Labor Specialization as a Source of Market Frictions

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This paper investigates why labor specialization brings additional frictions to the labor market. The intuition is that labor specialized firms rely on complementarity and firm-specific human capital, assigning high value to the worker-employer match. The findings show that specialized firms preserve their workforce: these firms labor hoard and increase wages during slowdowns. Additionally, when specialized firms unexpectedly face a labor supply shock — albeit managing to decrease the wages of the remaining coworkers, they become less productive. Overall, the empirical evidence suggests that labor specialization can become an employment protection.

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I Introduction

This study analyzes why labor specialized firms may operate away from perfect competition. The hypothesis is that a specialized employer is more keen on locating and preserving a good job match than a generalist one. On the one hand, the process of matching workers to jobs may take more time and effort for specialized employers — making the matching precious for these employers. On the other hand, employees working for specialized employers have less incentives to leave the firm, because the outside labor market is thin for his idiosyncratic skills. To preserve these precious matches, specialized firms could foster slow job reallocation and might be ready to share rents. In turn, employees working for specialized employers may have less incentives to leave the firm.

The relevance of the worker-employer match becomes apparent when firms face adverse shocks. The study investigates the heterogeneous response given by employers working at different levels of specialization to exogenous shocks. The results show that specialized firms tend to preserve their workers and increase wages during industry specific downturns. In parallel, specialized firms appear less productive than generalist firms, when they unexpectedly lose an employee. As in Lazear (2009), the intuitive explanation is that specialized firms operate under a sort of bilateral monopoly, bringing additional frictions to the labor market.

From a theoretical perspective, this paper relates to the literature on the complementarity between employees (Becker and Murphy, 1994) — which leads to superadditivity (Rosen, 1978); as well as on an extensive body of studies on firm-specific human capital (Gathmann and Schönberg, 2010; Gibbons and Waldman, 2004; Becker, 1962) highlighting aspects such as low substitutability of employees. This study is also intersected by rent sharing (Lamadon, Mogstad, and Setzler, 2019, Card et al., 2018) monopsony (Dube et al., 2020; Azar, Marinescu, and Steinbaum, 2019; Benmelech, Bergman, and Kim, 2018; Ashenfelter, Farber, and Ransom, 2010; Manning, 2003), and search models (Pissarides, 2011; Mortensen and Pissarides, 1994), and comes close to empirical evidence documenting firms' little power over wages (Staiger, Spetz and Phibbs, 2010; Sullivan, 1989).

The paper assumes that the employer can contract with employees on a single basis, hence he is able to reward a worker with whom he matches well (Jovanovic, 1979), and that the specialization of one worker lets others specialize, creating an externality at the worker level. Two mechanisms jointly underpin the specialization hypothesis: the specialization due to job assignment by skills and the sorting of workers into firms due to the role of skills held by the workers. Intuitively, under the first mechanism, employees make less mistakes in the Smithian and Beckerian way, and are more productive because they specialize and concentrate on a narrow set of tasks (conditioned for instance, on coordination costs). Under the second mechanism and in line with the O-Ring theory (Kremer, 1993), employers avoid mistakes by employing individuals who possess expertise at a task or have the probability of successfully completing that task (i.e. even beyond the educational attainment).

An example can be found in a watch maker production line. Typical stages are the dial assembly, the mounting of the hands, the setting into the case and the manual tests. Each of these steps requires a specialist who is an expert in his role. He is fully responsible for his task and conveys the finished piece to the next work stage. This sequence is repeated until the watch is ready to be sold. The dexterity of an individual worker determines the quality of each step, the quality of the subsequent steps of the process, and ultimately the excellence in quality of the watch.

The empirical strategy uses matched employee-employer data (LIAB 1993-2010) from the German social security, which covers all workers employed in one of the surveyed establishments[1]. This data feature is important, because it allows us to build the specialization proxy — based on the entire occupation distribution within each firm, which measures occupation concentration. To assess the business cycle, the study relies on changes in the National Account industry gross value added in Germany as a source of variation, and focuses on downturns.

The results document that more specialized firms preserve their labor force dur-

[1]Thie study uses the Linked-Employer-Employee Data (LIAB) version from the IAB. Data access was provided via on-site use at the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB) and subsequently remote data access (fdz1059-1060-1061). LIAB version: longitudinal model 1993-2010 (LIAB LM 9310). Data documentation: Heining, Klosterhuber, and Seth (2014), Klosterhuber, Heining, and Seth (2013), Fischer et al., (2009).

ing slumps, appearing less productive — as search, hiring and training are particularly costly in time and resources for these firms. Within our sample, a one standard deviation increase in specialization decreases labor productivity by around 0.03 percent during downturns. Additionally, a one standard deviation increase in specialization increases wages by almost a 0.01 percent — to preserve, and potentially to attract new employees. Consistent with an extensive literature (Burnside, Eichenbaum, and Rebelo,1993; Bernanke and Parkinson, 1991; Hall, 1988; Bernanke, 1986; Fair, 1985; Fay and Medoff, 1985), we obtain insignificant evidence regarding specialized firm's changes in separations and net employment during downturns.

The logic is that once the match is achieved, the specialized employer may prefer to avoid restarting the search process. The single employee is precious and could enjoy some monopoly rents for at least two reasons: (i) he raises the productivity of his coworkers, (ii) he works on a fairly limited number of specific and closely related tasks (see Molina-Domene (2018) among others), being the only one who possesses information about the role. Crucially, the employee becomes more precious over time: the specialized firm needs him on the grounds they have already developed firm-specific human capital, obtained by learning through specialization or by training (Acemoglu and Pischke, 1998).

Along these lines, an implication is that specialized firms should be more affected than generalist firms by the unexpected loss of an employee. That is, specilalized firms take more of a hit in terms of labor productivity when they unexpectedly face an idiosyncratic establishment-specific labor supply shock — compared to generalist firms.

To test this implication empirically, the paper investigates the response of specialized employers to the absence of an employee. To circumvent endogeneity concerns (e.g. an employee quits because he is unsatisfied with the job experience), it follows previous research (Jaravel, Petkova, and Bell, 2018; Fadlon and Nielsen, 2017; Jäger, 2016; Isen, 2013; Becker and Hvide 2013; Oettl, 2012; Azoulay, Zivin, and Wang, 2010; Bennedsen et al., 2007; Jones and Olken, 2005) and uses employee's deaths as a source of variation. The setting is a quasi-experimental research design, which compares the response of firms of different levels of specialization, in terms of different labor outcomes. The evidence suggests that the death of an employee hits specialized

firms hard: a standard deviation increase in specialization decreases firm productivity by around 0.04 percent in the second year and around 0.03 percent in the third year. This is true even if specialized employers decrease the wages of the remaining coworkers more than their counterparts generalist firms. The effects are stronger for smaller firms and extend till the third year after the death, suggesting some monopsonistic power.

We could expect that the time needed to match a new employee to the remaining workforce, should be longer for specialized firms. Nevertheless and consistent with complementarities, the paper provides evidence that specialized firms fill the vacancy of high-tenured employees more promptly, conditioned on the labor market availability.

The remainder of the paper is organized as follows. Section II illustrates the conceptual framework, under different modelling assumptions. Section III focuses on adverse demand shocks, outlining the empirical strategy and providing results and Section IV concentrates on labor supply shocks, conveying the empirical strategy and results. In Section V, the paper concludes by drawing some implications derived from labor specialization.

II Conceptual Framework

A *Labor Specialization*

Consider a static model, where workers match to firms. Workers differ in their preference and firms differ in their productivity. The hiring decision of the firm is endogenous, which implies that the firm searches specific employees characterized by one or more attributes that contribute to firm's utility maximization.

At time t, there is no production and firms make their organizational choice. Firms and workers are risk neutral. Assuming perfect information, generalist firms hire 'jack-of all-trades' workers, who have more balanced talents and are versed in a variety of fields. Alternatively, specialized firms hire individuals who have expertise in certain skills[2].

[2]Beyond the level of education attainment, specialists perform their roles at high quality as in Kremer (1993), and Jones (2014) 'quality' beyond 'quantity' approach.

For simplicity, let the production line include 2 workers w (A and B)[3] and assume there are two skills S^s : S^1 and S^2. There is assortative matching between employees and employers based on observable and unobservable characteristics (Hagedorn, Law, and Manovskii, 2017; Shimer and Smith, 2000). Generalist firms hire workers who are equally proficient at S^1 and S^2. Each worker possesses skills S^s_w:

$$q = \frac{1}{2}(S^1_A S^2_A, S^1_B S^2_B) \tag{1}$$

Conversely, specialized firms hire workers who possess higher dexterity in one of the skills[4] S^1 and S^2, and not in the other, and assign employees to one task where they produce at the maximum skill level $max[S_1, S_2]$ as in Lazear (2005). The specialized firm achieves complementarity and high levels of productivity — as far as the costs of coordination, communication or adaptation[5] do not outweigh the benefits of the division of labor. In the extreme the firm cannot operate if one employee is missing (i.e. $q = 0$). Therefore, the specialized firm output is:

$$q = max(S^1_A S^2_B, S^2_A S^1_B) \tag{2}$$

In this setting, an employee working for a generalist employer alone divides his time equally, contributing to $q\frac{1}{2}$.

At time $t + 1$, the firm assigns workers to tasks (i.e. not a choice for the worker). For simplicity, assume there are two tasks, $Task^1$ and $Task^2$ that correspond to S^1 and S^2 respectively. Within specialized firms both tasks 'must be' performed (i.e. as in Becker and Murphy, 1994). Each worker maximizes income by devoting full time to $Task^1$ or $Task^2$ (see Rosen, 1978) and there are no overlaps between coworkers[6]. There are neither hold-up nor principal-agent problems, which means each

[3] As in the Roy (1951) model, individuals are different.

[4] The probability of a specialized firm's meeting an employee is independent of the number of searchers and once firms find a good match, they stop searching.

[5] For instance, Dessein and Santos (2006) suggest that rigid organizations can rely on rules and task guidelines to coordinate tasks ex ante, while adaptive organizations require task bundling and intensive communication to ensure coordination ex post.

[6] There is non-cooperation (Baumgardner, 1988) or minimum employee' interaction with peers, which implies infrequent or negligible overlap between coworkers across sets of activities (i.e. each worker is uninformed about the role of other coworkers).

worker focuses on a task and combines his output with that of another worker without compensation (Jones, 2005).

A specialized firm's production function exhibits increasing returns to tenure: the longer the employee stays in the firm, the more productive he becomes. Employees working for specialized employers receive an income associated with applying their best skill to the task they perform. They increase their firm-specific human capital (for instance, due to high on-the-job learning by training) and do not have obvious reasons to quit his job. The firm has no incentive to lay-off, because it possesses information about its employees and has invested in their human capital.

An ex post bilateral monopoly arises within specialized firms. These firms have some market power over their specialists and are able to set wages (i.e. the elasticity of the supply is less than infinite), even below the competitive market. Nevertheless, firms' monopsony power decreases when their employees becomes power monopolists.

B *The Labor Matching and the Exogenous Shocks*

Assume ϵ is a random firm's component that evolves according to a Poisson process. Following Wasmer (2006), we define the surplus of the initial match at time 0 as:

$$S_0^k = J_0^k(\epsilon) - V + W_0^k(\epsilon) - U^k \tag{3}$$

where k takes the value s for a job match in a specialized firm and g for a job match in a generalist firm. S_0^k is the total surplus of an initial match. The firm's value is J_0^k and V is the outside option of the firm. W_0^k is the present discounted value of employment at the entry stage, and U^k denotes the outside option in terms of separation — the asset value of being unemployed after separation.

At a random time, a new value of ϵ is drawn from its distribution and the surplus after this change is denoted as $S_{(\epsilon)}$.

$$S_{(\epsilon)} = J^k(\epsilon) - V + W^k(\epsilon) - U^k + T \tag{4}$$

where T is a firing tax or other protection for workers from separation (i.e. paid by the firm in case of separation).

If there is a positive surplus to share ($S_{(\epsilon)} > 0$), the employee and the employer bargain and agree on a wage, and if there is negative surplus, they optimally separate. The positive surplus splits into shares β and $1-\beta$, where β is an index of the bargaining power with $0 \leq \beta \leq 1$. Within specialized firms, this index is away from the extremes because nor the employee neither the employer possess all the bargaining power. The opposite happens within generalist firms, where the bargaining power is less balanced.

If the new value of $S_{(\epsilon)} < 0$, both parties may decide to dissolve the match. If $S_{(\epsilon)} < 0$ — for instance during an adverse demand shock, it is jointly profitable for the generalists (employee and employer) to dissolve the match and to separate. No wage renegotiation can satisfy both bargaining parties because U^g at any time $t \geq 0$ is high and the matching is fragile. This is different for specialists. Due to complementarity and low level of substitutability of workers, the specialized employer has no incentive to lay off (V is very high) and instead he labor hoards — even if $S_{(\epsilon)} < 0$, due to complementarity and low level of substitutability of workers (i.e. the firm already knows the employee's personal efficiency). Plausible strategies for the speclalized employer are to retain workers via rent sharing or to increase wages.

In parallel, employees working for more or less specialized employers have different incentives to stay or to leave the current employment. It is expected that an employee who leaves a firm looses specific skills but retain general skills. If this is the case, employees working for specialized employers should have less or no incentive to leave the current employer (U^s is very low), compared to generalist employees, during downturns.

The higher the level of labor specialization, the higher the probability of facing market frictions. This becomes apparent when firms come to grips with a labor supply shock. The specialized firm appears less prepared (e.g. due to status quo bias) and suffers a non trivial disutility shock after the unexpected exit of an employee. The significance of this shock is determined by the missing employee' substitutability[7], which is a function of the missing employee's firm-specific human capital and the firm's level of the division of labor. The shock is a concave function of the difficulty

[7]Working with the 1990 UK Employer's Manpower and Skills Practices Surveys, Manning (2003) provides evidence that employers report problems with recruiting specialist workers. Conversely, vacancies in jobs that require general skills cause less of a problem because other workers in the firm can adjust their work patterns to mitigate the costs associated to the vacancy.

to find the deceased's skill. This function decreases when the skill of the deceased becomes general or common knowledge (i.e whether human capital is labeled specific or general depends on observable market parameters, as in Lazear, 2009).

III Adverse Demand Shocks

Firms working at different levels of specialization could respond differently to adverse demand shocks at the industry level. The predictions are that:

1. Specialized employers are hit more in terms of labor productivity — compared to generalist firms.

2. Specialized employers do not decrease wages.

3. Specialized employers do not lay off and their employees do not quit. These employees may prefer to continue working for the firm because they possess highly distinct skills (e.g. specifically trained for the firm).

Given search, recruiting and training costs, specialized firm's workforce is particularly valuable and quasi-fixed: specialized employees' internal value to the firm exceeds their external value in the labor market (Oi, 1983). While labor specialized firms exhibit low turnover and hoard workers even above the minimum level required in order to produce a given output, generalist firms have greater turnover and a wider labor market — especially during downturns. An appealing derivation is that labor specialization could be a reassurance against frictionary unemployment (Michaillat, 2012).

A Empirical Strategy

To evaluate these patterns, the empirical strategy focuses on industry transitory demand shocks (via recessions)[8] and estimates the differential effect of being specialized,

[8]Guiso, Pistaferri and Schivardi (2005) focus on idiosyncratic shocks to the firm to offer empirical evidence on the extent of wage insurance within the firm. In some cases, firms appear more resilient to negative shocks. For instance, Aghion et al., (2020) find evidence that 'bad times' can be less tough for decentralized firms.

in terms of firm's labor productivity and other labor outcomes (wages, hires and separations[9]).

The study uses German administrative data which is merged with data regarding downturns — coming from Eurostat German National Accounts. The data is described in Appendix A. To work on a more homogeneous basis, our sample focuses on firms with more than 10 employees. The reason is that since 2003, firms with more than 10 employees face specific procedures and costs to terminate employment relationships[10].

The study implements a difference-in-difference specification, which is:

$$Y_{jt} = \alpha_i + \rho_j + \beta SP_{jt} + \tau Down_{kt} + \sigma(SP_{jt} * Down_{kt}) + \upsilon X_{jt} + \varepsilon_{jt} \qquad (5)$$

where subscripts $j = 1, ..., n$ represent firms, k is the industry and t is year (1995-2010). Y_{jt} is the midpoint change in productivity, firm average wages and the net change of employment, hires and separations[11]. SP_{jt} denotes labor specialization, $Down_{kt}$ is the dummy variable indicating slumps[12] at time t ($Down_{kt} = 1$ if the business cycle $BC_{k(t)} < BC_{k(t-1)}$ and 0 otherwise).

The coeffiicient of interest is σ, which represents the differential effect of being specialized during downturns. The control variables X_{jt} are lagged size (when the dependent variable is productivity) or size (when the dependent variables are labor outcomes) and year. The specification also controls for the interactions between the downturn indicator variable and the other covariates (e.g. firm characteristics), to account for differential levels of outcome changes by firm size and year. Firm fixed

[9]Separations adds up quits and layoffs (i.e. include disguised or induced dismissals).

[10]This is due to the Dismissals Protection Act, which applies to workers employed in the business unit for at least six months, working under an employment contract. Additional rules apply to collective dismissals and certain groups of employees (members of the works council, disabled people, pregnant women, etc.).

[11]Instead of the natural logarithm, the study uses the midpoint change, given these three variables can be zero.

[12]As checks of robustness of the results, we work with the same specification but use a measure of the business cycle incremental change, based on the industry gross value added: $BC_{k(t-1)} = VA_{k(t)} - VA_{k(t-1)}/VA_{k(t-1)}$. Another strategy is to consider slowdowns in the whole economy. In this case, the downturn variable is computed as described above, but using the aggregated GDP (constant prices, national base year). In both cases, the results look similar to the ones presented in Table II.

effects ρ_j allow absorbing the unobserved heterogeneity across firms[13]. Standard errors are clustered at the firm level.

B Results

As a starting point, we take an overview of firm characteristics. Firms of low (below mean) and high (above mean) levels of specialization in this sample look different in many aspects. Table I documents how more specialized firms pay higher average wages and have higher wage dispersion. Their business volume and size are in mean, also greater.

Consistent with the development of firm-specific human capital, specialized firm's employees are in mean, older and exhibit a higher tenure. These features give preliminary signs that specialized firms may be keen on preserving employees, during adverse shocks.

We further evaluate this pattern and observe that there are three major downturns in annual GDP growth rate (Figure I) within the studied period. The most important slump happens in 2008. Figure II reveals that these shocks are not homogeneous across industries: different industries face plunges in value added growth rates at different time and even at different extent. We exploit this heterogeneity as a source of variation.

Table II documents the effects of these shocks regarding productivity, separations, net changes of employment and wages. To control for differences between firms — that go beyond specialization, the specifications include firm fixed effect. Column 1 shows that specialized firms are hit in terms of labor productivity. The coefficient of the interaction term between $Downturn$ and $Specialization$ is negative and highly statistically significant, suggesting specialized firms procyclical behaviour in terms of productivity. An explanation is that specialized firms could appear less productive, because they hoard employees during slumps due to sunk costs and low levels of sub-

[13]Abowd, Kramarz, and Margolis (1999) use worker and firm fixed effects in wage regressions to document unobserved worker and firm characteristics that account for an important part of the variation in wages. Hagedorn, Law, and Manovskii (2017) among others, highlight that this regression approach seem to face some limitations as it assumes that wages are monotone in firm's productivity, which in many contexts such as this one may not be plausible.

stitutability. Instead of laying off, these firms retain workers even above the minimum level required to produce a given output.

Columns 2 to 4 show that the coefficients of the interaction term in the absolute and relative change separations and the net employment are close to zero and not statistically significant at any conventional level. This implies that the differential effect of downturn — on top of the level of specialization regarding separations and changes in net employment, seems negligible.

Interestingly, specialized firms countercyclically do not decrease average wages during slowdowns as much as generalist firns (i.e. the coefficient of the interaction between $Downturn$ and $Specialization$ is positive and statistically significant), as shown in column 5. The logic is that specialized employers may use wages to retain their employees and avoid them moving to sectors that may be facing more prosperous times and could offer more attractive wages.

The evidence suggests that specialized firms may be less resilient to adverse shocks: they have a harder time to adjust, as reflected in their productivity. Instead, their employees are preserved and are offered higher wages. Taken together, specialized firms seem to bear the brunt during downturns.

IV Adverse Labor Supply Shocks

Being more or less labor specialized can have an impact on how firms react to a labor supply shock. Potentially, specialized firms could be more concerned about finding another good job match (i.e. typically their search process is more involving in time and effort) than generalist firms, given the degree of specificity of the required skills. The prediction is that, conditioned on the level of specialization and on the bargaining power, a firm which unexpectedly loses an employee may have at least two options:

1. It internally reorganizes and invests in retraining the surviving coworkers to perform the deceased's role. This option can be nonexistent, if the firm relies on complementarity.

2. It poaches a suitable replacement for the deceased. This entails facing search and training costs, and potentially paying a higher wage (i.e. the higher the

wage, the easier to fill the vacancy).

If the firm is specialized and possesses ex-post monopsonist power, it puts forward option one. It may also change the wages of the remaining workers, conditioned on the difficulty of the replacement. If the remaining workers are powerful monopolists, the firm is already paying a competitive wage or even a wage premium and prefers option two — creating a job opportunity for a specialist (e.g. an individual who is highly productive on the deceased's role and who has low outside options).

A Empirical Strategy

The strategy is to evaluate the effects of the unexpected death of an employee, on firms which work at different levels of specialization. The study uses again the German administrative data, described in Appendix A.. The setting allows to consider deaths that happen in different years.

Firstly, the study concentrates on the replacement of a deceased employee. The basic specification is:

$$TTR_{jt} = \alpha + \beta SP_j + \omega Tnr_{jt} + \phi(SP_j * Tnr_{jt}) + \upsilon X_{jt} + \varepsilon_{jt} \tag{6}$$

where TTR_{jt} is the time needed to replace the deceased, the subscript j keeps track of which firm the death is assigned to, and Tnr_{jt} is the tenure of the deceased — as an additional regressor of interest. The focus is on the causal effect of interest ϕ or the differential effect the deceased's tenure has on the span needed to replace a deceased employee — on top of being a specialized firm. X_{jt} represents a set of firm controls (size, industry, region, year).

This kind of firm-specific shock should not affect the labor market. Nevertheless, the replacement of the missing employee may be conditioned by the labor market availability. The second specification delves into this aspect and introduces the variable $Agglom_l$ that accounts for a greater pool of employees in the occupation of the

deceased — within the local labor market.

$$TTR_{jt} = \alpha + \beta SP_j + \omega Tnr_{jt} + \phi(SP_j * Tnr_{jt}) + \psi(SP_j * Agglom_l) + \gamma(Tnr_{jt} * SP_j * Agglom_l) + \upsilon X_{jt} + \varepsilon_{jt} \quad (7)$$

This specification is especially relevant because it allows disentangling whether specialized firms peremptorily replace a missing employee, when they have the opportunity to do it. In this case, the relevant effect is γ or the differential effect the deceased's tenure has on the time needed to replace a deceased employee — on top of being a specialized firm and given the labor market agglomeration.

To investigate the effects of the unexpected loss of an employee, we extend the analysis to productivity and wages. The sample includes firms that experience the death of an employee and firms that do not suffer this shock at different points in time. The following difference-in-differences specification is implemented:

$$Y_{jt} = \alpha + \rho_j + \beta SP_j + \sum_{t=-3}^{5} \kappa_t DRDth_{jt} + \sum_{t=-3}^{5} \delta_t (DRDth_{jt} * SP_j) + \eta X_{it} + \upsilon X_{jt} + \varepsilon_{jt} \quad (8)$$

where the dependent variable Y_{jt} are labor productivity and average wages paid by firm j after the death of an employee to the deceased's coworkers, and $DRDth_{jt}$ are the leads and lags around death time occurred in firm j.

The difference in firm's patterns predates the death and δ could be spurious. To capture differences in trends in the absence of a death effect, the study introduces firm fixed effect parameters ρ_j and includes covariates to control for other sources of omitted firm-specific trends at the firm level X_{jt} and at the individual level X_{it}, as described above. X_{jt} and X_{it} also include leads and lags, interactions of covariates and the death, as well as leads and lags of those interactions. In this case, the evidence of a death effect comes from the sharp deviation from otherwise smooth trends (i.e. even if those trends are not common).

B Results

Table III shows that firms that suffer the death of an employee tend to be different to those that do not experience a death, in several aspects. On average, the former firms are larger (i.e. larger firms have a higher probability to experience a death), their workforce is longer tenured and exhibit a higher level of net employment change.

Delving into the former firms, Figure III compares the deceased and his coworker's characteristics. It illustrates that around the 80 percent of the dead employees have achieved at the most secondary education — with vocational qualification, and were working within non managerial or professional occupations[14], compared to around a 70 percent of the surviving deceased's coworkers. Figure IV complements this characterization, showing that the vast majority of the deceased exhibits low propensity to change job or occupation[15]: they did it only once, at the time they died. These findings seem appealing and could indicate that the deceased possessed some dexterity in their roles at the time they died.

An important feature, is that the surviving employees may not be able to substitute the deceased in his role within specialized firms — given complementarities and low levels of communication between employees. As a result, we could expect that specialized firms should expedite the deceased's replacement[16]. Interestingly, the evidence suggests the opposite: there is no instantaneous job matching for specialized firms, as they spend more time to replace a deceased worker than their counterparts generalist firms, controlling for size, industry, region and year (i.e. in Table IV columns 1 and 2, the specialization coefficients are positive and highly significant). Nevertheless, the time spent is substantially lower, while replacing a high-tenured employee: the differential effect of tenure on top of specialization is negative and highly significant (-0.697 and -0.661). Intuitively, there is more haste in finding a substitute of an employee who

[14] Most of the deceased employees were not covering managerial or supervising tasks (i.e. they were not decision makers). This suggests, that labor productivity decreases probably due to the employee's absence from his role — rather than, for instance, due to changes in firm's strategy issued by the deceased's replacement.

[15] In this sample, neither lateral moves nor promotions appear relevant.

[16] Furthermore, if specialized firms behave as monopsonists, they could be already falling short of what would be hired in a perfectly competitive labor market, therefore $n-1$ employees could make the production process infeasible.

has matured experience within the firm, as shown in columns 3 and 4.

Additionally, the study looks at the effects a thicker or more agglomerated local labor market can have on the replacement of the deceased. The evidence is not quite conclusive, as the estimates are not statistically significant at any conventional level (column 5 and 6) . Columns 7 and 8 leverage the previous results and provide evidence combining the deceased's tenure and the labor market agglomeration. The coefficients of the triple interaction $Tnr_{jt} * Specialization_j * Agglom_l$ indicate that specialized firms spend less time replacing a high-tenured deceased employee, conditioned on the labor market agglomeration. This seems reasonable and supports the premise that specialized firms aim to replace a missing experienced employee shortly, as long as the labor market allows it.

The results from the econometric strategy suggested in equation (8) are presented in Figure V and Table V. Columns 1, 2, 5 and 6 (Table V) complement the previous results and present evidence regarding labor productivity. All regressions include firm fixed effect and a set of controls, as described above. The findings suggest that firms are not immediately hit by the death of an employee in terms of labor productivity (i.e. the effect in the first year is negligible and not statistically significant), but the effect arises in the second year after the death — for the sample of all firms, or in the third year after the death — for the subsample of small firms. Considering the sample of all firms, the interaction term between the second and third year dummies and specialization are negative and around -0.06. The effect is substantially stronger (in absolute values) for the subsample of small firms, but at a lower significance level. In both samples, the differential effect of being specialized eventually (from the fourth year in the aftermath of the death) becomes not statistically significant at any conventional level. There can be different explanations for becoming less productive, the simplest one suggests that, specialized firms rely on firm specific human capital and gets particularly hit by the loss of an employee.

Delving into the effect on wages, columns 3, 4, 7 and 8 (Table V) show that the coefficients of the interaction terms between the year dummies and specialization are negative and statistically significant for three years after the unexpected death of an employee. Figure V expand on the results presented on Table V and displays

the dynamics of the differential effect of specialization, on the average wages of the deceased's surviving coworkers. It documents that specialized firms decrease average wages — in the aftermath of the unexpected death of an employee, and confirms the sharp deviation from previous trends (i.e. the coefficients of the interaction between $Specialization$ and $DRDth_{jt}$ are statistically indistinguishable from zero). This effect is stronger even though less precise, for small specialized firms — as shown in the lower panel, presumably due to small employer's higher monopsony power.

The interpretation is that specialized firms are particularly affected by the loss of the employee and therefore lower the remaining employee's wages. A complementary explanation is that the deceased's coworkers accept the unfavorable conditions due to the specificity of their human capital and limited outside labor market options.

V Conclusion

This paper empirically evaluated some frictions derived from labor specialization. The hypothesis was that a good match is particularly important for firms that work under high levels of the division of labor and rely on firm specific human capital due to complementarities among employees and low levels of substitutability.

To delve into these patterns, the first story looked at downturns. Specialized firms' strong dependence on employees, propelled them to preserve employees, even during slumps. The reasons revolved around developing employment relationships consolidated by specific skills, and pointed at frictions in the labor market. These decisions echoed in specialized firms' labor productivity. These firms appeared less productive than generalist firms during downturns. As a testimonial of labor hoarding, these firms ended increasing their employee's wages.

The second story focused on exogenous labor supply shocks. The results suggested search frictions related to the replacement of a missing employee. Consistent with the specificity of human capital, specialized firms took more time for the replacement than generalist firms did. Instead, the replacement of high-tenured employees was faster, as far as the labor market allowed it. Additionally, specialized firms became less productive than their counterpart generalist firms, in the aftermath of the unex-

pected death of an employee. Regarding firm average wages, the evidence casts doubt on how much monopoly power employees possessed over their employers, given that specialized employers decreased a deceased's coworkers' wage at a higher level than generalist employers. This effect was even higher within small firms, where specialized employers probably exercised more monopsonistic power.

Specialized employers appeared to rely on their employees more than generalist firms. Given the employee-employer mutual dependence, a bilateral monopoly was plausibly in place within specialized firms. The results implied that these firm's bargaining power was limited (adverse demand shock), albeit providing a signal of some employer's monopsonistic power (adverse labor supply shock). All in all, specialized firms emerged as not quite resilient to adverse shocks.

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Tables and Figures

TABLE I. Firm Characteristics by Different Levels of Specialization

	Low specialization			High specialization		
	Mean	St.Dev.	N Firms	Mean	St.Dev.	N Firms
Avg Ln Wage	3.90	0.69	29,774	4.07	0.52	54,728
Within Firm Wage Dispersion	0.45	0.45	29,774	0.48	0.31	54,728
Business Volume	11,700	159,000	27,863	33.90	625,000	50,338
Average Number of Employees	234.07	544.25	29,774	432.63	1,518.50	54,728
Average Employee Age	38.29	7.79	29,774	40.94	5.66	54,728
Average Employee Tenure	1,791.62	1,389.71	29,774	2,573.66	1,575.68	54,728

Notes: The specialization proxy EG is the average level of specialization across years. Low specialization equals 1 if firm's EG is less than mean EG across firms. High specialization equals 1 if firm's EG is greater or equal than mean EG across firms. Within firm wage dispersion denotes the standard deviation of wages by firm and by year. Business volume is expressed in 10,000 euro. Average measures are computed by firm and by year. Tenure is the number of days within an establishment.

TABLE II. Regressions with a Demand Shock. Data from LIAB9310+Eurostat

	(1) Productivity	(2) Separations	(3) Separations	(4) Net Employment	(5) Avg Wages
Downturn	0.028	-0.070	0.214	-0.193	-0.024
	(0.066)	(0.103)	(0.120)	(0.186)	(0.011)
Downturn x Special	-0.065	0.003	0.013	0.079	0.017
	(0.037)	(0.062)	(0.143)	(0.134)	(0.007))
Observations	32,103	48,456	48,456	48,456	61,947

Notes: All dependent variables are midpoint changes. Col (1): change in productivity is the firm value added divided by the number of employees; col (2): annual absolute change in separations; col (3): annual change in separations relative to employment within the firm; col (4): annual change in hires minus annual separations; col (5) annual change in the average of gross daily wages paid by the firm. The specialization proxy (EG) is the average level of specialization across years. Regressions in col (1) to (4) control for firm lagged size, year and interactions of covariates and the downturn dummy. Regression in col (5) controls for firm size, year and interactions of covariates and the dummy. Grouped data regressions, weighted by firm. Fixed-effect estimates at the firm level. Standard errors clustered at the industry level, in parentheses.

TABLE III. Firm Characteristics. With and Without a Death

	Without a Death			With a Death		
PANEL A: ALL FIRMS	Mean	Sd.Dev.	N Firms	Mean	Sd.Dev.	N Firms
Ln AvgWage	3.99	0.59	81,645	4.28	0.47	2,857
Average Business Volume	24,400	506,000	75,612	72,800	628,000	2,589
Average Size	339.10	1223.51	81,645	1,036.30	2,067.68	2,857
Annual Net Employm Change	-2.45	27.81	81,645	-23.86	137.84	2,857
Average Employee Tenure	2,253.78	1,529.59	81,645	3,564.94	1,814.66	2,857
Average Employee Age	39.91	6.67	81,645	42.76	3.84	2,857
PANEL B: SMALL FIRMS	Mean	Sd.Dev.	N Firms	Mean	Sd.Dev.	N Firms
Ln AvgWage	3.61	0.66	16,999	3.70	0.74	46
Average Business Volume	126.91	1,880.00	15,811	260.53	759.17	35
Average Size	5.36	2.49	16,999	5.93	2.59	46
Annual Net Employment Change	-0.90	16.01	16,999	-27.5	127.33	46
Average Employee Tenure	2,462.35	1,648.91	16,999	2,629.63	1,793.01	46
Average Employee Age	41.68	7.72	16,999	45.23	6.20	46

Notes: The sample excludes firms that experience the death of more than one employee within a calendar year. Ln AvgWage is the natural logarithm of the average gross daily wages (in euros) paid by a firm within a year. Business volume is expressed in ten thousands. Average Employee Tenure is the average number of days the employee worked within a firm. Average Size is the average number of employees by firm within a year. Annual Net Employment Change is the number of annual hires minus annual separations.

TABLE IV. Deceased Replacement Regressions

	(1) TTR	(2) TTR	(3) TTR	(4) TTR	(5) TTR	(6) TTR	(7) TTR	(8) TTR
Specialization	1.934	1.944	1.969	1.994	1.957	1.969	1.984	1.995
	(0.408)	(0.410)	(0.438)	(0.431)	(0.413)	(0.413)	(0.430)	(0.432)
Tenure			-1.129	-1.070			-1.154	-1.133
			(0.421)	(0.423)			(0.506)	(0.509)
Spec X Tenure			-0.697	-0.661			-0.631	-0.613
			(0.255)	(0.255)			(0.259)	(0.259)
LMktAgglom					-47.964	-51.923	69.924	72.678
					(36.822)	(36.498)	(59.870)	(60.071)
Spec X LMktAgglom					-33.885	-36.333	60.915	64.110
					(22.799)	(22.475)	(46.505)	(46.621)
Spec X Tenure X LMktAgglom							-20.142	-21.915
							(11.146)	(11.060)
Surving Employees Charact	No	Yes	No	Yes	No	Yes	No	Yes

Notes: Number of observations: 12,925. The dependent variable TTR is the natural logarithm of the number of days requested to replace a dead employee. The specialization proxy (EG) is the average level of specialization across years and its standard deviation is 0.52. Tenure is the number of days the employee worked within an establishment. LMktAgglom is the ratio between individuals in the deceased's occupation within the firm's district and individuals in the deceased's occupation in total employment. Grouped data regressions (weighted by firm) control for size, industry, region and year. Standard errors in parentheses are clustered at the firm level.

TABLE V. Regression DD estimates - The effect of the death of an employee on labor productivity and average wage

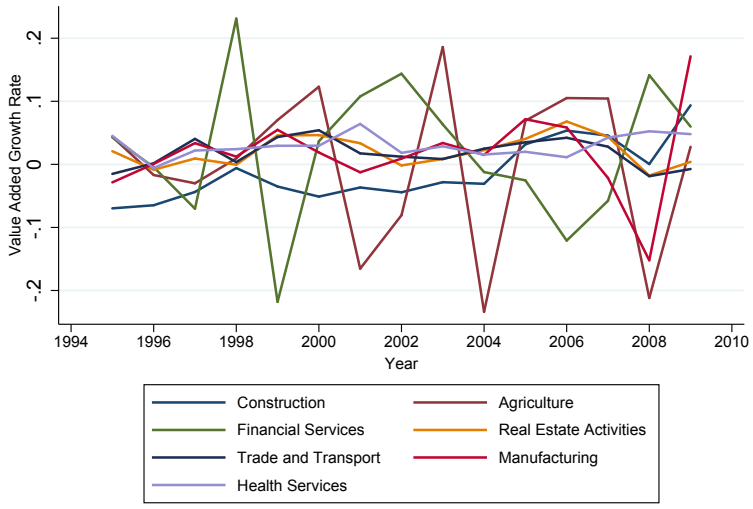
	All firms				Small firms			
	(1) Ln Prod	(2) Ln Prod	(3) Ln AvgWage	(4) Ln AvgWage	(5) Ln Prod	(6) Ln Prod	(7) Ln AvgWage	(8) Ln AvgWage
YearOneDRDth X Special	0.000	0.002	-0.017	-0.008	-0.016	-0.005	-0.172	-0.166
	(0.027)	(0.025)	(0.005)	(0.004)	(0.083)	(0.083)	(0.089)	(0.085)
YearTwoDRDth X Special	-0.070	-0.063	-0.016	-0.009	-0.129	-0.133	-0.180	-0.182
	(0.026)	(0.025)	(0.004)	(0.004)	(0.107)	(0.110)	(0.105)	(0.104)
YearThreeDRDth X Special	-0.064	-0.057	-0.013	-0.007	-0.348	-0.370	-0.108	-0.114
	(0.035)	(0.033)	(0.005)	(0.005)	(0.199)	(0.206)	(0.058)	(0.057)
YearFourDRDth X Special	0.006	0.009	-0.005	0.001	0.026	0.024	0.028	0.027
	(0.025)	(0.024)	(0.008)	(0.008)	(0.166)	(0.157)	(0.078)	(0.078)
YearFiveDRDth X Special	0.030	0.033	0.003	0.008	0.074	0.086	0.116	0.114
	(0.019)	(0.020)	(0.006)	(0.005)	(0.104)	(0.105)	(0.122)	(0.124)
Leads and lags of Covar	No	Yes	No	Yes	No	Yes	No	Yes
No. of Observations	4,393,439	4,393,439	7,395,888	7,395,888	60,727	60,727	83,585	83,585

Notes: Small firms are those with less than 10 employees. Ln Prod is the natural logarithm of the value added divided by the number of employees working in a firm. Ln AvgWage is the natural logarithm of the average gross daily wages (in euros) paid by a firm within a year. All regressions control for size (except productivity regressions that control for lagged size), level of education, age, age squared, occupational status, gender, industry, region and interactions of covariates and the DRDth dummies. Grouped data regressions, weighted by firm. Fixed effect estimates at the firm level. Standard errors in parentheses are clustered at the firm level.

FIGURE I. German Gross Domestic Product - Growth Rate (1994-2009)

Source: Eurostat

FIGURE II. German Industry Value Added - Growth Rate (1995-2010)



Source: Eurostat

FIGURE III. Summary Statistics of Deceased and Surviving Coworkers (in percentages)

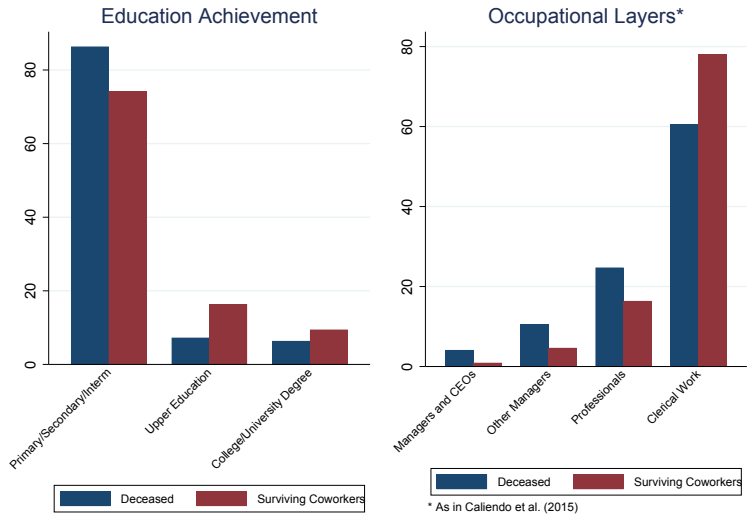


FIGURE IV. Summary Statistics of the Deceased and Surviving Coworkers (in percentages)

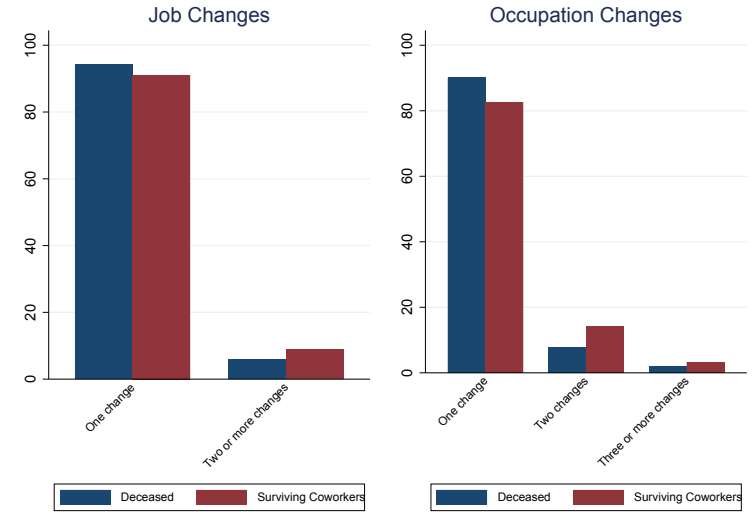
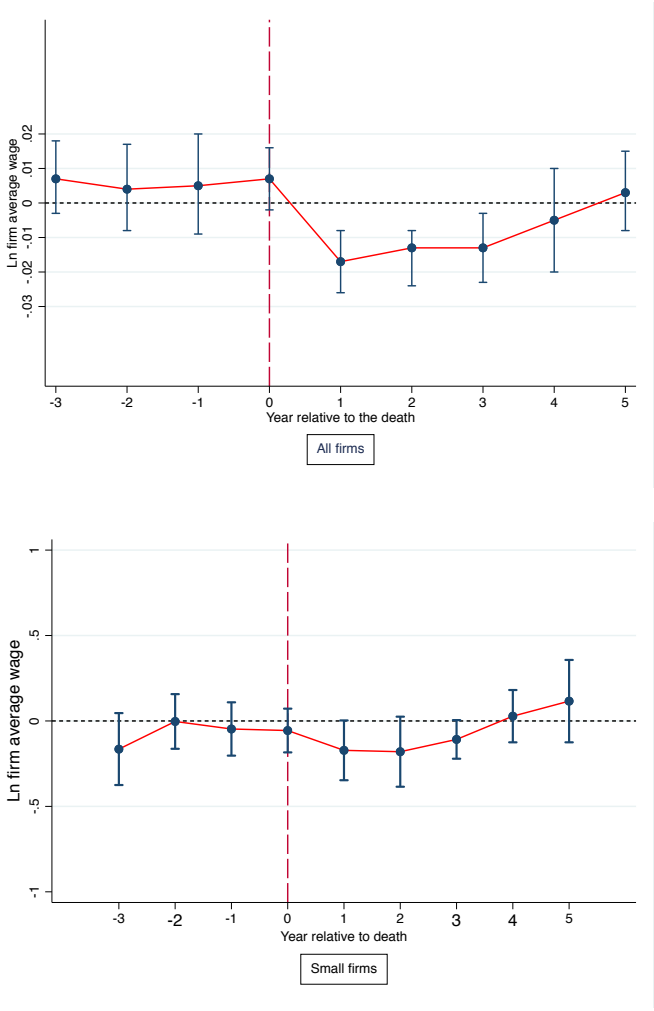


FIGURE V. Differential Effect on Deceased's Coworkers Wage for Specialized Firms



Notes: Regression coefficients and associated 95 percent confidence intervals of the differential effect of being a specialized firm (i.e. the interaction between the dummies DRDth and the specialization variable EG). Average wages grouped data regressions, weighted by firm. Fixed effect estimates at the firm level. Standard errors are clustered at the firm level.

Appendix A: Data and Variables Description

A *Data*

Employer-employee data (LIAB LM9310) and Establishment Panel

The analysis combines German linked employer-employee data (LIAB[17] LM9310) with the waves of surveys[18] from the unbalanced IAB Establishment Panel (1993-2010). The sample consists of around 9 million observations excluding those in Public Administration and Defense; Political Parties; Educational, Scientific and Cultural Organizations; Christian Churches and Representations of Foreign Countries,

National Accounts (Eurostat)

The data regarding downturns come from German National Accounts (Eurostat), which provide different national macroeconomic indicators, aiming to convey an overall view of the country's economy. In particular, the study focuses the gross value added[19] — by industry breakdowns, according to NACE Rev.2 classification. This data is merged with LIAB 9310 through the industry code.

B *Dependent Variables*

B.1 Midpoint changes

These are changes in separations, the net employment and the variables described below.

[17] LIAB matches establishment data (BHP Establishment History Panel) to administrative biographies of individuals (IEB Integrated Employment Biographies).

[18] These surveys' sampling frame is all establishments covered by the social security system, stratified according to industry, firm size and federal state. Consequently, the data is considered representative of the German firm population.

[19] Eurostat defines gross value added as the output value (at basic prices, in euro) minus intermediate consumption (valued at purchasers' prices), and calculates it before consumption of fixed capital (http://ec.europa.eu/eurostat/web/national-accounts).

B.2 Labor productivity

It is defined as the value added divided by the number of employees working in firm j at time t. In turn, the value added equals the business volume (sales in euro) minus intermediate inputs (e.g. all raw materials and supplies purchased, external services, rents, etc.)[20]

B.3 Average wages

The variable is computed as the average of gross daily wages (in euros) paid by firm j at time t.

B.4 Time to Replace

It is the natural logarithm of the number of days needed to hire a new employee after an employee unexpectedly dies (i.e. excludes firms that do not replace the deceased).

C *Independent Variables*

C.1 The Specialization Proxy (EG)

For computing the specialization proxy variable, we work with all individuals employed in one of the surveyed establishments for at least one day during the studied period. The data contains information of around 330 titles provided in the 3-digit coded Classification of Occupations (Systematic and Alphabetical Directory of Job Titles, KldB88). Employers encode an employee's occupation with the title that best defines the main activity performed (i.e. even if more than one title could apply to one employee), in accordance with any of the German systematic classification of occupations.

The proxy of specialization is the dynamic version of the Ellison and Glaeser Index (hereafter EG)[21] applied in this case to compute the distribution of occupations in a firm. Given its construction, one advantage of working with EG is that it tells us

[20] As productivity is computed using the current number of employees, productivity regressions include the lagged size as a control (to avoid working with a simultaneously determined regressor).

[21] Dumais, Ellison, and Glaeser (2002) apply the Ellison and Glaeser Index to measure the geographic concentration of industries. The original version was proposed by Ellison and Glaeser in 1997.

to what extent the distribution of occupations in a firm departs from the distribution of occupations within a specific industry.

This index is corrected by the Herfindahl-style measure to account for the fact that the concentration of occupations should be larger in small firms. It compares the degree of concentration of occupations within an establishment to the concentration of occupation of other establishments within the same economic activity. The EG index is given by:

$$EG_{jt} = \frac{G_{jt}/(1 - \sum_s S_{st}^2) - H_{it}}{1 - H_{it}} \tag{9}$$

where:

N_{kjst} is the number of workers in occupation k working in establishment j, sector s, at time t.

N_{jst} is the total number of workers in establishment j, sector s, at time t.

$k = 1, ..., K$ are the 3-digit coded occupations.

i=1,...,n indicate the different establishments.

$s = 1, ..., m$ represent 3-digit coded industry according to the WS73 or Classification of Economic Activities for the Statistics of the Federal Employment Services (1973). Before 2003 the variable contains the original values and from 2003 this information is continued or recoded (if necessary). It includes primary economic activities, manufacturing, construction and services.

$t = 1, ..., T$ are the different split episodes, which are non-overlapping periods.

S_{jst} is the establishment occupation share computed as N_{kjst}/N_{jst}.

S_{st} is the average of S_{jst} within each industry.

$G_{jt} = \sum_s (S_{jt} - S_{jt})^2$ is the sum of squared deviations of establishment occupation share S_{jst} from a measure S_{st} of the share of occupations within a specific industry.

$H_{it} = \sum_k b_{jt}^2)/(\sum_k (b_{jt})^2$ is a Herfindahl-style measure where b_{jt} is the number of occupations within an establishment at different split episodes.

Specialization is considered a firm pattern and is computed as the EG firm average across years.

C.2 Downturn

The $Down_{kt}$ variable is based on the industry aggregated gross value added[22] by industry breakdowns, according to NACE Rev.2 classification. The variable $Down_{kt}$ equals 1, indicating downturns if $VA_{k(t)} < VA_{k(t-1)}$ and 0 otherwise.

C.3 Dummies relative to the death

The $DRDth_{jt}$ dummies are eight — for years -3 to 5 relative to the death (e.g $DRDth_0$ is the dummy for the year of the death and $DRDth_3$ is the dummy for the third year after the death). They are based on employer's notifications to the social security system. These records are sent at least once a year or when there are special reasons for notification such as employment interruption, unemployment, employee's illnesses, death, etc. These dummies equal one in the relevant year — for employers that meet the following conditions: (a) they sent the social security agencies one notification stating that the end of the spell is due to the death of an employee occurred between July 1 and June 30 of the previous year, (b) the deceased has not been lingering with any health condition (i.e. the employee who dies, does not have an employment interruption notification that entitles him to compensation for six months or more, due to illness). The $DRDth_{jt}$ dummies are zero, otherwise. The samples exclude firms with multiple death notification within a year — these are 61 firms. The logic for excluding these firms is twofold: ruling out collective accidents or disasters, and avoiding further selection bias derived from the heterogenous recovery speed after the death of an employee.

C.4 Agglomeration

It reflects the preponderance of employment in a specific occupation within a particular area (Glaeser, 2007). Specifically, high levels of local agglomeration of employees in an occupation — say for instance due to the presence of an industry cluster, can correlate with a pool of potential specialists or individuals with a specific skill in the local labor

[22]Eurostat defines gross value added as the output value at basic prices less intermediate consumption valued at purchasers' prices and it is calculated before consumption of fixed capital (http://ec.europa.eu/eurostat/web/national-accounts).

market.

In this case, the variable $Agglom_l$ reflects the availability of an occupation within a district (5-digit code *Kreis*). Agglomeration represents the probability of finding an individual who works in the deceased's occupation within the district where the deceased used to work. It is computed as the ratio between individuals in the deceased's occupation within the firm's district and individuals in the deceased's occupation in total employment.

C.5 Control Variables

X_{jt} are firm size or lagged firm size (i.e. in productivity regressions), calendar year dummies, sector and region; as well as individual characteristics X_{ijt} (age, age squared, school education level and vocational training such as upper secondary school, university degree, etc.), occupation status (blue-collar, white collar, trainee, apprentice, etc.) and gender.

For the demand shock regressions, additional controls are the interactions between the $Down_{kt}$ indicator variable and the other covariates. For the supply shock regressions, additional controls are the interactions between the $DRDth_{jt}$ indicator variable and the other covariates as well as the interactions and leads and lags of those interactions.