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ABSTRACT

Immigrant Labour and Workplace Safety*

Using standard as well as recently developed univariate and bivariate count data models, this paper analyses the determinants of workplace accidents using a firm data set for Germany. Given the tight system of public workplace safety regulation, introduced partly as early as in 1869 and the important role of foreign labour in manufacturing, the focus is on the impact of work organization and interdependence between native and foreign workers. The empirical results indicate that there are no significant differences between natives and foreign workers regarding technological determinants of workplace accidents. The employment of guest workers has a strong positive effect on the job safety of natives, however. The estimates imply that a 1% increase in the employment of guest workers is associated with a 1.7% decrease of less severe accidents and a 1.3% decrease of severe accidents of natives. The empirical results also indicate that foreigners' representation in the work council is an important factor for increasing workplace safety for guest workers.

JEL Classification: C25, C35, J28, L60
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NON-TECHNICAL SUMMARY

The determinants and consequences of workplace safety have been an important issue in the IO literature since the end of the 1960s. Various theoretical and empirical studies have been inspired by the introduction of workplace safety regulations in the United States, notably the Coal Mine Health and Safety Act (CMHSA) of 1969 and the Occupational Safety and Health Act (OSHA) of 1970. The theoretical literature mainly focuses on the justification of government interventions on the market for workplace safety. In a world of perfect markets and complete information the presence of wage differentials for risky jobs implies that public regulation of occupational safety is unnecessary since risk premiums in dangerous occupations guarantees the compensation of workers in the case of an accident and induce the socially optimal effort needed to reduce job hazards.

In incomplete markets or with incomplete information non-optimal situations can occur, however. Assuming that workers are not well informed about safety standards in different firms, the outcomes on the market for workplace safety is inefficient which justifies mandatory insurance and the enforcement of safety standards. Taking into account that firms and workers can influence the probability of workplace accidents as well as the possibility of moral hazard problems with regard to workers' and firms' precaution, it has been shown that non-optimal levels of safety investments of workers and firms may occur. This does not necessarily mean that safety investments are inefficiently low, however. Theoretical models further show that regulatory safety policies may not be welfare improving. Thus, the theoretical literature on workplace safety obtains different results regarding the necessity and the effects of state regulations depending on the specific assumptions of the respective theoretical model.

Empirical work on workplace accidents have mainly concentrated on the effect of CMHSA and OSHA regulations on the frequency and severity of workplace injuries, the relationship between workers' compensation and job safety, as well as the impact of unionization. The empirical evidence for the consequences of government safety regulation and workers' compensation benefits is also mixed.

The German system of regulations, aiming at providing optimal workplace safety is especially dense and surveillance of firms is tight. Already the Conduct of Commercial and Industrial Activities Act (*Gewerbeordnung*) of 1869 introduced workplace safety regulations, followed by relevant parts of a whole range of laws. Enforcement of those regulations and their updates is the task of Labour Inspection Offices (*Gewerbeaufsichtsämter*) at State level, of Employers' Liability Insurance Associations (*Berufsgenossenschaften*) at the local level and of company medical officers, occupational safety engineers and technicians on the firm level. Each firm with more than 20 employees has to have such an occupational safety commissioner. Furthermore, the safety commissioners have to cooperate with the work council, the elected representative body of the workers in all firms with more than five full-time employees. Especially in firms with more than 20 full-time employees, the work council, which is usually dominated by the trade unions, has an important influence on all firm matters concerning social affairs, including work organization and workplace safety.

In this paper we analyse the empirical causes of workplace accidents of blue-collar workers, focusing on the interdependence between native and foreign employees. So far, the role of immigrant labour in the problem of workplace safety has not been addressed in a substantial way in the relevant literature. Based on the finding of previous studies that race and regional origin play a significant role as determinants of workplace injuries in the United States, we use a unique micro-data set of manufacturing establishments in Germany in order to investigate the question whether immigrant labour has a special, more risky part in industrial production because of internal work organization and representation in the work council. We further address the question whether the availability of cheap foreign labour for risky jobs has a positive impact on the job security of natives by opening to them the opportunity to be promoted to more secure jobs or a negative effect through decreasing incentives of firms to invest in injury prevention. The empirical analysis of this paper includes the development and application of a new bivariate count data model.

The estimation results show that workplace accidents are influenced by production technology and work organization. The effects of these variables on the accidents of foreigners and natives are very similar. The latter result could be explained with the dense system of safety regulations in Germany that prevents discrimination in the field of technologically provided workplace safety. Concerning the relationship between foreign and native labour we found strong evidence that guest worker employment has a positive effect on the workplace safety of natives. The empirical results imply that a 1% increase of the employment of guest workers decreases less severe accidents of natives by 1.7% and severe accidents of natives by 1.3%. In general, the results suggest that guest workers primarily are employed in risky activities and that the availability of foreign labour for risky jobs disclosed native workers the opportunity to be promoted to more secure jobs. Finally, representation of foreign workers in the work council significantly decreases the accidents of guest workers without having an impact on the security of natives, indicating an important role of the institution of work councils as a 'voice' for foreign workers.

1. INTRODUCTION

The determinants and consequences of workplace safety have been an important issue in the IO literature since the end of the 1960s.[1] Various theoretical and empirical studies have been inspired by the introduction of workplace safety regulations in the U.S., notably the Coal Mine Health and Safety Act (CMHSA) of 1969, and the Occupational Safety and Health Act (OSHA) of 1970. The theoretical literature mainly focus on the justification of government interventions on the market for workplace safety. In a world of perfect markets and complete information the presence of wage differentials for risky jobs implies that public regulation of occupational safety is unnecessary since risk premiums in dangerous occupations guarantees the compensation of workers in the case of an accident and induce the socially optimal effort needed to reduce job hazards (see Thaler and Rosen, 1976).

However, in incomplete markets or with incomplete information nonoptimal situations can occur. Assuming that workers are not well informed about safety standards in different firms, the outcomes on the market for workplace safety is inefficient which justifies mandatory insurance and the enforcement of safety standards.[2] Taking into account that firms and workers can influence the probability of workplace accidents as well as the possibility of moral hazard problems with regard to workers' and firms' precaution, Lanoie (1991) shows that nonoptimal levels of safety investments of workers and firms may occur. However, this does not necessarily mean that safety investments are inefficiently low. Lanoie's (1991) model further shows that regulatory safety policies may not be welfare-improving. To summarize, the theoretical literature

1 See Viscusi (1993) for an overview.

2 See Oi (1974), Diamond (1977), Carmichael (1986), and Lanoie (1990). In a model where workers systematically underestimate risk, Rea (1981) shows that mandatory insurance and saftey regulation may reduce the level of safety.

on workplace safety obtains different results regarding the necessity and the effects of state regulations depending on the specific assumptions of the respective theoretical model.

Empirical work on workplace accidents have mainly concentrated on the effect of CMHSA and OSHA regulations on the frequency and severity of workplace injuries, the relationship between workers' compensation and job safety, as well as the impact of unionization. The empirical evidence for the consequences of government safety regulation and workers' compensation benefits is mixed. Whereas Viscusi (1986), McCaffrey (1983) and Lanoie (1992) found no or little impact of government safety regulations, the empirical results of Gray and Jones (1991a, 1991b) indicate that there is a significant positive influence of OSHA inspections on workplace safety. Chelius (1982) and Neumann and Nelson (1982) conclude that high compensation benefits result in less serious injuries since employers invest more in safety but in more slighter injuries since employees behave less careful. Ruser's (1991, 1993) results, on the other hand, indicate that increased workers' benefits lead to more lost workdays and to more severe accidents at work.

In this paper we adopt a new perspective and analyze the empirical causes of workplace accidents of blue collar workers, focussing on the interdependence between native and foreign employees. So far, the role of immigrant labor in the problem of workplace saftey has not been addressed in a substantial way in the relevant literature. Based on the finding of previous studies that race and regional origin play a significant role as determinants of workplace injuries in the U.S. (Worral and Butler, 1983; Bartel and Thomas, 1985; Graham and Shakow, 1990; Hamermesh, 1997), we use a unique micro data set of manufacturing establishments in Germany in order to investigate the question whether immigrant labor has a special, more risky part in industrial production because of internal work organization and representation in the work council. We further address the question whether the availability of cheap foreign labor for risky jobs has a positive impact on the job security of natives by opening them the opportunity to be promoted to more secure jobs or a negative effect through decreasing incentives of firms to invest in injury prevention. The empirical analysis of this paper includes the development and application of a new bivariate count data model.

The paper is organized as follows: The next section provides some basic background information of the German system of workplace security regulation and workers' participation, which constitute the framework of our analysis. A short description of the German immigration experience further enables us to develop some hypotheses why immigrant labor could be treated differently in actual work organization and risk distribution than native labor. Section 3 describes the data set used in the empirical analysis, and the hypothesized relationships between workplace accidents and the independent variables. Section 4 provides details about the econometric count data models with which this data set is analyzed. The estimation results are presented in Section 5. Finally, the empirical results are summarized in Section 6.

2. FOREIGN LABOR AND WORKPLACE SAFETY

One topic which has not been addressed in any substantial way in the economic literature so far is the role of immigrant labor for workplace safety. Although some empirical results for the U.S. indicate that non-white and Southern employees have a higher risk of a work injury (e.g. Worrall and Butler, 1983; Butler and Worrall, 1983; Bartel and Thomas, 1985; and Graham and Shakow, 1990), standard theory gives only an indirect hint by discussing the possibility of race-related discrimination in wages and compensation (e.g. Chelius, 1974). Graham and Shakow (1990) ascribe higher job risks and lower compensating wage differentials to non-whites as a result of labor market segmentation in a "primary" and a (worse) "secondary" segment. Hamermesh (1997) has found no empirical evidence for such a segmented labor market for native whites, Hispanics and immigrants in the U.S. However, he confirms the observation that African-Americans tend to work in jobs of significantly lower quality than the other groups. Apart from racial discrimination issues, the performance of foreign laborers in workplace safety is of special interest if it comes to the question whether immigrant labor, especially if projected as temporary, is used for particularly risky activities in industrial production, as Chelius (1974) hypothesizes.

Especially in Germany, where most of foreign immigration was perceived as temporary at least during the guestworker-regime of the 1960s and early 1970s, it is interesting to see whether foreign workers show a different pattern of job risk than natives. In the late 60's and early 70's the German labor market experienced an increasing shortage of unskilled labor. To satisfy this excess demand for unskilled labor Germany actively recruited foreign guestworkers from south European countries.[3] These guestworkers were mainly hired for low-quality jobs in the manufacturing sector for which German firms could not hire enough natives. Persistently different risk patterns for foreigners and natives, if controlled for job and technology characteristics as well as for experience, could therefore indicate basically different strategies of management and work organization on firm level for workers of different origin. Our first objective is thus to identify the determinants of workplace accidents for foreigners and natives, and to check whether there are significant differences.

The German system of regulations, however, aiming at providing optimal workplace safety is very dense and surveillance of firms is tight. Already the Conduct of Commercial and Industrial Activities Act (*Gewerbeordnung*) of 1869 introduced workplace safety regulations, followed by relevant parts of a whole range of laws like the Imperial Insurance Act

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3 For a detailed description of the German migration policy and immigration experience in this time period see Schmidt and Zimmermann (1992) and Zimmermann (1995). Bauer and Zimmermann (1997) and Bauer et. al. (1998) give a detailed description of the organization and enforcement of the recruitment of guestworkers.

(*Reichsversicherungsordnung*, 1911), the Radiation Protection Act (*Strahlenschutzverordnung*, 1965), the Dangerous Materials Act (*Verordnung über gefährliche Arbeitsstoffe*, 1971), Work Protection Act (*Arbeitssicherungsgesetz*, 1973), or the Workplace Regulations Act (*Arbeitsstättenordnung*, 1975). Enforcement of those regulations and their updates is the task of Labor Inspection Offices (*Gewerbeaufsichtsämter*) at State level, of Employers' Liability Insurance Associations (*Berufsgenossenschaften*, ELIA) at the local level, and of company medical officers, occupational safety engineers and technicians on the firm level. Each firm with more than 20 employees has to have such an occupational safety commissioner. Furthermore, the safety commissioners have to cooperate with the work council, the elected representative body of the workers in all firms with more than 5 full-time employees.[4] Especially in firms with more than 20 full-time employees, the work council, which is usually dominated by the trade unions, has an important influence on all firm matters concerning social affairs, including work organisation and workplace safety.

The effectiveness of the legal control system is illustrated by the following numbers: In 1975, the year which is relevant for our data set, there were 2,532 employees in the state and local inspection offices, and 300,195 occupational safety commissioners in 103,668 firms in Germany. 493,070 inspections in 307,420 (non-agricultural) firms resulted in 7,994 sanctions by the Labor Inspection offices and 4,263 by Employers' Liability Insurance Associations. Sanctions range from warnings and ad hoc orders to fines and law suits (German Federal Government, 1976). In view of the dense regulation system and the tight enforcement of these regulations it seems reasonable to hypothesize that at least in the field of technologically provided workplace safety, foreigners should not be discriminated against.

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4 The right of workers to constitute a work council and the rights of this council are regulated in the Law on Labor Relations at the Workplace (*Betriebsverfassungsgesetz*, 1972). Note that until 1971 guestworkers needed the agreement of the employer if he wanted to candidate for the work council.

Lower investments in the safety of immigrant workers by the firm will therefore be most likely in the field of work organization, where the work council takes part in management decision-making. In the economic literature on union "voice" (Freeman, 1980; Freeman and Medoff, 1984) it has been argued that unions provide workers with a forum in which to express dissatisfaction. According to this framework, the opportunity to express dissatisfaction with job conditions using the union as a "voice" reduces voluntary employee turnover and increase job tenure, training, productivity and workplace safety. Since German unions are organized on industry, district and national levels instead of the firm level, it is plausible to look at the work council instead of unionization of establishment. The representation of guestworkers in the work council empowers them with increased "voice" and may give rise to increased complaints about guestworker specific job risks or racial differences in work organization.[5] Thus, representation of guestworkes in the work council may result in a lower number of work-related accidents for this group of workers. Due to the democratic structure of the work council increasing attention on guestworker-specific job risks through foreign members of the work council may not necessarily have negative effects on the job security of natives.

The second objective of this paper is to analyze whether there are interactions between the job risks of native and foreign workers. From empirical studies on the labor market effects of immigration, we know that foreign labor tends to serve as a buffer for native employment, with foreign workers being the first to lose their jobs in times of economic stagnation and the last being re-employed in boom periods (e.g. Zimmermann, 1995; Bauer und Zimmermann, 1997). A similar problem might occur at the micro level, where firms may ascribe especially risky activities to immigrant workers and promoting natives to more secure jobs. One the other hand,

5 See Heywood (1992) for an analysis whether unions influence the pattern of racial treatment.

one could argue that the availability of cheap labor for risky jobs might decrease the incentive for German firms to invest in injury prevention. Therefore, *a priori* the effect of guestworkers on job security of natives is ambiguous.

To summarize, the objectives of this paper are twofold. First, we want to identify the determinants of workplace accidents for natives and guestworkers. In particular, we are interested whether there exist significant differences between these two groups of workers. Our second objective is the question whether there are interactions between native and foreign workers, and whether these potential interactions are reciprocal vis-à-vis job risks. Given the institutional framework, representation of foreigners in the work council is an important point to be taken into account.

3. DATA

The data set used to evaluate the determinants of workplace safety in German manufacturing was collected in 1976. For the questions we address in this paper, this data set is extremely valuable despite its age: It is the only data set available for the firm level, and it was collected at the peak of foreign employment in Germany in the mid-seventies. The firms in the data set had at least 200 employed persons, or a capital stock of at least DM 500,000, or annual revenues of at least DM 5 million in 1975. After eliminating all observations with missing values to at least one of the used variables a final sample of 809 observations remain for estimation. Descriptive statistics of the variables appear in Table 1.

As dependent variables we use the number of accidents of native and foreign blue collar workers in 1975. The data set further enables us to distinguish between less severe accidents which results with up to 3 days of work absence and severe accidents with more than 3 days of absence. Absence of more than three days has to be reported by the firm to the

Berufsgenossenschaften (ELIAs). From Table 1 it can be calculated that there are on average 0.05 less severe accidents per native worker and 0.06 less severe accidents per foreign worker. These numbers indicate that the unconditional probability of less severe accidents is not significantly different between natives and foreigners. However, with regard to severe accidents it appears that foreigners face higher job risks, since the average number of severe accidents per foreign worker is 0.16 whereas it is only 0.10 for natives. It is also interesting that the number of severe accidents is higher than the number of less severe accidents for both, foreigners and natives. This indicates some measurement problems in the case of less severe accidents which have not to be reported to the ELIA.[6]

As explanatory variables we use industry dummies on a 2-digit level to control for safety differences between industries. It can be further expected that firms with interdependent production processes (e.g., assembly line or process production) are more likely to experience lost production time when an injury occurs and should therefore result in a higher incentive to invest in workplace safety. The existing literature often assumes that these firms are more capital intensive and uses measures for capital intensity as a proxy of the firm-specific production technology (Curington, 1986). The data set used in this study provides us with very detailed information on the production processes used in a particular firm. The following dummies have been constructed to evaluate the influence of different production technologies on workplace safety: single production, small series, middle series, large series, whether the firm uses an assembly line and whether the firm has process production. It should be noted that there is no reference group for this group of dummy variables since each firm could use several of the described production technologies. The number of accidents may further be influenced by the

6 See Eisenberg and McDonald (1988) for a discussion of the problems of recording injuries in the workplace by firms and their reporting to official institutions.

organization of the working processes. It could be expected that firms with shift working show higher injury rates, since shift workers often work in the night and do not have a stable work schedule. In order to control for this we used the share of workers in a firm who are employed as shift workers. Apart from the production process we also control for the age of a firm. On the one hand it could be expected that older firms use older machines which are less safe and therefore should lead to higher injury rates. On the other hand, older firms have more experience with the sources of workplace accidents and should be more efficient in using their safety expenditures and the organization of their working processes. Therefore, the effect of the age of a firm on the number of workplace accidents is ambiguous.

Usually, firms and workers can influence the probability of workplace accidents. Depending on the extent that a worker's precaution cannot be observed by a firm moral hazard problems may arise which lead to nonoptimal levels of precaution from firms and workers (Lanoie, 1991). The efficiency wage literature shows that such moral hazard problems can be solved by effort-dependent wages. In the case of workplace accidents it could be expected that workers who get a piecework rate or premium payments should have an higher incentive to invest in self-protection activities since they normally experience higher income losses through work absence than workers who get a fixed time payment. However, it may be the case that workers underestimate the job risk. In this case workers with piecework or premium payments may be less cautious than workers with a time payment since they can increase their income by working faster and taking less care of their security. To study the effects of the payment structure on workplace safety we include the share of workers who get a piecework and premium payment, respectively.

Previous research on workplace safety has shown that injury rates are inversely related to firm size (Curington, 1986, Lanoie, 1992, and Ruser, 1991, 1993), which has been explained by economics of scale in the production of safety. To control for the size of the firm we use the logarithm of the number of blue collar workers as a scaling factor. The share of foreign workers on all workers in a firm is the central variable of interest to analyze whether the employment of guestworkers has a negative or positive effect on the job security of natives. It is often hypothesized that injury rates are negatively related to the experience and formal education of the work force. Therefore, we include the total number of skilled workers as percentage of all blue collar workers in the firm and the number of skilled foreign workers as percentage of all guestworkers as proxies for the ability of the work force to acquire injury avoiding skills. Furthermore, we use the share of workers hired in the year previous to the survey and the number of new hired guestworkers as percentage of all foreign workers in the firm, since new workers are unfamiliar with the work equipment and procedures specific to the particular firm and therefore may be involved in a disproportionate share of accidents.

Given the German system of democracy on the firm level, as described in the last section, one can expect that the work council will be more interested in the security of foreign workers if one or more guestworkers are members of this council. Furthermore, it could be hypothesized that foreign superiors have a positive effect on workplace safety in firms with guestworkers since it is reasonable to assume that they are better informed about the specific problems of foreigners than native superiors. To take account of these potentially important effects we included two additional dummy variables: one which indicates whether there are foreign members in the work council and one which indicates whether a firm employs foreigners as superiors.

4. BIVARIATE COUNT DATA MODELS

Count data models have become quite popular in discrete data econometrics in recent years.[7] In the field of workplace safety, however, only Gray and Jones (1991a) and Ruser (1991, 1993) have already applied such models. While Gray and Jones (1991a) use fixed effects Poisson and NEGBIN models to investigate the significance of OSHA rules for a data set of U.S. manufacturing plants between 1972 and 1983, Ruser (1991, 1993) analyzes another U.S. firm data set for 1979 to 1984 by applying NEGBIN and QGPMLE techniques as well as a mixed NEGBIN-multinomial model. None of those studies uses a bi- or multivariate approach which we do in order to model the interaction of workplace accidents of foreigners and natives. The basic idea of such an approach is the following: From our consideration above, it seems sensible to distinguish between four types of workplace accidents, depending on the origin of the workers involved and the severity of the accident. This results in a firm's job risk record being described by four count variables (number of less severe and severe accidents of natives and foreigners, respectively). One could proceed modelling these variables separately, and estimate an adequate model for each kind of observations. This, however, is problematic since the counts can be expected to be closely related representing a competing risk of accidents for a firm. Taking this interdependence into account may increase the efficiency of the estimation. We tested for this interdependence by using a test proposed by Cameron and Trivedi (1993).

The technical starting point of our empirical analysis are univariate models. As point of departure we apply a standard Poisson model. This basic model has the familiar form[8]:

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7 For an overview of some basic modelling techniques for count data see Winkelmann and Zimmermann (1995). A review of the literature on bivariate and multivariate count models is given by Cameron and Johansson (1996) and Cameron and Trivedi (1998), respectively.

8 Indices for observations are ommitted to facilitate reading.

$$P(Y=y|x) = e^{-\lambda}\lambda^{y}\frac{1}{y!} \ , \qquad (1)$$

where $E(Y|x) = V(Y|x) = \lambda = e^{\beta' x}$. x is a vector of covariates and β a vector of coefficients to be estimated. The main limitation of the Poisson regression model is its requirement of an equal mean and variance of Y which results from the assumptions that (i) the events of Y occur randomly over time and (ii) the full amount of individual heterogeneity is captured by the regression. If these assumptions are violated, the Poisson regression model leads to consistent but inefficient parameter estimates. In the case of unobserverd heterogeneity or a positive correlation between the events overdispersion (the variance exceeds the mean) can occur, whereas negative contagion causes underdispersion. In most economic applications of count data models overdispersion can be observed.

To overcome these problems more general models have been developed which allows for overdispersion. In these models the Poisson parameter λ itself is treated as a random parameter. Within this framework we use a compound count process (Winkelmann und Zimmermann, 1995). Let

$$\tilde{\lambda} = e^{\beta' x + \epsilon} = e^{\beta' x} u \ , \qquad (2)$$

where the error u captures unobserved heterogeneity and is assumed to be uncorrelated with the explanatory variables. Setting E(u) = 1, $\tilde{\lambda}$ is a random variable with mean $E(\tilde{\lambda}) = \lambda$ and variance $V(\tilde{\lambda}) = \lambda^2 \sigma_u^2$. Since $\tilde{\lambda}$ cannot be observed, conditioning is not possible, and the marginal distribution for Y is obtained by integrating the joint distribution over $\tilde{\lambda}$:

$$f(Y) = \int f(y|\tilde{\lambda}) \ g(\tilde{\lambda}) \ d\tilde{\lambda} \ . \qquad (3)$$

A specific parametric distribution has to be assumed to integrate (3). Assuming a gamma distribution for u with $E(u) = 1$ and $V(u) = \sigma_u^2 = \nu^{-1}$, it can be shown that $\tilde{\lambda}$ is also gamma distributed with mean $E(\tilde{\lambda}) = \lambda$ and variance $V(\tilde{\lambda}) = \nu^{-1}\lambda^2$. Integration of (3) then leads to the following negative binomial distributed probability function for Y:

$$P(Y=y\,|\,\lambda,\nu) = \frac{\Gamma(y+\nu)}{\Gamma(y+1)\;\Gamma(\nu)}\left(\frac{\nu}{\nu+\lambda}\right)^{\nu}\left(\frac{\lambda}{\nu+\lambda}\right)^{y}, \tag{4}$$

where $E(Y|\lambda,\nu) = \lambda_x = e^{\beta' x}$, and $V(Y|\lambda,\nu) = \lambda(1+\nu^{-1}\lambda)$.

This technique was first used by Hausman et al. (1984) who applied it in modelling panel data. A recent application of these models is provided by Geil et al. (1997). Cameron and Trivedi (1986) examined various different specifications for cross sectional count models. According to their methodology, the model presented here is called NEGBIN II. In principle, other distributions than gamma could be assumed for λ. The problem is to obtain a closed expression for the probabilities and therefore for the likelihood function. If this is not a necessary objective one could also use normal or lognormal distributions, as introduced by Preston (1948).

If the problem under consideration involves dependent counts for the endogeneous variables, joint estimation of these equations is desirable. In order to obtain a multi- or bivariate model, several different approaches are possible. Among those approaches the most popular method has been the so-called trivariate reduction method or seemingly unrelated Poisson regression model (SUPREME). This method uses the property that any sum of Poisson variables is also Poisson distributed. A formal analysis can be found in Johnson and Kotz (1972). Applications are provided in Gourieroux, Monfort and Trognon (1984), Jung and Winkelmann (1993) and King (1989).

For the bivariate case the trivariate reduction method assumes the existence of two Poisson distributed count variables (Y_i) which are the sums of an equation-specific Poisson variable (Y_i^*) and a cross-equation count (U), where the latter links both equations together:

$$\begin{aligned} Y_1 &= Y_1^* + U \\ Y_2 &= Y_2^* + U. \end{aligned} \tag{5}$$

Using the characteristic that any sum of Poisson distributed random variables is also Poisson distributed, it is possible to derive a probability function which can be estimated using maximum likelihood. Within this general framework two different approaches can be derived depending on whether the mean of the linking count is parametrized or treated as a constant. The main limitation of the trivariate reduction method is similar to that of the univariate Poisson model, namely the implicit assumption of equal means and variances. A violation of this assumption (over - and underdispersion) leads to consistent but inefficient estimates of the parameter vector β. Similar to the NEGBIN model described above one solution to this problem is to treat the parameters of the bivariate Poisson model as a gamma distributed random variable. However, this proceeding leads to severe computational problems which have not been solved so far (see Jung and Winkelmann, 1993). These computational problems could be avoided by using a semiparametric approach which makes no specific assumptions about the distribution of the parameters of the bivariate Poisson model.

Differently to the bivariate models discussed so far, this paper makes use of the compounding technique described above. In order to apply this technique for the derivation of a multinomial model based on Poisson, one has to assume a multinomial distribution for the Poisson parameters. Analogously to the approach for univariate models, a possible multivariate model can be formulated as:

$$P(Y_i = y_i | \tilde{\lambda}_i) = e^{-\tilde{\lambda}_i} \, \tilde{\lambda}_i^{y} \, \frac{1}{y!} \qquad i = 1, 2, ..., N , \tag{6}$$

where

$$\tilde{\lambda}_i = e^{\beta_i' x_i + \epsilon} = \lambda_i u \ , \quad u \sim \gamma(1, \nu). \tag{7}$$

For the bivariate case (i = 2), integration of the resulting joint distribution for Y_i over $\tilde{\lambda}_i$ leads to the following probability function:

$$\begin{aligned} P(Y_1 = y_1, Y_2 = y_2 | x_1, x_2) &= \frac{\Gamma(y_1 + y_2 + \nu)}{\Gamma(y_1 + 1)\Gamma(y_2 + 1)\Gamma(\nu)} \left(\frac{\nu}{\nu + \lambda_1 + \lambda_2} \right)^{\nu} \\ &\quad \times \left(\frac{\lambda_1}{\nu + \lambda_1 + \lambda_2} \right)^{y_1} \left(\frac{\lambda_2}{\nu + \lambda_1 + \lambda_2} \right)^{y_2} . \end{aligned} \tag{8}$$

This model can be thought of as a bi- or multivariate Poisson model.[9]

Following the approach of Hausman et al. (1984) the univariate NEGBIN model can also be extended to a multivariate setting. We start with two Poisson count variables Y_1 and Y_2 and their parameters λ_1 and λ_2. Now these λ_i differ in a fundamental way from the λ of the last model since it is only assumed that they are outcomes of the same distribution whereas the λ_i of the multivariate Poisson model are assumed to be outcomes of the same draw. In particular, the random term u from equation (7) is assumed to be gamma distributed with parameters δ which generates the NEGBIN model with a parameter that varies across i. Then it is assumed that $d = \delta/(1 + \delta)$ is beta distributed with parameters a and b to take into account the possibility

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[9] This model was first derived by Marshall and Olkin (1990) who called it a bivariate NEGBIN because of the NEGBIN marginals.

of a correlation of the different counts. Given this modification the multivariate version of the NEGBIN model can be formulated as:

$$P(Y_i = y_i | \tilde{\lambda}_i) = e^{-\tilde{\lambda}_i} \tilde{\lambda}_i^{y} \frac{1}{y!},$$
$$\text{where } \tilde{\lambda}_i \sim \gamma(\lambda_i, \delta),\ d = \frac{\delta}{\delta + 1} \sim \beta(a,b),\ \text{for } i = 1,2. \tag{9}$$

Conditional only on the exogenous variables we obtain the following expression for the probability function in the bivariate case:

$$P(Y_1 = y_1, Y_2 = y_2 | x_1, x_2, a, b) = \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)} \frac{\Gamma(y_1 + \lambda_1)}{\Gamma(y_1 + 1)\Gamma(\lambda_1)} \frac{\Gamma(y_2 + \lambda_2)}{\Gamma(y_2 + 1)\Gamma(\lambda_2)}$$
$$\times \frac{\Gamma(a + \lambda_1 + \lambda_2)\Gamma(b + y_1 + y_2)}{\Gamma(a + \lambda_1 + \lambda_2 + b + y_1 + y_2)}, \tag{10}$$
$$\text{where } \lambda_i = e^{\beta_i' x_i} \text{ for } i = 1, 2.$$

This bivariate NEGBIN model is more flexible than its Poisson counterpart because the correlation is now achieved by assuming that the compounders λ_i have the same distribution for one unit. This is not as hard as to assume that a random effect has the identical impact on different counts like it is done in the bivariate Poisson model.

5. Estimation Results

We have estimated successively univariate Poisson and NEGBIN models for workplace accidents of foreigners and natives as well as their bivariate Poisson and NEGBIN counterparts. We have further distinguished less severe and severe accidents according to the categories of up to three days of absence and more than three days of absence, respectively. However, to justify the application of bivariate models a significant interdependence between the counts under investigation must exist. A general framework for testing the assumption of zero interdependence in bivariate and multivariate settings has been developed by Cameron and Trivedi (1993). Using results from the theory of series expansions for joint distributions in terms of marginal distributions and their related orthonormal polynomials they derive a conditional moment test which is based on the covariance between pairs of orthonormal polynomials. This test procedure is very general because it copes with any form of interdependence. It is not necessary to specify a specific model of interdependence to test against it since only marginals are used.

We use the test procedure of Cameron and Trivedi (1993) to test the Poisson and NEGBIN approaches against their correlated counterparts (see Table 2). The relevant test statistic τ^2_{nm} is asymptotically $\chi^2(1)$ distributed.[10] For approximate independence it is required that all four test statistics in any row of Table 2 to be small. The tests reveal that for both, foreigners and natives, less severe and severe accidents seem to be uncorrelated. However, zero interdependence between foreigners and natives can be rejected in all cases. A likelihood ratio test of the bivariate NEGBIN model against the bivariate Poisson resulted in refusal of the bivariate Poisson model in the case of the less severe as well as the severe accidents. Therefore, the following discussion of the estimation results concentrates on the bivariate NEGBIN model.

Estimation results for less severe accidents are given in Table 3. Significantly positive industry effects for natives and foreigners are found in metals, and in machinery and transport if compared to the reference industry of chemicals and chemical products. In both cases, the estimated coefficients are significantly higher for foreigners than for natives. In the food and luxury business, job risks are significantly higher than in the reference industry only for

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10 The test statistic is based on Cameron and Trivedi (1993), p. 32, equation (2.9).

foreigners. When looking at the impact of production technology, we find that small series production increases the likelihood of workplace injuries for natives as well as for foreigners with the estimated coefficients for natives and foreigners being not significantly different from each other. The finding that the choice of production technology has similar effects on natives and foreigners are in line with the hypothesis that the German system of safety regulations prevents discrimination with regard to the technological risks of the workplace.

While shift working significantly increases only the job risk of foreigners on a 10% level, the age of a firm has no significant impact on the number of less severe workplace injuries for both groups of workers. The share of workers in a firm who are paid a piecework rate increases the number of less severe accidents for native and foreign workers whereas the share of workers with a premium payment significantly increases only the number of accidents for foreigners. These results indicate that workers with an effort-dependent wage part behave less cautious against slighter risks than workers with a pure time payment scheme.

With regard to the interaction between natives and foreigners it appears that the share of foreign workers in a firm has a statistically significant negative effect on the foreign workers themselves whereas the job risks of natives decrease significantly with increasing employment of guestworkers. The estimated coefficients imply that a 1 percent increase in the employment of guestworkers results in an 2.6 percent increase of less severe accidents of foreigners and a 1.7 percent decrease of less severe accidents of natives. Both coefficients are significantly different from 1. With an average number of 409 workers in a firm of which 97 are foreigners, employment of ten more foreigners would thus result in a reduction of natives' less severe accidents from 15.9 to 13.1. These results suggest that guestworkers primarily are employed in risky activities and that the availability of guestworkers disclosed native workers the opportunity to be promoted to more secure jobs. This interpretation is supported by the result that it is inexperience of foreigners which increases significantly the number of foreigners' accidents only, whereas overall turnover has no impact on the accidents of foreigners, and native labor is not affected at all. These results further cast some light on intra-firm work organization, which seems characterized by a hierarchical system in which less skilled foreign labor does not interact intensively with higher skilled native one. While low firm-specific experience results in more injuries of foreigners who are mainly employed in training-on-the-job tasks, generally better trained German workers are not affected by firm-specific inexperience. This basic scheme seems to be confirmed by the positive impact of foreign superiors on both group of workers: If foreigners have lower skills, foreign superiors should cause a higher job risk for both Germans and foreigners. However, the significantly positive effect of foreign superiors can be also ascribed to a lower degree of authority vis-à-vis native and foreign workers if compared to their German counterparts. Finally, the significantly negative and numerically large influence of foreign representatives in the work council in connection with the insignificant effect of this variable on natives' accidents support the importance of this institution as a "voice" for foreign workers.

In general, the results for less severe accidents are supported by the estimation results for severe accidents, which are provided in Table 4. However, some interesting differences between less severe and severe accidents exist. First, the estimated industry effects indicate that over industries there exists a higher variance of the number of accidents of foreigners than for natives. Only in the industry for basic metals and metal products both natives and foreigners have a significantly higher risk propensity than in the referency industry of chemicals and chemical products. In rubber and plastic products native workers are faced with a statistically significant lower and foreigners with a statistically significant higher job risk if compared to the reference group. A similar pattern of higher relative risk propensities for foreigners if compared to natives is found for all other industries despite electronics and precision instruments.

With regard to the variables controlling for the production process in a firm it appears that firms with single production and with process production have significantly higher accident rates, with the respective coefficients being similar for natives and foreigners. Shift working has a statistically significant positive effect on severe accidents of natives and foreigners where the difference between the two coefficients again is not statistically significant. These results support our hypothesis that foreigners and natives face similar technological workplace risks. The positive influence of firms' age on both groups of workers supports the hypothesis that the effect of age of equipement is not offset by higher experience with the machinery or work process organization. Different to the case of less severe accidents, the type of payment seems not to affect severe accidents. Only the coefficient for premium payment is significantly positive on the 10% level for foreigners.

Similar to the case of less severe accidents an increasing share of guestworkers in a firm is associated with less severe accidents for natives and more severe accidents for the foreigners themselves. According to the estimated coefficients which are significantly different from 1, a 1 percent increase in the employment of foreigners is associated with a 2.9 percent increase of severe accidents of guestworkers and a 1.3 percent decrease of severe accidents of natives. For the average firm, this means that employment of ten more foreigners decreases the number of natives' severe accidents from 32.6 to 28.2. The skill level of the work force has no significant effect on both groups. The number of new hirings only increase the number of severe accidents for natives on a significant level whereas new hirings of foreigners only have a significantly positive effect on the foreigners themselves. These results again indicate a segmented labor market between natives and foreigners. Finally, the highly significant negative coefficient of the incidence of foreign work council members on the number of severe accidents of foreigners confirm the important role of guestworkers' representation in the work council.

6. CONCLUSIONS

Our paper aimed at identifying the determinants of workplace accidents in Germany with its tight public control system of workplace safety. We analyzed whether there are significant differences between natives and foreigners with regard to less severe and severe accidents and placed special attention to the interaction of native and foreign labor. The analysis has been performed by applying improved bivariate count data models on an unique micro data set of manufacturing establishments in Germany.

The estimation results show that workplace accidents are influenced by production technology and work organization. The effects of these variables on the accidents of foreigners and natives are very similar. The latter result could be explained with the dense system of safety regulations in Germany which prevents discrimination in the field of technologically provided workplace safety. Concerning the relationship between foreign and native labor we found strong evidence that guestworker employment has a positive effect on the workplace safety of natives. The empirical results imply that a 1 percent increase of the employment of guestworkers decreases less severe accidents of natives by 1.7 percent and severe accidents of natives by 1.3 percent. In general, the results suggest that guestworkers primarily are employed in risky activities and that the availability of foreign labor for risky jobs disclosed native workers the opportunity to be promoted to more secure jobs. Finally, representation of foreign workers in the work council significantly decreases the accidents of guestworkers without having an impact on the security of natives, indicating an important role of the institution of work councils as a "voice" for foreign workers.

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Table 2: Tests of Independence

Table 2a: Test of Independence for the Poisson Model

Test statistic τ^2_{nm}	$\tau^2_{1,1}$	$\tau^2_{1,2}$	$\tau^2_{2,1}$	$\tau^2_{2,2}$
Foreigners with less than 4 vs. more than 3 days of absence	3.94	0.16	1.04	6.37
Germans with less than 4 vs. more than 3 days of absence	4.54	1.94	0.58	3.41
Foreigners vs. Germans with less than 4 days of absence	16.08	2.98	5.33	7.10
Foreigners vs. Germans with more than 3 days of absence	15.39	0.00	0.02	4.46

Table 2b: Test of Independence for the Negbin Model

Test statistic τ^2_{nm}	$\tau^2_{1,1}$	$\tau^2_{1,2}$	$\tau^2_{2,1}$	$\tau^2_{2,2}$
Foreigners with less than 4 vs. more than 3 days of absence	1.47	1.09	1.37	1.03
Germans with less than 4 vs. more than 3 days of absence	2.37	0.93	0.64	0.65
Foreigners vs. Germans with less than 4 days of absence	7.76	2.18	1.36	1.18
Foreigners vs. Germans with more than 3 days of absence	5.46	0.02	2.82	2.09

For independence it is required that all four test statistics are small. They are asymptotically $\chi^2(1)$-distributed.

Table 2: Tests of Independence

Table 2a: Test of Independence for the Poisson Model

Test statistic τ^2_{nm}	$\tau^2_{1,1}$	$\tau^2_{1,2}$	$\tau^2_{2,1}$	$\tau^2_{2,2}$
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Table 2b: Test of Independence for the Negbin Model

Test statistic τ^2_{nm}	$\tau^2_{1,1}$	$\tau^2_{1,2}$	$\tau^2_{2,1}$	$\tau^2_{2,2}$
Foreigners with less than 4 vs. more than 3 days of absence	1.47	1.09	1.37	1.03
Germans with less than 4 vs. more than 3 days of absence	2.37	0.93	0.64	0.65
Foreigners vs. Germans with less than 4 days of absence	7.76	2.18	1.36	1.18
Foreigners vs. Germans with more than 3 days of absence	5.46	0.02	2.82	2.09

For independence it is required that all four test statistics are small. They are asymptotically $\chi^2(1)$-distributed.

Table 3: Workplace Accidents with up to 3 Days of Absence*

	Poisson		NEGBIN		Bivariate Poisson		Bivariate NEGBIN	
	Natives	Foreigner	Natives	Foreigner	Natives	Foreigner	Natives	Foreigner
Constant	-4.890††	-6.537††	-4.409††	-7.212††	-4.406††	-7.015††	-2.583††	-5.123††
	(51.98)	(43.98)	(10.09)	(13.21)	(9.96)	(15.02)	(5.60)	(10.87)
Rubber and Plastic Products	0.419††	0.280††	0.172	-0.016	-0.059	0.570	-0.191	0.331
	(5.25)	(2.41)	(0.50)	(0.04)	(0.17)	(1.58)	(0.54)	(0.88)
Construction, Material	1.532††	0.974††	0.353	0.107	0.270	0.285	-0.152	-0.052
	(22.94)	(8.65)	(1.03)	(0.24)	(0.78)	(0.78)	(0.43)	(0.15)
Basic Metals, Metal Products	1.594††	1.239††	1.148††	1.324††	1.082††	1.450††	0.521†	0.932††
	(25.96)	(13.35)	(3.71)	(3.51)	(3.48)	(4.50)	(1.68)	(2.86)
Machinery, Equipment, Transport	1.551††	1.030††	1.021††	0.890††	0.919††	1.090††	0.539†	0.896††
	(24.89)	(10.93)	(3.46)	(2.39)	(3.09)	(3.51)	(1.81)	(2.87)
Electronics, Precision Instruments	1.291††	0.345††	0.427	0.503	0.436	0.399	-0.012	0.142
	(19.90)	(3.46)	(1.45)	(1.35)	(1.47)	(1.28)	(0.04)	(0.46)
Pulp, Paper, Printing	0.137	-0.202	-0.352	-0.579	-0.436	-0.344	-0.465	-0.373
	(1.41)	(1.46)	(1.12)	(1.44)	(1.38)	(1.02)	(1.41)	(1.03)
Leather, Textiles, Waering Apparel	0.228††	-0.261††	-0.297	-0.068	-0.393	0.011	-0.519	-0.158
	(2.54)	(1.95)	(0.92)	(0.17)	(1.20)	(0.03)	(1.51)	(0.45)
Food and Luxury	0.869††	0.589††	0.518	0.623	0.452	0.565†	0.400	0.713†
	(10.70)	(5.12)	(1.57)	(1.54)	(1.37)	(1.65)	(1.14)	(1.90)
Single Production	0.366††	-0.024	0.218	0.320†	0.281†	0.210	0.100	0.160
	(16.06)	(0.67)	(1.52)	(1.93)	(1.94)	(1.41)	(0.73)	(1.09)
Small Series	0.625††	0.564††	0.324††	0.282†	0.328††	0.318††	0.340††	0.425††
	(28.95)	(16.45)	(2.48)	(1.82)	(2.47)	(2.34)	(2.89)	(2.97)
Middle Series	-0.139††	-0.005	-0.146	0.059	-0.122	-0.082	-0.142	-0.134
	(6.53)	(0.16)	(1.19)	(0.42)	(0.99)	(0.65)	(1.14)	(1.06)
Large Series	-0.291††	0.054	-0.129	0.114	-0.127	0.022	-0.101	-0.085
	(10.07)	(1.34)	(0.84)	(0.65)	(0.81)	(0.14)	(0.60)	(0.52)
Assembly Line	0.879††	0.656††	0.235†	0.030	0.195	0.148	-0.148	-0.154
	(36.19)	(17.98)	(1.65)	(0.18)	(1.35)	(1.01)	(1.02)	(1.08)
Process Production	0.337††	-0.414††	0.399††	0.150	0.404††	0.187	-0.020	0.090
	(11.66)	(7.69)	(2.24)	(0.70)	(2.24)	(1.00)	(0.11)	(0.47)
Age of Firm $\cdot 10^{-3}$	-0.120	2.660††	-1.740	0.400	-1.360	-2.910††	-0.730	-1.360
	(0.58)	(7.60)	(1.23)	(0.25)	(0.97)	(2.00)	(0.51)	(0.93)
Shift Working	0.097††	-0.064	0.200	0.278†	0.243†	0.210	0.137	0.278†
	(3.91)	(1.60)	(1.45)	(1.74)	(1.74)	(1.46)	(0.98)	(1.91)
Piecework Rate	0.626††	0.254††	0.612††	0.525†	0.618††	0.496†	0.610††	0.582††
	(12.98)	(3.25)	(2.47)	(1.85)	(2.48)	(1.93)	(2.42)	(2.24)
Premium Payment	-0.048	-0.378††	0.282	0.484†	0.310	0.545††	0.280	0.486††
	(0.96)	(5.20)	(1.28)	(1.94)	(1.41)	(2.40)	(1.30)	(2.20)

Table 3: continued

	Poisson		NEGBIN		Bivariate Poisson		Bivariate NEGBIN	
	Natives	**Foreigner**	**Natives**	**Foreigner**	**Natives**	**Foreigner**	**Natives**	**Foreigner**
ln(Workers)	0.996†† (101.11)	1.003†† (63.57)	1.009†† (15.25)	1.062†† (14.34)	1.006†† (15.11)	1.066†† (15.72)	0.764†† (12.49)	0.788†† (12.67)
Share of Foreign Workers	-2.916†† (29.29)	2.518†† (17.77)	-2.093†† (4.83)	2.665†† (5.14)	-2.056†† (4.70)	2.397†† (5.32)	-1.653†† (3.70)	2.577†† (5.79)
Skilled Worker	-0.273†† (3.75)	1.129†† (8.76)	0.140 (0.36)	1.071†† (2.26)	0.177 (0.44)	1.097†† (2.63)	0.330 (0.83)	0.532 (1.19)
Skilled Worker: Foreigners	0.479†† (7.95)	-0.088 (0.76)	0.124 (0.34)	-0.082 (0.19)	0.045 (0.12)	0.023 (0.06)	-0.254 (0.69)	-0.027 (0.07)
Hirings	-0.521†† (4.61)	-1.578†† (9.00)	-0.933† (1.71)	-1.079† (1.71)	-0.896† (1.65)	-1.278†† (2.25)	0.068 (0.12)	-0.374 (0.64)
Hirings: Foreigners	1.324†† (23.62)	1.635†† (15.01)	1.205†† (2.90)	1.053†† (2.19)	1.111†† (2.63)	1.451†† (3.30)	0.412 (0.97)	0.750†† (1.97)
Foreign Superior	0.243†† (10.21)	0.295†† (7.71)	0.386†† (2.54)	0.469†† (2.74)	0.396†† (2.58)	0.389†† (2.49)	0.285†† (1.99)	0.308†† (2.07)
Foreign Work Council Members	0.457†† (2.13)	-4.174†† (4.19)	0.760 (0.37)	-3.960 (1.43)	1.245 (0.58)	-10.042†† (4.01)	0.365 (0.31)	-6.919†† (2.76)
ν	-	-	1.945†† (16.49)	2.238†† (13.26)	2.063†† (17.20)		-	
a	-	-	-	-	-		1.690†† (12.21)	
b	-	-	-	-	-		0.857†† (13.37)	
Log-likelihood	-10749.34	-4340.04	-2188.84	-1524.82	-3715.36		-3488.21	

*: Absolute t-values in parentheses. Obeservations: 809. Reference industry: Chemicals and chemical products.

Table 4: Workplace Accidents with more than 4 Days of Absence*

	Poisson		NEGBIN		Bivariate Poisson		Bivariate NEGBIN	
	Natives	Foreigner	Natives	Foreigner	Natives	Foreigner	Natives	Foreigner
Constant	-2.107††	-4.785††	-2.111††	-4.385††	-1.951††	-4.687††	-1.443††	-3.993††
	(39.84)	(54.56)	(11.44)	(20.38)	(11.26)	(24.59)	(6.54)	(17.75)
Rubber and Plastic Products	-0.104††	0.777††	-0.049	0.056	-0.234†	0.496††	-0.316††	0.312†
	(2.48)	(12.12)	(0.33)	(0.32)	(1.69)	(3.32)	(1.98)	(1.94)
Construction, Material	0.260††	0.745††	0.061	0.180	0.014	0.357††	-0.014	0.324†
	(6.91)	(10.92)	(0.42)	(1.04)	(0.10)	(2.38)	(0.09)	(1.89)
Basic Metals, Metal Products	0.306††	1.069††	0.380††	0.690††	0.335††	0.866††	0.338††	0.858††
	(9.72)	(19.25)	(2.92)	(4.55)	(2.74)	(6.54)	(2.31)	(5.98)
Machinery, Equipment, Transport	0.164††	0.727††	0.277††	0.347††	0.201†	0.560††	0.174	0.547††
	(5.15)	(12.64)	(2.23)	(2.34)	(1.71)	(4.34)	(1.29)	(4.03)
Electronics, Precision Instruments	-0.165††	0.309††	-0.036	0.086	-0.086	0.248†	-0.176	0.080
	(4.66)	(5.12)	(0.29)	(0.57)	(0.73)	(1.89)	(1.31)	(0.61)
Pulp, Paper, Printing	0.010	0.655††	0.037	0.162	-0.051	0.361††	-0.022	0.377††
	(0.26)	(10.04)	(0.29)	(1.05)	(0.42)	(2.65)	(0.15)	(2.44)
Leather, Textiles, Waering Apparel	-0.610††	0.407††	-0.557††	-0.129	-0.658††	0.028	-0.742††	-0.050
	(13.35)	(6.15)	(4.06)	(0.81)	(5.10)	(0.20)	(4.86)	(0.31)
Food and Luxury	0.033	0.610††	-0.042	0.069	-0.116	0.299††	-0.101	0.276†
	(0.79)	(8.91)	(0.30)	(0.42)	(0.87)	(2.05)	(0.66)	(1.73)
Single Production	0.158††	0.167††	0.175††	0.088	0.155††	0.163††	0.149††	0.150††
	(9.84)	(6.91)	(2.93)	(1.30)	(2.75)	(2.73)	(2.32)	(2.12)
Small Series	-0.034††	-0.016	-0.064	-0.003	-0.037	-0.047	-0.004	-0.005
	(2.19)	(0.70)	(1.16)	(0.05)	(0.73)	(0.85)	(0.08)	(0.08)
Middle Series	0.020	-0.011	-0.053	-0.074	-0.028	-0.137††	-0.024	-0.085
	(1.36)	(0.51)	(1.01)	(1.27)	(0.56)	(2.60)	(0.44)	(1.47)
Large Series	0.054††	0.179††	0.092	0.205††	0.055	0.212††	-0.033	0.102
	(2.96)	(7.58)	(1.40)	(2.94)	(0.90)	(3.33)	(0.52)	(1.51)
Assembly Line	0.079††	0.103††	0.061	-0.037	0.037	0.022	0.081	0.066
	(4.71)	(4.56)	(0.96)	(0.53)	(0.62)	(0.35)	(1.34)	(1.02)
Process Production	0.198††	0.204††	0.199††	0.167††	0.184††	0.188††	0.207††	0.170††
	(10.69)	(8.04)	(2.63)	(2.01)	(2.59)	(2.55)	(2.44)	(2.09)
Age of Firm $\cdot 10^{-3}$	0.970††	0.940††	1.860††	0.128††	1.870††	1.240††	2.190††	1.500††
	(6.61)	(4.25)	(3.19)	(1.97)	(3.39)	(2.15)	(3.60)	(2.23)
Shift Working	0.147††	0.148††	0.160††	0.127††	0.150††	0.163††	0.200††	0.184††
	(8.69)	(5.77)	(2.87)	(2.00)	(2.84)	(2.88)	(3.36)	(2.62)
Piecework Rate	0.137††	0.083††	-0.067	-0.047	-0.074	-0.018	0.001	0.004
	(4.31)	(1.76)	(0.63)	(0.39)	(0.75)	(0.17)	(0.01)	(0.03)
Premium Payment	0.284††	0.218††	0.160†	0.243††	0.179††	0.241††	0.125	0.181†
	(10.00)	(5.55)	(1.72)	(2.33)	(2.03)	(2.58)	(1.34)	(1.68)

Table 4: continued

	Poisson		NEGBIN		Bivariate Poisson		Bivariate NEGBIN	
	Natives	Foreigner	Natives	Foreigner	Natives	Foreigner	Natives	Foreigner
ln(Workers)	0.874††	0.937††	0.883††	0.913††	0.867††	0.955††	0.758††	0.832††
	(138.35)	(98.53)	(32.50)	(30.64)	(34.18)	(35.92)	(27.61)	(25.96)
Share of Foreign Workers	-1.316††	2.805††	-1.045††	3.332††	-1.162††	3.138††	-1.302††	2.900††
	(21.66)	(35.00)	(5.58)	(15.72)	(6.49)	(16.59)	(6.69)	(14.52)
Skilled Worker	0.261††	0.177††	0.124	0.432††	0.199	0.243	0.193	0.206
	(5.39)	(2.19)	(0.73)	(2.15)	(1.24)	(1.38)	(1.13)	(0.96)
Skilled Worker: Foreigners	0.479††	0.558††	0.249†	0.109	0.182	0.168	0.176	0.101
	(11.83)	(7.67)	(1.66)	(0.60)	(1.28)	(1.06)	(1.28)	(0.54)
Hirings	0.843††	-0.248††	0.904††	0.037	1.036††	0.032	0.816††	0.050
	(12.21)	(2.39)	(3.87)	(0.15)	(4.73)	(0.13)	(3.88)	(0.19)
Hirings: Foreigners	0.229††	0.916††	-0.0002	0.735††	-0.039	0.708††	-0.018	0.509††
	(4.40)	(11.30)	(0.002)	(4.10)	(0.26)	(4.33)	(0.10)	(2.24)
Foreign Superior	-0.082††	-0.081††	-0.061	0.045	-0.021	-0.012	0.011	0.013
	(5.04)	(3.50)	(0.98)	(0.69)	(0.36)	(0.19)	(0.18)	(0.20)
Foreign Work Council Members	0.285††	-4.730††	0.123	-2.124††	0.168	-5.497††	0.301	-4.810††
	(2.20)	(7.34)	(0.23)	(2.31)	(0.34)	(6.40)	(0.34)	(4.46)
v	-	-	0.352††	0.362††	0.318††		-	
			(16.51)	(14.55)	(17.59)			
a	-	-	-	-	-		6.933††	
							(14.90)	
b	-	-	-	-	-		6.783††	
							(13.37)	
Log-likelihood	-5718.42	-3762.95	-2985.21	-2343.16	-5487.74		-5287.55	

*: Absolute t-values in parentheses. Obeservations: 809. Reference industry: Chemicals and chemical products.