The Skill Shortage in German Establishments Before, During and After the Great Recession

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Summary

This paper investigates the development of skill shortages during the period 2007-2012. Using the German Establishment Panel of the Institute for Employment Research (IAB), we find differences across the years before, during and after the Great Recession. Furthermore, we analyze the importance of firm characteristics and that of certain, specific measures with respect to the skill shortage.

The empirical analysis reveals that the relative skill shortage in the service sector during the Great Recession was more substantial than before and after 2009. The opposite pattern is observed for working time accounts. Firms with a high share of female workers typically experience usually less difficulty in finding qualified employees to fill jobs. However, during the Great Recession, the opposite was observed. Young firms facing competitive pressure, high wages, and without working time accounts that did not hoard skilled workers in the past tend to skill shortage. The estimations confirm that apprenticeship and further training serve to reduce the number of unfilled, high-skill jobs. It is also helpful when the firm has developed a plan for its personnel requirements. Other measures such as retaining older workers or hiring foreign workers were not successful. Ultimately, a skill shortage within a firm is often only a short-term phenomenon and less often observed over a longer period.

1 Introduction

From an international perspective, resilience of the German labor market, in terms of maintaining a stable level of unemployment, was an important feature of the Great Recession in 2009. A further distinguishing characteristic was the scarcity of skilled personnel during the pre-recession period. These two topics are interrelated. We argue that to understand the German labor market's response to the Great Recession, it is necessary to account for the scarcity of skilled personnel.

There is a public and scientific debate on the extent to which Germany experiences a shortage of skilled workers. The reasons are manifold. Some argue from long-term and others from short-term perspectives. Regions, occupations and industries differ in their exposure to skill shortages. Seasonal, yearly, and cyclical fluctuations occur. Some commentators emphasize supply side and others demand side reasons. Moreover, different definitions of skilled workers and shortages lead to conflicting assessments of whether scarcities of qualified personnel exist. The scientific debate is represented by Brenke (2010), Helmrich et al. (2012), Kettner (2012) and Kubis et al. (2013). There is substantial ambiguity concerning the definition of a skill shortage: In a broader sense, it may refer to difficulties in recruiting workers with adequate skills. In a more narrow sense, it means that current staff lacks the skills needed to effectively perform their jobs (Green et al. 1998).

It appears paradoxical that worker shortages exist during periods of high national unemployment (West 2013). A number of sectors report a shortage of workers and problems filling key positions, such as high-tech, advanced manufacturing and medical specialists. On the labor-intensive side of the economy, restaurants, hotels, hospitals and elder care, it is difficult to fill vacancies. There are shortages of nurses and engineers.

Thus far, empirical investigations of skill shortages focus on aggregate data for different occupations and industries. Predictions and simulations of labor supply and labor demand are presented. These analyses are concerned with short-term and long-term effects but are often unable to reveal short-term adjustments at the establishment level, which are of substantial importance. Two-thirds of the establishments surveyed in the 2011 wave of the IAB Establishment Panel assumed that they would face skill shortages in the next two years (Bechmann et al. 2012). Studies based on establishment data are rare – see, e.g., Bundesverband der Deutschen Industrie (2013), Falk (2002), Kettner (2012), Klinger et al. (2011), Kölling (2002), Kubis et al. (2013) and section 2.3. Little is known about the effectiveness of different measures to reduce or eliminate skill shortages and the development of the skill shortage near the Great Recession.

In the following, the results of an empirical investigation into skill shortages are presented based on establishment data for the period from 2007 to 2012. This includes the periods before, during and after the Great Recession in Germany. Specifically, we investigate whether the skill shortage is more pronounced in 2007/08 than in the following years, whether the Great Recession significantly reduced the skill shortage, whether the post-recession period is characterized by similar developments as in 2007/08 or we observe a structural break in 2009 that is not only effective during the Great Recession but also thereafter, and whether the extent of the skill shortage decreased or increased relative to the pre-recession period. We analyze which firm characteristics are responsible for the skill shortage, whether short-term or long-term shortages dominate, and whether specific measures are successful.

During the Great Recession, sales decreased substantially worldwide, and as a consequence, the demand for labor declined to a greater extent than during other recessions. However, in Germany, the unemployment rate remained nearly unchanged. Firms hoarded labor. This is well known. However, the situation of skilled workers before, during and after the recession is less clear.

In the years before the recession, German establishments were reluctant to hire new skilled workers. Employers expected that the boom from 2005 to 2007 would be short-lived (Burda/Hunt 2011: 24). They hesitated to hire during the brief boom due to lack of confidence in the economic outlook. Compared to other countries, there were relatively

high layoff costs imposed by Germany's strict job protection legislation (Venn 2009), and these outweighed the additional gains from the recruitment of new personnel. Thus, as the recession arrived, the need to dismiss skilled employees was less urgent. Companies had not foreseen the severity of the Great Recession's impact on sales. They only expected a brief downturn because the growth potential of the emerging economies (especially China) was assessed very positively. In addition, industries with the highest shares of vacancies during the year 2008 – such as the mechanical engineering, automotive and chemical industries – were also the most severely affected by the Great Recession of 2008/09 (Möller 2010). Thus, both layoff costs and potential hiring costs provided reasons for companies to hoard qualified labor during the crisis.

If labor hoarding occurs, the employment cycle has smaller amplitudes than the production cycle (Oi 1962). During the Great Recession, not only Germany but also many other countries used short-term work programs to partially subsidize reductions in working hours in exchange for firms retaining employees (Boeri/Brücker 2011; Scholz 2012; Brenke et al. 2013; Bellmann et al. 2013). However, during the recession, we must also expect a less extensive skill shortage than in the pre-recession period. Due to the substantial growth potential of the emerging economies that are among the most important export markets for the German economy, many German companies prepared themselves during the crisis to serve the needs of emerging countries during the recovery expected after the Great Recession. Therefore, they strategically hoarded and even recruited personnel to avoid a skill shortage after the crisis.

An analysis of the cyclical development of a skill shortage provides evidence concerning how the trend is overlaid by cyclical movements. A more detailed analysis can reveal whether the cycle affects the trend, specifically whether the trend is enhanced or weakened. It is unclear whether the trend returns to its former level or there is a break. The Great Recession is an excellent example to demonstrate whether cyclical effects are effective, which determinants are responsible for a skill shortage and whether the success of policy interventions varies over the cycle. If we do not find substantial deviations around the year 2009, we cannot expect deviations in weaker recessions.

The paper is organized as follows. Section 2 briefly discusses the reasons for, measures of and previous evidence on skill shortages. Section 3 presents the data and descriptive statistics. Section 4 reports the applied methods and results of the econometric investigation, including robustness checks. Section 5 concludes.

2 Sources of skill shortages, measures and previous empirical evidence

2.1 Sources of a skill shortage

From a national perspective, skill shortages are associated with demographic developments, technological and organizational changes and adjustments of the education system to the requirements of working life. First, a decline in population, late labor market entry and early retirement reduce labor supply. However, higher levels of female labor market participation, improved education, a higher share of graduates and additional training have the potential to expand the labor supply. Second, skill-biased technological change increases the demand for skilled workers: skill shortages are more pronounced for establishments using advanced technology in the production process (Haskel/Martin 2001). Third, it is argued that schooling is responsible for deficiencies in the quality of human capital (Bertelsmann Stiftung 2002; Industrie- und Handelskammer 2011). In addition

to political failures, an insufficient supply of labor and increases in the demand for labor and mismatches can induce shortages of qualified workers. All of these factors determine the long-run macroeconomic development of skill shortages. We are more interested in cyclical and microeconomic effects.

Skill shortages underlie cyclical fluctuations. Based on the Beveridge curve and Okun's law, we expect skill shortages to increase when the national economy grows, national unemployment falls and more vacancies are supplied. Elsby et al. (2010) found that the characteristics of labor market adjustment displayed a notable resemblance to those observed in past severe downtowns. However, beginning in mid-2009 real activity and labor market indicators began to diverge from past patterns in the U.S. Recent developments on unemployment and job vacancies imply a rightward shift in the Beveridge curve.

There are various reasons to believe that in periods of crisis the conventional mechanism is hindered (Dietz et al. 2010; Elsby et al. 2010, 2011; Franz 1994; Ghayad 2013; Ghayad/Dickens 2012). First, emergency unemployment compensation contributes to deviations in the Beveridge curve. Second, the long-term unemployed are discouraged and do not apply for posted vacancies. Third, the mismatch in skills between the unemployed and requirements listed for vacancies varies over the cycle. Fourth, there is the possibility of a geographical mismatch. Fifth, firms do not hire the long-term unemployed, as they believe that these workers are not suitable applicants. Ghayad and Dickens (2012) and Ghayad (2013), through a decomposition of the Beveridge curve, demonstrate that this result is only observed for individuals unemployed for more than six months. Those who were unemployed for briefer periods and have experience in the industry have significant application advantages. Sixth, establishments hoarded labor during the crisis, particularly skilled labor, to avoid firing and hiring costs during the recovery phase. Typically, it is argued that effective labor productivity decreases under a policy of labor hoarding. However, if this hoarding strategy is accompanied by a decline in unqualified workers, the consequence may be a rise in productivity (Hübler 2010). Labor productivity may also increase because of a scale effect. Lazear et al. (2013) distinguish two possibilities. On the one hand, the average worker has higher productivity during a recession than in the preceding period. On the other hand, each worker produces more while worker quality remains constant. Empirical evidence demonstrates that the second effect dominates the first over the business cycle in the U.S. We should mention that labor productivity also increases, due to the law of diminishing marginal revenue, when less labor is used. In all of these cases, the shortage of skilled workers decreases. One can expect that the attenuating effect is greater in the case of higher quality. The consequences of a labor shortage for the post-recession period are unclear. They depend on whether the increased productivity decreases again.

Ultimately, there are many possible explanations for skill shortages and their long- and short-run fluctuations. However, little is known regarding which of the positive and negative determinants dominate and which measures are successful in reducing skill shortages.

2.2 Measures to counter skill shortages

There are various ways to fill skill gaps. The Chamber of Commerce and Industry (Industrie- und Handelskammer 2011) highlights the collective responsibility of politicians and employers. Incentives to intensify STEM-related education, the reduction of the student dropout rate and, within the dual education system, the removal of barriers between vocational training and the university are suggested as remedies. Firms should

intensifying contacts with universities, hire additional university dropouts and adolescents with migrant backgrounds. Additional training of older workers is also recommended. The unions (Deutscher Gewerkschaftsbund 2011) emphasize the insufficient reforms to the education system. Furthermore, they argue that the required standards developed during the crisis are too high to be maintained in the recovery phase. In the long run, the danger of shortages due to demographic change must be combated through improved education and training.

Kolodziej (2011) summarizes the recommendations of various institutions (the Federal Employment Agency, Council of Economic Advisors, McKinsey, IAB, IZA). The strategies she mentions are: a longer working career, intensified and better-regulated immigration by skilled workers, extended working time, improved education and training, detailed information on the labor market, family-friendly work schedules, greater compatibility between job and family, lifelong learning, the improved transitions into jobs, increasing wages, enhanced firm attractiveness, and cooperation between firms and other institutions. Moreover, enhanced labor market participation, particularly by women, is suggested. Currently, the proportion of highly skilled female employees with STEM qualifications is still lower compared to men although an expansion is observed. This implies that skill shortages could be reduced if more women conduct studies in these fields (Fischer et al. 2009). Especially, two approaches are emphasized in the literature. The first is to retrain workers. The second is to take advantage of foreign workers who possess the skill sets and mobility to fill the existing gaps. Further, the Bertelsmann Foundation (Bertelsmann Stiftung 2002) recommends the elimination of restrictive regulations in social and tax law, the adoption of company-level agreements to reduce shortages of skilled workers, increased wage differences between qualification levels and anticipatory personal management.

2.3 Previous empirical evidence

Most existing and pending empirical evidence on skill shortages is provided by politicians, ministries, employer associations, unions or research institutes – see the Federal Ministry of Economics and Technology (Bundesministerium für Wirtschaft und Technologie 2012), Federal Ministry of Labor and Social Affairs (Bundesministerium für Arbeit und Soziales 2011), Federation of German Industry (Bundesverband der Deutschen Industrie 2013), German Trades Union Confederation (Deutscher Gewerkschaftsbund 2011), Federal Institute for Vocational Training (Bundesinstitut für Berufsbildung 2008, ..., 2013), and Prognos (2010).

Trends and fluctuations in skilled employees are not restricted to Germany. For example, Dunkel (2011) presents information concerning the expected shortage of skilled workers in Europe. He predicts that by 2020, six million additional jobs will be created in Europe, three-fourths of which are expected in the service sector. The growth in academic occupations will be particularly strong. Predictions for Europe and the U.S. indicate a shortage of skilled workers in future. In the U.S., one can argue that this may result from the retirement of the baby boomer cohort. However, Neumark et al. (2012) find no evidence of skill shortages emerging by the end of the present decade. They believe that skill shortages are more likely in the near term in states with large and growing immigrant populations. Lakey (2006) has shown that, from a longer-term demographic perspective, the composition of the population of Northern Alberta may exacerbate skill shortages, particular over the period from approximately 2014 to 2020. During this period, the

number of retirees will increase rapidly. The number of individuals of prime working age will not keep pace with withdrawals. Over the period from the present to 2026, the population will be characterized by a rapidly growing youth and senior population. Changes in technology are, in general, not likely to mitigate the shortage of skills in the near term.

The typical indicators employed to identify skill shortage problems are the average period required to fill a position and the ratio of applicants or unemployed individuals to vacancies based on macroeconomic information. Many reports are not restricted to skilled workers but more generally consider the development of the labor force. Bruno et al. (2012) are skeptical that these methods and the applied indicators are suitable to making inferences regarding shortages of skilled labor. Changes in the variables considered have numerous potential causes that are independent of shortages. Short-term shortages generally provide little information on long-term problems. Zimmermann (2011) emphasizes that due to insufficient data and unsatisfactory indicators, it is not possible to determine the actual shortage of skilled workers in detail. Establishment data are needed. Thus far, there are very few investigations based on this type of data. In the following, we briefly report the results of microeconomic investigations based on German establishment data.

Using the IAB Establishment Panel data from the waves 2000, 2005, and 2007, Fischer et al. (2008) investigate how often establishments searched for skilled employees and how often they were unable to fill their vacancies. According to their analyses, most establishments did not search for skilled personnel (61 percent), while 29 percent of the establishments searched occasionally. Among those establishments that searched, 68 percent were able to fill their vacancies every year, 12 percent only occasionally.

Bechmann et al. (2012) determine the share of establishments searching for skilled employees during the period from 2007 to 2010, also using the IAB Establishment Panel. They demonstrate that 49 percent of all establishments never searched for skilled employees, 46 percent searched occasionally and 5 percent always did so. They found that only 1 percent of all establishments searching for skilled employees were unable to fill them during all years in the period from 2007 to 2010, while 21 percent could not find skilled workers to fill their vacancies in one of the four years.

Zagelmeyer et al. (2012: 3371) demonstrate that having experience with a shortage of skilled labor is positively associated with the exploration of new markets and restructuring activities. Klinger et al. (2011) stress that firms experiencing labor shortages in 2008 have not used significantly more short-time work or other forms of working time or wage reductions than establishments without labor shortage problems. Workforce development for these firms was approximately identical to that of their non-labor shortage counterparts. The authors use data from the German Job Vacancy Survey between the fourth quarter of 2008 and the third quarter of 2009.

Based on over 900 firms, observed in 2013, the BDI Establishment Panel (Bundesverband der Deutschen Industrie 2013) finds that more than 50 percent of German companies regard skill shortages as important to their business prospects. This issue has become more relevant since the Great Recession. Firms facing positive economic circumstances particularly emphasize this point. Two-thirds of the firms adopt measures to retain and to train qualified workers to secure competitiveness in the long run. An additional quarter wishes to become active in this field in the future.

Thus far, empirical analyses of shortages of skilled workers are unsatisfying: firm-level data are rarely used. Firm characteristics are neglected. We know very little about the
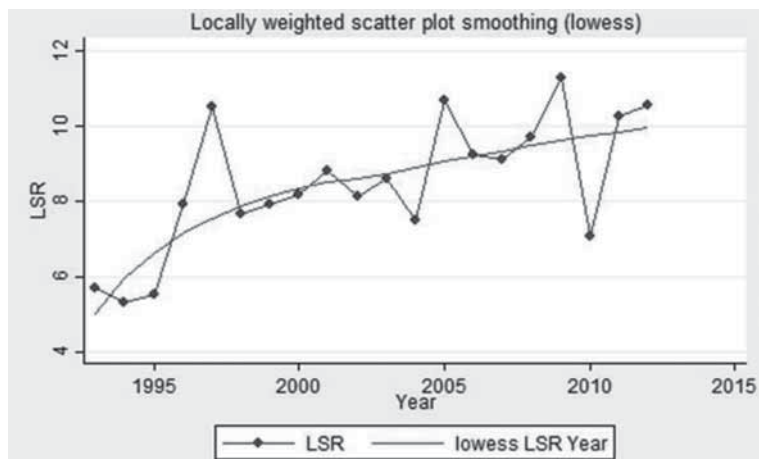
Figure 1

effectiveness of various measures to reduce the shortages of qualified workers. The predictions of prior studies are often based on one-dimensional indicators. We wish to address these deficiencies in what follows.

3 Data and descriptive results

The following investigation is based on the German IAB Establishment Panel Survey conducted by the Institute for Employment Research (IAB) of the Federal Employment Agency (Fischer et al. 2009). In this representative survey, private-sector German establishments employing one or more employees, excluding agriculture, forestry and fishing establishments covered by social insurance, are interviewed. The panel began in 1993 with an annual survey of West German establishments and was extended to East Germany in 1996. Since 1996, more than 15,000 establishments have been included in the survey. The IAB Establishment Panel provides information on numerous labor market topics, including employment, wages, sales, bargaining levels, works councils, profit sharing and investments.

Figure 1 presents the labor search rate (LSR) over the complete period of the IAB Establishment Panel Survey, 1993-2012. Substantial fluctuations and a nonlinear, positive trend are observed. The following investigation focuses on data for the period from 2007 to 2012, as we will determine the skill shortage before, during and after the Great Recession. In the years before 2007, information on the number of unfilled qualified jobs (UQJ) is missing. The IAB panel contains details on the skill shortage and firm needs. Specifically, the 2011 wave asks whether an establishment expects to encounter difficulties in filling qualified jobs over the next two years and, if so, what the likely reasons are. Furthermore, the survey identifies the importance of 12 explicit strategies that firms believe will satisfy their demand for skilled workers in the future.

In the following descriptive and econometric analysis, a skill shortage is measured by the number of unfilled qualified jobs (UQJ). Skilled workers include employees with a university degree and those who completed vocational training. In some instances, only

a dummy variable D_UQJ is used, where D_UQJ = 0 if UQJ = 0 and D_UQJ = 1 if UQJ > 0. Additionally, we calculate the number of years exhibiting a skill shortage $YUQJi = \Sigma t \ (D\_UQJit)$, where i = 1, ..., N and t = 2007, ..., 2012, and the ratio of UQJ to the total number of employees E in firm i for all establishments (UQJit/Eit). The ratio of number of unfilled qualified jobs UQJ to the total number of qualified workers (QW) can also be employed (UQJit/QWit).

Table 1 presents the descriptive statistics for D_UQJ, UQJ, UQJ/E and UQJ/QW. These indicators are divided by year for the period from 2007 to 2012. Line (D_UQJ) in Table 1, where 6,118 observations are considered, reveals clear effects of the Great Recession. In 2009, we observe an obvious decline in the skill shortage. Nevertheless, despite the most substantial decline in sales since the Great Depression in 1929/30, the shortage does not entirely vanish. Nearly 7 percent of the firms were unable to fill all qualified jobs in this year. During the recovery, the percentage increases again and rapidly exceeds the pre-crisis level. It seems that labor hoarding in 2009 had no remarkable effects on the further development of the skill shortage.

Table 1 Descriptive statistics of the skill shortage indicators – 2007–2012

	2007 mean(std.dev)[p-value] 2007/08			2008 mean(std.dev)[p-value] 2008/09			2009 mean(std.dev)[p-value] 2009/10		
D_UQJ	0.086	(0.28)	[0.000]	0.109	(0.31)	[0.000]	0.066	(0.25)	[0.000]
UQJ	4.615	(9.21)	[0.363]	4.849	(12.69)	[0.264]	4.353	(11.95)	[0.080]
UQJ/E	0.080	(0.13)	[0.403]	0.078	(0.11)	[0.251]	0.083	(0.13)	[0.053]
UQJ/QW	0.121	(0.22)	[0.390]	0.124	(0.22)	[0.455]	0.123	(0.21)	[0.328]
	2010		2011/11	2011		2011/12	2012		
D_UQJ	0.095	(0.29)	[0.000]	0.132	(0.34)	[0.479]	0.133	(0.34)	
UQJ	3.512	(6.62)	[0.066]	4.302	(11.17)	[0.445]	4.209	(15.20)	
UQJ/E	0.071	(0.10)	[0.138]	0.077	(0.11)	[0.242]	0.074	(0.10)	
UQJ/QW	0.117	(0.22)	[0.328]	0.118	(0.19)	[0.439]	0.122	(0.24)	

Notes: D_UQJ – dummy (D_UQJ = 1 if the firm has unfilled qualified jobs; = 0 otherwise); UQJ – number of unfilled qualified jobs, where D_UQJ = 1; E – total number of employees and QW – the number of qualified workers in a firm. The p-value is the probability that the mean of a skill shortage indicator does not differ between two years, e.g., 2007/08. The number of observations in line D_UQJ is N = 6,118. In line UQJ, UQJ/E and UQJ/QW the number of observations varies ($397 \leq N \leq 798$).

The picture changes somewhat when the absolute number of unfilled qualified jobs is considered. A kernel density estimation – Figure 2 – demonstrates for the year 2009, that the number of qualified vacancies is generally small, and in line (UQJ) of Table 1, we observe that the dispersion is large. Here, we only consider firms that have unfilled qualified job vacancies. In this case, the number of observations varies from year to year (2007: 512; 2008: 662; 2009: 397; 2010: 568; 2011: 792; 2012: 798). The average number of unfilled skilled jobs is highest in 2008 and then falls to a minimal value in 2010. The following increase results in a lower total than that observed in the pre-crisis period. It is unclear whether labor hoarding during the recession, more successful policy responses or firms employing a completely different strategy induced by the crisis is responsible for this development. We should stress that the differences between two years are insignificant in many cases, as the p-values of t-tests for the equality of means reveal.
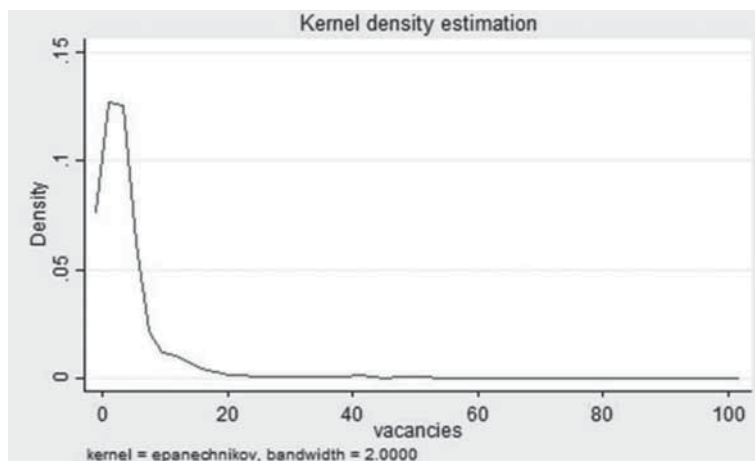
Figure 2

The indicators UQJ/E and UQJ/QW also show that the extent of the shortage is lowest in 2010. The development over the entire period is comparable to that of UQJ, insofar as the numerator in lines (UQJ/E) and (UQJ/QW) governs its movement. It is interesting to note that the average of D_UQJ in 2009, restricted to establishments with D_UQJ = 1 in 2007 or 2008, is higher (0.232) than the unconditional value in 2009 (0.066 – see Table 1, line (D_UQJ), 2009).

A possible interpretation is as follows: the pre-crisis situation is important for the extent of the shortage in 2009. This assessment is in accord with Burda and Hunt (2011), who explain the labor market miracle in Germany through the reluctance of German firms to hire additional employees in the pre-crisis phase. Additionally, for firms with skilled worker shortages in 2009, we observe a high probability of unfilled jobs in the following years (2010: 0.457; 2011: 0.454; 2012: 0.437).

Table 2 Frequency distribution of firms with respect to the number of years with unfilled qualified jobs (YUQJ)

Number of years	Freq.	Percent	Cum.
0	4,172	68.19	68.19
1	1,019	16.66	84.85
2	428	7.00	91.84
3	242	3.96	95.80
4	138	2.26	98.05
5	66	1.08	99.13
6	53	0.87	100.00
Total	6,118	100.00	

Notes: The distribution is based on data of the IAB Establishment Panel 2007–2012, where only those establishments are considered that have reported in all six years whether they could or could not fill all qualified jobs.

The average number of years with a skill shortage (YUQJ) is 0.621 with a standard deviation of 1.166, including the establishments without skill shortage in any of the six years considered (N = 6,118). The frequency distribution is presented in Table 2. More than two-thirds of the establishments never experienced a shortage of qualified workers. Firms experiencing four or more years of skill shortages represent less than 5 percent of the sample. The average of number of shortage years excluding firms without shortage years is approximately 2. It seems that most firms overcome short-run shortages by employing specific measures.

4 Methods and econometric estimations

4.1 Econometric strategy

The first step is the model selection. No theory can convincingly explain why some companies report skills shortages. It is also unclear why some of these firms only experience short-run difficulties in filling positions. For other firms, the difficulties are substantial and cannot be solved within a few years. The literature only reports limited explanations for these phenomena from a one-dimensional perspective. Therefore, the econometric analysis begins with the selection of firm characteristics that are relevant in a statistical sense. For this purpose, we estimate a least angle regression (LARS) developed by Efron et al. (2004). A parsimonious set of the available covariates is selected for the efficient prediction of response variables. Few steps are required. The procedure begins with all coefficients being set equal to zero and identifies the predictor most correlated with the response variable, say x1. The largest step in the direction of this predictor is taken until some other predictor – say x2 – has an equal amount of correlation with the current residual. LARS proceeds in a direction equiangular between the two predictors, x1 and x2, until a third predictor, x3, earns its way into the "most correlated" set. LARS proceeds equiangularly among x1, x2 and x3, that is along the "least angle direction" until a fourth variable, x4, enters, and so on. As is common practice, the Cp criterion is used as the stopping rule, i.e., no more regressors are incorporated when Cp reaches its smallest value. As Cp is an unbiased estimator of prediction error, Cp minimization can be regarded as an unbiased estimator of the optimal stopping point. Conventional forward stepwise regressions are too strongly focused on the prediction accuracy. The Lasso (least absolute shrinkage and selection operator) alternative (Tibshirani 1996) has also a parsimony property. Both methods are variants of LARS. There are numerous criticisms of stepwise regression, one of which is that it is a "greedy" algorithm and that the regression coefficients are too large. Ridge regression is one method of model-building that shrinks the coefficients by making the sum of the squared coefficients less than some constant. Lasso tends to shrink the OLS coefficients toward zero. Shrinkage often improves prediction accuracy, trading off decreased variance for increased bias (Efron et al. 2004: 409).

One must decide whether LARS is applied separately for each year, and hence the specification differs between years, or a joint specification should be used. We prefer the second option because this allows for a better comparison. Again, there are two possibilities. The LARS result for a specific year may be the basis of the estimates, or LARS can be determined for the entire sample period, 2007–2012. The latter procedure has the disadvantage of only considering average effects and smoothing cyclical influences. However, we wish to distinguish among the effects before, during and after the Great Recession. Therefore, we adopt a compromise, namely, the LARS selection for the year

with the most covariates is also applied to the other years. This is only sensible if the year-specific LARS selections are nested models of the largest LARS model. We find that the LARS models for 2007 and 2012 select the same covariates and are optimal under our definition. However, the order of the variable selection differs between 2007 and 2012. Table A1 presents the LARS selection for 2012. For this list of covariates, Table A2 reports the descriptive statistics, separately, for 2007, 2009 and 2011.

The second step of the econometric strategy is to estimate probit models in which the dependent variable is the dummy D_UQJ (= 1 if the firm has reported a skills shortage). First, only the covariates, selected by LARS, are incorporated. Then, measures are added that are essentially intended to eliminate or reduce a lack of qualified personnel. Dummies are only incorporated to allow for an improved comparison of the effects. In Table A5, the investigated measures are described and descriptive statistics for 2007, 2009 and 2011 are presented (Table A6). We also investigate whether labor hoarding in the previous period affects the skills shortage. Hoarding is often measured by the vacancy-unemployment rate, working hours or productivity (Dietz et al. 2010). The first cannot be determined at the firm level. The latter two are affected by factors in addition to hoarding (Hübler 2010). In this paper, labor hoarding is determined from the responses to the following question in the IAB Establishment Panel: Assume the demand for products increases, would it be possible to satisfy the additional sales with the available personnel and capital? If the management has responded: yes, this is possible, we assume that labor was hoarded in the past.

The third step is to analyze the influences of firm characteristics to explain why some establishments never report a skill shortage, others only do so for a single and still others do so more than once. For this purpose, ordered probit or multinomial estimates can be used. Another possibility is to apply the negative binomial regression method and analyze whether the number of years with skill shortages is affected by the same variables as an individual skill shortage. We focus on ordered probit estimates.

The fourth step concerns on the share of unfilled positions with respect to the total number of employees (UQJ/E), where only firms that reported a skill shortage in one or more years are included. In this context, we investigate the effects of measures on skill shortages. Interdependency is a possible problem. On the one hand, a skill shortage could induce responses, and on the other hand, the responses could affect the number of unfilled positions. Moreover, unobserved heterogeneity as management behavior might be important. Some managers tend to report skill shortages, although this problem does not exist. They want to establish with this argument that it is difficult for them to solve other problems. They want to cover up their own inability. For example, when an order is not timely completed, the managers claim a veil of spurious pretexts, e.g. missing skilled workers. In such a situation it is not plausible that the managers introduce measures to eliminate a pretended skill shortage. Based on these arguments we prefer IV estimates. Tests for exogeneity reject the null hypothesis in approximately 30 percent of cases – see Table A8.

If the described management behavior is relevant in some firms but not in all, it seems implausible to assume that future strategies lead to the same relationship with actual or pretended skill shortage as currently adopted, short-run measures. Our arguments of interdependencies and unobserved heterogeneity are supported by empirical evidence and statistical tests – see sections 4.2.1 and 4.2.2.

The remedies employed are instrumented by the management's assessments which of specific strategies from a given set of strategies are important to diminish or eliminate future

skill shortages. In 2011, the IAB Establishment Panel offered 12 specific strategies – question 37 – and asked management about the importance of the various strategies, measured using a categorical variable (= 1, if highly important; = 2, if of little importance; = 3, if not important). Of the 12 strategies, 9 are appropriate instruments for the applied measures – see S1–S9, Table A7. On the one hand, we expect that firms only adopt measures that they believe will also be important in the future. In this respect, we presume that a highly assessed measure is not a weak instrument (WIV). The strategy variables are rescaled into dummies (S = 1, if of high importance; S = 0 otherwise), and an F-test demonstrates the significance of the instruments in the first-stage regression. On the other hand, it is not necessarily the case that a highly rated strategy to provide the necessary skilled personnel in the future is currently applied. Other strategies may be superior in a real situation, and possibly, the firm is more short- than long-run oriented in its measures. We assume that the importance of a strategy does not directly affect the extent of a skill shortage but only does so indirectly via concrete measures. A strategy dummy (= 1 if the strategy is assessed as important to satisfy the demand for skilled workers in the future) can be incorporated in the skill shortage equation including the measures and then it can be tested whether S has a significant influence on UQJ/E. For this purpose, a test of overidentifying restrictions (OIR) is applied.

Further methodological problems should be discussed. First, a sample selection problem is possible. A firm reporting a skill shortage may be due to self-selection, resulting in a non-random sample. Unfilled positions may be a less serious problem for firms with respect to profits or costs than measures to redress the problem or vice versa. In this case, the number of unfilled positions and the decision to allow a skill shortage to persist would be correlated. In other words, an OLS estimator of the former could be inconsistent. The Heckit estimator provides a solution to this issue. Second, outliers in the dependent variable or dependent share variables may affect the estimates. Then, a median estimator should be preferred. Third, as an alternative to the incorporation of a single measure, the joint incorporation of different measures might be useful, as more than one measure is applied. In this case, we have to expect multicollinearity problems. One solution is principal component analysis. The factor scores of the different principle components are determined. The latter are incorporated as artificial regressors. Fourth, a matching estimator of treatment effects should also be applied as a robustness check, where a measure to resolve the skill shortage is the treatment. Preliminary investigations (Bellmann/Hübler 2014) revealed that none of the four problems are particularly significant.

4.2 Econometric results

4.2.1 Firm characteristics as determinants of skill shortages

The probit estimates are presented in Table 3, divided on an annual basis over the period from 2007 to 2012. This is more a reduced form equation than a causal relationship. The dependent variable is a dummy variable indicating whether a firm reported a lack of skilled workers (D_UQJ). If we wish to test the equality of individual regression parameters of a given covariate between two years, we encounter the fundamental problem when variances are unequal that is known as the Behrens-Fisher problem. Many methods have been proposed to address this issue, but none are satisfactory (Amemiya 1985: 36). Therefore, we abstain from these approaches.

Table 3 Probit ML estimates of skill shortages

	(1) 2007	(2) 2008	(3) 2009	(4) 2010	(5) 2011	(6) 2012
SOUTHERN GERMANY	0.019**	0.017*	−0.008	−0.003	0.004	0.020*
	(0.009)	(0.009)	(0.006)	(0.008)	(0.010)	(0.011)
SERVICE SECTOR	−0.013	0.003	0.025***	0.017*	−0.013	0.016
	(0.008)	(0.009)	(0.006)	(0.009)	(0.011)	(0.011)
TRADE SECTOR	−0.035***	−0.043***	−0.020**	−0.027**	−0.050***	−0.047***
	(0.008)	(0.010)	(0.009)	(0.010)	(0.010)	(0.012)
EXPORTS	0.007	0.006	−0.009	−0.000	−0.010	−0.004
	(0.008)	(0.008)	(0.006)	(0.008)	(0.009)	(0.009)
WORKING TIME ACCOUNT	0.016**	0.038***	0.015**	0.024***	0.041***	0.045***
	(0.007)	(0.008)	(0.006)	(0.008)	(0.009)	(0.009)
COMPETITIVE PRESSURE	0.014**	0.014*	0.003	0.001	0.027***	0.014
	(0.007)	(0.008)	(0.006)	(0.007)	(0.009)	(0.009)
SHARE of SKILLED WORKERS	0.049***	0.051***	0.056***	0.038**	0.062***	0.066***
	(0.015)	(0.016)	(0.013)	(0.016)	(0.019)	(0.019)
SHARE of FEMALE WORKERS	−0.031**	−0.032**	0.025**	0.003	−0.035**	−0.040**
	(0.013)	(0.014)	(0.011)	(0.014)	(0.017)	(0.017)
WORKS COUNCIL	0.002	−0.008	−0.014**	−0.020**	−0.007	−0.029***
	(0.008)	(0.009)	(0.006)	(0.008)	(0.011)	(0.010)
FOUNDATION BEFORE 1990	−0.025***	−0.020**	−0.018***	−0.026***	−0.035***	−0.020**
	(0.007)	(0.008)	(0.006)	(0.007)	(0.009)	(0.009)
FURTHER TRAINING	0.017**	0.033***	0.024***	0.037***	0.055***	0.054***
	(0.007)	(0.008)	(0.006)	(0.008)	(0.009)	(0.010)
HIGH WAGES	0.044***	0.045***	0.029***	0.063***	0.048***	0.069***
	(0.010)	(0.011)	(0.009)	(0.012)	(0.013)	(0.014)
PROFIT SHARING	0.045***	0.038***	0.044***	0.056***	0.056***	0.054***
	(0.010)	(0.011)	(0.010)	(0.012)	(0.013)	(0.013)
SHARE of MINI JOBS	−0.039	−0.036	−0.035	−0.068**	−0.034	−0.000
	(0.028)	(0.030)	(0.022)	(0.028)	(0.034)	(0.031)
NON-OWNER MANAGEMENT	0.019**	0.018**	0.015**	0.017*	0.023**	0.013
	(0.009)	(0.010)	(0.008)	(0.010)	(0.012)	(0.011)
POSITIVE SALES EXPECTATIONS	0.048***	0.147***	0.026***	0.061***	0.076***	0.068***
	(0.009)	(0.015)	(0.009)	(0.010)	(0.011)	(0.012)
LABOR HOARDING	−0.032***	−0.044***	−0.032***	−0.037***	−0.055***	−0.047***
	(0.007)	(0.008)	(0.006)	(0.008)	(0.009)	(0.009)
Pseudo-R^2	0.10	0.12	0.09	0.08	0.09	0.07
Observations	6107	6111	6103	6056	5943	6055

Notes: The dependent variable is D_UQJ. The table reports marginal effects (dF/dx) and robust standard errors in parentheses. All independent variables are dummies except the three share variables SHARE of SKILLED WORKERS, SHARE of FEMALE WORKERS and SHARE of MINI JOBS; * $p < 0.1$; ** $p < 0.05$; and *** $p < 0.01$.

In detail, we obtain the following results. The lack of qualified workers is generally larger in the service than in the manufacturing sector. There are fewer such issues in the trade sector. In southern Germany, the shortage is more pronounced than in other regions of the country except during the Great Recession. Negative coefficients are estimated in

2009 and 2010. We observe significantly positive effects at the beginning and the end of the period from 2007 to 2012. The coefficient in 2010 can be explained by the fact that the south was particularly affected by the crisis (Schwengler/Loibl 2010) and firms had positive expectations. Therefore, they hoarded labor in 2009. During the recovery, they initially encountered no problems in increasing production without hiring new workers. Labor hoarding seems to reduce the general deficiency in each year.

Working time accounts (WTA) and skill shortages are positively correlated over the entire period. In a causal sense, the reverse was expected. WTA allow for greater flexibility, and hence skill shortage problems should be less important. The positive coefficient is evidence that a skill shortage induces the adoption of WTA. If lagged working time accounts are used, the positive and significant sign does not change. The post-recession WTA effect exceeds that during and before the recession. An analogous argument of reverse causality helps to understand the positive relationship between D_UQJ and wages above the average of collective bargaining agreements, profit sharing and further training.

Less surprising is the result that the higher the share of qualified workers, the more likely a lack of qualified personnel is. Positive expectations regarding the trend of sales also accompany vacancies due to skill shortages. This relationship was strongest in 2008 and weakest in 2009. Firms with positive expectations in 2009 had fewer problems in meeting their requirements than in the year before.

The result that older firms founded before 1990 have fewer problems relative to younger firms seems plausible. The former had already satisfied their needs for a skilled workforce, did not expand substantially and retained their personnel. Younger firms generally produce new products that demand special and rare skills. Skill shortages are also not typical for firms with numerous mini-jobs and a high percentage of female workers, except during the crisis. The labor market participation of the latter increased in recent years, and women often search for part-time and mini-jobs. The opposite effect observed in 2009 agrees with the finding that, on average, male workers were more strongly affected by the recession than female workers.

If a firm is not managed by its owners but by professional managers, then the estimation indicates a higher probability of a skill shortage being reported, but this effect is statistically insignificant in the last year. Two hypotheses may explain this result. On the one hand, managers may exaggerate this deficiency to demonstrate that the difficulty in hiring new skilled workers is not exclusively their fault. On the other hand, large firms are often not managed by their owners, and one can expect skill shortage to be more likely among large firms. The latter hypothesis is partially confirmed. If firm size is incorporated in the estimation equation, we observe a positive and significant effect – see Table A4. If a works council exists, a negative effect is expected. This is especially the case during the Great Recession. Unions and works councils often disagree with management and employer associations that skill shortages are actually an important problem. The former believe that specific measures could easily eliminate such shortages in the short run.

It could be argued that the basis for our LARS selection and, as a consequence, Table 3 is too narrowly related to certain industries and regional differentiation. Therefore, we added probit estimates – Table A3 – analogously to Table 3, with 43 industries and 16 German states as a robustness check. No remarkable distinctions can be detected. A supposed east-west effect cannot be observed. We should mention that certain influences in Table A3 are insignificant in comparison with those in Table 3. We find this for works councils and non-owner management effects.

As a further robustness check, random-effects probit estimates are presented in Table A4, where time dummies are incorporated. The results indicate similar effects to those in Table 3, however, with a tendency towards greater significance. The time dummies indicate that skill shortages are more pronounced in the pre- and post-recession periods, and those in the latter are more extensive than those in the former. The skill shortage differences between 2009 and the pre- and post-recession periods, considered separately, are highly significant. It makes no difference whether pre- and post-recession years are disaggregated (column (1)) or aggregated (column (2)). In column (3), firm size, measured by the number of employees, is incorporated. The intention is to demonstrate whether the covariates of non-owner management, works councils and exports are simply proxies for firm size. This hypothesis is not confirmed. Works councils, non-owner management and firm size have independent effects on skill shortages. Although Table A4 provides some new insights, Table 3 is not superfluous. We wish to learn more about the variation in the covariates' effects from year to year. Of course, interaction variables between time dummies and firm characteristics could be incorporated in Table A4. However, it is well known that a saturated interaction model leads to substantial multicollinearity, and annual variations in the disturbance term are not allowed in this model. If these problems are neglected, we find that the influence of the 2009 interactions with some firm characteristics on skill shortages significantly deviate from that of the other years This is revealed for variables SERVICE SECTOR, EXPORTS, COMPETITIVE PRESSURE and SHARE of FEMALE WORKERS. For interactions with other firm characteristics like TRADE SECTOR, SHARE of SKILLED WORKERS, WORKS COUNCIL, FOUNDATION BEFORE 1990, FURTHER TRAINING, PROFIT SHARING, SHARE of MINI JOBS und NON-OWNER MANAGEMENT we could not find significant differences between the recession year and the other five years.

In the next step, we analyze whether skill shortages are concentrated in one period, whether the problems are short-run, or whether we find clusters of shortages. As mentioned in section 3, based on the results of Table 2, it is clear that the majority of firms experience a shortage in less than one year. An ordered probit estimation – Table 4 – is employed, in which we distinguish between three alternatives ($YUQJ = 0$ – no years with a skill shortage; $YUQJ = 1$ – only one year with a skill shortage; $YUQJ > 1$ – more than one year with a skill shortage). The comparison of Table 4, where ordered probit estimates are employed, with Table 3 reveals the following remarkable results: (a) the effects on the number of shortages are more stable than in the probit estimates and are only insignificant in very few cases. Few sign changes are observed. (b) Systematical effects of the recession are nearly undetectable in Table 4. This is partially due to the fact that the vector of the endogenous variable does not vary between the years in Table 4. However, we should note that the coefficients of the regressors deviate more or less from year to year. The same pattern as that observed in Table 4 can be detected, in which not only three categories but a count variable is used as the dependent variable and the estimates are based on a negative binomial approach (Bellmann/Hübler 2014).

4.2.2 The effects of measures to reduce skill shortages

In the following, we restrict our investigation to firms experiencing skill shortages. We wish to discover whether the determinants are the same as those in Table 3. In other words, do skill shortages and the frequency of this phenomenon depend on the same characteristics? The share of unfilled skilled positions to the entire number of employees

Table 4 Ordered probit ML estimates of skill shortages

	(1) 2007	(2) 2008	(3) 2009	(4) 2010	(5) 2011	(6) 2012
SOUTHERN GERMANY	0.091**	0.081**	0.093**	0.064	0.087**	0.070*
	(0.041)	(0.041)	(0.040)	(0.041)	(0.042)	(0.041)
SERVICE SECTOR	−0.062	−0.074*	−0.035	0.016	0.048	−0.012
	(0.042)	(0.042)	(0.043)	(0.043)	(0.045)	(0.043)
TRADE SECTOR	−0.412***	−0.381***	−0.353***	−0.351***	−0.308***	−0.336***
	(0.057)	(0.058)	(0.058)	(0.057)	(0.053)	(0.058)
EXPORTS	−0.045	0.059	0.124***	0.089**	0.043	0.087**
	(0.044)	(0.038)	(0.037)	(0.037)	(0.038)	(0.038)
WORKING TIME ACCOUNT	0.193***	0.225***	0.216***	0.227***	0.272***	0.238***
	(0.037)	(0.037)	(0.037)	(0.037)	(0.038)	(0.037)
COMPETITIVE PRESSURE	0.091***	0.101***	0.185***	0.064*	0.150***	0.143***
	(0.035)	(0.035)	(0.035)	(0.036)	(0.036)	(0.036)
SHARE of SKILLED WORKERS	0.435***	0.405***	0.352***	0.359***	0.321***	0.314***
	(0.074)	(0.074)	(0.074)	(0.077)	(0.077)	(0.076)
SHARE of FEMALE WORKERS	−0.119*	−0.158**	−0.247***	−0.230***	−0.286***	−0.206***
	(0.066)	(0.067)	(0.067)	(0.067)	(0.071)	(0.067)
WORKS COUNCIL	−0.067	−0.073*	−0.098**	−0.102**	−0.090**	−0.104**
	(0.045)	(0.044)	(0.044)	(0.045)	(0.045)	(0.045)
FOUNDATION BEFORE 1990	−0.132***	−0.114***	−0.144***	−0.151***	−0.142***	−0.154***
	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
FURTHER TRAINING	0.268***	0.287***	0.265***	0.285***	0.319***	0.312***
	(0.038)	(0.042)	(0.040)	(0.040)	(0.044)	(0.043)
HIGH WAGES	0.237***	0.215***	0.281***	0.296***	0.208***	0.284***
	(0.043)	(0.046)	(0.046)	(0.047)	(0.047)	(0.047)
PROFIT SHARING	0.307***	0.308***	0.274***	0.322***	0.294***	0.344***
	(0.044)	(0.044)	(0.046)	(0.045)	(0.046)	(0.045)
SHARE of MINI JOBS	−0.249**	−0.195	−0.264**	−0.287**	−0.257**	−0.330***
	(0.122)	(0.126)	(0.123)	(0.126)	(0.128)	(0.124)
NON-OWNER MANAGEMENT	0.082*	0.070	0.117***	0.089**	0.110**	0.101**
	(0.045)	(0.045)	(0.045)	(0.045)	(0.046)	(0.045)
LABOR HOARDING	−0.227***	−0.158***	−0.166***	−0.089**	−0.212***	−0.218***
	(0.036)	(0.037)	(0.036)	(0.037)	(0.037)	(0.036)
POSITIVE SALES EXPECTATIONS	0.218***	0.576***	0.147***	0.293***	0.318***	0.246***
	(0.037)	(0.046)	(0.046)	(0.037)	(0.037)	(0.041)
Cut1	0.927***	1.046***	0.946***	1.012***	1.028***	0.974***
	(0.072)	(0.075)	(0.074)	(0.077)	(0.077)	(0.076)
Cut2	1.531***	1.664***	1.549***	1.619***	1.643***	1.581***
	(0.073)	(0.076)	(0.075)	(0.079)	(0.079)	(0.077)
Pseudo-R^2	0.06	0.08	0.06	0.06	0.07	0.07
Observations	6107	6111	6103	6056	5943	6055

Notes: The dependent variable is an ordered variable: YUQJ = 0 if the firm had no unfilled qualified positions in any of the six years (2007–2012); YUQJ = 1 if the firm had unfilled qualified positions in a single year; YUQJ = 2 if the firm had unfilled qualified positions in multiple years. Robust standard errors are presented in parentheses. All regressors are dummies except the three share variables SHARE of SKILLED WORKERS, SHARE of FEMALE WORKERS and SHARE of MINI JOBS; * $p < 0.1$; ** $p < 0.05$; and *** $p < 0.01$.

is now used as the dependent variable. Again, the LARS procedure is used to select the set of control variables. The analysis focuses on the question of whether certain measures contribute to reducing skill shortages and not whether this problem can be completely eliminated.

The effects of nine measures, based on the IAB Establishment Panel, are investigated. The explanation of and descriptive statistics for these measures can be found in Tables A5 and A6. Our strategy is to analyze each measure separately. Certain alternatives exist. First, we can jointly incorporate all nine measures. The consequences of this approach are strong multicollinearity and problems with convergence when an IV approach is applied. Second, certain measures can be bundled and factor scores can be incorporated as artificial regressors via principal component analysis. The disadvantage of this method is that a clear interpretation of the effects is not possible. Table 5 presents the IV estimates and only the coefficients and significance of the measures, and not the firm characteristics, are displayed. For the applied instruments, see section 4.1 and Table A7. OLS estimates are suppressed. However, we note that OLS leads to more significant results and nearly all coefficients are negative. The IV estimates produce larger coefficients than OLS – a commonly observed phenomenon (see Card 2001). In Table A8 we find that the hypothesis of weak instruments (WIV) has to be rejected. In most overidentifying restriction (OIR) tests the null hypothesis is not rejected. The latter means that we have no hint of bad instruments. A further support that the applied instruments are suitable is given by the comparison of Table 3 and 5. We observe a sign change of the coefficient of FURTHER TRAINING from positive in Table 3 to negative in Table 5. If the measure is effective, we expect a negative sign. The positive sign in Table 3, where no IV estimation is applied, may be induced by reverse causality or unobserved heterogeneity.

The IV estimates highlight a clear and significant effect if the firms have hired apprentices in the past. On average, the number of unfilled qualified jobs relative to firm size is lower in establishments with apprenticeship contracts. This effect holds over the entire period from 2007 to 2012, where the absolute effect was larger in the pre-recession period. Less qualified applicants and the decrease in the total number of new apprentices since the onset of the Great Recession may be an explanation. Further training induces similar effects with smaller and only partially significant coefficients. It should be highlighted that in 2010 and 2011, we do not find any training effect. In the recession year of 2009, numerous hoarded employees with reduced working time received training. It is unsurprising that the training effect in this year was large, while it is negligible in the next (cf. Bellmann et al. 2014). The only further factor that reduces skill shortages over the entire period is observed when the firm has developed a plan for its personnel requirements. All other measures are unsuccessful. One implication of this is that incentives to retain older workers and hire foreign workers were not successful in reducing skill shortages over the considered period from 2007 to 2012.

It is possible that the subsample considered in Table 5 suffers from a sample selection problem – see section 4.1. Then, the inverse Mills ratio λ should be included as an artificial regressor. However, this does not seem important. The incorporation of λ reduces the apprentice training effect observed in Table 5, but the coefficients are similar. Furthermore, we note that in this case, the development of a personnel requirement plan seems more beneficial than shown in Table 5. Except for 2010, we obtain a negative and significant correlation with the number of unfilled skilled positions relative to firm size (Bellmann/Hübler 2014). Generally, the other results do not substantially differ from the estimates obtained without including the inverse Mills ratio.

Table 5 Instrumental variable estimation of the share of unfilled skilled jobs in the total number of employees among firms experiencing skill shortages (UQJ/E) with respect to measures to reduce or eliminate the skill shortage

	(1) 2007	(2) 2008	(3) 2009	(4) 2010	(5) 2011	(6) 2012
Apprenticeship contracts	−0.161*** (0.040)	−0.094*** (0.028)	−0.129*** (0.036)	−0.075*** (0.024)	−0.095*** (0.020)	−0.104*** (0.018)
Further Training	-0.124 (0.337)	−0.090** (0.043)	−0.101* (0.056)	−0.021 (0.043)	−0.051 (0.035)	−0.121*** (0.041)
Requirements plan for the personnel	−0.124 (0.093)	−0.188** (0.080)	−0.267** (0.132)	−0.068** (0.029)	−0.008 (0.042)	−0.133*** (0.049)
Measures to retain older workers	−0.346 (1.703)	0.092 (0.342)	−0.025 (0.519)	0.586 (5.417)	0.140 (0.167)	−0.051 (0.073)
Leasing of workers	−0.036 (0.036)	0.004 (0.032)	−0.058 (0.053)	−0.055 (0.039)	0.013 (0.030)	0.017 (0.038)
Hiring of foreign workers	1.465 (11.546)	0.088 (0.300)	−2.652 (21.990)	0.318 (0.227)	−0.676 (2.105)	0.104 (0.241)
High wages per employee	−0.405 (0.976)	0.199 (0.300)	1.634 (4.735)	−0.128 (0.165)	−0.363 (0.281)	0.253 (0.230)
Reconciliation of family and working	−0.401 (1.452)	0.090 (0.236)	−0.091 (0.289)	−0.048 (0.107)	−0.023 (0.033)	−0.042 (0.038)
Attractive working conditions	0.085 (0.124)	0.109 (0.129)	−0.222 (0.196)	0.102 (0.128)	−0.086 (0.071)	−0.128** (0.062)

Notes: The measures are explained in Table A5 and the instruments in Table A6. Further covariates determined by LARS are services sector, trade sector, exports, working time accounts, competitive pressure, share of qualified workers, share of female workers, works council, establishment of the firm before 1990, and labor hoarding. The number of observations varies in the 54 estimations (9 measures over 6 years; $360 \leq N \leq 790$); * $p < 0.1$; ** $p < 0.05$; and *** $p < 0.01$.

As a further robustness check, we perform a random-effects instrumental variables estimation of the share of unfilled skilled positions relative to the total number of employees. The results can be found in Table A9. This approach also indicates that apprenticeship and further training and the presence of a plan for future personnel requirements are the only successful measures to reduce skill shortages. It is noteworthy that no significant time effects can be detected. Finally, we can compare the effects of firm characteristics in column (1) of Table A4 and Table A9. The differences between these two approaches are threefold: (i) in the latter table, remediation measures are included; (ii) a quota (UQJ/E) instead of a dummy (D_UQJ) is used as the dependent variable; and (iii) instrumental variable estimates are presented. We observe some important differences. Sign changes are observed for the coefficients of the following covariates: trade sector, exports, working time accounts, share of skilled workers and management by non-owners. The results in Table A9 are preferred, but we should again note that only average effects over the entire period from 2007 to 2012 are presented.

5 Conclusions

This paper analyzes the development and determinants of skill shortages in Germany before, during and after the Great Recession and the effectiveness of measures pursued to satisfy the demand for qualified workers. Based on data from the IAB Establishment Panel, our findings are the following: Skill shortages are an increasingly common long-

run phenomenon with a break during the Great Recession. This does not mean that the number of vacant qualified jobs per establishment also increases. Frequently, the firms only experience problems in a single year and less frequently over a longer period of time. We find that young firms in the service sector facing competitive pressure, high wages, and without working time accounts that did not hoard skilled workers in the past are more likely to report skill shortages than other firms. In 2009, the recession year, some estimates indicate a weaker or no relationship between certain firm characteristics and skill shortages than during the other years. For example, if the firms are exposed to competitive pressure, they typically report problems in filling all skilled vacancies. In 2009, however, we cannot observe such a correlation. Given the increased job losses in the labor market during the crisis, it was easier to find qualified workers. This recession effect is widely operative in the following years.

We should note that in the pre-recession period skill shortage in a firm was not affected by the existence of a works council. However, this has changed in 2009 and also in the following years we observe fewer problems with skill shortage in establishments with a works council. Furthermore, we find that firms with a large share of female workers have fewer problems with skill shortages. Generally, this correlation were strengthened from 2007 to 2012. In accordance with arguments in section 2.2, one explanation for this trend might be the increasing labor market participation and on average a better qualification of women in the last years. All in all, a more complex mechanism is responsible for the gender composition effects on skill shortage and their development

Another interesting issue is the pattern of the effects of working time accounts. A priori, one could expect that the adoption of this instrument would reduce problems with short-run skill shortages. Based on such accounts, the working time can be extended if the demand for labor increases and reduced again if demand declines. However, we observe the opposite when measures to address such shortages are neglected. Working time accounts and difficulties in filling vacancies for qualified workers are correlated, and this relationship is strengthened during the period considered. This is an indication that the number of firms experiencing skill shortages increases and firms attempt to attenuate short-run problems through working time accounts. Moreover, when remedial measures are incorporated in the skill shortage equation and instrumental variables estimates are applied, we find effects of working time accounts that dampen the skill shortage.

Finally, let us make a few remarks concerning differences across economic sectors. Generally, the service sector experiences more problems and the trade sector fewer problems with skill shortages than the manufacturing sector. No clear trend can be identified. The shortages in the service sector are the largest, in a relative sense, in 2009.

Specific policy measures that should help to reduce skill shortage differ substantially in their effects. At the firm level, apprenticeship training has proven effective in preventing skill shortages. With some caveats, additional training and developing plans for the future demand for skilled workers are also successful instruments. In contrast, monetary incentives, increased hiring of foreign qualified workers, family-friendly policy and attractive working conditions have not increased firms' resilience to skill shortages in the past. The effects of apprentice training exhibit a decreasing trend. Although the empirical analysis definitively demonstrates that apprentice training is successful in combating skill shortages, we observe a decline in the number of apprentices since the Great Recession. Apprenticeships and further training should be expanded, and plans for staff requirements contribute to more rapid and successful firm reactions to skill shortages.

Appendix

Table A1 Selection of regressors by least angle regression (LARS) in 2012

Step	Cp	R-square	Action
1	395.6659	0.0000	
2	335.1741	0.0088	+working time account
3	335.9307	0.0090	+profit sharing
4	329.5263	0.0102	+further training
5	261.3561	0.0201	+positive sales expectations
6	226.5115	0.0253	+labor hoarding
7	170.8207	0.0335	+wages above collective bargaining
8	118.6230	0.0412	+trade sector
9	120.5323	0.0412	+competitive pressure
10	99.2363	0.0445	+share of skilled workers
11	70.3982	0.0489	+share of female workers
12	42.9082	0.0530	+foundation before 1990
13	39.0106	0.0539	+service sector
14	32.7386	0.0550	+southern Germany
15	30.5046	0.0556	+exports
16	32.4441	0.0556	+works council
17	25.1254	0.0570	+share of workers with a mini-job
18	18.9804*	0.0581	+executive board only managers
19	19.5292	0.0583	+owners from western Germany
20	20.2593	0.0585	+manufacturing sector
21	21.0000	0.0587	+capital participation of employees

Note: * indicates the smallest value for Cp. Variables in lines 19–21 are excluded in estimates that are based on LARS.

Table A2 Descriptive statistics of firm characteristics – 2007, 2009 and 2011

	2007 mean (std.dev)		2009 mean (std.dev)		2011 mean (std.dev)	
SOUTHERN GERMANY	0.229	(0.42)	0.229	(0.42)	0.229	(0.42)
SERVICE SECTOR	0.441	(0.50)	0.441	(0.50)	0.441	(0.50)
TRADE SECTOR	0.169	(0.37)	0.169	(0.37)	0.169	(0.37)
EXPORTS	0.388	(0.49)	0.388	(0.49)	0.388	(0.49)
WORKING TIME ACCOUNT	0.556	(0.50)	0.556	(0.50)	0.556	(0.50)
COMPETITIVE PRESSURE	0.366	(0.48)	0.366	(0.48)	0.366	(0.48)
SHARE of SKILLED WORKERS	0.719	(0.25)	0.719	(0.25)	0.719	(0.25)
SHARE of FEMALE WORKERS	0.435	(0.30)	0.435	(0.30)	0.435	(0.30)
WORKS COUNCIL	0.326	(0.47)	0.326	(0.47)	0.326	(0.47)
FOUNDATION BEFORE 1990	0.509	(0.50)	0.509	(0.50)	0.509	(0.50)
FURTHER TRAINING	0.734	(0.44)	0.734	(0.44)	0.734	(0.44)
HIGH WAGES	0.168	(0.37)	0.168	(0.37)	0.168	(0.37)
PROFIT SHARING	0.161	(0.37)	0.161	(0.37)	0.161	(0.37)
SHARE of MINI JOBS	0.094	(0.15)	0.094	(0.15)	0.094	(0.15)
NON-OWNER MANAGEMENT	0.210	(0.41)	0.210	(0.41)	0.210	(0.41)
POSITIVE SALES EXPECTATIONS	0.259	(0.44)	0.141	(0.35)	0.265	(0.44)
LABOR HOARDING	0.448	(0.50)	0.490	(0.50)	0.485	(0.50)

Notes: All independent variables except the share variables are dummies. HIGH WAGES are equal one, if a firm pays higher wages than that agreed on the sectoral level.

Table A3 Probit ML estimates of skill shortages (D_UQJ) including 43 industries and 16 regions as covariates

	(1) 2007	(2) 2008	(3) 2009	(4) 2010	(5) 2011	(6) 2012
EXPORTS	0.007	−0.002	−0.003	0.009	−0.011	0.009
	(0.009)	(0.009)	(0.006)	(0.009)	(0.010)	(0.010)
WORKING TIME ACCOUNT	0.012*	0.033***	0.013**	0.023***	0.034***	0.040***
	(0.007)	(0.008)	(0.005)	(0.007)	(0.009)	(0.009)
COMPETITIVE PRESSURE	0.014**	0.012	0.002	0.001	0.021**	0.007
	(0.007)	(0.008)	(0.005)	(0.007)	(0.009)	(0.009)
SHARE of SKILLED WORKERS	0.052***	0.066***	0.056***	0.041**	0.079***	0.083***
	(0.015)	(0.017)	(0.013)	(0.016)	(0.019)	(0.020)
SHARE of FEMALE WORKERS	−0.032**	−0.030*	0.002	−0.018	−0.045**	−0.046**
	(0.015)	(0.018)	(0.012)	(0.016)	(0.020)	(0.020)
WORKS COUNCIL	0.012	0.002	−0.004	−0.008	0.012	−0.009
	(0.008)	(0.009)	(0.006)	(0.009)	(0.011)	(0.011)
FOUNDATION BEFORE 1990	−0.017**	−0.019**	−0.014**	−0.014*	−0.022**	−0.005
	(0.008)	(0.008)	(0.006)	(0.008)	(0.010)	(0.010)
FURTHER TRAINING	0.011	0.032***	0.019***	0.035***	0.054***	0.053***
	(0.007)	(0.008)	(0.006)	(0.008)	(0.009)	(0.009)
HIGH WAGES	0.037***	10.028***	0.019**	0.050***	0.034***	0.056***
	(0.010)	(0.011)	(0.008)	(0.012)	(0.012)	(0.013)
PROFIT SHARING	0.036***	0.028***	0.048***	0.060***	0.058***	0.053***
	(0.010)	(0.011)	(0.010)	(0.012)	(0.013)	(0.013)
SHARE of MINI JOBS	−0.034	−0.044	−0.037*	−0.055**	−0.013	0.009
	(0.028)	(0.030)	(0.022)	(0.028)	(0.034)	(0.030)
NON-OWNER MANAGEMENT	0.010	0.012	0.012*	0.013	0.009	0.004
	(0.009)	(0.010)	(0.007)	(0.010)	(0.011)	(0.011)
POSITIVE SALES EXPECTATIONS	0.033***	0.118***	0.023***	0.056***	0.060***	0.058***
	(0.008)	(0.014)	(0.009)	(0.009)	(0.010)	(0.012)
LABOR HOARDING	−0.027***	−0.040***	−0.026***	−0.031***	−0.054***	−0.049***
	(0.007)	(0.008)	(0.006)	(0.008)	(0.009)	(0.009)
Pseudo-R^2	0.15	0.16	0.14	0.12	0.13	0.11
Observations	5989	5990	6054	6047	5916	6046

Notes: The table reports marginal effects (dF/dx) and robust standard errors in parentheses. All independent variables except the share variables are dummies; * $p < 0.1$, ** $p < 0.05$; *** $p < 0.01$.

Table A4 Random-effects probit estimates of skill shortages

	(1)		(2)		(3)	
	coef.	(std.err.)	coef.	(std.err.)	coef.	(std.err)
SOUTHERN GERMANY	0.054	(0.042)	0.054	(0.042)	0.051	(0.042)
SERVICE SECTOR	0.165***	(0.048)	0.163***	(0.048)	0.163***	(0.047)
TRADE SECTOR	−0.340***	(0.057)	−0.338***	(0.057)	−0.335***	(0.057)
EXPORTS	0.043	(0.039)	0.042	(0.040)	0.036	(0.039)
WORKING TIME ACCOUNT	0.483***	(0.042)	0.479***	(0.042)	0.478***	(0.041)
COMPETITIVE PRESSURE	0.203***	(0.038)	0.202***	(0.038)	0.202***	(0.038)
SHARE of SKILLED WORKERS	0.347***	(0.084)	0.346***	(0.083)	0.343***	(0.083)
SHARE of FEMALE WORKERS	−0.360***	(0.075)	−0.363***	(0.074)	−0.362***	(0.074)
WORKS COUNCIL	−0.086*	(0.046)	−0.085**	(0.046)	−0.096**	(0.046)
FOUNDATION BEFORE 1990	−0.225***	(0.039)	−0.223***	(0.038)	−0.227***	(0.038)
FURTHER TRAINING	0.374***	(0.049)	0.372***	(0.049)	0.371***	(0.049)
HIGH WAGES	0.335***	(0.047)	0.332***	(0.047)	0.325***	(0.047)
PROFIT SHARING	0.357***	(0.047)	0.354***	(0.046)	0.348***	(0.046)
SHARE of MINI JOBS	−0.445***	(0.147)	−0.438***	(0.146)	−0.434***	(0.146)
NON-OWNER MANAGEMENT	0.129***	(0.047)	0.127***	(0.046)	0.123***	(0.046)
POSITIVE SALES EXPECTATIONS	0.278***	(0.044)	0.277***	(0.026)	0.274***	(0.044)
LABOR HOARDING	−0.232***	(0.038)	−0.231***	(0.038)	−0.234***	(0.038)
FIRM SIZE/10,000					0.418**	(0.164)
D2007	0.203***	(0.040)				
D2008	0.380***	(0.039)				
D2010	0.266***	(0.040)				
D2011	0.548***	(0.038)				
D2012	0.559***	(0.038)				
D2007–2008			0.294***	(0.035)	0.294***	(0.035)
D2010–2012			0.463***	(0.033)	0.463***	(0.033)
_cons	−2.916***	(0.095)	−2.902***	(0.094)	−2.892***	(0.094)
sigma_u	0.991		0.982		0.980	
rho	0.495		0.491		0.490	
N	40,614		40,614		40,614	
LRT of rho = 0	2661.98		2635.03		2624.86	

Notes: The dependent variable is D_UQJ; sigma_u – standard deviation of the random effects and rho = sigma_u^2/(sigma_u^2 + 1) – proportion of the total variance contributed by the variance in the random effects. The likelihood ratio tests (LRT) reject the null hypothesis that no random effects exist; * $p < 0.1$, ** $p < 0.05$; and *** $p < 0.01$.

Table A5 Description of measures to reduce or eliminate skill shortages

Variable	description
(1) Apprentice contracts	= 1 if apprenticeship contracts were concluded in the last year
(2) Further training	= 1 if the firm trains and incurs the costs
(3) Requirements plan	= 1 if the firm has plans for personnel requirements
(4) Retaining of older workers	= 1 if individual adjustments of job and performance requirements exist in the firm
(5) Leasing of workers	= 1 if leased workers are employed in the firm
(6) Employment of foreign workers	= 1 if foreign sales are larger than 10 percent and the owner is a foreigner; no direct information on whether the firm employs foreign workers is available
(7) High wages	= 1 if wages per employee in the firm are larger than the average wage per employee in the sample
(8) Reconciliation of family and work	= 1 if there are measures to reconcile of family and work, if the firm has implemented 4 or more of 8 measures[1]
(9) Attractive working conditions	= 1 if 4 or more of 10 measures exist in the firm that make working conditions attractive[2]

Notes: [1] Measures are: support for child care, assistance or respecting the working time of employees who have to care for persons in need, supply of additional training for workers during parental leave, targeted promotions of mothers, a member of a network for family-friendly firms, exemption for family time, other measures; [2] Measures are: shifting of responsibility to lower levels of the firm's hierarchy, establishment of working groups with own authority, and 8 different measures concerning the protection and promotion of workers' health.

Table A6 Descriptive statistics of firms' measures to combat skill shortages, separately for 2007, 2009 and 2011

	2007 mean (std.dev)		2009 mean (std.dev)		2011 mean (std.dev)	
Apprentice contracts	0.372	(0.48)	0.368	(0.48)	0.340	(0.47)
Further training	0.883	(0.32)	0.669	(0.47)	0.736	(0.44)
Requirements plan for the personnel	0.281	(0.45)	0.280	(0.46)	0.320	(0.47)
Retaining of older workers	0.043	(0.20)	0.092	(0.29)	0.131	(0.34)
Leasing of workers	0.147	(0.35)	0.108	(0.31)	0.153	(0.36)
Employment of foreign workers	0.025	(0.15)	0.023	(0.15)	0.028	(0.17)
High wages	0.551	(0.50)	0.541	(0.50)	0.567	(0.50)
Reconciliation of family and work	0.070	(0.26)	0.070	(0.26)	0.069	(0.25)
Attractive working conditions	0.161	(0.37)	0.161	(0.37)	0.164	(0.37)
N	6118		6118		6118	

Table A7 Description of strategies as instruments for measures to reduce or eliminate skill shortages

strategy	definition	mean	(std.dev)
S1	increase in apprenticeship training	0.503	(0.500)
S2	intensified effort to further training of employees	0.568	(0.495)
S3	identification of the long-run need for skilled workers	0.369	(0.483)
S4	incentives for older persons to prolong their careers	0.269	(0.443)
S5	reinforced worker leasing	0.042	(0.201)
S6	recruitment of skilled foreign workers	0.016	(0.125)
S7	willingness to pay higher wages	0.106	(0.308)
S8	improved reconciliation of family and working life	0.279	(0.448)
S9	creation of fair working conditions	0.416	(0.493)

Notes: N = 6092. The strategy variables S1–S9 that are used as instruments for apprentice contracts, further training, a plan for personnel requirements, retaining of older workers, leasing of workers, employment of foreign workers, high wages, reconciliation of family and work, attractive working conditions – see Table A5 – are measured using dummies (= 1 if the strategy has substantial importance for the firm to secure its future requirements for skilled workers; = 0 if the strategy is of no or only little importance for the firm – see question 37, IAB Establishment Panel 2011).

Table A8 Tests for weak instrumental variables (WIV), overidentifying restrictions (OIR) and exogeneity (EXO)

Measure	2007		2008		2009		2010		2011		2012	
	WIV EXO	OIR	WIV EXO	OIR	WIV EXO	OIR	WIV EXO	OIR	WIV EXO	OIR	WIV EXO	OIR
Apprentice contracts	0.000 0.000	0.194	0.000 0.000	0.815	0.000 0.000	0.307	0.000 0.000	0.555	0.000 0.000	0.851	0.000 0.000	0.274
Further training	0.000 0.671	0.880	0.000 0.601	0.807	0.000 0.002	0.213	0.000 0.213	0.336	0.000 0.373	0.421	0.000 0.081	0.674
Requirements plan for the personnel	0.000 0.179	0.541	0.000 0.043	0.025	0.000 0.052	0.132	0.000 0.000	0.824	0.000 0.007	0.198	0.000 0.000	0.121
Retaining of older workers	0.000 0.416	0.611	0.000 0.186	0.396	0.000 0.079	0.930	0.000 0.742	0.962	0.000 0.953	0.412	0.000 0.007	0.860
Leasing of workers	0.000 0.419	0.742	0.000 0.621	0.143	0.000 0.002	0.725	0.000 0.000	0.896	0.000 0.892	0.139	0.000 0.901	0.167
Employment of foreign workers	0.000 0.986	0.665	0.000 0.322	0.708	0.000 0.915	0.260	0.000 0.153	0.122	0.000 0.609	0.505	0.000 0.993	0.829
High wages	0.000 0.132	0.590	0.000 0.021	0.163	0.000 0.018	0.026	0.000 0.202	0.666	0.000 0.097	0.077	0.000 0.310	0.065
Reconciliation of family and work	0.000 0.252	0.761	0.000 0.702	0.770	0.000 0.638	0.667	0.000 0.490	0.893	0.000 0.375	0.669	0.000 0.190	0.869
Attractive working conditions	0.004 0.242	0.354	0.005 0.435	0.276	0.000 0.129	0.461	0.000 0.320	0.266	0.000 0.207	0.811	0.000 0.044	0.741

Notes: p-values are presented in the table. Additional covariates determined by LARS are service sector, trade sector, exports, working time accounts, competitive pressure, share of qualified workers, share of female workers, works council, establishment of the firm before 1990, and labor hoarding. If the coefficient of the instrument in the first equation (selection (measure) equation) is significant ($p < 0.05$), then the null hypothesis of weak instruments has to be rejected. If the F-test for OIR is significant ($p < 0.05$), the instrument is bad or the specification is incorrect. If the F-test, the robust Durbin-Wu-Hausman test, is significant ($p < 0.05$), the null hypothesis of exogeneity has to be rejected.

Table A9 Random-effects instrumental variables estimation of the share of unfilled qualified jobs in the total number of employees among firms experiencing a skill shortage

	(1)	(2)	(3)	(4)	(5)
SOUTHERN GERMANY	−0.008*	−0.010**	−0.016***	−0.012**	−0.018**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.008)
SERVICE SECTOR	0.016***	0.036***	0.042***	0.022***	0.026***
	(0.006)	(0.006)	(0.007)	(0.007)	(0.006)
TRADE SECTOR	0.019***	0.039***	0.036***	0.021***	0.018**
	(0.007)	(0.008)	(0.008)	(0.008)	(0.007)
EXPORTS	−0.014***	−0.008*	−0.009*	−0.015***	−0.018***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
WORKING TIME ACCOUNTS	−0.031***	−0.033***	−0.033***	−0.041***	−0.042***
	(0.005)	(0.006)	(0.006)	(0.006)	(0.007)
COMPETITIVE PRESSURE	0.003	0.004	0.010**	0.002	−0.001
	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)
SHARE of SKILLED WORKERS	−0.088***	−0.050***	−0.056***	−0.061***	−0.028**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
SHARE of FEMALE WORKERS	−0.025***	−0.031***	−0.034***	−0.043***	−0.044***
	(0.009)	(0.009)	(0.010)	(0.009)	(0.010)
WORKS COUNCIL	−0.049***	−0.065***	−0.047***	−0.070***	−0.080***
	(0.006)	(0.006)	(0.009)	(0.007)	(0.014)
FOUNDATION BEFORE 1990	−0.010**	−0.020***	−0.019***	−0.019***	−0.015***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
PROFIT SHARING	0.005	−0.001	0.002	−0.007	−0.017
	(0.005)	(0.005)	(0.006)	(0.005)	(0.011)
SHARE of MINI JOBS	−0.055***	−0.050**	−0.055**	−0.019	0.017
	(0.020)	(0.021)	(0.022)	(0.020)	(0.021)
NON-OWNER MANAGEMENT	−0.007	−0.005	0.001	−0.010*	−0.011*
	(0.005)	(0.005)	(0.006)	(0.005)	(0.006)
POSITIVE SALES EXPECTATIONS	0.001	0.001	0.001	0.000	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
LABOR HOARDING	−0.014***	−0.014***	−0.014***	−0.014***	−0.011***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
D2007	0.007	0.005	0.006	0.006	0.010***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
D2008	0.005	0.004	0.005	0.005	0.009**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
D2010	−0.002	−0.003	−0.003	−0.003	−0.000
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
D2011	0.005	0.003	0.003	0.003	0.007*
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
D2012	−0.001	−0.002	−0.002	−0.002	0.002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Apprentice contracts	−0.104***				
	(0.011)				
Further training		−0.094***			
		(0.019)			
Requirements plan			−0.090***		
			(0.022)		
Leasing of workers				−0.020	
				(0.017)	
Retaining of older workers					0.133
					(0.122)
_cons	0.263***	0.269***	0.225***	0.229***	0.174***
	(0.012)	(0.014)	(0.011)	(0.012)	(0.012)
R^2 (overall)	0.26	0.25	0.21	0.23	0.09
Observations	4299	4299	4299	4299	4123

Notes: The table reports robust standard errors in parentheses. All independent variables except the share variables are dummies, where D2007 to D2012 are year dummies. In each column, only one measure is incorporated and instrumented; * $p < 0.1$, ** $p < 0.05$; and *** $p < 0.01$.

Table A9 Continued

	(6)	(7)	(8)	(9)
SOUTHERN GERMANY	−0.013**	−0.023**	−0.012**	−0.011**
	(0.006)	(0.009)	(0.005)	(0.005)
SERVICE SECTOR	0.017	0.026***	0.030***	0.029***
	(0.017)	(0.007)	(0.006)	(0.006)
TRADE SECTOR	0.021*	0.018**	0.026***	0.025***
	(0.011)	(0.009)	(0.007)	(0.007)
EXPORTS	0.009	−0.001	−0.016***	−0.016***
	(0.030)	(0.012)	(0.005)	(0.005)
WORKING TIME ACCOUNTS	−0.045***	−0.049***	−0.042***	−0.040***
	(0.007)	(0.007)	(0.005)	(0.006)
COMPETITIVE PRESSURE	0.002	−0.008	0.002	0.004
	(0.005)	(0.008)	(0.004)	(0.005)
SHARE of SKILLED WORKERS	−0.067***	−0.056***	−0.058***	−0.059***
	(0.014)	(0.012)	(0.011)	(0.011)
SHARE of FEMALE WORKERS	−0.041***	−0.018	−0.040***	−0.037***
	(0.011)	(0.019)	(0.009)	(0.011)
WORKS COUNCIL	−0.069***	−0.083***	−0.070***	−0.064***
	(0.008)	(0.008)	(0.007)	(0.012)
FOUNDATION BEFORE 1990	−0.022***	−0.033***	−0.018***	−0.019***
	(0.005)	(0.011)	(0.005)	(0.005)
PROFIT SHARING	−0.006	−0.016**	−0.006	−0.004
	(0.007)	(0.008)	(0.005)	(0.006)
SHARE of MINI JOBS	−0.025	−0.004	−0.020	−0.026
	(0.023)	(0.024)	(0.020)	(0.022)
NON-OWNER MANAGEMENT	0.017	−0.018**	−0.011**	−0.008
	(0.038)	(0.007)	(0.005)	(0.006)
POSITIVE EXPECTATIONS of SALES	0.000	0.000	0.000	0.000
	(0.003)	(0.002)	(0.002)	(0.002)
LABOR HOARDING	−0.013***	−0.014***	−0.014***	−0.014***
	(0.003)	(0.003)	(0.003)	(0.003)
D2007	0.007	0.006	0.006	0.006
	(0.004)	(0.004)	(0.004)	(0.004)
D2008	0.005	0.005	0.005	0.004
	(0.004)	(0.004)	(0.004)	(0.004)
D2010	−0.003	−0.003	−0.003	−0.003
	(0.004)	(0.004)	(0.004)	(0.004)
D2011	0.004	0.003	0.003	0.003
	(0.004)	(0.004)	(0.004)	(0.004)
D2012	−0.002	−0.001	−0.002	−0.002
	(0.004)	(0.004)	(0.004)	(0.004)
Employment of foreign workers	−0.278			
	(0.341)			
High wages		0.119		
		(0.079)		
Reconciliation of family and work			−0.033	
			(0.030)	
Attractive working conditions				−0.043
				(0.040)
_cons	0.230***	0.204***	0.221***	0.221***
	(0.013)	(0.018)	(0.012)	(0.012)
R^2 (overall)	0.11	0.13	0.22	0.23
Observations	3949	4288	4299	4299

Notes: The table reports robust standard errors in parentheses. All independent variables except the share variables are dummies, where D2007 to D2012 are year dummies. In each column, only one measure is incorporated and instrumented; * $p < 0.1$, ** $p < 0.05$; and *** $p < 0.01$.

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