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The Productivity Effects of Excess Labour Turnover in Young Firms

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Abstract
This paper assesses the effects of worker replacement (excess labour turnover) on the productivity of young firms. Young firms are prone to most risk factors for excessively high turnover rates and are not covered by most of the existing literature on effects of labour turnover on firm performance. Existing research on the effects of worker replacement on the performance of established firms is difficult to relate to young firms and shows ambiguous results. Using structural identification to account for potential endogeneity of worker replacement, this paper finds that worker replacement has negative effects on the productivity of young firms. It is disproportionally deleterious in igh-tech manufacturing startups, startups which employ highly educated employees, and in young firms above the median size and age of the sample. A robustness check indicates that these results are driven by firms with a high share of quits (by employees) on total separations. Replacements in the sequel of dismissals, initiated by young firms themselves, seem to be less detrimental.

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1 Introduction

Employment in young firms accounts for a considerable share of total employment in an economy. Besides jobs for the founders themselves, many startups start to create jobs for additional employees early in their lives. By doing so, they compete against other young and established firms for the most capable employees. However, while there is extensive research on the start-up size and growth of young firms, only very little is known about labour turnover and potential consequences of labour turnover for young firms. Labour turnover is a common phenomenon in labour markets. On the aggregate level, as well as on the firm level, essentially more worker flows than job flows can be observed (Hamermesh et al., 1996; Lane et al., 1996a). On the aggregate level, this observation can be explained by a reallocation of workers between firms. On the firm level, so called ”excess” labour turnover (also named churning by some authors) occurs due to replacements of employees. When an employee is hired only to replace another employee, no employment increase or decrease is triggered by the hiring. Labour turnover due to worker replacement therefore occurs in excess of the labour turnover that would be necessary due to a decline or an increase in employment size. Nevertheless, the replacement leads to two worker flows - one into the firm and one out of the firm - that have to be managed. While the inflow of human capital can bring new knowledge and ideas into a firm, the outflow of human capital can be associated with a loss of important tacit knowledge and adjustment costs (e.g. search costs for new employees or costs associated with the training of new employees). This might have major implications for the future development of a young firm.

However, there are almost no economic studies that deal with the consequences of worker replacement for the performance of young firms so far. Rather, studies reversely explain worker replacement by firm performance and consider potential simultaneous effects, but do not unravel these effects in more detail (Faberman and Nagypál, 2008). Studies on the consequences of worker replacement on the performance of established firms are rare and their results are mixed. While most authors conclude that negative effects predominate (Lane et al., 1996b; Burgess et al., 2000a,b; Mamede and Mota, 2012), some papers report inverted u-shaped (Müller and Peters, 2010) or even strictly positive relationships (Ilmakunnas et al., 2005). For several reasons, the transferability of results about labour turnover in established firms is limited. Firstly, small firms are not represented by most studies on labour turnover at all. To avoid frictions in the analysis, most studies systematically exclude small firms from their samples and most young firms are still small. Secondly, young firms might be more financially restricted in competing with established firms for the best employees. Therefore, highly qualified employees with well remunerated outside options might be responsible for a disproportionately high share of worker quits in young firms. Thirdly, and maybe most importantly, hierarchies in new ventures can be considered to be mostly flat and processes within those ventures to be often informal and not yet standardised. One single employee might bear a much larger share of important tacit knowledge than in larger established firms. The inflow or outflow of one single employee might trigger much larger frictions for a new venture - compared to an established firm - therefore.

The focus of this paper is to unravel how worker replacement affects the productivity of young firms. Due to the mixed findings about the consequences of worker replacement for established firms the relationship is tested very generally at first. It is asked whether worker replacement affects the productivity of young firms at all and if yes, whether an optimal replacement rate can be identified. Research on the extent of labour turnover in established firms suggest differing results according to firm size, firm age, and industry (Lane et al., 1996b). This seems reasonable since costs for on-the-job training of new employees should differ highly between different industries. For example, one might expect the replacement of employees to be less costly in low-tech services firms compared to high-tech manufacturing firms. Firm age and size might be associated with the availability of corporate knowledge about recruiting techniques and the buildup of specialised human resource divisions to manage worker flows. This could moderate the consequences of worker turnover. Thus, this paper analyses whether different levels of excess turnover which can be expected over the industry, firm age and firm size distributions reflect optimal behaviour or whether they bring forth consequences for firm performance. The extent of labour turnover and its impact on firm performance are also likely to depend on the capability of its managers to manage worker flows (Lane et al., 1996b) and on the human capital of the employees involved in this flows (Mamede and Mota, 2012). Therefore, this paper considers differing productivity effects dependent on the human capital of founders and employees, i.e. the managerial and entrepreneurial experience of the founders and the qualification structure of the workforce.

By addressing these questions, this paper contributes to two streams of literature: Firstly, it is the first paper to study the effects of excess labour turnover on firm performance in the specific context of young firms. Thus, it has important managerial implications for personnel strategies of young firms. Secondly, this paper helps to deepen the general understanding of the effects of labour market flows on firm performance. Productivity is chosen as a very broad and direct measure of firm performance. It should be less affected by mediating factors than other potential performance measures like survival or profits. The likely endogeneity of worker replacement is taken into account by using structural identification methods for production functions proposed by Levinsohn and Petrin (2003) and Ackerberg et al. (2006). Possible impacts of additional factors which might compromise identification, e.g. omitted variables in the production function, are discussed and addressed in robustness checks. Using data from the KfW/ZEW Start-Up Panel, a representative dataset on young German businesses, this paper finds that excess worker turnover has negative effects on the productivity of young firms. A robustness check indicates that these results are driven by firms with a high share of quits (by employees) on total separations. Replacements in the sequel of dismissals, initiated by young firms themselves, seem to be less detrimental. Worker replacement is disproportionally deleterious in high-tech manufacturing startups, startups which employ highly educated employees, and in young firms above the median size and age of the sample.

2 Related literature

Two streams of literature offer especially interesting starting points for the empirical analysis in this paper. Firstly, literature that studies the occurrence of labour turnover and identifies risk factors for involuntarily high labour turnover rates. Secondly, streams of literature that deal with the effects of (excess) labour turnover on firm performance.

Amongst other, match quality and firm performance can be risk factors for (involuntarily) high labour turnover rates. Lane et al. (1996b) analyse the occurrence of labour turnover on the firm level. They find that labour turnover rates vary substantially between firms of different size, age, and industries but are persistent on the firm level. This persistence is explained by differing abilities of managers to manage worker flows and to guarantee good matches between the firm and the employee. With respect to this match quality, theoretical considerations of Jovanovic

(1979) show that the probability of separation is higher the shorter the respective job tenures are. Jovanovic assumes the true quality of the match between employer and employee to be revealed after a contract is made. Bad matches lead to fast separations, good matches survive longer. Thus, the probability of separation is highest when job tenures are short and decreases the longer tenures last. Other reasons for worker replacement due to bad matches might be little experience in recruiting (Lane et al., 1996a) and strong employment growth in previous periods (Burgess et al., 2000a). In both cases the match quality between employer and employee worsens because the management cannot assure the quality of each single match. This triggers a need for subsequent replacement.

A second set of firm-level risk factors for involuntarily high labour turnover rates is related to the economic situation of the firm. Faberman and Nagypál (2008) present a theoretical framework which relates firm productivity to worker flows. Their model predicts an increasing outflow of human capital for firms with bad productivity. In their framework, firms are only willing to replace quitting workers within certain productivity thresholds. However, while the authors consider potential simultaneous effects between outflows of human capital and a further deterioration of firm performance, they do not illustrate this aspect. Doing so might have important implications for personnel strategies of firms. Related to this, in several empirical studies low wages are shown to be important drivers of labour turnover. Amongst others, Martin (2003) and Ilmakunnas and Maliranta (2005) demonstrate this relationship.

These risk factors seem to be relevant for young firms. Due to the young age, job tenures in startups are short by definition. Often management experience of the founder(s) is still limited. Corporate learning about hiring practises is still developing and specialised human resource departments taking care of the selection of new employees might not be available. In addition, employment growth, as well as potential downturns, are most pronounced at a very young age. Finally, young firms' possibilities on the labour market are limited. E.g. Brixy et al. (2007) show that especially very young German startups often pay lower wages than established firms. This might lead to an unfavourable outflow of human capital.

As a reflection of its uncertain consequences, the existing findings about the effects of excess labour turnover on the performance of established firms are mixed. Müller and Peters (2010) study the impact of worker replacement among R&D-personnel on firms' innovative productivity. They find an inverted u-shaped relationship and conclude that moderate constant exchange of R&D-personnel is favourable for the innovative capacity of established firms. Closest to the research presented in this paper, Ilmakunnas et al. (2005) analyse the impact of worker replacement on total factor productivity. They find a strictly positive impact of worker replacement on productivity. Constantly replacing employees leads to productivity gains which the authors attribute to an increase in match quality. Potential endogeneity of the worker replacement measure, which might bias the results, is not addressed however. Burgess et al. (2000a) analyse worker and job flows and find a complex dynamic interconnection between the two. As discussed above, past job flows increase subsequent worker replacement. In turn, increasing worker replacement effects subsequent growth negatively. Other empirical papers highlight the interrelation between labour turnover and firm survival. Lane et al. (1996b) and in more detail Burgess et al. (2000b), as well as Mamede and Mota (2012) analyse hazard rates and report worker replacement to be associated with a lower probability of survival. According to Lane et al. (1996b), these negative consequences of worker replacement on firm survival are highly dependent on the industry sector. In addition, Burgess et al. (2000b) report negative consequences on survival especially for young firms with very high worker replacement rates. Therefore, their study is one of the scarce exemptions to report insights on young firms. However, the finding is only a side note in their study and it is not possible to assess if the relationship is causal. In their recent working paper, Mamede and Mota (2012) confirm negative effects of worker replacement on firm survival. Interestingly, they find the effects of worker flows on firm survival to be more pronounced if highly skilled workers are involved. This holds for both, negative effects due to separations of high-skilled employees and positive effects due to high-skilled hirings.

3 Empirical setup

3.1 Model Choice

3.1.1 Productivity model

The empirical part of this study aims to establish whether worker replacement in young German businesses affects their productivity. Therefore, productivity is modelled by an augmented Cobb-Douglas production function and estimated in log-linear form:

$$lnY_{it} = \alpha + \beta lnL_{it} + \gamma lnK_{it} + \rho WRR_{it} + \theta X_{it} + u_{it}$$

Y denotes real value added. L is the full-time equivalent size of the labour force, K denotes capital, and WRR the worker replacement rate of a firm. X contains additional control variables: the logarithmic age of a firm, a dummy variable indicating whether a firm is a limited liability corporation, dummy variables to indicate whether the founder of a firm has prior experience as an entrepreneur or has gained managerial experience as an employee[1], per capita gross value added in the federal state and the industry a firm operates in (to control for macroeconomic influences on firm level productivity), as well as industry and time dummies. More details on the measurement of variables are provided in Section 3.3 and Section 3.4.

3.1.2 Estimation & identification strategies

To identify causal relationships when estimating production functions, (potential) endogeneity of variable production factors must be taken into account. Endogeneity can stem from simultaneity between a productivity shock and the use of variable inputs in the production function. If a productivity shock is anticipated by the firm but unobserved or not measurable by the economist, the estimated coefficients of variable inputs can be expected to be biased upwards and those of fixed inputs to be biased downwards. This might happen since firms are assumed to expand production in anticipation of a positive productivity shock and use more variable inputs in the production process (see Ackerberg et al. (2006) for a survey of procedures to tackle the endogeneity problem). While classical production function literature is mainly concerned with the endogeneity of the flexible production factor labour, the same reasoning holds for the worker replacement measure in this study. In anticipation of a negative productivity shock not observed in the productivity model, firms could decide to replace unproductive employees. Alternatively, employees with high productivity could decide to voluntarily leave the firm, since

[1]For founding teams at least one of the founders must have managerial experience as an employee.

they are able to get better remunerated positions in more productive firms.[2] Applying the same reasoning for identification as used with labour input, the measure for worker replacement is treated as an additional variable input into the production function.

Olley and Pakes (1996) suggest a semi-parametric procedure to identify the coefficients of production functions. They propose to use structural assumptions about the optimal behaviour of a firm in the production process and investments in the period the shock occurs as proxy variable, to model the unobserved productivity shock in the estimation. However, this procedure is only feasible if the proxy variable is non-zero and monotonically increasing in the productivity shock. This makes the choice of the proxy variable problematic in the case of startups. Often, young firms do not invest continuously but with gaps of several years in between. This leads to many zero values (approximately 32 % of the observations in the sample used in this study) in the investment series of a firm and makes the investment proxy hardly feasible. Levinsohn and Petrin (2003) (LP henceforth) modify the procedure of Olley & Pakes and suggest to use intermediate inputs (e.g. materials) as proxy. Since materials are needed to derive output as value added in this study anyway and the proportion of zero values is distinctly smaller (approximately 2 % of the observations), the LP procedure seems to be a superior choice here.[3]

The basic intuitions and assumptions behind the LP procedure are the following (Levinsohn and Petrin (2003) and Petrin et al. (2004)): The capital stock is assumed to be a fixed input in the current period t and not affected by a potential unobserved productivity shock. In contrast, variable inputs into the production function (e.g. labour and intermediate inputs) are considered to be freely adjustable in t and therefore potentially affected by an unobserved productivity shock. The error term of the production function equation u_{it} is assumed to consist of two parts: $u_{it} = v_{it} + \epsilon_{it}$. v_{it} is known by the firm but unknown by the economist, ϵ_{it} is an innovation unknown to both the firm and the economist. Assuming that a firm's demand for intermediate inputs depends on the fixed capital level and is strictly increasing in the productivity shock, the demand for materials can be expressed as a function of capital and the productivity shock: $lnM_{it} = f(v_{it}, lnK_{it})$. Under the condition that the demand for materials increases monotonically for all levels of the productivity shock this function can be inverted to $\hat{v}_{it} = f^{-1}(lnM_{it}, lnK_{it})$ to obtain a measure for the unobserved productivity shock. LP suggest to approximate $\hat{v}_{it}$ with a third order polynomial in lnM_{it} and lnK_{it} and to include this proxy in the first stage of the estimation procedure to obtain unbiased OLS estimates of the variable inputs.[4] Assuming that the productivity shock follows a first-order Markov process, the coefficients for capital and materials can be disentangled in the second step of the estimation procedure using a non-linear least squared regression. Finally, the standard errors are derived using a bootstrap procedure to account for estimations on both stages.

The most crucial assumption might be that a firm's labour input is seen as freely variable. In general, this might be hard to justify in the rigid German labour market. However, there is an exclusion from dismissal protection for small firms in German law, known as "small firm

[2]Such behaviour is explained within the theoretical framework of Faberman and Nagypál (2008)

[3]Ackerberg et al. (2006) discuss the limitations of the approaches suggested by Olley and Pakes (1996) and Levinsohn and Petrin (2003) and suggest a modified estimation method. Their procedure is implemented as a robustness check.

[4]A (smoothed) graph of the relationship between materials, capital and the estimated productivity shock is shown in Figure 1 in the appendix. The estimated productivity shock is measured on the vertical axis, capital and materials on the horizontal axes. The use of materials is higher for all levels of capital input and all levels of the estimated productivity shock.

clause". Firms which employ ten employees or less are not restricted by dismissal protection in Germany. Roughly 90 % of the sample used in this study fall under this special legislation.[5]. To address this problem more formally, results are checked for robustness using an estimation approach suggested by Ackerberg et al. (2006). This approach allows lagged variable inputs into the production function to influence productivity and relaxes the timing assumptions therefore Parrotta and Pozzoli (2012). This might also offer a more realistic scenario for the impact of worker replacement on productivity therefore. In the following, presented baseline estimations are conducted by pooled OLS with cluster robust standard errors and than confirmed by the semi-parametric approach suggested by LP. All estimations are done in Stata. Results for LP approach are estimated using the routine implemented by Petrin et al. (2004). Results do not change qualitatively when models are re-estimated by the procedure suggested by Ackerberg et al. (2006).[6]

An important limitation of this study is the inability to control for human resource management practises implemented by the firms or the existence of an own human resource department. These factors could influence both the degree of labour turnover and the productivity of the employees (e.g. by influencing motivation) and impair the identification of a causal effect of worker turnover on productivity. However, it is argued that such factors are covered to a large extent by controlling for the skill level and professional experience of the founders, firm age and firm size.

3.2 Data

The empirical analysis is based on the first six survey waves of the KfW/ZEW Start-Up Panel[7], a yearly survey of newly established firms representative for Germany. The panel was started in 2008 with a survey of about 5,500 firms founded as legally independent companies between 2005 and 2007. A follow-up survey of firms which have already participated in the survey is conducted in each of the subsequent years since. In addition, each year the dataset is enhanced with a sample of new firms which have been founded within the last three years. By now, the database contains information on 15,300 firms founded between 2005 and 2012. The sample is a stratified random samples drawn from the population of all firm creations which are recorded by Creditreform (Germany's largest credit rating agency). The stratification criteria are the year of foundation, the industry and funding by the KfW. The main goal of the stratification is an oversampling of high-tech startups which allows to conduct separate analyses for this groups of startups.[8] Detailed information about the founders, their human capital, the firms' labour demands, and indicators of firm performance are retrieved by computer-assisted telephone interviews. More detailed information on the survey design of the dataset is provided in Fryges et al. (2010).

There are some restrictions on the data used for estimation in the empirical section of this paper. Since costs of materials can only be identified from the third survey wave onwards, only data points from 2009 to 2012 are used. Since calculating the worker replacement measure as a rate involves dividing by the average number of employees, all estimations can only be done

[5]As a further robustness check, firms that do not fall under the "small firm clause" were deleted from the sample. This does not alter the results.

[6]Results of the robustness check are available from the author upon request.

[7]The KfW/ZEW Start-Up Panel is a joint project of the Centre for European Economic Research (ZEW), the KfW-Bankengruppe, a publicly-owned bank, and Creditreform (Germany's largest credit rating agency)

[8]Stratification criteria are controlled for in all regressions and extrapolated descriptive statistics.

for startups with at least one employee. All variables measured in monetary units are converted to 2010 prices using a GDP price deflator series provided by the German Federal Statistical Office. Additional data, for a gross value added index series, is taken from data provided by the Statistical Office of the Federal State of Baden-Württemberg. To adjust for erroneous data, the largest percentile of all variables measured in monetary values and of the worker replacement rate is cut.

3.3 Worker replacement measure

To measure worker replacement, a slightly adjusted version of the churning rate introduced by Burgess et al. (2000a) is used. Burgess et al. consider all worker flows in and out of a firm that occur in a period and define churning flows as the difference between worker flows and job reallocation. Worker flows equal all hirings plus all separations. They measure the total amount of worker turnover that occurs in a firm in a period. The job reallocation in a firm is measured as the absolute value of the difference between hirings and separations ($Job\,reallocation = |Hirings - Separations|$). Thus, it measures the net change of a firm's employment size. Job reallocation equals the lower bound of worker flows that are necessary to adjust the labour force of a firm for changes in it's labour demand. All worker flows that exceed this lower bound occur just to replace existing workers. May it be because workers quit, because they are dismissed or because they leave the workforce (e.g. because of retirement). Therefore, churning is employment-neutral and allows to separate labour turnover, due to an adjustment to economic conditions, and additional "exceeding" labour turnover. The employment neutrality makes the churning measure particularly useful for the analysis of young firms, which are often subject to enormous frictions in their development. Since their need for a steady adjustment of labour inputs might be very high, analysing firm performance based on turnover measures incorporating all worker flows might less beneficial.

The aim of Burgess et al. (2000a) is to separate all worker flows that occur in a firm (in one period) into categories. The replacement of one worker leads to two churning flows: One hiring and one separation. The focus of this study is on the effects of worker replacement on firm performance however. Therefore, the churning rate is divided by two, to get a measure for the proportion of replaced employees, which is straightforward to interpret on the firm level.[9] Following Burgess et al. (2000a), to relate worker flows to the size of a firm, rates are calculated by dividing total churning flows by average employment in a period.

$$Worker\ Replacement\ Rate\ _{it} = \frac{Hirings_{it} + Separations_{it} - |Hirings_{it} - Separations_{it}|}{2 * 0.5 * (\#Employees_{it} + \#Employees_{it-1})}$$

3.4 Descriptive statistics

Descriptive statistics for variables that enter the estimations are reported in Table 1. Variables measured in monetary units enter the estimations in logarithmic form but are reported as absolute (deflated) values in the descriptive statistics table.

On average, the startups in the regression sample generate a real value added of 350,000 EUR per year. A histogram of the dependent variable, logarithmic real value added, is provided

[9]A comparable measure is used e.g. by Albaek and Sorensen (1998) and Müller and Peters (2010).

in Figure 2 in the appendix. The distribution of logarithmic real value added seems to be reasonably close to the (indicated) normal distribution. Using OLS as baseline model and at the first stage of the semiparametric estimator seems a justifiable choice with respect to the distribution of the dependent variable therefore.

The average size of the capital stock is 156,000 EUR. Following Levinsohn and Petrin (2003), the capital stock for a period is calculated as the sum of the depreciated capital stock of the last period and investments in the current period. Since no detailed information on depreciation rates is available for the firms, the capital stock of the forgone period is always depreciated by 10 %.[10]. The startups engage on average 5.6 employees (full-time equivalent workforce size including founders). The employment size is widespread and varies between 1 and 143 employees. Since founders contribute to value added they are included in the measure for labour input. However, they are excluded in the calculation of the worker replacement measure which is derived for dependently employed workers only and, in accordance with most literature on labour turnover, measured in headcounts. 27 % of the observations in the sample exhibit positive worker replacement rates. The average worker replacement rate is 11 %. More detailed information on the extent and the distribution of worker replacement in German startups is provided in the appendix.[11] The second and third sections of Table 1 demonstrate that firms with positive WRR are larger in terms of employment size and value added than firms with no worker replacement. There do not seem to be distinct differences in firm age however.

Firms are on average 3.7 years old (at the end of the respective reporting period). 46 % of the observations are from limited liability companies. 47 % of the observations are from firms whose founders are managerially experienced. Managerial experience is measured by a dummy variable which indicates whether the founder (or at least one of the founders in the team) worked in an executive position in dependent employment directly prior to the foundation of the startup. 37 % of the founders have entrepreneurial experience, which means that the founder (or at least one founder in the team) was self-employed before. On average 22 % of the workforce of the startups are highly qualified, i.e. they hold a university degree.

To control for macroeconomic conditions, real gross value added (GVA) in the federal state a firm operates in is included as an index series. To consider industry and period specific differences in the macroeconomic conditions a firm operates under, GVA is differentiated by year and a rough three sector industry classification (i.e. manufacturing, services & retail and construction). In addition, industry and year dummies are included. While data points are distributed relatively evenly over the four years from 2009 to 2012, the distribution of firms over different industries reflects the stratification criterion reported in Section 3.2. High-tech firms (first four industries) account for roughly 40 % of the estimation sample. About 14 % of the data points are from high-tech manufacturing firms (first two industries), another 27 % of the data points are from high-tech services firms (third and fourth industries).

[10]Other depreciation rates between 10 % and 15 % have been tested as a robustness check and do not alter the results remarkably.

[11]Please note that the deviation in mean WRR, compared to the extrapolated values reported in the appendix, is a consequence of the overrepresentation of high-tech startups in the sample. On average, high-tech startups report lower worker replacement rates.

Table 1: Descriptive Statistics

	Complete regression sample					No worker replacement			Positive worker replacement		
Variables	Obs.	Mean	Std. Dev.	Min.	Max.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Real value added	5613	350262.30	427760	987.77	4673189	4124	313616.60	392824.10	1489	451757.60	498503.10
Labour (# employees)	5613	5.63	6.23	1	143	4124	4.64	4.05	1489	8.37	9.54
Capital	5613	156310.30	294328.80	810	11000000	4124	142426.40	291976.30	1489	194764.00	297481.80
Materials	5613	186087.90	351711	101.03	5257337	4124	165469.60	310286.30	1489	243193.40	441958.00
Churning y/n	5613	0.27	0.44	0	1	4124	0.00	0.00	1489	1.00	0.00
Churning rate	5613	0.11	0.25	0	2	4124	0.00	0.00	1489	0.40	0.34
Age of firm	5613	3.72	1.64	1.08	8	4124	3.78	1.65	1489	3.57	1.60
Limited liability corporation	5613	0.46	0.50	0	1	4124	0.45	0.50	1489	0.51	0.50
Managerial experience	5613	0.47	0.50	0	1	4124	0.48	0.50	1489	0.46	0.50
Entrepreneurial exp.	5613	0.37	0.48	0	1	4124	0.36	0.48	1489	0.41	0.49
Highly qual. workers	5613	0.22	0.33	0	1	4124	0.23	0.34	1489	0.20	0.31
GVA p.c. (industry/state)	5613	102.65	7.38	78.50	129.32	4124	102.70	7.42	1489	102.51	7.27
Cutting-edge tech. manuf.	5613	0.08	0.27	0	1	4124	0.08	0.28	1489	0.06	0.23
High-tech manufacturing	5613	0.06	0.24	0	1	4124	0.06	0.24	1489	0.06	0.23
Technology-intensive services	5613	0.20	0.40	0	1	4124	0.22	0.41	1489	0.15	0.35
Software supply and consult.	5613	0.07	0.25	0	1	4124	0.07	0.25	1489	0.06	0.24
Non-high-tech manufacturing	5613	0.13	0.34	0	1	4124	0.13	0.34	1489	0.14	0.35
Skill-intensive services	5613	0.07	0.25	0	1	4124	0.07	0.25	1489	0.06	0.24
Other business-oriented serv.	5613	0.05	0.22	0	1	4124	0.04	0.21	1489	0.08	0.27
Consumer-oriented services	5613	0.11	0.31	0	1	4124	0.09	0.29	1489	0.17	0.37
Construction	5613	0.11	0.31	0	1	4124	0.10	0.30	1489	0.12	0.32
Wholesale and retail trade	5613	0.13	0.33	0	1	4124	0.13	0.34	1489	0.12	0.32
Year 2009	5613	0.20	0.40	0	1	4124	0.20	0.40	1489	0.19	0.40
Year 2010	5613	0.24	0.42	0	1	4124	0.23	0.42	1489	0.24	0.43
Year 2011	5613	0.27	0.44	0	1	4124	0.27	0.44	1489	0.28	0.45
Year 2012	5613	0.29	0.46	0	1	4124	0.30	0.46	1489	0.29	0.45

4 Empirical results

General results Main regression results are shown in Table 2. At first, the baseline model, without the measure for worker replacement, is estimated by pooled OLS with cluster robust standard errors (first column). Coefficients for labour and capital input are in a plausible range. Older startups, limited liability corporations, startups whose founders have prior management experience as employees, and startups which operate in a better macroeconomic environment (approximated by gross value added in the federal state and the industry) have significantly higher productivity. When the baseline model is re-estimated with the structural LP approach (second column), the labour coefficient decreases clearly and the capital coefficient increases slightly. This is the expected effect when endogeneity of the variable inputs is controlled for by the LP procedure and indicates the functioning of the approach in the setup of this study.

To address research question if worker replacement affects productivity, worker replacement is integrated in the model as an additional variable (third column for pooled OLS results, fourth column for LP). The estimated semi-elasticities indicate that worker replacement has a significant negative effect on the productivity of young firms. All other coefficients of the model remain stable. As expected, the coefficient of WRR increases slightly (from -0,106 to -0.095) when the model is estimated by the LP procedure but the qualitative implications do not change once potential endogeneity is taken into account. Since differences between pooled OLS and LP estimates are only minor for all specifications, only the slightly more conservative LP results are discussed for all remaining regressions. Corresponding OLS results are provided in Tables 5 and 6 in the appendix. To check for turning points in the relationship between labour turnover and productivity, squared WRR is considered in addition (fifth column). The coefficient of the squared term is insignificant, thus the negative relationship seems to hold over the whole distribution of the WRR. This result can be confirmed when worker replacement is integrated only as a dummy variable (sixth column). In general, firms with a positive WRR exhibit significantly lower productivity.

Sensitivity analysis A more detailed sensitivity analysis is conducted to better explain the origin of the observed negative relationship between worker replacement and productivity (see Table 3). The sensitivity analysis is performed by split sample analyses to asses the influence of subgroups of the sample on regression results. In addition, versions of the model are extended by interaction terms between WRR and several measures that potentially mediate the effect of labour turnover on productivity. As a first step of the sensitivity analysis, the regression sample is split into the larger and the smaller half of young firms according to their employment size (first and second column). This is done for two reasons. Firstly, to check for size effects in the relationship between labour replacement and productivity in general. Secondly, to make sure the results are not driven by basis effects in the calculation of the worker replacement rate. Since some of the firms are very small, the replacement of a single employee can trigger large WRR. The results rule out pollution through basis effects. The negative relationship between worker replacement and productivity seems to be driven mainly by firms above the median size of the sample.

Table 2: Estimated Productivity Effects of Worker Replacement - Main Results

Dependent variable:	Baseline - OLS		Baseline - LP		With WRR - OLS		With WRR - LP		WRR & WRR-sq. - LP		WRR y/n - LP	
Real value added	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Labour (# employees)	0.772	(0.021)***	0.702	(0.020)***	0.774	(0.021)***	0.705	(0.020)***	0.708	(0.021)***	0.712	(0.021)***
Capital	0.231	(0.015)***	0.237	(0.082)***	0.231	(0.015)***	0.238	(0.082)***	0.237	(0.081)***	0.237	(0.082)***
Worker replacement rate					-0.106	(0.047)**	-0.095	(0.045)**	-0.211	(0.097)**		
Worker replacement sq.									0.107	(0.094)		
Worker replacement y/n											-0.048	(0.024)**
Age of firm	0.117	(0.027)***	0.090	(0.028)***	0.112	(0.027)***	0.085	(0.028)***	0.085	(0.028)***	0.087	(0.028)***
Limited liability corporation	0.256	(0.031)***	0.189	(0.030)***	0.254	(0.031)***	0.188	(0.030)***	0.188	(0.030)***	0.188	(0.030)***
Managerial experience	0.129	(0.026)***	0.117	(0.025)***	0.127	(0.026)***	0.116	(0.025)***	0.114	(0.025)***	0.116	(0.025)***
Entrepreneurial experience	0.010	(0.029)	0.011	(0.027)	0.012	(0.029)	0.013	(0.027)	0.012	(0.027)	0.012	(0.027)
Highly qual. workers (share)	0.063	(0.045)	0.088	(0.041)**	0.063	(0.045)	0.088	(0.041)**	0.087	(0.041)**	0.087	(0.041)**
GVA p.c. (industry/state)	0.003	(0.002)*	0.002	(0.002)	0.003	(0.002)*	0.002	(0.002)	0.003	(0.002)	0.002	(0.002)
Cut.-edge tech. manuf.	-0.116	(0.056)**	0.019	(0.058)	-0.120	(0.056)**	0.015	(0.057)	0.014	(0.057)	0.015	(0.057)
High-technology manuf.	-0.194	(0.068)***	-0.129	(0.061)**	-0.197	(0.068)***	-0.132	(0.061)**	-0.133	(0.061)**	-0.133	(0.061)**
Tech.-intensive services	0.036	(0.053)	0.193	(0.053)***	0.032	(0.053)	0.189	(0.053)***	0.188	(0.053)***	0.190	(0.053)***
Software supply and cons.	-0.067	(0.065)	0.167	(0.065)**	-0.069	(0.065)	0.164	(0.065)**	0.162	(0.065)**	0.165	(0.065)**
Non-high-tech manuf.	-0.157	(0.052)***	-0.053	(0.050)	-0.160	(0.052)***	-0.056	(0.050)	-0.056	(0.050)	-0.054	(0.050)
Skill-intensive services	-0.068	(0.059)	0.134	(0.063)**	-0.069	(0.059)	0.132	(0.062)**	0.133	(0.062)**	0.134	(0.063)**
Other business-or. serv.	-0.107	(0.070)	0.078	(0.071)	-0.100	(0.070)	0.083	(0.072)	0.083	(0.072)	0.082	(0.072)
Consumer-or. services	-0.221	(0.059)***	-0.037	(0.058)	-0.215	(0.059)***	-0.032	(0.058)	-0.030	(0.058)	-0.031	(0.058)
Construction	-0.076	(0.053)	-0.024	(0.050)	-0.074	(0.053)	-0.022	(0.050)	-0.022	(0.050)	-0.024	(0.050)
Year 2010	-0.029	(0.029)	-0.015	(0.027)	-0.030	(0.029)	-0.016	(0.027)	-0.015	(0.027)	-0.015	(0.027)
Year 2011	-0.005	(0.032)	-0.009	(0.031)	-0.005	(0.032)	-0.009	(0.031)	-0.009	(0.031)	-0.008	(0.031)
Year 2012	0.003	(0.032)	0.010	(0.032)	0.002	(0.032)	0.010	(0.032)	0.010	(0.032)	0.011	(0.032)
Constant	Yes		Yes		Yes		Yes		Yes		Yes	
Observations / R-squared	5,613 / 0.514		5,613		5,613 / 0.514		5,613		5,613		5,613	

Notes: *** 1%, ** 5 %, * 10 %. Cluster robust / bootstrapped standard errors in parentheses. Additional control variable in all regressions: Funding by the KfW bank.

Table 3: Estimated Productivity Effects of Worker Replacement - Sensitivity Analysis 1

Dependent variable:	Empl. > MED - LP		Empl. <= MED - LP		Industries - LP		Firm Age > MED - LP		Firm Age <= MED - LP		Firm Age det. - LP	
Real value added	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Labour (# employees)	0.724	(0.026)***	0.503	(0.048)***	0.705	(0.020)***	0.686	(0.030)***	0.713	(0.024)***	0.706	(0.020)***
Capital	0.326	(0.111)***	0.376	(0.114)***	0.237	(0.081)***	0.117	(0.096)	0.385	(0.140)***	0.234	(0.079)***
Worker replacement rate	-0.196	(0.054)***	-0.052	(0.061)	-0.077	(0.062)	-0.165	(0.069)**	-0.049	(0.058)	-0.073	(0.068)
WRR # HTM					-0.153	(0.117)						
WRR # HTS					-0.013	(0.137)						
WRR # LTM					0.056	(0.178)						
WRR # Constr					-0.048	(0.112)						
WRR # Age 3											-0.016	(0.092)
WRR # Age 4											0.068	(0.101)
WRR # Age 5											-0.035	(0.148)
WRR # Age 6											-0.199	(0.122)
WRR # Age 7											-0.344	(0.187)*
WRR # Age 8											-0.047	(0.144)
Age of firm	0.063	(0.027)**	0.076	(0.041)*	0.085	(0.028)***	-0.114	(0.082)	0.190	(0.044)***	0.095	(0.030)***
Limited liability corporation	0.193	(0.032)***	0.193	(0.047)***	0.188	(0.030)***	0.165	(0.036)***	0.200	(0.043)***	0.187	(0.030)***
Managerial experience	0.050	(0.030)*	0.168	(0.038)***	0.115	(0.025)***	0.123	(0.030)***	0.111	(0.035)***	0.116	(0.025)***
Restarter	0.011	(0.026)	0.005	(0.045)	0.012	(0.027)	0.050	(0.031)	-0.015	(0.037)	0.012	(0.027)
Highly qual. workers (share)	0.122	(0.056)**	0.089	(0.064)	0.089	(0.041)**	0.066	(0.053)	0.109	(0.061)*	0.088	(0.041)**
Constant / All Controls	Yes		Yes		Yes		Yes		Yes		Yes	
Observations / R-squared	2,787		2,826		5,613		2,737		2,876		5,613	

Notes: *** 1%, ** 5 %, * 10 %. Bootstrapped standard errors in parentheses. Additional control variable in all regressions: Funding by the KfW bank.

A similar pattern arises when the sample is split into the older and the younger half of firms to control for the influence of firm age on the relationship between excess turnover and productivity. Results are only significant for firms of above median age. Clearly, the overlap between the older and the larger half of the sample can be expected to be high. To control for the age effect in more detail, the WRR is interacted with the firm age categorised into years (sixth column). The sum of the main and the interaction effect of worker replacement on productivity is only significant for six- and seven-year-old firms (6 years: 1 % level, 7 years: 5% level). Since the group of eight-year-old startups in the regression sample is very small this could blur effects at the upper end of the firm age distribution. So, despite the smooth evolution of the WRR over the first period of the life-cycle (see Section 2), excess labour turnover is most deleterious when firms grow.

The extent of labour turnover differs distinctly between firms of different industries. To address the question whether the effect of labour turnover on productivity differs between industries, the WRR is interacted with five sector dummies (third column). The sum of effects is only significant for high-tech manufacturing startups (5 % level). So despite the descriptive result that high-tech manufacturing startups have the lowest worker replacement rates of all sectors, worker replacement seems to be most harmful to them. While turnover rates in other sectors are more pronounced, their effects on productivity are not significant. However, the sum of the direct effect and the interaction effect is in no case positive.

As a further sensitivity check it is analysed how founders and employees human capital moderate the effect of excess labour turnover on productivity (see Table 4). As discussed in Section 2, the experience of a firm's managerial staff can assure good quality of the employer-employee matches and thus, limit involuntary labour turnover. The mediating effects of relevant prior experience of the founder(s) is approximated in two ways. Firstly, by interacting the WRR with the dummy variable indicating whether the founder (or one founder in the team) has prior managerial experience in dependent work (first column). Secondly, by interacting the WRR with the dummy variable indicating if the founder (or one founder in the team) has prior entrepreneurial experience (second column). The extension of the productivity model by the interaction between WRR and managerial experience does not provide any insights. In contrast, results indicate that mainly startups whose founders have no experience as entrepreneurs are responsible for the significant negative overall effect of worker replacement on productivity (the sum of the direct effect and the interaction effect is not significantly different from zero). This result is reinforced if prior entrepreneurial experience is split into two categories, successful prior entrepreneurs and failed prior entrepreneurs.[12] In both cases the sum of the direct effect of WRR and the interaction effect is not significantly different from zero. However, the positive interaction effect is clearly more distinct for successful entrepreneurs.

Finally, since Mamede and Mota (2012) find an amplifying effect of worker flows involving highly skilled workers on firm performance, it is tested whether this holds for the effect of worker replacement on the productivity of young firms as well. Unfortunately, the data used in this study does not allow to observe the qualification of a replaced worker directly. To shed some light on the question if labour turnover is more deleterious for young firms if highly skilled labour is involved, an interaction term between the WRR and a dummy variable indicating

[12]Entrepreneurs are considered successful if they continued their old business, passed it on to friends or family members who continued it, or if they sold it profitably. Entrepreneurs are considered unsuccessful (failed entrepreneurs) if their prior business was divested or went bankrupt.

Table 4: Estimated Productivity Effects of Worker Replacement - Sensitivity Analysis 2

Dependent variable:	Manag. Exp. - LP		Entrepr. Exp. - LP		Entrepr. Exp. (+-) - LP		Qual. Empl. - LP	
Real value added	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Labour (# employees)	0.705	(0.020)***	0.705	(0.020)***	0.705	(0.018)***	0.706	(0.021)***
Capital	0.238	(0.081)***	0.237	(0.082)***	0.240	(0.084)***	0.236	(0.081)***
Worker replacement rate	-0.095	(0.063)	-0.127	(0.062)**	-0.127	(0.067)*	-0.061	(0.045)
WRR # Managerial experience	-0.000	(0.087)						
WRR # Entrepreneurial exp.			0.074	(0.086)				
WRR # Successful entrepreneur					0.096	(0.108)		
WRR # Failed entrepreneur					0.008	(0.122)		
WRR # Hi. qual. work (y/n)							-0.093	(0.098)
Age of firm	0.085	(0.028)***	0.085	(0.028)***	0.085	(0.028)***	0.086	(0.028)***
Limited liability corporation	0.188	(0.030)***	0.188	(0.030)***	0.189	(0.031)***	0.189	(0.031)***
Managerial experience	0.116	(0.027)***	0.116	(0.025)***	0.121	(0.025)***	0.115	(0.025)***
Entrepreneurial experience	0.013	(0.027)	0.004	(0.028)			0.012	(0.027)
Successful entrepreneur					0.009	(0.035)		
Failed entrepreneur					0.006	(0.035)		
Highly qual. workers (share)	0.088	(0.041)**	0.088	(0.041)**	0.089	(0.042)**	0.098	(0.041)**
Constant / All Controls	Yes		Yes		Yes		Yes	
Observations / R-squared	5,613		5,613		5,576		5,613	

Notes: *** 1%, ** 5 %, * 10 %. Bootstrapped standard errors in parentheses. Additional control variable in all regressions: Funding by the KfW bank.

whether a firm employs highly qualified personnel is included (fourth column). The results are in line with the existing findings for established firms. The sum of the direct effect of WRR and the interaction effect is significant (on a 10 % level) while the direct effect is not significant alone. Excess labour turnover is most deleterious in young firms that employ highly qualified personnel. This supports the suspicion that highly qualified personnel, with well remunerated outside options in other firms, might be responsible for a important share of quits in young firms.

Quits vs. dismissals Two possible explanations are in line with the observed negative effect of worker replacement on productivity. On the one hand, the negative productivity effect could stem from the replacement of employees who were dismissed by the firm. The negative effect would either reflect an underestimation of the adjustment costs associated with replacements or a bad quality of the original match then. On the other hand, the negative effect might stem from quits of employees. It seems reasonable that the most productive employees might be the first to leave a firm voluntarily and that young firms might find it difficult to replace this outflow equivalently. Both explanations seem to be convincing in the context of young firms, with comparably low power on the labour market and limited experience in recruiting.

To shed light on possibly different impacts of quits and dismissals a robustness check is conducted. Unfortunately, the data available neither allows to distinguish if a separation was a quit or a dismissal on the individual level, nor to identify which employee was replaced in the case of multiple separations in one period.[13] However, for the years 2007 and 2012 information on the total number of separations due to quits and due to dismissals is available for the firms

[13]e.g. if there are two separations and one hiring, it cannot be distinguished which one of the two separations was replaced and which one not.

which took part in the corresponding waves. To not loose to many observations for the robustness check, the share of quits on all separations is treated constant over time on the firm level. In case the information is available for a firm in 2007 and 2012, the share of quits is set to the closest observed value available for each year. Table 7 (OLS results) and Table 8 (corresponding LP results) in the appendix show the estimation results for the robustness check. Due to the incomplete availability of data on quits and dismissals and the strong assumption about the constancy of the share of quits over time, the results of the robustness check should be treated cautiously.

In a first step (first columns of Table 7 and Table 8 respectively) the model is re-estimated with the smaller set of observations that the share of quits is available for. Using both procedures most estimated coefficients remain in the same range as in the model including the full set of observations. OLS results seem to be more stable over the different specifications of the robustness check. Since they do not lead to qualitatively different conclusions than the LP procedure, the remaining discussion is based on the OLS results. In a second step the sample is split into observations for which dismissals account for 50 % of the separations or more (second row) and observations with more than 50 % quits (third row). The results indicate that the negative effects of worker replacement on productivity only hold for firms with high shares of quits, not for firms with mainly firm initiated separations. This result can be confirmed if the information on the share of quits is introduced in the model by interaction terms (fourth and fifth row). Only the sum of the direct and the interaction effect is (negatively) significant (on a 1 % level). This result holds independently of interacting worker replacement with a dummy, indicating a share of quits on all separations of more than 50 % (fourth row), or the actual share of quits (fifth row).

5 Conclusion

The analyses in this paper show that the overall effect of worker replacement on the productivity of young firms is negative. This result is independent of the extent of observed worker replacement. In a more detailed sensitivity analysis, high-risk groups for harmful worker replacement are identified: young firms of above median employment size and median age of the sample, young firms that employ highly educated employees, manufacturing startups in high-tech sectors and startups whose founders do not have any prior experience as entrepreneurs. Conditions under which worker replacement triggers positive effects on productivity cannot be identified. A robustness check which has to rely on a restricted set of data indicates that the negative productivity effects stem from replacements of employees who quit their jobs. For firms which initiate most of the separations themselves, negative effects are not measurable. However, even in the case of dismissals, a positive impact of worker replacement on firm performance cannot be found.

A one unit increase in worker replacement is associated with a decrease in value added of approximately 10 %. This results differs only minimally dependent on the regression method used. Expressed in mean terms, the replacement of a young firms entire workforce during one period leads to a value added loss of approximately 35,000 EUR. A more graspable example might be the following: if the median employment size young firm in the sample, with four full-time equivalent employees, replaces (or has to replace) two of its four employees during a period, this is associated with an average loss in value added of approximately 17,500 EUR. These losses become up to three times as high in firms where most separations are initiated by quits of employees.

The negative effects of worker replacement on young firms' performance are in line with the theoretical considerations and might be explained best by a comparably low market power of young firms on the labour market. It seems to hold true that, in many cases, well educated employees leave young firms for more attractive other options. This does most harm firms in high-tech manufacturing sectors which depend crucially on a highly skilled workforce. Interestingly, the negative effect is strongest as firms grow. With the increasing size it seems to becomes more difficult for the founders to manage the human resources of their startup adequately. This is underpinned by the finding that founders with prior entrepreneurial experience succeed in avoiding harmful worker replacement.

From these results important managerial guidelines can be derived. The managerial staff of high-tech manufacturing start-ups should consider to increase the effort put into avoiding excess labour turnover among highly skilled employees. A useful way to go might be to the develop or reconsider their firms' strategies to increase the job embeddedness of highly educated employees. Especially for founders without prior entrepreneurial experience, it might be valuable to consider seeking the assistance of personnel consultants to develop better human resource management strategies.

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Appendix

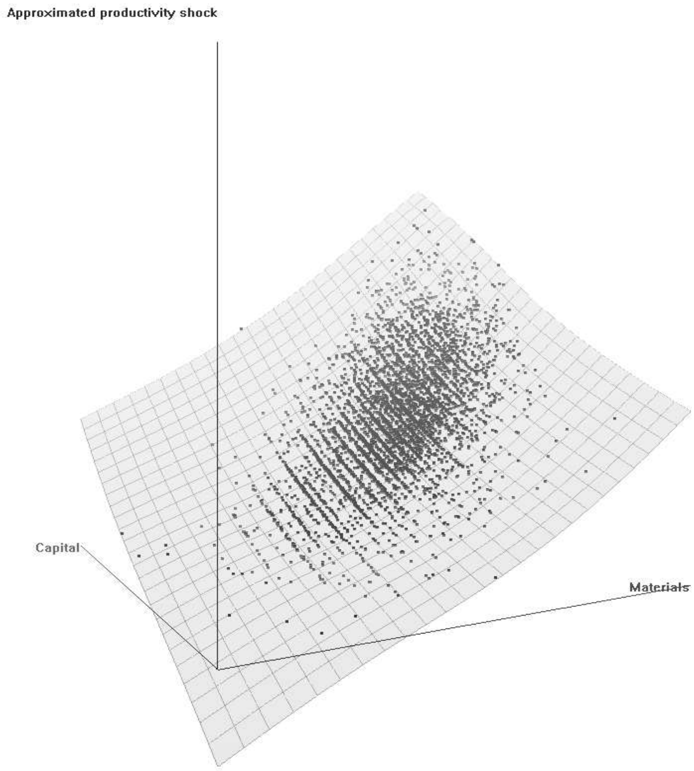

Figure 1: Estimated approximate productivity shock (vertical axis), materials and capital

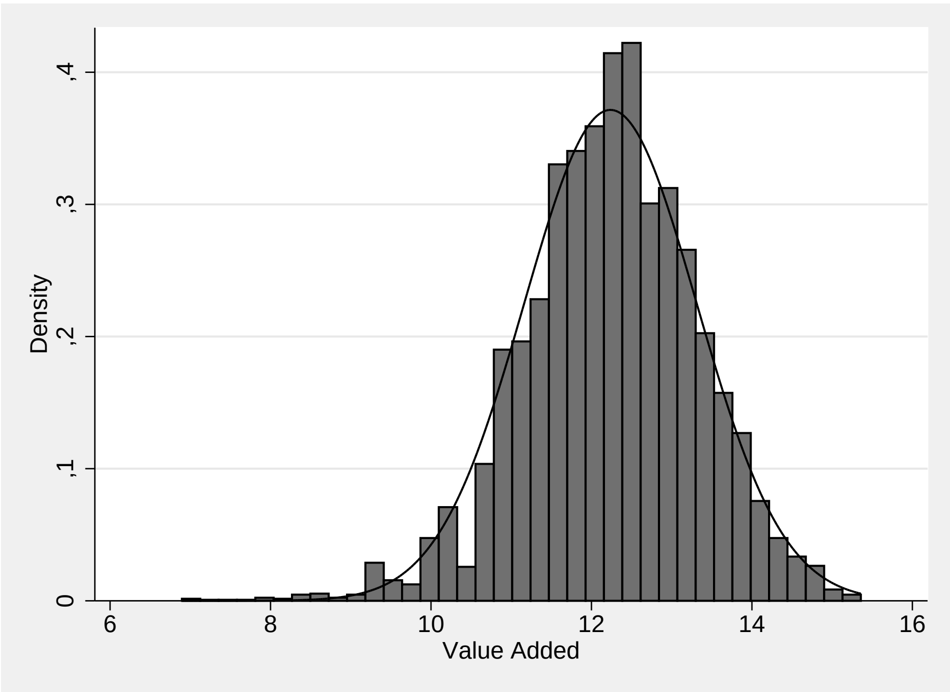

Figure 2: Histogram of dependent variable: log(real value added)

Table 5: Estimated Productivity Effects of Worker Replacement - OLS results I

Dependent variable:	WRR & WRR-sq. - OLS		WRR y/n - OLS		Empl. > MED - OLS		Empl. <= MED - OLS		Industries - OLS		Firm age > MED - OLS	
Real value added	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Labour (# of employees)	0.777	(0.021)***	0.781	(0.022)***	0.768	(0.026)***	0.554	(0.050)***	0.774	(0.021)***	0.746	(0.028)***
Capital	0.231	(0.015)***	0.231	(0.015)***	0.171	(0.016)***	0.279	(0.024)***	0.231	(0.015)***	0.252	(0.022)***
Worker replacement rate	-0.198	(0.103)*			-0.225	(0.056)***	-0.041	(0.063)	-0.089	(0.064)	-0.165	(0.078)**
Worker replacement sq.	0.085	(0.095)										
Worker replacement y/n			-0.043	(0.024)*								
WRR # HTM									-0.104	(0.132)		
WRR # HTS									-0.020	(0.147)		
WRR # LTM									0.072	(0.165)		
WRR # Constr									-0.066	(0.121)		
Age of firm	0.112	(0.027)***	0.115	(0.027)***	0.077	(0.031)**	0.109	(0.042)***	0.113	(0.027)***	-0.097	(0.086)
Limited liability corporation	0.254	(0.031)***	0.255	(0.031)***	0.241	(0.033)***	0.256	(0.050)***	0.254	(0.031)***	0.233	(0.040)***
Managerial experience	0.126	(0.026)***	0.128	(0.026)***	0.059	(0.030)**	0.184	(0.040)***	0.127	(0.026)***	0.133	(0.036)***
Entrepreneurial experience	0.012	(0.029)	0.011	(0.029)	0.010	(0.031)	0.018	(0.047)	0.011	(0.029)	0.056	(0.038)
Successful entrepreneur												
Failed entrepreneur												
Highly qual. workers (share)	0.062	(0.045)	0.062	(0.045)	0.094	(0.056)*	0.083	(0.062)	0.064	(0.045)	0.061	(0.057)
Constant / All controls	Yes		Yes		Yes		Yes		Yes		Yes	
Observations	5,613 / 0.514		5,613 / 0.514		2,787 / 0.506		2,826 / 0.225		5,613 / 0.514		2,737 / 0.556	

Notes: *** 1%, ** 5 %, * 10 %. Cluster robust standard errors in parentheses. Additional control variable in all regressions: Funding by the KfW bank.

Table 6: Estimated Productivity Effects of Worker Replacement - OLS results II

Dependent variable:	Firm age <= MED - OLS		Firm age det. - OLS		Manag. Exp. - OLS		Entrep. Exp. - OLS		Entrepr. Exp. (+-) - OLS		Qual. Empl. - OLS	
Real value added	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Labour (# of employees)	0.796	(0.028)***	0.775	(0.021)***	0.774	(0.021)***	0.774	(0.021)***	0.774	(0.021)***	0.775	(0.021)***
Capital	0.210	(0.019)***	0.231	(0.015)***	0.231	(0.015)***	0.231	(0.015)***	0.231	(0.015)***	0.230	(0.015)***
Worker replacement rate	-0.063	(0.057)	-0.120	(0.079)	-0.110	(0.065)*	-0.142	(0.067)**	-0.141	(0.066)**	-0.080	(0.049)
WRR # Age 3			0.072	(0.105)								
WRR # Age 4			0.103	(0.107)								
WRR # Age 5			-0.031	(0.177)								
WRR # Age 6			-0.201	(0.140)								
WRR # Age 7			-0.246	(0.180)								
WRR # Age 8			0.201	(0.151)								
WRR # Managerial experience					0.011	(0.089)						
WRR # Entrepreneurial exp.							0.084	(0.089)				
WRR # Successful entrepreneur									0.092	(0.103)		
WRR # Failed entrepreneur									0.039	(0.108)		
WRR # Hi. qual. work (y/n)											-0.072	(0.098)
Age of firm	0.220	(0.047)***	0.119	(0.029)***	0.112	(0.027)***	0.112	(0.027)***	0.112	(0.027)***	0.113	(0.027)***
Limited liability corporation	0.259	(0.041)***	0.253	(0.031)***	0.254	(0.031)***	0.255	(0.031)***	0.252	(0.031)***	0.255	(0.031)***
Managerial experience	0.122	(0.034)***	0.127	(0.026)***	0.126	(0.028)***	0.127	(0.026)***	0.133	(0.026)***	0.127	(0.026)***
Entrepreneurial experience	-0.029	(0.039)	0.013	(0.029)	0.012	(0.029)	0.003	(0.031)			0.012	(0.029)
Successful entrepreneur									0.019	(0.037)		
Failed entrepreneur									-0.013	(0.041)		
Highly qual. workers (share)	0.074	(0.065)	0.062	(0.045)	0.063	(0.045)	0.063	(0.045)	0.067	(0.045)	0.070	(0.046)
Constant / All controls	Yes		Yes		Yes		Yes		Yes		Yes	
Observations	2,876 / 0.481		5,613 / 0.515		5,613 / 0.514		5,613 / 0.514		5,576 / 0.515		5,613 / 0.514	

Notes: *** 1%, ** 5 %, * 10 %. Cluster robust standard errors in parentheses. Additional control variable in all regressions: Funding by the KfW bank.

Table 7: Estimated Productivity Effects of Worker Replacement - Quits vs. Dismissals - OLS results

Dependent variable:	Robust Baseline - OLS		Dismissals >= 50 % - OLS		Quits > 50% - OLS		Quits interacted - OLS		Quits (share) interacted - OLS	
Real value added	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Capital	0.201	(0.024)***	0.181	(0.034)***	0.215	(0.031)***	0.199	(0.024)***	0.200	(0.024)***
Labour (# of employees)	0.795	(0.033)***	0.798	(0.047)***	0.799	(0.048)***	0.795	(0.033)***	0.796	(0.033)***
Worker replacement rate	-0.113	(0.060)*	0.011	(0.079)	-0.303	(0.092)***	-0.016	(0.077)	-0.037	(0.081)
WRR # Quits > 50%							-0.269	(0.113)**		
WRR # Share of quits									-0.201	(0.124)
Share of quits > 50%							0.065	(0.048)		
Share of quits									0.033	(0.051)
Age of firm	-0.031	(0.044)	0.037	(0.059)	-0.125	(0.066)*	-0.033	(0.044)	-0.033	(0.044)
Limited liability corporation	0.183	(0.049)***	0.161	(0.071)**	0.193	(0.064)***	0.182	(0.048)***	0.182	(0.048)***
Managerial experience	0.129	(0.044)***	0.130	(0.064)**	0.124	(0.057)**	0.125	(0.044)***	0.126	(0.044)***
Entrepreneurial experience	0.102	(0.046)**	0.107	(0.063)*	0.113	(0.065)*	0.106	(0.046)**	0.104	(0.046)**
Highly qual. workers (share)	0.064	(0.081)	0.065	(0.123)	0.052	(0.092)	0.058	(0.081)	0.062	(0.081)
GVA p.c. (industry/state)	0.002	(0.003)	0.005	(0.003)	-0.002	(0.004)	0.002	(0.003)	0.002	(0.003)
Cutting-edge technology manufacturing	-0.147	(0.087)*	0.015	(0.118)	-0.302	(0.115)***	-0.142	(0.086)	-0.143	(0.086)*
High-technology manufacturing	-0.143	(0.099)	-0.093	(0.131)	-0.204	(0.147)	-0.142	(0.099)	-0.142	(0.099)
Technology-intensive services	-0.016	(0.097)	0.063	(0.136)	-0.108	(0.122)	-0.010	(0.097)	-0.014	(0.097)
Software supply and consultancy	-0.200	(0.115)*	-0.155	(0.159)	-0.271	(0.148)*	-0.196	(0.114)*	-0.195	(0.114)*
Non-high-tech manufacturing	-0.239	(0.093)**	-0.103	(0.140)	-0.383	(0.121)***	-0.236	(0.093)**	-0.236	(0.093)**
Skill-intensive services	-0.033	(0.102)	0.078	(0.143)	-0.177	(0.131)	-0.026	(0.101)	-0.029	(0.101)
Other business-oriented services	-0.189	(0.110)*	-0.175	(0.156)	-0.236	(0.148)	-0.185	(0.110)*	-0.185	(0.110)*
Consumer-oriented services	-0.389	(0.085)***	-0.219	(0.124)*	-0.590	(0.106)***	-0.384	(0.084)***	-0.385	(0.084)***
Construction	-0.058	(0.086)	-0.032	(0.114)	-0.100	(0.122)	-0.057	(0.085)	-0.057	(0.085)
Year 2010	0.015	(0.048)	0.038	(0.071)	0.002	(0.066)	0.016	(0.048)	0.015	(0.048)
Year 2011	0.016	(0.049)	-0.045	(0.074)	0.124	(0.066)*	0.019	(0.049)	0.017	(0.049)
Year 2012	0.095	(0.050)*	0.065	(0.070)	0.158	(0.076)**	0.097	(0.050)*	0.096	(0.050)*
Constant	Yes		Yes		Yes		Yes		Yes	
Observations / R-squared	1,543 / 0.609		842 / 0.563		701 / 0.676		1,543 / 0.610		1,543 / 0.609	

Notes: *** 1%, ** 5 %, * 10 %. Cluster robust standard errors in parentheses. Additional control variable in all regressions: Funding by the KfW bank.

Table 8: Estimated Productivity Effects of Worker Replacement - Quits vs. Dismissals - LP results

Dependent variable:	Robust Baseline LP		Dismissals >= 50 % - LP		Quits > 50% - LP		Quits interacted - LP		Quits (share) interacted - LP	
Real value added	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Capital	0.172	(0.141)	0.009	(0.222)	0.389	(0.125)***	0.173	(0.142)	0.172	(0.142)
Labour (# of employees)	0.729	(0.031)***	0.707	(0.052)***	0.762	(0.054)***	0.729	(0.030)***	0.730	(0.030)***
Worker replacement rate	-0.076	(0.055)	0.048	(0.081)	-0.261	(0.094)***	0.022	(0.076)	-0.000	(0.077)
WRR # Quits > 50%							-0.269	(0.116)**		
WRR # Share of quits									-0.199	(0.112)*
Share of quits > 50%							0.066	(0.047)		
Share of quits									0.034	(0.048)
Age of firm	-0.058	(0.042)	-0.000	(0.058)	-0.129	(0.056)**	-0.059	(0.041)	-0.059	(0.042)
Limited liability corporation	0.137	(0.048)***	0.125	(0.078)	0.159	(0.070)**	0.136	(0.047)***	0.136	(0.048)***
Managerial experience	0.120	(0.041)***	0.120	(0.072)*	0.120	(0.058)**	0.116	(0.041)***	0.116	(0.041)***
Entrepreneurial experience	0.096	(0.046)**	0.101	(0.062)	0.092	(0.061)	0.099	(0.045)**	0.097	(0.045)**
Highly qual. workers (share)	0.085	(0.074)	0.069	(0.125)	0.065	(0.089)	0.079	(0.075)	0.083	(0.075)
GVA p.c. (industry/state)	0.002	(0.002)	0.004	(0.004)	-0.001	(0.004)	0.002	(0.002)	0.002	(0.002)
Cutting-edge technology manufacturing	-0.025	(0.081)	0.164	(0.124)	-0.243	(0.131)*	-0.020	(0.080)	-0.021	(0.080)
High-technology manufacturing	-0.109	(0.106)	-0.019	(0.134)	-0.234	(0.171)	-0.107	(0.105)	-0.108	(0.105)
Technology-intensive services	0.124	(0.105)	0.227	(0.135)*	-0.009	(0.139)	0.131	(0.105)	0.127	(0.105)
Software supply and consultancy	0.011	(0.118)	0.123	(0.178)	-0.141	(0.165)	0.015	(0.117)	0.016	(0.117)
Non-high-tech manufacturing	-0.144	(0.086)*	0.008	(0.130)	-0.330	(0.108)***	-0.141	(0.086)	-0.142	(0.086)
Skill-intensive services	0.133	(0.111)	0.255	(0.155)*	-0.004	(0.158)	0.141	(0.111)	0.138	(0.111)
Other business-oriented services	-0.034	(0.111)	0.041	(0.172)	-0.137	(0.155)	-0.029	(0.110)	-0.030	(0.111)
Consumer-oriented services	-0.230	(0.091)**	-0.030	(0.128)	-0.499	(0.106)***	-0.223	(0.092)**	-0.226	(0.091)**
Construction	-0.026	(0.084)	0.045	(0.112)	-0.133	(0.118)	-0.026	(0.083)	-0.025	(0.083)
Year 2010	0.018	(0.043)	0.032	(0.067)	0.016	(0.055)	0.019	(0.043)	0.018	(0.043)
Year 2011	0.002	(0.049)	-0.058	(0.075)	0.113	(0.063)*	0.005	(0.048)	0.004	(0.049)
Year 2012	0.091	(0.048)*	0.059	(0.065)	0.156	(0.070)**	0.093	(0.048)*	0.091	(0.048)*
Constant	Yes		Yes		Yes		Yes		Yes	
Observations / R-squared	1,543		842		701		1,543		1,543	

Notes: *** 1%, ** 5 %, * 10 %. Bootstrapped standard errors in parentheses. Additional control variable in all regressions: Funding by the KfW bank.

A Worker replacement in German startups

So far, no studies about excess labour turnover in German startups are available. Therefore, a short descriptive impression is given to facilitate the interpretation of the regression analyses. The data is taken from KfW/ZEW Start-Up Panel and extrapolated to the population of up to four year old German start-ups.[14] Due to the definition of the worker replacement rate (also WRR henceforth) in Section 2, calculations can only be done for startups with at least one employee in the last or the current period.[15] In 2012, 31 % of all German startups with employees show positive labour replacement rates. In these 31 % of the startups, 44% of all employees of young German firms are employed. Firstly, this shows that excess labour turnover takes place mainly in larger startups (which have higher potential for labour turnover). Secondly, excess labour turnover in German startups and its interrelation with firm performance affects a large proportion of workers employed in young German firms.

Table 9: Worker replacement in 1-4 years old German firms 2012

WRR 2012	Mean	MED	p75	p90
CTM&HTM	0.07	0.00	0.00	0.18
TIS&Software	0.09	0.00	0.00	0.25
NTM	0.10	0.00	0.07	0.35
Construction	0.19	0.00	0.07	0.75
LTS&Trade	0.16	0.00	0.24	0.50
All	0.15	0.00	0.19	0.50

From literature about excess labour turnover in established firms, large differences in the extent of replacement hiring can be expected depending on industry and firm age. Table 9 shows the average and percentiles of the worker replacement rate split for sectors. The average WRR in German startups in the year 2012 (over all cohorts) is 15 %. Thus, excess labour turnover in German startups seems to be in a comparable range to the excess turnover rates Haltiwanger et al. (2012) report for US startups. The average WRR is lowest for high-tech startups in the manufacturing sector (first row). While the average WRR of high-tech services startups (second row) and non-high-tech manufacturing startups (third row) is only slightly higher, construction (fourth row) and low-tech services startups (fifth row) show notably higher WRR. In manufacturing as well as in services sectors, excess labour turnover is lower among high-tech firms compared to non-high-tech firms. In accordance, splitting the results for percentiles of the WRR distribution shows that in non-high-tech sectors a larger fraction of startups have positive replacement rates than in high-tech sectors. There are at least two possible explanations for these sectoral differences. On the one hand, higher replacement rates could be favourable for firm performance in non-high-tech sectors, since costs for on the job training of employees might be lower. On the other hand, higher replacement rates in low-tech sectors could reflect worse bargaining situations of low-tech startups compared to incumbents in their sectors on the labour market. This could then trigger negative effects on firm performance.

Figure 3 gives an impression of the development of different job and worker flow measures over the early years of young firms' lifespan.[16] The hiring rate and the resulting job flow and

[14] Extrapolation is not possible for longer periods due to data restrictions.

[15] All worker flow and job flow measures are calculated as headcounts.

[16] Average values of the foundation cohorts 2005 and 2006 are reported. Due to data restrictions, all values

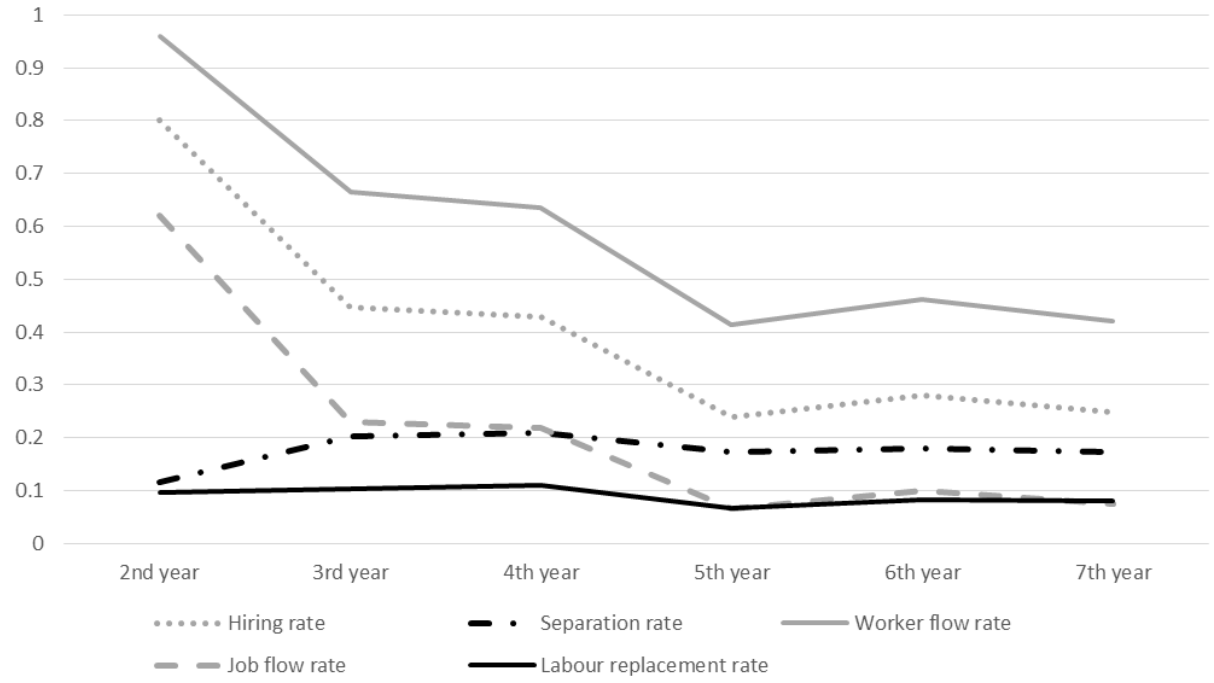

Figure 3: Turnover measures for foundation cohorts 2005 and 2006 over time

worker flow rates are distinctly higher at the beginning of the life-cycle of young firms and level off after the first five years. This reflects disproportionally fast growth at the beginning of the firm lifecycle. In contrast, the separation rate and the worker replacement rate show a more stable pattern. Especially the WRR seems to be very stable over the whole snapshot of the lifecycle of surviving firms. However, the question if worker replacement is more favourable or harmful at different stages of the development of a young firm remains. In addition, all measures for Figure 3 are calculated for firms surviving a seven year period only. Therefore, the stable labour replacement pattern could reflect the successful personnel strategy of these firms.

reported in Figure 3 are not extrapolated and only calculated for firms surviving the whole period up to the 7th year of life.