participating firms are asked to indicate whether their prices, profits, sales, employment and demand increased, stayed the same or decreased during the last quarter. While the first part of the questionnaire does not change quarterly, the second does. The second part is used to cover topics of current economic interest.

Throughout this paper the 6th (1995), 10th (1996) and 14th (1997) wave of the SSBS are taken, all corresponding to the first quarter of each year. The second questionnaire part of these waves included a question on expected and realized changes – depicted on an ordinal scale – in number of employees differentiated by skill level. The original question in the SSBS questionnaire is: "In what direction did the number of employees change in the last twelve months within the following skill groups?". Answers could be given on a three-point scale (increased, unchanged or decreased employment figures). It is not known from the SSBS how many employees of the different skill levels are actually employed by an individual firm. Only qualitative information on the direction of change is observed.

The SSBS is an unbalanced panel. On average, 1000 firms participate quarterly. 314 firms participated in all of the three waves in consideration, 278 two times and 866 just once.

### **The ZEW Innovation Survey in the Service Sector (MIP-S)**

This data set was originally collected in order to analyze the innovation behaviour of the German service sector. It is thoroughly described in Licht et al. (1997).

The MIP-S is a mail survey which was designed and conducted in 1995. The survey's population refers to all firms with more than four employees found in the records of CREDITREFORM.<sup>12</sup> The CREDITREFORM data were used to stratify the sample by sector and firm size classes as well as by region (East/West Germany). The survey is restricted to marketed services and therefore only comprises firms from wholesale and retail trade, transportation, banking, insurance, transport, software and technical consultancy.

Since the industrial affiliation is not as disaggregated as in the SSBS, the second part of the empirical investigation considers only transport, software, consulting and other business services — among these the other seven sectors covered by the SSBS.

Overall, about 2,900 firms participated in this voluntary survey. 1,750 belong to transport, consultancy, software and other business services.

The survey design extends the traditional concept of innovation surveys in manufacturing as summarized in the OECD Oslo-Manual (1997) to the service sector. Information collected in the questionnaire include (1) general information about the firm (size, industry, sales, number of employees, labor costs, exports, strategic management objectives, customers and product characteristics), (2) workforce of the firm and (3) investment in new physical assets and investment in information technologies.

## 4 Evidence for shifting employment patterns

In this section it will be shown that employment patterns are also shifting in business related services. Before proceeding, a few words should be devoted to the dimensions of the different skill groups relative to total employment in business-related services. Table 1 displays mean, median and standard deviation of the shares of each skill group in total employment. The data are taken from the MIP-S and are expanded.<sup>13</sup>

Table 1 shows that workers with completed vocational training make up the largest share of total employment in business-related services. The two

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<sup>12</sup>Due to inadequacy of official registers, this source seems to be the most accurate sampling frame available.

<sup>13</sup>The MIP-S is a stratified random sample, stratified with respect to sectors, regions and employment classes. The sample was drawn proportionally. The expansion factors are calculated from a sampling frame provided by CREDITREFORM for the ZEW as the inverse of the drawing probability corrected by non-response.

Table 1: Share of each skill group in total employment in business related services

	mean	median	std. dev.
univ. grad. Nat. sc.	0.14	0	0.24
univ. grad. Soc. Sc.	0.08	0	0.14
techn. Skilled	0.13	0.06	0.17
skilled	0.43	0.40	0.30
unskilled	0.22	0.08	0.29

Table 1 displays mean, median and standard deviation of each skill group share in total employment. Source: MIP-S.

academic skill groups taken together are as important as unskilled labor.

The figures in Table 1 have been calculated from the MIP-S since a drawback of the SSBS data is that they do not contain information on the actual employment figures for the different skill levels. However, the SSBS provides useful information on the direction of skill changes in business related services. Therefore, the first view on employment patterns in business related services considers the balance between firms indicating employment in a certain skill level has increased minus the share of enterprises reporting a decrease. A positive balance means that the share of enterprises reporting an increase is larger than the share of enterprises reporting a decrease. Figure 2 shows the balances for the different skill categories for 1995, 1996 and 1997. As in Table 1, the data were expanded by employment weights.<sup>14</sup>

**insert Figure 2 about here**

Figure 2 shows that the relative demand for skilled and unskilled labor has declined between 1995 and 1997. Unskilled labor has undergone a decrease in employment for the entire period. Employment opportunities did not change much for technically skilled workers. University graduates even had relatively good employment chances in 1996 when a majority of enterprises reported decreasing total employment figures. The employment situation for skilled and unskilled workers worsened considerably in 1996. It thus seems that cyclical fluctuations merely affected the amplitude and not the direction of employment patterns in business related services.

One problem with figure 2 is that information on what happens to an individual firm over time is not taken into account: these balances only reflect an average across the participating firms rather than skill level changes of an individual enterprise.

<sup>14</sup>The SSBS data are expanded in a similar way as the MIP-S data.

Whether these skill shifts are transitory rather than persistent is central to the discussion on shifting employment patterns. It could be argued that cyclical fluctuations drive the decreased relative demand for low skilled labor. Due to lower hiring and firing costs for low skilled labor, labor hoarding is more likely to occur for the more qualified in times of a sluggish economy.

A standard device in analyzing panel data is to calculate transition probabilities. Transition probabilities assess the probability of a firm or an individual switching from one category to another (or staying in one category) given the initial decision. Such transition probabilities are depicted in Table 2. The probability to either switch from "up" to the other categories "unchanged" and "down" or to stay in "up" is shown in columns two to four of Table 2. The probability to stay in the "up" category is largest for university graduates. While 47 (37) percent of the firms which initially reported increased employment for university graduates from the social sciences (natural sciences) stay in this category, this is true for only roughly 24 percent for skilled and unskilled workers. 15 percent of those firms which initially indicated "up" for technically skilled workers actually did indicate experiencing an "up".

The strongest persistency effect is present for the "unchanged" category. A majority of enterprises which initially indicated unchanged employment figures keep reporting "unchanged" employment figures. The effect is present across all skill groups. However, the probability of switching from "unchanged" to "up" is higher for the high skilled while just the reverse is true for the less skilled. Likewise, the probability of switching from "unchanged" to "down" is considerably higher for the lower skill groups.

Transition probabilities for the "down" category do not differ much across skill groups. Firms tend to switch, if at all, from "down" to "unchanged". A similar share of enterprises switches from "down" to "unchanged" as stays in "down".

It is quite striking that the probability to switch from "down" to "up" or from "up" to "down" – except for the unskilled group – is relatively low. This indicates that firms only gradually make adjustments to their labor force across all skill levels.

The inspection of transition probabilities shows three things: (1) persistency is quite large especially for the "unchanged" category and the probability to stay in "up" for the high skilled workers, (2) the probability to stay in "unchanged" and the probability to switch from "unchanged" to "up" is larger for high skilled labor than for low skilled labor and (3) firms

Table 2: Transition probabilities

	from "up" to...			from "unchanged" to...			from "down" to...		
	"up"	"unch."	"down"	"up"	"unch."	"down"	"up"	"unch."	"down"
Univ. grad.	36.9	50.8	12.3	13.7	75.8	10.5	3.7	48.2	48.2
Nat. Sc.	(45)	(62)	(15)	(39)	(216)	(30)	(3)	(39)	(39)
Univ. grad.	47.3	46.0	6.8	11.1	76.5	12.4	14.6	41.7	43.8
Soc. Sc.	(35)	(34)	(5)	(33)	(228)	(37)	(7)	(20)	(21)
Techn.	14.6	77.1	8.3	5.8	83.4	10.8	1.5	47.0	51.5
Skilled	(7)	(37)	(4)	(21)	(301)	(39)	(1)	(31)	(34)
Skilled	24.3	65.4	10.3	7.9	74.0	18.1	3.3	49.2	47.5
	(26)	(70)	(11)	(35)	(327)	(80)	(4)	(59)	(57)
Unskilled	24.6	49.1	26.3	9.1	71.7	19.2	4.6	52.8	42.6
	(14)	(28)	(15)	(33)	(261)	(70)	(5)	(57)	(46)

**Table 2** shows that, e.g., the probability of an enterprise switching from an indication of increased employment figures to unchanged employment figures for technically skilled workers lies at 77.1 percent. The value given in brackets shows the actual frequencies. Source: SSBS.

rarely switch from "up" to "down" – with the exception of the demand for unskilled labor – or from "down" to "up".

The descriptive analysis of the SSBS dataset thus gives evidence on shifting employment patterns being present in business related services and the effect being persistent rather than transitory. The remaining part of this paper is concerned with uncovering determinants of these skill shifts.

## 5 Theoretical framework

In this section a simple theoretical model of the dynamic demand for heterogeneous labor is outlined.

The theoretical framework stems from the classical paper by Nadiri and Rosen (1969) which basically is an extension of the partial adjustment model widely used in labor economics [c.f. Hamermesh (1993, ch. 6)]:

$$\Delta L_t = \gamma [L^* - L_{t-1}], \quad \gamma > 0, \quad (1)$$

where  $L^*$  is the equilibrium or optimal employment level. The parameter  $\gamma$  denotes the size of adjustment.

If, e.g., four factors of heterogeneous labor ( $L_{1t}, \dots, L_{4t}$ ) are used in the production, and output is assumed to be exogenous, equation (1) can be



generalized to the system [Nadiri and Rosen (1969)]

$$\begin{bmatrix} \Delta L_{1t} \\ \Delta L_{2t} \\ \Delta L_{3t} \\ \Delta L_{4t} \end{bmatrix} = \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} & \beta_{14} \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \\ \beta_{41} & \beta_{42} & \beta_{43} & \beta_{44} \end{bmatrix} \begin{bmatrix} L_{1t}^* - L_{1t-1} \\ L_{2t}^* - L_{2t-1} \\ L_{3t}^* - L_{3t-1} \\ L_{4t}^* - L_{4t-1} \end{bmatrix}. \quad (2)$$

In the Nadiri and Rosen (1969) paper, variables influencing  $L_{jt}^*$  ( $j = 1, 2, 3, 4$ ) are output and factor price ratios. Due to measurement problems, Nadiri and Rosen did not include capital stock.

In the empirical specification of equation (2), output is approximated by sales per capita. Difficulties in measuring capital endowment of individual firms also arise in the MIP-S data. Therefore, I assume that the capital stock  $K_t$  is proportional to investment  $I_t$ , thus  $K_t = \alpha I_t$ . This assumption is probably not so misleading since the main input factor in the production of services — despite labor, of course — is capital in the form of IT technologies [Maleri (1997, ch. 2)] which depreciates quickly. In the estimation equations, both investment per capita and investment in IT as the share of total investment, are included.<sup>15</sup> The share of the  $j$ th skill group in total employment can be directly calculated from the MIP-S. More difficulties arise from the calculation of prices for labor and capital. I assume that differences in interest rates only arise from different credit standings. Therefore, in the empirical analysis a potential credit rationing variable is constructed as an approximation for the interest rate. It is coded with one if an enterprise in the MIP-S questionnaire reports that either debt or equity shortages hampered innovative activity. I hereby follow Winker (1996).

From the MIP-S dataset neither labor cost nor wages for the different skill groups can be observed directly. Fortunately, the dataset gives information on total labor cost and the share of the different skill groups per firm. From these two pieces of information a labor cost decomposition is derived in appendix A so that labor costs for each skill group  $j$  can be calculated.

In order to elaborate more on the dynamics of demand for heterogeneous labor, the *expected* rather than the actual change of labor demand is considered here. Specifically, in the MIP-S questionnaire firms indicate on a five point scale the expected change in the demand for heterogenous labor,  $E[\Delta L_{t+1j}]$ . The MIP-S data contain the level of sales in period  $t$ . Further,

<sup>15</sup>I have chosen different denominators in order to avoid potential colinearity problems.

firms are asked to indicate on a five point scale the expected direction of change in sales for the next period. Thus, as an approximation of expected sales in period  $t + 1$ , I use sales in period  $t$  and the information of expected sales changes, included in the estimation equation as dummy variables. The estimation equation thus includes the following variables ( $j$  denotes the corresponding skill level and  $j = 1, 2, 3, 4$ ):

- (1) labor cost by skill  $j$  group,  $LC_j$
- (2) total investment per capita,  $INV^{pc}$
- (3) IT-investment as share of total investment,  $IT$
- (4) number of employees in each skill group,  $L_{jt}$
- (5) sales  $T_t$  and sales expectation (as dummy variables),  $TEXP$
- (6) potential credit rationing dummy variable,  $RAT$ .

The total investment and sales variables are transformed by taking the natural logarithms.

I further assume that each firm  $k$  reaches its decision on employment changes in skill group  $j$  conditional on an information set  $\Omega_k$  which includes the variables noted above and an i.i.d. Gaussian distributed error term  $\epsilon_k$  which is known to the firm but not to the econometrician. Thus, the following equation is estimated

$$E[\Delta L_{jtk} \mid \Omega_k] = \gamma_1 LC_{jk} + \gamma_2 INV_k^{pc} + \gamma_3 IT_k + \gamma_4 TEXP_k + \gamma_5 RAT_k - \sum_i^4 \beta_{ji} L_{tik} + \gamma_6 T_{tk} + \epsilon_k. \quad (3)$$

In order to control for observable firm heterogeneity, various other variables are included in the estimation equation. These comprise export activity, firm size, sector affiliation and regional affiliation (East/West Germany). Also, two dummy variables are constructed which (a) indicate that a firm either already has or expects foreign competitors in the home market and (b) indicate that it expects foreign competition but does not have to compete with foreign firms as yet.

Export activity and expected or present foreign competition may force an enterprise to upgrade the skill level of its workforce in order to be more competitive. These variables can be interpreted as proxies for the impact

Table 3: Distribution of answering categories across skill groups

	univ. grad. nat. sc.	univ grad. soc. sc.	techn. skilled	skilled	unskilled
strong decrease	3.00	2.53	1.83	3.30	8.10
decrease	4.53	3.94	6.56	11.61	13.36
no change	72.88	72.56	67.26	52.09	61.23
increase	16.71	17.80	21.81	27.87	13.83
strong increase	2.88	3.17	2.54	5.13	3.49

of international competition on labor demand. The impact of international competition is incorporated by an export dummy variable. Size effects are captured by the logarithm of the total number of employees and its square.

The dependent variable of equation (3) can be adopted directly from the questionnaire. The participating firms are asked: "Please give your opinion on the expected development of employment in your enterprise according to skill levels for the period 1995 til 1997". Five answering categories were allowed: (1) "great increase", (2) "increase", (3) "unchanged", (4) "decrease" and (5) "great decrease". It is thus not known explicitly how large the expected change in labor demand is; the direction of change and the indicator of the magnitude of change are available. Table 3 shows how the answers were distributed across categories and skill groups. As can be seen, the extreme categories are rather thinly occupied so it is the decrease/strong decrease and the increase/strong increase which are summarized for the empirical analysis.

Since there should only be (and actually are) marginal differences between the demand for university graduates from the natural and social sciences, both skill groups are aggregated into to an "academic" skill group. I proceeded as follows: if a firm expected decreased (increased) employment figures in both skill groups or if it expected decreased (increased) employment figures for one skill group and unchanged figures for the other, I coded the new "academic" skill group variable as "decreased" ("increased"). If a firm reported unchanged figures for both groups, the new variable was also coded as "unchanged". By proceeding this way, 37 observations were lost because firms indicated increasing employment figures for one group and decreasing figures for the other.

Labor cost should exhibit a negative effect on labor demand at least for the skilled and unskilled.

In order to account for the discreteness of the expected change of employment figures across different skill groups, separate ordered probit models are estimated for each of the skill groups.<sup>16</sup> Simultaneous estimation of the ordered probit models where correlation among the error terms is allowed (multivariate probit models) clearly is a topic for further research. Albert and Chib (1993) propose a Bayesian estimation approach which is more advantageous than classical estimation since it does not require calculating multivariate normal integrals and provides for the basis of exact inference, as opposed to inference relying on asymptotic approximations. However, allowing for correlation of the error terms increases the efficiency of the estimates. In a second step, an estimating technique which allows for simultaneity in the sense that effects of a decision reached for one skill group on labor demand is desired for the other skill groups. An appropriate tool would be the nonlinear conditional method of moments estimator proposed by Newey (1990, 1993). Both improvements of the estimation procedure are left for further research.

If technological change is actually substitutive to less skilled labor and complementary to more skilled labor, investment per capita and IT-investment relative to total investment should have a significantly negative impact on the demand for unskilled labor and a significantly positive impact on the demand for high skilled labor. If this is actually the case, evidence in favor of skill-biased technological change is given. Capital then replaces low skilled labor and favors high skilled labor.

The capital shortage variable should turn out to be significantly negative for low skilled labor while having no impact on high skilled labor due to labor hoarding effects. As Bartel and Sicherman (1995) show, firms invest more in the human capital of high skilled labor which implies that low skilled labor is more likely to be released in times of economic trouble.

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<sup>16</sup>See Greene (1997, ch. 19.8) for details on the ordered probit model. The software package STATA5.0 was used for the estimation.

## 6 Estimation results

Estimation results are presented in Table 4. The share of IT-investment in total investment influences expected labor demand quite differently across skill groups. It has a significantly positive impact on university graduates and is negatively significant for skilled labor. Total investment is significantly negative in the demand for unskilled labor. Neither total nor IT investment has a significant effect on the expected demand for technical skilled labor.<sup>17</sup>

The positive impact of IT-investment on the demand for high skilled labor is consistent with the findings by Autor et al. (1997) and Wolff (1996). Both papers show that the number of PCs per employee positively affects the demand for high skilled labor. High skilled labor is needed to implement new IT-technologies in a firm. IT-technology is then used to replace skilled labor. A little surprisingly, IT investment does not seem to influence the demand for unskilled labor. However, total investment has a negative and significant impact on the demand for unskilled labor pointing at a substitutive relation between unskilled labor and capital. For unskilled labor only the total amount of investment and not the distribution of investment across types of investment matters.

In Acemoglu's (1997) interpretation, IT-investment is "directed" at replacing skilled labor while investment in general is directed at replacing unskilled labor.

IT-investment favors university graduates and substitutes skilled labor. Likewise, total investment complements technical skilled labor and substitutes unskilled labor. Thus, evidence for both skill-biased technological change and capital-skill complementarities is found.

insert table 4 about here
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Labor costs only have a significant impact on the expected demand for skilled labor. This implies that decreased labor costs could improve employment prospects at least for skilled labor. This reasoning does not apply to the unskilled. Even lower labor cost would not improve employment prospects indicating that the abilities of this group simply do not match the current demand for skills.

<sup>17</sup>Note that no comparison of the coefficients is possible across equations due to the scaling problem in ordered probit and ordered logit models.

Potential credit rationing only significantly influences the demand for unskilled labor. The effect is negative. This implies that firms lay off low skilled workers if getting into economic trouble. A reason for this may be the lower opportunity cost of firing low skilled workers.

While the dummy variables for expected sales are jointly significant for all skill groups, where favorable sales expectations increase the probability to hire additional labor and vice versa, the level of sales is significant (and positive) for academics and technically skilled labor only. This suggests that in order to employ relatively expensive academics and technically skilled workers, good business prospects are not sufficient. A good performance is needed in the most recent year, too. Good business prospects increase c.p. the expected demand for labor across all skill levels, the absolute level plays a role only in the demand for higher skill groups.

The parameters of  $LEVEL_j$  cannot really be interpreted as own and cross adjustment cost terms due to the ordinal nature of the dependent variable. However, it turns out that the number of university graduates and technically skilled workers increases the probability of expecting increased employment figures in these two categories. This implies workers from these two categories are preferably hired if already a considerable number of workers of this skill level exists.

The control variable for East German firms turns out to be significantly negative for all but the unskilled and academics groups, indicating worse general business conditions for East Germany.

Exporting firms do not differ from non-exporting firms in their demand for heterogeneous labor. However, the proxy variables for import pressure show some significant effects. On the one hand, the dummy variable for firms which expect foreign competitors to enter the home market turn out to be significantly positive concerning expected demand for unskilled labor. One interpretation of these opposing effects is that firms try to improve product quality and services when threatened by foreign competition. The firms then try to become more competitive in terms of production costs if already faced by foreign competition.

## 7 Conclusions and suggestions for further research

The empirical investigation yields evidence of shifting employment patterns present in business related services. While the absolute effect remains unclear due to the lack of quantitative data, descriptive panel data analysis shows that a shift towards high skill labor is occurring and that this effect is persistent.

By further analyzing the reasons for these skill shifts I find that technological change and capital-skill complementarities make up important determinants. Technological skill bias is a controversially discussed topic in public policy. If technology decreases employment chances of low skilled workers, policy has to put a lot of effort into an upskilling of the less qualified. Low skilled workers are said to have more difficulties in adapting to new technologies than the high skilled ones. Technological change favors the skilled and the educated. The effect may be especially severe for services where IT investment makes up a large share of total investment.

By estimating separate ordered probit models for four different skill groups, I find that the larger the share of IT investment in total investment, the higher the probability of expecting increased employment figures for university graduates and the lower the probability of expecting increased employment figures for skilled labor. Total investment turns out to be complementary to technically skilled labor and substitutive for unskilled labor.

One weakness of this approach is that the demand equations are estimated separately for the five skill groups. Simultaneous estimation allowing for correlation among the error terms would appear to be more adequate here. Also, simultaneous estimation where the expected changes in one skill group also matters in the expected demand for the other skill groups would be desirable. The appropriate microeconomic tool would consist of a nonlinear conditional method of moments estimator proposed by Newey (1990 and 1993).

Further, the impact of innovative activity on the demand for heterogenous labor should be of great interest. However, since innovative activity in services is often associated with organizational changes which in turn affect investment in information and communication technologies, the innovation variables have to be instrumented. Instrumentation will be facilitated as soon as the second wave of the MIP-S will be available.

Figure 1: Unemployment levels by skill group

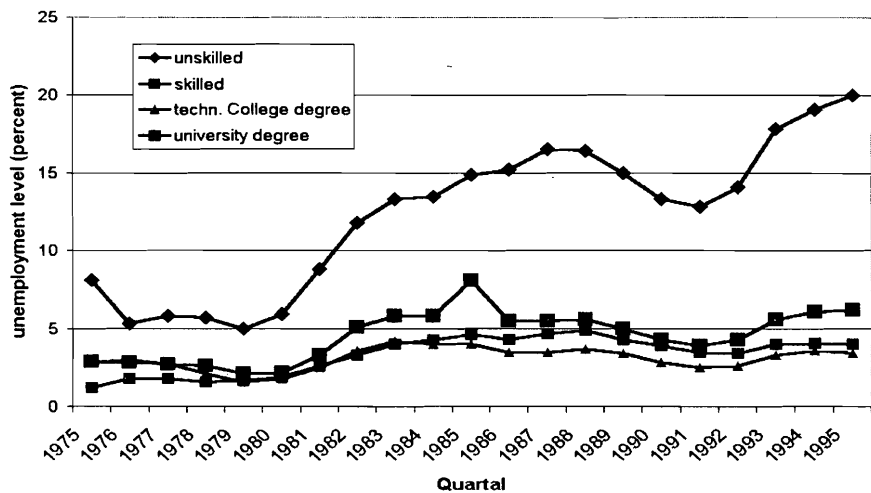


Figure 1 displays unemployment levels according to skill groups for the period 1975 – 1995 (West Germany). Source: IAB and Mikrozensus, various issues.



Figure 2: Balance of employment judgements

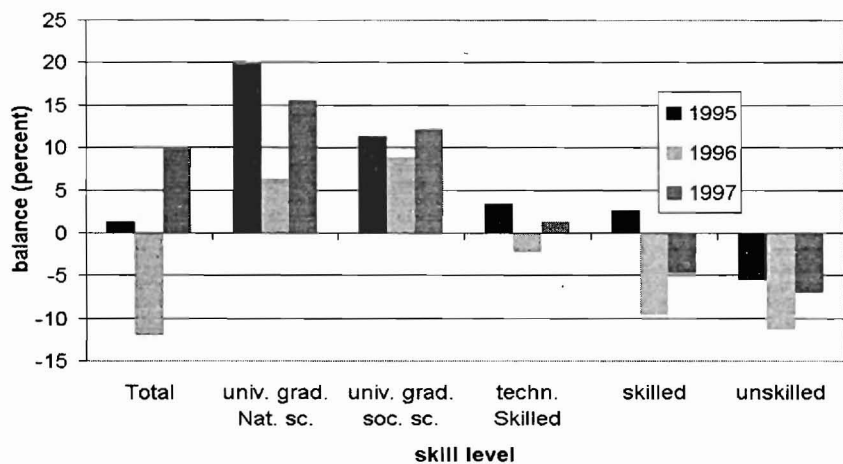


Figure 2 illustrates the share of firms reporting increased employment figures minus the share of firms reporting decreased employment figures for 1995, 1996, 1997. Source: SSBS.

Table 4: Ordered probit results of labor demand equations according to skill group

	univ. grad.			techn. skilled			skilled			unskilled		
	Coeff.	t-stat.	p-value	Coeff.	t-stat.	p-value	Coeff.	t-stat.	p-value	Coeff.	t-stat.	p-value
LCj	0.001	0.492	0.623	0.000	-0.277	0.782	-0.004	-2.712	0.007	-0.001	-0.765	0.444
IT	0.004	2.581	0.010	-0.001	-0.732	0.464	-0.003	-1.998	0.046	0.000	0.270	0.787
log(INV/pc)	0.020	0.931	0.352	0.022	0.980	0.327	0.006	0.277	0.781	-0.038	-1.779	0.075
log(univ. grad.)	0.035	3.092	0.002	-0.008	-0.669	0.504	-0.033	-3.027	0.002	-0.048	-4.347	0.000
log(techn. skilled)	0.013	1.282	0.200	0.034	3.434	0.001	-0.021	-2.259	0.024	-0.011	-1.112	0.266
log(skilled)	-0.001	-0.071	0.944	-0.015	-0.988	0.323	0.000	-0.021	0.983	-0.046	-3.112	0.002
log(unskilled)	0.016	1.772	0.076	0.019	2.048	0.041	0.020	2.231	0.026	0.009	1.035	0.301
log(turnover)	0.079	1.695	0.090	0.095	2.081	0.037	-0.012	-0.280	0.779	-0.038	-0.175	0.382
turnover exp. -	-0.754	-4.144	0.000	-0.854	-4.651	0.000	-0.956	-5.385	0.000	-0.666	-3.707	0.000
turnover exp. -	-0.477	-3.731	0.000	-0.320	-2.506	0.012	-0.410	-3.378	0.001	-0.083	-0.676	0.499
turnover exp. +	0.228	2.561	0.010	0.018	0.205	0.837	0.142	1.673	0.094	0.236	2.758	0.006
turnover exp. ++	0.690	3.886	0.000	0.378	2.254	0.024	0.487	2.959	0.003	0.511	3.192	0.001
pot. credit rationing	0.022	0.273	0.785	-0.017	-0.214	0.831	-0.067	-0.892	0.372	-0.199	-2.622	0.009
East Germany	-0.159	-1.766	0.077	-0.351	-3.913	0.000	-0.197	-2.304	0.021	0.105	1.227	0.220
transportation	-0.580	-3.381	0.001	0.024	0.146	0.884	0.333	2.107	0.035	0.170	1.069	0.285
consulting	-0.553	-3.501	0.000	-0.075	-0.501	0.616	0.101	0.702	0.483	0.140	0.963	0.335
other	-0.427	-2.869	0.004	0.089	0.637	0.524	0.314	2.360	0.018	0.198	1.467	0.142
foreign comp. expected	0.167	1.619	0.105	0.094	0.912	0.362	0.078	0.796	0.426	0.175	1.768	0.077
foreign comp. present	0.230	2.509	0.012	-0.022	-0.246	0.806	0.031	0.358	0.720	0.111	1.270	0.204
exporting firm	-0.012	-0.114	0.909	-0.122	-1.219	0.223	-0.037	-0.389	0.697	0.133	1.371	0.170
threshold1	-1.220			-1.222			-1.282			-0.867		
threshold2	0.821			0.936			0.279			0.938		
no. of obs.:	1037			1059			1059			1059		
log-likelihood	-829.797			-833.671			-992.685			-949.982		

Table 4 displays ordered probit estimation results for each of the four skill groups. The "thresholds" depict the cutoff points in the ordered probit model. That is, if the value of the latent variable is below *threshold1*, the dependent variable takes on the value 1. If it is in between *threshold1* and *threshold2*, it takes on the value 2, if the latent variable exceeds *threshold2*, it takes on the value 3.

# A Labor cost decomposition

The average labor costs per employee for firm  $k$  are given by

$$\frac{\sum_{j=1}^4 LC_{jk}}{EMP_k} = \sum_{j=1}^4 w(j) \frac{Q_{jk}}{EMP_k} + \epsilon_k, \quad (4)$$

where  $j$  denotes the skill level,  $LC_{jk}$  the labor costs for skill group  $j$  and firm  $k$ ,  $Q_{jk}$  denotes the number of employees in skill group  $j$ ,  $EMP_k$  the total number of employees and  $\epsilon_k$  is an error term. Then,  $w(j)$  are the annual average labor cost for a worker with skill level  $j$ . Since  $Q_{jk}$ ,  $EMP_k$  and  $\sum_{j=1}^4 LC_{jk}/EMP_k$  are known, the coefficients  $w(k)$  can be estimated by ordinary least squares (OLS). OLS regression results of equation (4) are shown in table A1. Descriptive statistics of the variables used in this and the following estimations are displayed in appendix B. In order to control for observable firm specific effects, various control variables are also included in the estimation.<sup>18</sup> Returns to education (Mincer, 1991) should be reflected by the larger wage coefficients for higher skill levels.

The estimated residuals  $\hat{\epsilon}_k$  from the estimated equation can, given correct specification, be interpreted as an unobserved firm specific wage effect. Therefore, total average payroll costs  $w_k(j)$  for individual skill levels  $j$  and firm  $k$  can be decomposed as

$$w_k(j) = \hat{w}(j) + \hat{\gamma} K_k + \hat{\epsilon}_k, \quad (5)$$

where  $\hat{\gamma}$  is the estimated coefficient of the matrix of control variables  $K$  and  $\hat{w}(j)$  is the estimated coefficient from equation (4). In the estimation equation, the share of unskilled workers serves as the base category.

Table A1: OLS regression results of wage decomposition equation

	Coeff.	Std. err.
share of univ. grad.	46.0895	2.9436
share of techn. Skilled	33.1552	4.4531
share of skilled	11.9892	2.7328
east	-19.2411	1.4776
export	9.0406	1.8263
caps	-1.7798	0.4620
size2049	3.4135	1.8735
size50249	3.7972	1.7458
size250+	5.0301	2.0937
constant	48.5264	2.6798

<sup>18</sup>Steiner and Wagner (1997) give motivation for the inclusion of firm-specific variables in wage equations.

## B Descriptive statistics

Variable	No. of obs.	Mean/Share	Std. Dev.	Median	Type
<b>Labor cost</b>					
LC(univ. grad.)	1420	84.5368	28.7204	81.2716	continuous
LC (skilled)	1420	71.6368	28.7204	68.3716	continuous
LC (skilled)	1420	50.4368	28.7204	47.1716	continuous
LC (unskilled)	1420	38.4368	28.7204	35.1716	continuous
<b>Investment</b>					
IT	1352	30.5806	32.4256	16.6667	continuous
log(INVpc)	1584	0.8348	3.4861	1.8612	continuous
<b>Employment figures</b>					
log(univ. grad.)	1668	0.2118	4.0714	1.3863	continuous
log(techn. skilled)	1648	-0.9138	4.1927	0.6931	continuous
log(skilled)	1651	2.0729	2.9834	2.4849	continuous
log(unskilled)	1651	-0.5850	4.8190	1.0986	continuous
<b>Sales</b>					
log(sales)	1659	5.1173	1.1600	5.0239	continuous
sales exp. -	1677	0.0471	-	-	dummy
sales exp. -	1677	0.1193	-	-	dummy
sales exp. +	1677	0.4890	-	-	dummy
sales exp. ++	1677	0.0811	-	-	dummy
<b>Credit rationing</b>					
RAT	1745	0.3794	-	-	dummy
<b>Control variables</b>					
East Germany	1745	0.3897	-	-	dummy
foreign comp. exp.	1733	0.1852	-	-	dummy
foreign comp. present	1733	0.2949	-	-	dummy
exporting firm	1738	0.1830	-	-	dummy
<b>Labor cost decomposition</b>					
total labor cost	1610	65.8574	108.5058	56.7361	continuous
share(univ. grad.)	1668	0.2223	0.2704	0.0913	continuous
share(techn. skilled)	1668	0.1150	0.1582	0.0556	continuous
share(skilled)	1668	0.4235	0.2937	0.1667	continuous
20-49 employees	1741	0.1953	-	-	dummy
50-249 employees	1741	0.2740	-	-	dummy
geq 250 employees	1741	0.1815	-	-	dummy
transport	1745	0.2264	-	-	dummy
consulting	1745	0.1662	-	-	dummy
other	1745	0.5255	-	-	dummy

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