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Michael Beckmann

Universität Basel
Peter Merian-Weg 6
4052 Basel, Switzerland
wwz.unibas.ch

Corresponding Author:
Michael Beckmann
Tel: +41 (0) 61 207 32 24
Mail: michael.beckmann@unibas.ch

Self-managed working time and firm performance: Microeconometric evidence

Michael Beckmann*

* University of Basel, Faculty of Business and Economics, Human Resources and Organization, Peter Merian-Weg 6, CH-4002 Basel, Switzerland, and Institute for Employment Research (IAB), Nuremberg, Germany.
Phone: +41 61 207 32 24, e-mail: michael.beckmann@unibas.ch

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Abstract

This paper empirically examines the impact of self-managed working time (SMWT) on firm performance using panel data from German establishments. As a policy for the decentralization of decision rights, SMWT provides employees with extensive control over scheduling individual working time. From a theoretical viewpoint, SMWT has ambiguous effects on both worker productivity and wages. Based on the construction of a quasi-natural experiment and the combination of a differences-in-differences approach with propensity score matching as an identification strategy, the empirical analysis shows that up to five years after introduction, SMWT increases firm productivity by about 9% and wage costs by about 8.5%. This implies that SMWT improves both individual and firm productivity, and supplemental evidence shows that these productivity enhancements can primarily be explained by incentive effects associated with decentralization policies in general.

JEL Classification: J24; J81; M50
Keywords: Self-managed working time, job autonomy, firm performance, treatment effect, quasi-natural experiment

1. Introduction

The policy of delegating decision rights to subordinate workers is one of the most controversially discussed issues in personnel and organizational economics. On the one hand, it is argued that providing workers with autonomy over certain job dimensions may enhance individual and firm performance via improved worker motivation or the usage of superior knowledge at lower hierarchical levels. On the other hand, it is emphasized that promoting a worker's job autonomy involves a serious moral hazard problem as monitoring is made more difficult, so workers might behave opportunistically by abusing their authority at the expense of firm performance. As a result, decentralization policies typically create challenging dilemma situations for the delegating manager (Holmstrom 1984; Melumad et al. 1997).

Self-managed working time (SMWT) is one of these policies of decentralization. Here, workers are endowed with extensive control over the duration, position, and distribution of their working hours (Kelly and Moen 2007; Nijp et al. 2012; Shockley and Allen 2012). This includes discretion over starting and finishing times, breaks, vacation days and days off. Under SMWT employees are also allowed to distribute their workdays over the working week autonomously. Sometimes SMWT workers can even decide where to work (e.g., in the workplace or at home).[1] At the firm-level, SMWT implies that employers do no longer need to register and control their employees' working time. Today, about 15% of the employees in the United States and 17% of the employees working in one of the EU27 countries are free to set their working hours on their own responsibility (Golden 2012; Goudswaard et al. 2012).

The literature on working time autonomy and flexibility provides two reasons for the introduction of practices such as SMWT (Golden 2009; Ortega 2009; Bloom et al. 2011; Shockley and Allen 2012). First, firms might provide workers with SMWT in order to increase individual productivity. In this case, one should not only expect a positive impact on firm productivity but also on the wage bill, because increased worker productivity should be compensated via higher wages. Second, granting SMWT might be a firm's response to a growing need of its employees to balance work and family obligations. In this case, firms are more likely to benefit from reduced wage costs than from increased productivity, unless SMWT allows firms to attract better workers. Individual productivity may even decline when workers opportunistically exploit the

[1] There are alternative expressions for SMWT in the literature, e.g., work time control, schedule control, trust hours, trust-based working time or boundary-less work (Singe and Croucher 2003; Kelly and Moen 2007; Beckers et al. 2012; Godart et al. 2014).

discretion over their working hours in the absence of working time registration by caring more about their personal lives than about organizational duties. Under these conditions, adopting SMWT can only be beneficial for firms if the workers concerned perceive SMWT as a fringe benefit and are thus willing to accept sufficient wage concessions in return.

Apart from these explanations that apply to policies of working time autonomy and flexibility in general, firms may also find SMWT attractive for another, regime-specific reason. Since the concept of SMWT relieves the employer of the obligation to record working hours, overtime work is no longer defined. Consequently, the employees concerned are no longer compensated for working overtime. In this manner, SMWT might help firms to reduce their wage costs without necessarily reducing actual extra work. Whether this proceeding can be profitable or not largely depends on the workers' response to the elimination of paid overtime.

All in all, therefore, the impact of SMWT on firm performance remains an open question and the net-effect is ex ante unclear. Hence, the objective of the present paper is to empirically investigate the actual impact of SMWT on firm performance. For this purpose, I use panel data from German establishments (the IAB Establishment Panel). Firm performance is measured by both firm productivity and the wage bill, which also allows conclusions to be drawn regarding firm profitability. In order to be able to identify causal effects rather than conditional correlations, I simulate a quasi-natural experiment by constructing a balanced panel and using survey information from various periods before, during, and after intervention, where intervention is defined by the introduction of SMWT. The estimation strategy for identifying the treatment effects of interest is a differences-in-differences approach that is combined with propensity score matching to meet the key assumption of common trends between the treatment group and the control group.

In order to incorporate a study on the performance effects of measures of working time autonomy such as SMWT into the existing literature, one has to consider the broad range of flexible working time arrangements, which typically includes practices of working time autonomy. The impact of flexible working time policies on firm performance has often been investigated in the context of family-friendly workplace practices or work-life balance programs (e.g., Konrad and Mangel 2000; Perry-Smith and Blum 2000; Arthur 2003; Baughman et al. 2003; Bloom and Van Reenen 2006; Heywood et al. 2007; Giardini and Kabst 2008; Beauregard and Henry 2009; Ngo et al. 2009; Bloom et al. 2011; Leslie et al. 2012). However, none of these studies explicitly considers SMWT as a measure of these practices. Other studies focus on specific working time arrangements that are related to SMWT, such as flextime or working from home, and predominantly find positive effects on firm performance (e.g., Shepard et al. 1996; Lee and DeVoe 2012; Bloom et al. 2015).

Studies that directly examine the consequences of SMWT (or work time control) are scarce. They are either interested in individual-level outcomes, such as job satisfaction, organizational commitment, worker effort or health (e.g., Ala-Mursula et al. 2004, 2005; Moen et al. 2011a; Takahashi et al. 2011; Lyness et al. 2012; Kubo et al. 2013; Beckmann et al. 2015), or estimate the impact on firm-level outcomes other than financial performance, such as product innovations and turnover (e.g., Moen et al. 2011b; Godart et al. 2014). All these studies identify positive outcomes for both employees and employers or at least no negative outcomes. To the best of my knowledge, there is so far no other study that empirically examines the impact of SMWT on firm performance measured as firm productivity and wage costs.

A second contribution of the paper can be seen in the use of a large-scale establishment-level panel data set. Previous studies have often relied on cross-sectional data, very small sample sizes, non-random or non-representative samples (e.g., industry-specific data, data from one or just a few selected firms). Results from these studies may, of course, be informative and meaningful, especially when they are based on controlled experimental settings such as the seminal paper by Bloom et al. (2015), who conduct a randomized field experiment using panel data on Chinese call center employees. The great benefit of such studies is that an experimental set-up provides ideal conditions for identifying causal intervention effects. However, relying on specific experimental scenarios usually diminishes the transferability and representability of the results. In contrast, I conduct a representative analysis based on one of the most extensive establishment-level panel data sets in Europe, the IAB Establishment Panel. In studies based on large-scale survey data, the identification of causal treatment effects is usually more demanding than in randomized experiments. Nevertheless, I aim at estimating causal performance effects of SMWT by combining a differences-in-differences approach with propensity score matching. This procedure provides a solid basis for deriving management implications with regard to the effective use of SMWT in firms.

The remainder of this paper is organized as follows. Section 2 provides a brief description of the theoretical background. In Section 3, I describe the data, explain the key variables, and provide some descriptive statistics. Subsequently, I introduce the econometric model and the estimation strategy in Section 4, followed by the presentation and discussion of the empirical results in Section 5. The robustness of the estimates is checked in Section 6. In Section 7, I discriminate between various explanations for the obtained effect of SMWT on firm productivity. Finally, Section 8 concludes.

2. Theoretical background

As already mentioned in the introduction, firms adopt policies of working time autonomy to increase productivity and/or as a response to the growing demand for human resource management policies that help employees to improve the coordination of work and private life issues. This implies that it is ex ante unclear whether working time arrangements such as SMWT effectively increase or perhaps even harm firm productivity.[2]

Why can SMWT be expected to increase firm productivity? The answer to this question is manifold. First, as a policy that provides employees with control over individual working hours, SMWT contributes to enriching an employee's job via enhanced job autonomy. Job autonomy itself is an important channel of an individual's self-motivation or work morale. As a consequence, SMWT is likely to increase the employees' self-motivation, which in turn increases individual effort levels and productivity (Askenazy and Caroli 2010). This view is consistent with a number of theories, including the theory of decentralization (e.g., Bloom et al. 2010; Lazear and Gibbs 2015), the job characteristics model (Hackman and Oldham 1976, 1980), or self-determination theory (Deci and Ryan 1985).

A second argument builds on another general benefit of decentralizing decision rights, whereby decision-making takes place at the level where the employees have superior information (e.g., Melumad et al. 1997; Bloom et al. 2010; Lazear and Gibbs 2015). Under SMWT, workers are allowed to make use of their private information about how to allocate individual working hours most efficiently. For example, workers can arrange their working hours according to their individual circadian rhythms and are then likely to work more productively (Pierce and Newstrom 1980). This should also have a positive impact on firm productivity.

A third explanation for a positive relationship between SMWT and employee effort can be derived from social exchange theory (Homans 1958; Blau 1964) or gift exchange theory (Akerlof

[2] A theoretical model on the consequences of SMWT on worker effort can be found in Beckmann et al. (2015).

1982). According to these approaches, workers may feel obliged to reciprocate in a positive way to benefits granted by their employers. Employees interpret these benefits as signals of recognition for past performance or trust in their work morale, and thus respond by exerting additional effort. In the present context, reciprocating workers may exert extra effort in return for receiving decision rights over the choice of their working hours, thus improving firm productivity.

Finally, productivity increases might also be the result of worker selection effects. For example, in an influential study on the productivity effects of performance pay, Lazear (2000) has shown that improved worker productivity can be explained by both incentive and selection effects. In the present case, this implies that SMWT might contribute to raising firm productivity if able workers join firms with SMWT arrangements rather than firms without such arrangements.

On the other hand, however, one may also question the efficacy of SMWT as an appropriate policy for increasing worker productivity. The key argument in this context is that decentralizing decision rights in general involves a serious moral hazard problem (e.g., Lazear and Gibbs 2015). In the present case, granting employees control over their working hours bears the risk that these employees might abuse their discretion and behave opportunistically by reducing their individual effort when their working hours are no longer recorded. This is because eliminating working time registration usually makes employee monitoring much more difficult. As a result, under the regime of SMWT employees face fewer shirking costs and may therefore be less productive than workers who do not have this autonomy.[3] For example, since SMWT enables employees to coordinate their work and family obligations, workers may be more concerned about their personal lives than about their organizational duties. In this case, SMWT is unlikely to affect productivity positively and may even have negative consequences at the firm level.[4]

The implementation of SMWT may not only have an impact on individual and firm productivity, but may also affect the wages of the concerned workers, and thus, the firm’s wage costs. One line of argument highlights the increased costs associated with raising worker productivity by means of SMWT. If SMWT does in fact motivate workers to increase their level of effort and productivity, workers are likely to receive higher wages in recompense, which in turn

[3] For this reason, employers may wish to control whether or not employees achieve fixed objectives (Moen et al. 2011a, 2011b). In this case, input control (recording working hours) would be replaced by output control (recording goal achievement).

[4] In contrast to this perspective, Singe and Croucher (2003) as well as MacEachen et al. (2008) argue that due to an improvement in work-life balance, control over individual working hours enhances job satisfaction and work morale and can then be assumed to improve worker performance.

increases the firm's wage bill. However, another line of argument supports the view of SMWT as a policy for wage reduction. For example, where working time is no longer recorded, firms can save on overtime premiums and thus reduce their wage bills. Another explanation for declining wages as a result of an SMWT policy rests on the well-known trade-off between wages and fringe benefits (e.g., Gariety and Shaffer 2001; Baughman et al. 2003; Heywood et al. 2007). In line with the theory of compensating wage differentials, SMWT employees may earn less than other workers, because they are willing to substitute wages for higher job autonomy via SMWT.

As a result of these considerations, the net-effect of SMWT on a firm's profitability depends on the direction and the size of the observed productivity and wage bill effect. However, some of the possible combinations appear to be economically implausible and are thus unlikely to occur. For example, one can hardly imagine that SMWT increases firm productivity and decreases wage costs at the same time. Even if firms were able to exploit the fringe benefit-wages trade-off or avoid overtime premiums after the adoption of SMWT, they would nevertheless have to pay workers for improved productivity. This latter cost would, most likely, outweigh the former wage-cost reduction. By the same token, it is economically and intuitively not very plausible to assume that SMWT could increase wage costs and decrease firm productivity simultaneously.

The most plausible combinations regarding the performance effects of SMWT are the following. First, if SMWT increases worker productivity, it is also likely to increase both firm productivity and wage costs. The resulting effect on firm profitability might be positive or not, depending on the difference between the productivity and the wage bill increase. This case is likely to occur if firms adopt SMWT to increase productivity. Second, the introduction of SMWT could reduce both wage costs and firm productivity. This case is not unlikely to occur if SMWT employees reduce their efforts in response to their firm's elimination of overtime compensation. Nevertheless, SMWT turns out to be profitable if the reduction in wage costs is greater than the decline in productivity. Similarly, if employees perceive SMWT as a policy that contributes to satisfying a growing need for work-life-balance issues, the adoption of SMWT is unlikely to improve individual and firm productivity. In spite of this, firms might benefit from introducing SMWT via the fringe benefits-wages trade-off.

In sum, therefore, the theoretical discussion regarding the impact of SMWT on firm performance is quite heterogeneous and less unambiguous. This calls for an empirical analysis to shed light on this issue.

3. Data, variables, and descriptive statistics

In this study, I use establishment-level panel data of the Institute for Employment Research (IAB). The IAB Establishment Panel is an annual survey of over 15,000 firms of all size classes and industries, which ranks it as being the most extensive establishment-level data set in Germany. The firms are selected from a parent sample of all German firms that employ at least one employee covered by social security. This parent sample can be considered as complete, because firms in Germany are required by law to report the number of employees they have who are covered by social security. The selection method is stratification with respect to ten categories of establishment size and 16 economic sectors. This is why an establishment's probability of being selected increases with the number of staff that it employs. Hence, the IAB Establishment Panel is approximately proportional to the national level of employment and therefore representative for the German economy. A large set of questions are covered periodically, such as employment, wage bills, sales, investments, international trade, innovations, organizational change, worker representation, vocational and continuing training, as well as other firm characteristics. Most importantly for the present study, the incidence of SMWT has been covered regularly in even-numbered years since 2004.[5]

In the questionnaires, the incidence of SMWT is captured by a binary variable that is composed of the responses to the following question: *Does your establishment make use of trust-based work hours / self-managed working time (including the company's elimination of recording working hours)?* The firm representatives could answer 'yes' or 'no'. Figures 1 and 2 provide some descriptive information about the development of SMWT in German firms over time.

[Insert Figure 1 and Figure 2 about here]

The statistics in Figures 1 and 2 clearly demonstrate that SMWT has become more and more popular, irrespective of sector affiliation and firm size. However, banks and insurance companies are especially likely to offer SMWT arrangements to their employees. More than 50% of the firms in this industry apply SMWT. The lowest incidence of SMWT can be observed in the construction sector, where less than 20% of the firms implemented an SMWT arrangement. Apart from the positive time trend, Figure 2 additionally demonstrates that the incidence of SMWT increases with establishment size.

[5] For an introduction to the IAB Establishment Panel, see Fischer et al. (2009).

Figures 1 and 2 reveal another interesting pattern with regard to the incidence of SMWT among German firms over time. Specifically, there is large increase in the average incidence rates between 2004 and 2008, while the corresponding rates between 2008 and 2012 remain quite stable. More precisely, the overall incidence rate of SMWT in German firms increases from about 16% in 2004 to 28% in 2008, while the corresponding increase between 2008 and 2012 is just slightly more than 1%.[6] This implies that a significant number of firms adopted SMWT between 2005 and 2008, which prompted me to simulate a natural experiment (in the absence of a working time reform) and to estimate an intervention effect of SMWT as a human resource management practice on firm performance, where the time between 2005 and 2008 is the intervention or treatment period.

For this purpose, I use the data from the panel waves 2002, 2003, 2004, 2006, 2008 and 2010 and restrict the sample to firms that provide information in each of these years and which employ at least one employee covered by social security.[7] Additionally, all firms in the sample share the fact that they did not implement SMWT in 2004, which is therefore the last pre-treatment or pre-intervention period. Firms that implemented SMWT between 2005 and 2008 and retained this arrangement at least until 2010 constitute the treatment group ($TREAT = 1$), while establishments without SMWT arrangements between 2004 and 2010 serve as control group ($TREAT = 0$). In addition to firms with an SMWT arrangement in 2004, I excluded firms that I call ‘status switchers’. Status switchers are firms exhibiting discontinuous SMWT patterns; i.e., these firms switch between periods with and without SMWT. Finally, I do not consider firms with an SMWT introduction after 2008, because the period between 2008 and 2010 is intended to represent the post-treatment or post-intervention period.[8] Conditioned on a set of covariates, the

[6] Other working time arrangements exhibit similar patterns. For example, the incidence of changing the working time duration and position of part-time workers increased from about 12% in 2004 to 30% in 2008, while there was virtually no subsequent increase until 2012. The patterns for SMWT and working time flexibility for part-time workers are interesting insofar as there was no reform on working time arrangements in Germany between 2005 and 2008 that could explain the distinct growth in these working time arrangements. The beginning of the global economic and financial crisis in 2008 is a possible explanation for the observation that the incidence of SMWT did not continue increasing between 2008 and 2012. From this time onwards, firms were likely to be more cautious regarding the adoption of innovative management practices in general. Another explanation for the stagnant SMWT rates after 2008 is that firms may have already tapped the full potential of SMWT and could identify no further employees whose jobs would permit extending working time autonomy.

[7] In every panel wave, the total sales measure refers to the previous period. Hence, I transferred the sales information of 2003 through 2011 to 2002 through 2010 to ensure that past productivity is not explained by the current use of SMWT.

[8] Furthermore, I excluded non-profit establishments and the public sector. I also excluded banks and insurance companies, because their productivity and profitability measures are based on total assets rather than total sales.

data used in this study is a balanced panel consisting of 82 firms belonging to the treatment group and 623 firms belonging to the control group.

Compared to an unbalanced panel, a balanced panel is typically achieved at the cost of a significant reduction in sample size. On the other hand, however, utilizing a balanced panel ensures that the sample consists of the same firms before, during and after the intervention. As a result, the empirical analysis is not subject to the risk of potential compositional bias. The timeline for my quasi-natural experiment is as follows: The period from 2002 to 2004 represents the pre-intervention period. The intervention itself, i.e., the adoption of SMWT, takes place between 2005 and 2008. Finally, the post-intervention period starts at the end of 2008 and finishes at the end of 2010.

[Insert Figure 3 and Figure 4 about here]

Figures 3 and 4 display the time series of the natural logarithms of total sales and wage bills (both deflated by the GDP deflator) separated for the treatment and the control group. The figures indicate two interesting facts. First, on average, the firms of the treatment group have already been more productive and exhibited higher wage costs (unconditioned on covariates) before the intervention than the firms of the control group. In absolute terms, for example, the average productivity difference in 2002 is about 2.3 million euros, while the corresponding average wage-bill difference is more than 512,000 euros. These differences indicate that the average SMWT adopter is substantially larger than the average non-SMWT firm. Second, starting in the first intervention period 2005, both the unconditioned productivity and wage-bill increases of firms belonging to the treatment group appear to be somewhat steeper than the corresponding measures for the control group.[9] Of course, the two findings are purely descriptive and do not provide any meaningful insights with regard to a causal impact of SMWT on firm performance. In order to be able to draw conclusions in terms of causal inference, it is necessary to apply regression analysis, thereby accounting for both observed and unobserved firm heterogeneity.

[9] Apart from these findings, the figures clearly demonstrate the consequences of the global economic and financial crisis, which led to a sharp decline especially in the sales profile in 2009. However, since the economic climate recovered quite quickly after 2009 and the analysis only considers the post-treatment even-numbered years, this event will not affect the results of this study.

4. Econometric model and estimation strategy

The econometric model that I use to estimate the impact of SMWT on firm performance is based on an augmented Cobb-Douglas production function. Firm performance is measured at first as firm productivity captured by the natural logarithm of GDP-deflated total sales ($\ln Y$). The input factors capital, labor, and materials are proxied by the GDP-deflated total investments ($\ln K$), the number of employees ($\ln L$), and the GDP-deflated amount of material inputs ($\ln M$), respectively. The approach of using total sales as a productivity measure and regressing this measure on the three input factors of capital, labor, and materials can also be found, for example, in Bloom and Van Reenen (2006, 2007).

In addition, I control for observable firm characteristics by using a set of control variables X that are quite common in estimating the performance effects of certain human resource management practices within a production function framework.[10] Specifically, I control for the structure of the workforce (the proportion of skilled workers, female workers, part-time workers, fixed-term workers, temporary agency workers, freelancers, mini-jobbers,[11] and apprentices), technological innovations (status of technological equipment, amount of expansion investments), worker representation (presence of collective wage bargaining and works councils), the degree of globalization (export share), the churning rate, wage incentives (dummy for payments above collective wage bargaining level), the presence of overtime work, and other firm characteristics (foreign ownership, legal form of a company, legal and economic independence of a company). Moreover, I include dummy variables for sector affiliation and firm location.[12] Following an approach proposed by Dearden et al. (2006), I analogously estimate a GDP-deflated wage-bill equation ($\ln W$) and a corresponding profitability equation, where firm profitability is proxied by $\ln(Y/W)$, using the same set of input factors and control variables as specified for the production function.

Given that I had the opportunity to edit the data so as to construct a quasi-natural experiment, the aim of the present study is the estimation of an average treatment effect on the treated (ATT) by applying a differences-in-differences (DID) estimation strategy. This procedure should

[10] See, e.g., Hirsch and Mueller (2012), who also use the IAB Establishment Panel to estimate the productivity effects of temporary agency work.

[11] Mini jobbers represent a widespread phenomenon of the German labor market. The term describes workers with a monthly gross wage of up to 400 euros (450 euros since 2012).

[12] The precise definitions and descriptive statistics of the complete set of variables used in this study are available from the author upon request.

allow me to capture the causal impact that SMWT has on firm performance when implemented as a human resource management practice. The estimation model can therefore be written as

$$\ln y_{it} = \alpha_1 \ln K_{it-1} + \alpha_2 \ln L_{it-1} + \alpha_3 \ln M_{it-1} + X_{it}\beta$$
$$+\gamma TREAT_i \times POST_t + TREAT_i \times PRE_t\delta + \mu_i + v_t + \varepsilon_{it}\,, \qquad (1)$$

where y represents the respective measure of firm performance, i.e., total sales (Y), the wage bill (W), or firm profitability (Y/W). The input factors K, L, and M are lagged by one period to avoid simultaneity problems. Furthermore, ε_{it} is an idiosyncratic error term, v_t are time fixed effects captured by a series of annual time dummies to account for cyclical fluctuations, and μ_i reflects firm fixed effects. PRE_t is a vector of pre-treatment time dummies. The variable of interest is the interaction term $TREAT_i \times POST_t$, where $POST_t$ is a dummy variable indicating the post-intervention period, i.e., the period from the end of 2008 to the end of 2010. Hence, the parameter γ captures the ATT, i.e., the performance effect of the introduction of SMWT between 2005 and 2008. It corresponds to the DID estimator.

The crucial identifying assumption for causal inference in a DID regression framework is the common trend or parallel paths assumption (e.g., Abadie 2005; Lechner 2010; Angrist and Pischke 2015). This assumption requires that prior to the adoption of SMWT the performance measures of firms in the treatment and control group evolve in a similar way. Consequently, the common trend assumption excludes pre-intervention anticipation effects (so-called Ashenfelter's dip[13]) or different macro trends (Blundell and Costa Dias 2009). Figures 3 and 4 provide first insights with respect to the validity or violation of the common trend assumption. It is evident that the time series of the treatment and the control group do not display a perfectly parallel evolution between 2002 and 2004, which possibly indicates that the common trend assumption may indeed be violated. Recall, however, that Figures 3 and 4 display unconditioned performance values rather than the corresponding averages conditioned on a set of covariates, so a cautious interpretation of the finding appears to be appropriate at this stage. Fortunately, equation (1) allows me to test the common trend assumption. The assumption cannot be rejected if the interaction terms $TREAT_i \times PRE_t$ turn out to be statistically insignificant, i.e., if $\delta = 0$ (Mora and Reggio 2012, 2014). Equation (1) is estimated using the fixed effects within estimator. As a refer-

[13] It should be mentioned that Ashenfelter (1978) observed this phenomenon in the context of the evaluation of training programs, where he found that the wages of participants in training programs tend to fall just before entering the program. Transferred to the present case, this means that, if firm productivity or the wage bill declined in the periods before SMWT adoption, DID would be likely to overestimate the true treatment effect.

ence case, I also estimate equation (1) using conventional OLS, thereby ignoring the firm fixed effects μ_i and adding a time-invariant treatment variable $TREAT$ to the specification.

In the case of a violation of the common trend assumption, combining the DID approach with propensity score matching (PSM) provides a potential solution (e.g., Blundell, Costa Dias, Meghir, and Van Reenen 2004; Abadie 2005; Blundell and Costa Dias 2009). The idea behind this strategy is to ensure that firms in both the treatment and the control group share the same or very similar pre-intervention characteristics.[14] This can be achieved by matching firms of the treatment group with observationally similar firms of the control group before applying the DID estimator. Prior to the intervention, therefore, the treatment and the control group differ at best only with respect to treatment status. It appears quite intuitive that this procedure could help to satisfy the common trend assumption.

5. Empirical results

Table 1 displays the regression results based on equation (1).[15]

[Insert Table 1 about here]

Column (1) displays the DID estimates of the reference case applying the OLS estimator, while column (2) reflects the corresponding estimates of equation (1) applying the within estimator (FE). The ATT of SMWT on firm productivity in column (1) is 13.5%, while the corresponding ATT in column (2) is slightly lower at 11.5%.[16] Both coefficients are significant at the 5% level. Analogously, I obtain significant wage effects of SMWT of 10.6% (column (1)) and 9.1% (column (2)), respectively. These results lead to the following preliminary conclusions. First, the introduction of SMWT has a positive impact on firm productivity. Second, in combination with this outcome the positive wage effect of SMWT suggests that SMWT increases worker productivity which has to be compensated by higher wages. As a result, the net-effect of SMWT on firm profitability is positive but relatively small and statistically insignificant (2.9% in column (1) and 2.4% in column (2)).

[14] An assumption underlying this idea is that a potential time-varying selection bias can be attributed to differences in initial observable firm characteristics.
[15] The estimates of the input factors and the control variables are available from the author upon request.
[16] In a semi-logarithmic model the estimated coefficients of dummy variables have to be technically adjusted according to the transformation $\gamma' = \exp(\gamma) - 1$. For simplicity and clearness, I abstain from this procedure during the course of the paper. The induced loss of precision should be acceptable, because in the present case the maximum deviation between γ' and γ is only about 1%.

The estimated productivity and wage effects of SMWT can only be interpreted as causal effects if the common trend assumption holds. This assumption can be tested by inclusion of the pre-treatment interaction terms $TREAT \times PRE_1$ (which tests on parallel trends in 2003 and 2004) and $TREAT \times PRE_2$ (which tests on parallel trends in the first pre-intervention period 2002 and 2004).[17] While none of the coefficients for $TREAT \times PRE_1$ is statistically significant from zero, this does not always hold for the coefficients of the interaction term $TREAT \times PRE_2$. This interaction term is statistically significant at the 10% level in the OLS DID wage function displayed in column (1). Furthermore, the size of the corresponding interaction term in the production function is relatively high, albeit insignificant, in the OLS DID specification (column (1)) as well as in the FE DID specification (column (2)). These results indicate that a violation of the common trend assumption cannot be ruled out, so one should be careful to interpret the estimated productivity and wage effects of SMWT in a causal manner.

As mentioned in the previous section, combining the DID estimation strategy with PSM contributes to solving this problem. The combined PSM-DID approach proceeds in three steps. In a first step, the propensity score is estimated by specifying a binary choice model and regressing treatment status $TREAT$ on a set of pre-intervention characteristics that are supposed to determine selection into treatment status and/or to be responsible for a violation of the common trend assumption. In a second step, matching quality is assessed by looking at the balancing properties of the pre-treatment covariates before and after matching. For this purpose, t-tests for equality of means in the treatment and control group samples before and after matching as well as comparisons of the standardized percentage biases before and after matching are applied. Finally, the third step is estimating equation (1) based on the matched sample and testing the common trend assumption.

The PSM model in step 1 includes the following covariates.[18] First, I consider the input factors K, L, and M of performance equation (1) as well as major covariates in X that exhibited substantial differences between treatment and control firms in step 2 (i.e., differences were statistically significant or quite close to statistical significance). The considered X-variables are the shares of skilled workers, apprentices, and freelancers, the export share, the state of the technical equipment, the presence of a works council, and dummies for foreign ownership of the firm, its

[17] The year 2004 represents the last pre-intervention period and therefore serves as reference group.
[18] The complete list of covariates of the PSM model is displayed in Table 2. The precise definitions and descriptive statistics of these variables are available from the author upon request.

legal form, its legal and economic independence, and service-sector affiliation. For example, since SMWT increases worker autonomy, it is more likely to be observed in firms with a relatively high share of skilled workers and freelancers and with a relatively low share of apprentices. By the same token, SMWT should be more common in firms with high exports shares, state-of-the-art technologies, and works councils that have codetermination rights in working time matters. Second, I add variables of working time flexibility (use of working time corridors, change of duration and position of working time for part-time employees), practices of organizational decentralization and change (dummies for the delegation of decision rights to lower hierarchical levels and the reorganization of departments and/or functions), and family-friendly workplace practices (incidence of offers for workers on parental leave to keep in touch with their job or firm) to the PSM equation. The intuition behind the inclusion of these variables is that measures of working time arrangements (other than SMWT), organizational decentralization and change, and work-life balance are unlikely to be equally distributed between the treatment and the control group. More precisely, firms are more likely to adopt a policy of worker autonomy such as SMWT if they also apply policies of working time flexibility, organizational decentralization and change, and family-friendly workplace practices (e.g., Baughman et al. 2003; Heywood et al. 2007; Giardini and Kabst 2008; Bloom et al. 2011). Third, I add a dummy variable for realized product innovations, thereby addressing the finding of Godart et al. (2014), according to which SMWT is positively associated with product improvements. Finally, the PSM model includes pre-treatment total sales and wage bills, both in absolute logged terms and in differences.[19] These variables are added to explicitly control for differences between treatment and control firms with regard to their pre-intervention performance, so that treatment firms are matched to control firms with similar pre-treatment performance levels and trends.[20]

In order to avoid the possibility of time-varying control groups (i.e., control firms that are matched to one particular treatment firm vary across the pre-treatment periods), PSM is conducted using information only from the last pre-treatment period of 2004. It is important to conduct matching on pre-treatment characteristics that are themselves not affected by treatment status,

[19] The differenced performance variables are calculated using two-period differences based on information from the pre-treatment periods 2004 and 2002.

[20] PSM helps to reduce the potential time-varying selection bias mentioned above, but is unlikely to completely eliminate it. The amount to which this selection bias can be reduced is largely determined by the quantity and quality of the covariates that are used to calculate the propensity score and conduct the matching (Becker and Ichino 2002). This is why the propensity score equation contains such a rich set of covariates. Using a large set of covariates increases the likelihood that the matching procedure matches treated and untreated establishments that are virtually equal based on observable characteristics.

because this will help to meet the conditional independence assumption, which is another important assumption in the context of estimating treatment effects (Caliendo and Kopeinig 2008). The matching algorithm is the nearest neighbor matching with 10 nearest neighbors and replacement.[21] The weighted and unweighted DID estimates that are based on a matched sample can be found in columns (3) to (5) of Table 1,[22] while the statistics providing information on matching quality are displayed in Table 2.

[Insert Table 2 about here]

Table 2 demonstrates that before matching, treated and untreated firms significantly differ regarding the mean values of the covariates in the PSM equation. This suggests that firms selecting into SMWT, in fact, differ systematically in various ways from firms not selecting into SMWT. After matching, however, the treatment and control group no longer differ significantly from each other in any of the considered firm characteristics and are thus comparable. Furthermore, none of the covariates exhibit a standardized percentage bias that appreciably exceeds $\pm 5\%$ and the $\pm 8\%$ level is never reached. All in all, these findings demonstrate that PSM leads to well-balanced distributions of the relevant covariates in the treatment and control group. Thus, they insistently confirm the high quality of the matching procedure.

The inspection of the parameter estimates in the last three columns of Table 1 reveals two important results. First, both pre-treatment interaction terms $TREAT \times PRE_1$ and $TREAT \times PRE_2$ are statistically insignificant. This result holds for both the productivity and the wage equation. It does also hold in each of the OLS DID and FE DID specifications, irrespective of whether the observations in the matched sample are weighted or unweighted. In addition, compared to the corresponding estimates in the unmatched sample, the coefficients of the critical interaction term $TREAT \times PRE_2$ decrease considerably. This also holds in each of the performance functions and model specifications. All in all, these results lead to the conclusion that the common trend assumption can no longer be rejected. Second, compared to their counterparts displayed in columns (1) and (2), the treatment effects resulting from DID estimation on the matched sample are somewhat smaller. For example, the comparison of columns (2) and (5) reveals that the ATT of

[21] I repeated the analysis using 15 and 20 nearest neighbors with replacement in the PSM procedure. The results are very similar to those presented and discussed in this paper.

[22] The matched DID estimates displayed in columns (3) and (5) are obtained using analytical weights, where higher weights are assigned to control firms with a close proximity (based on the propensity score) to the respective treatment firm, while weights decline with increasing distance between treatment and control firm. The weight of treatment firms is 1.

SMWT on firm productivity declines from 11.5% to 9.1%, while the corresponding ATT on the wage bill declines from 9.1% to 8.7%. In both cases, however, the treatment effects remain significant at the 5% level.

Since the common trend assumption cannot be rejected, the estimated treatment effects can be considered to be causal. Here, the preferred specification is the weighted FE DID model displayed in column (5). There are three reasons for this assessment. First, the treatment effects resulting from column (5) are more conservative than their counterparts resulting from the OLS DID model displayed in column (3). Second, unlike the OLS estimator, the within estimator eliminates the bias caused by time-invariant unobserved firm characteristics for the complete set of covariates and not just for treatment status. Proceeding this way may additionally affect the size of the ATT of interest, as demonstrated in the present regression analyses. Third, the FE DID specification using analytical weights is preferred over the unweighted specification displayed in column (4), because the weighting procedure ensures that observations of control firms receive more weight when they are more similar to the characteristics of treatment firms. This contributes to increasing the degree of firm homogeneity within the matched sample relative to the approach without analytical weights.

In sum, it can therefore be concluded that, on average, the introduction of SMWT increases firm productivity by about 9% up to five years after intervention. The corresponding average wage bill effect is also positive with a magnitude of about 8.5%. Both performance effects are economically as well as statistically significant and can be considered as causal. Since a large part of the productivity increase is obviously absorbed by the workers via higher wages, the average effect of SMWT on firm profitability is positive, but relatively small (about 0.5%) and insignificant. Hence, SMWT is found to be beneficial for firms in terms of productivity, but not in terms of profitability.

The finding of a positive productivity effect combined with a positive wage bill effect suggests that SMWT does not only have the potential to satisfy a growing need for work-life balance issues, but also to increase worker productivity. Furthermore, this result contradicts the concern that SMWT, as a policy of worker autonomy, might encourage opportunistic effort reduction (shirking). In addition, the positive wage bill effect is not in line with the theory of compensating wage differentials which postulates a trade-off between SMWT as a fringe benefit and wages.

Besides the increasing worker productivity explanation, there is an alternative interpretation which posits that SMWT has a positive impact on wage bills. Specifically, a positive wage bill effect would also be expected if SMWT were associated with more compensated overtime work. This interpretation, however, is not really convincing, because SMWT exempts the employer from the obligation to record working hours. Consequently, overtime work is no longer defined, so paid overtime is unlikely to increase when a firm adopts SMWT. It is more likely that SMWT firms aim at substituting paid overtime for unpaid extra work in order to save on their wage costs. In supplemental regression analyses, however, I found no significant associations between SMWT and the amount of paid overtime as well as the probability of unpaid extra work (i.e., workers are neither compensated by overtime premiums nor by leisure time).[23]

The findings of the present study are consistent with a number of related empirical studies that also examine the performance effects of policies of working time autonomy (i.e., SMWT, working from home, flextime). For example, using individual-level panel data and accounting for unobserved heterogeneity, Beckmann et al. (2015) find that SMWT has a positive impact on worker effort. Although large-scale individual-level data prevents the authors from constructing an unambiguous productivity measure, they can show that the increase in working hours caused by SMWT cannot be attributed to an inefficient usage of working time, so that increased working hours do actually reflect higher levels of worker effort. Furthermore, Godart et al. (2014), who also use data from the IAB Establishment Panel, find a positive association between the introduction of SMWT (called trust-based work-time) and the subsequent innovation performance of firms.

The results of this paper are also in line with studies investigating the performance effects of working from home (e.g., Heywood et al. 2007; Bloom et al. 2015). Studies on working from home are closely related to the present paper, because working from home is often an integral part of an SMWT policy. While Bloom et al. (2015) exclusively focus on the policy of working from home in their randomized field experiment involving call center employees of a large Chinese travel agency, Heywood et al. (2007) use linked employer-employee data and consider working from home as an integral part of a bundle of family-friendly workplace practices.

[23] I conducted conventional fixed effects estimations, where the amount of paid overtime and the probability of unpaid extra work were regressed on a lagged SMWT dummy, a series of other lagged working time arrangements, and the lagged covariates also used in the performance equations (1). In both cases, the coefficients of the lagged SMWT dummy are statistically insignificant. The regression results are available from the author upon request.

Among others, Bloom et al. (2015) find that working from home increases worker productivity by about 13%, which is in line with the 9% productivity increase ascribed to SMWT obtained in this paper. Finally, both Heywood et al. (2007), as well as Bloom et al. (2015) find a positive wage effect for working from home, which contradicts a fringe benefits-wage trade-off, but supports the view that employees working from home are compensated for increased productivity and is thus consistent with the respective finding in the present paper.

Furthermore, the empirical results of this paper are in line with studies that focus on the performance effects of flextime, which is also a policy of working time autonomy, but the amount of autonomy is less than that for SMWT or working from home.[24] For example, using panel data from a sample of slightly more than 30 companies of the pharmaceutical sector in the United States and applying random effects and two-stage least squares fixed effects estimates, Shepard et al. (1996) find that flextime contributes to increasing firm productivity by approximately 10%, which is comparable to the productivity effect of SMWT. Finally, using large-scale representative Canadian firm-level data and estimating (dynamic) fixed effects models, Lee and DeVoe (2012) find that flextime has a mixed impact on firm profitability, depending on whether the firms follow an employee-centered or a cost reduction strategy. Specifically, when flextime is implemented within a strategy centered on employees, both revenue and total payroll expenditures are positively affected, where the revenue effect outweighs the wage cost effect, thus leading to higher profitability. However, when flextime is implemented within a cost reduction strategy, the revenue effect is negative, while the wage cost effect is insignificant, so that profitability decreases. These findings fit with the results of the present study insofar as the overall effect on profitability is positive, but rather small.

6. Sensitivity analysis

This section contains the results of a number of alternative specifications and estimation strategies that aim at checking the robustness of the DID estimates discussed in the previous section. Specifically, five sensitivity checks are applied. First, DID is executed, but instead of combining DID with PSM, the treatment effect of SMWT is estimated by conditioning on lagged pre-treatment covariates rather than contemporary pre- and post-treatment covariates as before. In this case, the estimation model has the following form:

[24] Under flextime workers are restricted to work at certain core times and obliged to balance hours worked within a given time horizon.

$$\ln y_{it} = \gamma TREAT_i \times POST_t + Z_{i,t \le t^*}\beta + \mu_i + v_t + \varepsilon_{it} \; . \tag{2}$$

Here, Z is the matrix of covariates including the input factors $\ln K$, $\ln L$, $\ln M$, and the control variables specified in X.[25] The index $t \le t^*$ indicates the pre-treatment periods 2002, 2003, and 2004, where t^* represents the last pre-treatment period 2004.[26] Conditioning on pre-treatment covariates may be viewed as an alternative approach to matching based on pre-treatment characteristics and should therefore produce similar treatment effects to those reported in Table 1, columns (4) and (5).

Second, I repeat the estimation of equation (1), but instead of using $\ln y$, I choose $\ln(y/L)$ as the dependent variable, thereby considering the impact of SMWT on labor productivity and wage costs per employee rather than in absolute terms. Modifying the production and/or wage bill function in this way has also been applied in a number of empirical studies, including Addison et al. (2001), Bertschek and Kaiser (2004), Bloom et al. (2011), and Bellmann and Hübler (2015). The estimation model therefore is[27]

$$\ln\left(\frac{y_{it}}{L_{it}}\right) = \alpha_1 \ln K_{it-1} + (\alpha_2 - 1)\ln L_{it} + \alpha_3 \ln M_{it-1} + X_{it}\beta$$
$$+\gamma TREAT_i \times POST_t + TREAT_i \times PRE_t\delta + \mu_i + v_t + \varepsilon_{it} \; . \tag{3}$$

As before, the DID estimator of γ can be viewed as a causal treatment effect if $\delta = 0$.

The third robustness check is an estimation of the differenced regression model

$$\Delta \ln y_i = \gamma INTRO_i + \Delta Z_i\beta + \Delta\varepsilon_i \; , \tag{4}$$

where Δ denotes the difference operator that refers to the last post-treatment period 2010 and the last pre-treatment period 2004, i.e., $\Delta x_i = x_{it} - x_{it-6}$. Using differenced variables is an alternative procedure to account for time-constant unobserved heterogeneity. $INTRO$ is equivalent to $TREAT$ insofar as it indicates firms that have introduced SMWT between 2005 and 2008. The only difference between $INTRO$ and $TREAT$ is that $INTRO$ requires continuous participation of

[25] The composition of Z slightly differs between the following specifications depending on the considered observation period and the availability of variables within this period. For more details, see the explanations in the note at the bottom of Table 3.
[26] Hence, the regression includes the panel waves of 2004, 2008, and 2010, where the variables in Z are transferred from 2002 to 2004, from 2003 to 2008, and from 2004 to 2010.
[27] Note that in equation (3) the term $\ln L_{it}$ replaces the original term $\ln L_{it-1}$ used in equation (1). Without this change, equations (3) and (1) would be equivalent, both yielding identical parameter estimates, except for $\ln L_{it-1}$.

the firms merely in 2004, 2006, 2008, and 2010 (instead of 2002, 2003, 2004, 2006, 2008, and 2010).

A natural consequence of estimating the performance impact of the introduction of SMWT by means of a quasi-natural experimental setting as applied in this paper is the exclusion of firms that have already implemented SMWT in 2004 and before (first movers) as well as firms that have abolished their initial SMWT arrangements at some time after 2004 (abolishers). Moreover, this approach excludes status switchers as well as all firms with gaps in their survey participation between 2002 and 2010. Hence, the procedure of a quasi-natural experiment entails a substantial reduction in sample size. My fourth robustness check takes this point into account by specifying a conventional fixed effects model

$$\ln y_{it} = \gamma SMWT_{it} + Z_{it}\beta + \mu_i + v_t + \varepsilon_{it} \,. \tag{5}$$

Here, $SMWT$ is a dummy variable indicating whether or not firm i uses SMWT in period t. This specification keeps SMWT abolishers, first movers, and status switchers in the analysis. Furthermore, the fixed effects model does not require a balanced panel and thus utilizes all available information of the firms, even if they do not participate in the survey over the entire observation period.

As a final robustness check, I estimate a performance model that captures all possible adjustment strategies regarding SMWT, i.e., no adjustment (the SMWT status $SMWT = 1$ or $SMWT = 0$ in 2010 is the same as in the initial observation period 2004), the introduction of SMWT until 2008, and the abolishment of SMWT until 2008. In order to account for time-constant unobserved heterogeneity, I consider a six-period differences model. The regression model can therefore be written as

$$\Delta \ln y_i = \gamma_1 FM_i + \gamma_2 INTRO_i + \gamma_3 ABOLISH_i + \Delta Z_i\beta + \Delta\varepsilon_i \,, \tag{6}$$

where Δ and $INTRO$ are defined as before. FM is a dummy variable indicating first movers, i.e., firms that already established SMWT in 2004 and continued to apply SMWT at least until 2010, while $ABOLISH$ indicates firms that abolished their initial SMWT arrangement between 2005 and 2008. Firms without an SMWT arrangement between 2004 and 2010 serve as the reference group.

The regression results of the five robustness checks can be found in Table 3.[28]

[Insert Table 3 about here]

Column (1) displays the treatment effects resulting from the DID estimation of equation (2). It turns out that both the productivity effect and the wage effect of SMWT are about 1.5 percentage points larger than in the benchmark model displayed in Table 1, column (5). Column (2) contains the DID estimates of γ that are obtained from equation (3), when the performance measure $\ln y$ is replaced by $\ln(y/L)$. In this specification, the ATT on labor productivity is about 1.5 percentage points smaller than the corresponding effect obtained in the benchmark model, but remains statistically significant at the 5% level. In contrast, the ATT on wage costs per employee decreases to about 2.5%, which is statistically insignificant. Note that since both pre-treatment effects δ_1 and δ_2 are not statistically significant from zero (labor productivity equation: $\delta_1 = 0.029, p = 0.538, \delta_2 = 0.034, p = 0.539$; wage per employee equation: $\delta_1 = -0.012, p = 0.706, \delta_2 = -0.013, p = 0.692$), the common trend assumption cannot be rejected. Hence, unlike the benchmark model, causal inference in this case does not require the combination of DID with PSM. The SMWT effects resulting from the estimation of equation (4) are again similar to the benchmark effects (see column (3)). Furthermore, the estimates of the fixed effects model (5) displayed in column (4) indicate positive and significant productivity and wage effects of SMWT of approximately 1.5% and 1.3%, respectively.

There are two explanations for the finding that the sizes of the performance effects obtained from the fixed effects model (5) are smaller than in the PSM-DID benchmark case. First, the benchmark model and the fixed effects model refer to different time horizons. While the treatment effects in the benchmark model measure the average performance effect from 2008 to 2010 relative to 2004, the fixed effects estimates capture the average biannual performance effect between 2004 and 2010. Second, the PSM-DID benchmark model focusses on performance effects of the introduction of SMWT, while the fixed effects model provides information about the performance of firms that have established SMWT at some time between 2004 and 2010 relative to firms without an SMWT arrangement. In the latter approach, therefore, the performance effect of SMWT is identified using information of SMWT adopters, abolishers, and status switchers. For

[28] Table 3 only contains the estimates for the productivity and the wage equations, as the estimates for the respective profitability functions are not displayed to save space. All estimated profitability effects of SMWT are quite small and insignificant. The corresponding regression results are available from the author upon request.

example, the fixed effects estimates would turn out to be smaller than the corresponding ATT if status switchers achieved smaller performance effects of SMWT than adopters.

Finally, the results of the robustness check according to equation (6) can be found in column (5) of Table 3. The estimates confirm the previous impression from the fixed effects model. Most importantly, the introduction of SMWT as measured by $INTRO$ significantly increases both firm productivity and the wage bill, where the magnitudes of the coefficients are similar to the preceding findings. Interestingly, the corresponding coefficients for the firms that already implemented SMWT before 2004 are positive, but fail to be statistically significant. There are at least two explanations for this finding. First, the positive performance effect of SMWT might decrease over time. Second, there might be a late adopter or second mover advantage rather than a first mover advantage with regard to the implementation of SMWT, meaning that firms which implemented SMWT relatively early (in 2004 or before) did not achieve the same level of implementation quality as the firms which adopted SMWT later on. However, a precise answer as to which of the two explanations holds true is beyond the scope of this paper. Last but not least, the negative wage effect for firms that have abolished SMWT might at first sight be seen as good news, unless firm productivity also declines. The observed productivity loss is, in fact, negative, but insignificant. Altogether, this leads to a positive profitability effect of about 5.6% (not displayed), which is however statistically insignificant.

7. Explanations for the productivity effect of SMWT

The empirical analysis in Sections 5 and 6 has shown that the introduction of SMWT contributes to increasing firm productivity. The theoretical considerations in Section 2 offer four explanations for this finding: (a) improved worker motivation via enhanced working time autonomy, (b) more efficient working time allocation due to decentralized decision-making, (c) increased worker effort elicited by the feeling to reciprocate positively to the endowment with SMWT, (d) positive selection effects that may occur if SMWT firms are able to attract more productive workers. This section aims at discriminating between the four channels of increased firm productivity.

In their study on the impact of SMWT on worker effort, Beckmann et al. (2015) find that SMWT and intrinsic worker motivation are complements in exerting extra effort, while this does not hold for SMWT and worker reciprocity. Hence, intrinsically motivated workers are found to exert significantly more effort under an SMWT regime than less motivated workers, which is consistent with the increased worker motivation interpretation mentioned above. However, there is no evidence that workers with a high level of positive reciprocity exert more effort under SMWT than workers with less reciprocity. Against this background, worker reciprocity as a response to the firm's 'gift' of SMWT does not appear to be a significant driver of firm productivity. Hence, although I cannot explicitly rule out the reciprocity interpretation with the results of this study which is based on firm-level data, positive worker reciprocity is unlikely to be responsible for the productivity increase caused by SMWT.

In contrast to the worker reciprocity interpretation, the data set used in this study allows me to estimate the relevance of selection effects (at least to some extent) by disentangling the incentive and selection effects of SMWT. For this purpose, I proceed in two steps. First, I estimate whether the use of SMWT is associated with the hiring of skilled and high-skilled workers captured by the variable H_SK, which is defined as the number of skilled and high-skilled workers hired within the first term of a respective year relative to all hiring decisions within this period (as a percentage). Second, I examine whether the hiring of skilled and high-skilled workers mediates or moderates the use of SMWT in a firm's production function.

In the first step, therefore, I estimate the labor demand equation

$$H\_SK_{it} = \gamma SMWT_{it} + Z_{it}\beta + \mu_i + v_t + \varepsilon_{it} \,, \tag{7}$$

where again Z is the matrix of covariates. If $\gamma > 0$, SMWT is found to be associated with the hiring of skilled and high-skilled workers, thus indicating that SMWT contributes to attracting productive workers. Since H_SK is censored at zero, equation (7) is estimated using Tobit maximum likelihood (ML), thereby ignoring the firm fixed effects μ_i, and the fixed effects within estimator.[29]

The second step is related to an estimation approach used in Lazear (2000) by specifying the production function

$$\ln Y_{it} = \gamma_1 SMWT_{it} + \gamma_2 H\_SK_{it} + \gamma_3 SMWT_{it} \times H\_SK_{it} + Z_{it}\beta + \mu_i + v_t + \varepsilon_{it} \,. \tag{8}$$

As before, SMWT is expected to increase firm productivity, i.e., $\gamma_1 > 0$. In order to see whether or not H_SK mediates the productivity effect of $SMWT$, one has to compare the estimate of γ_1 when both H_SK and the interaction term are excluded (i.e., $\gamma_2 = \gamma_3 = 0$) with the corresponding

[29] The conventional fixed effects within estimator is used, since the fixed effects Tobit model leads to inconsistent parameter estimates (e.g., Baltagi 2008).

estimate of γ_1 when excluding only the interaction term (i.e., $\gamma_3 = 0$). If the latter is smaller than the former and $\gamma_2 > 0$, the overall productivity effect of $SMWT$ is composed of both an incentive effect and a selection effect. Finally, the parameter γ_3 indicates whether or not H_SK moderates the productivity effect of $SMWT$. Equation (8) is estimated using the fixed effects within estimator.[30]

The estimation results of equations (7) and (8) are displayed in Table 4.

[Insert Table 4 about here]

The parameter estimates displayed in columns (1) and (2) indicate that the use of SMWT contributes to increasing the share of hired skilled and high-skilled workers, which leads to the conclusion that firms can adopt SMWT as a recruiting device. Furthermore, the estimates of the augmented production function (8) displayed in column (5) show that the hiring of qualified employees does not moderate the productivity effect of $SMWT$ as the hypothesis $\gamma_3 = 0$ cannot be rejected. Finally, hiring qualified workers mediates the productivity effect of $SMWT$ only to a very small extent. The coefficient of $SMWT$ decreases only slightly from $\gamma_1 = 3.9\%$ in column (3) to $\gamma_1 = 3.7\%$ in column (4).[31] According to these estimates, the overall productivity effect of SMWT appears to be mainly driven by an incentive effect, while selection effects obviously only play a minor role. All in all, therefore, the findings obtained in this section suggest that the positive productivity effect of SMWT can be attributed to the benefits of decentralized decision-making, i.e., improved worker motivation and more efficient working time allocation due to utilizing superior knowledge at lower hierarchical levels.

8. Conclusions and implications

In this paper, I empirically examine the impact of SMWT on firm performance using German establishment-level panel data. The implementation of SMWT provides employees with a high degree of control over scheduling individual working time. Theoretically, workers may respond positively or negatively to their newly gained time sovereignty, depending on whether the productive incentives of time sovereignty outweigh the counterproductive incentives or not.

[30] The variable H_SK is only available in the data from 2008 onwards. Hence, equation (8) is estimated using the panel waves of 2008 and 2010. This is different to the estimation of equation (5), where the panel waves of 2004, 2006, 2008, and 2010 can be applied.

[31] Note that the coefficient for $SMWT$ is about 2.5 times larger than the corresponding estimate displayed in Table 3, column (4). This is in line with the previous finding obtained in Section 6, according to which the productivity effect of SMWT might diminish over time.

Based on the construction of a quasi-natural experiment and an estimation strategy that combines differences-in-differences estimation with propensity score matching, I find that both firm productivity and the wage bill increase after the adoption of SMWT. Up to five years after the introduction of SMWT, the estimated productivity effect of SMWT is approximately 9%, while the corresponding wage effect is approximately 8.5%, leaving an economically small and statistically insignificant effect on firm profitability. Since the estimation approach ensures the validity of the common trend assumption, the estimated productivity and wage effects of SMWT can be interpreted as causal effects. The parameter estimates are robust to several modifications with regard to sample size, model specification, and estimation technique.

The main conclusion from these results is that the introduction of SMWT has a positive impact on worker productivity, which has to be compensated by higher wages. At the firm level, improved worker productivity becomes visible in the form of increased sales. All in all, therefore, the finding of a positive productivity effect in combination with a positive wage bill effect argues for the view that firms adopt SMWT primarily in order to increase worker productivity rather than solely as a response to a growing demand for work-life balance policies. This view is consistent with related studies that also find positive performance effects as a result of working time autonomy (e.g., Heywood et al. 2007; Beckmann et al. 2015; Bloom et al. 2015). Moreover, the results contradict concerns that are common to decentralization policies in general, i.e., that the delegation of decision rights to subordinates encourages opportunistic behavior (here: effort reduction). In fact, the results of the study emphasize the importance of the benefits of decentralization policies. According to the theory of decentralization, increased work motivation and an effective utilization of the specialized competence of subordinate staff are the key drivers of improved worker productivity. This perspective is supported by supplemental empirical evidence suggesting that firm productivity is more likely to be explained by incentive effects than by selection effects or worker reciprocity.

Interestingly, the positive wage effect of SMWT clearly contradicts the concerns of those who suspect that the introduction of SMWT might first and foremost serve as a policy for saving wage costs by revoking the mandatory registration of working time and thereby eliminating paid overtime work. If reducing wage costs was really the motivation behind the firm's introduction of SMWT, one would expect to find a negative wage bill effect. And even if repealing paid overtime work did not impair the improved worker motivation induced by SMWT, it would still be unlikely for the overall wage bill effect to be significantly positive. Hence, it can at least be concluded that any potential wage cost saving effect is clearly outweighed by wage bill increases caused by improved worker productivity.

The results of the present study provide some important management implications for firms which are considering the introduction of SMWT arrangements. Most importantly, SMWT improves firm productivity and is therefore beneficial for firms. It is also beneficial for workers because of its positive effect on wages. The attractiveness of SMWT for workers is additionally emphasized in those studies which find that SMWT, or general job autonomy, is positively associated with job satisfaction when using large-scale individual-level data (e.g., Green 2004; Holly and Mohnen 2012). SMWT therefore appears to be a valuable human resource management practice, so firms can be encouraged to adopt SMWT arrangements. Even if one accepts that a substantial part of increased firm productivity is absorbed by the workers via higher wages, SMWT implementation might nevertheless be an interesting firm strategy. The first reason for this is that the implementation of SMWT might contribute to reducing a firm’s monitoring costs. For example, the elimination of recorded working time which is associated with the introduction of SMWT is a promising means for reducing monitoring costs. Furthermore, as a family-friendly workplace practice, SMWT might contribute to mitigating worker turnover, thereby reducing turnover costs. Finally, the analysis in Section 7 has shown that SMWT has the potential to improve the employers’ attractiveness for skilled and high-skilled workers.

Nevertheless, firms should keep an eye on the sustainability of the productivity improvements. According to a finding in the sensitivity analysis, it cannot be ruled out that the positive productivity effect of SMWT declines over time, and thus, fails to be persistent. In this context, it might be helpful to think about modifying the initial SMWT arrangement. For example, one might consider extending the degree of worker autonomy by additionally allowing SMWT employees to work from home. This response appears to be more promising than the prospect of abolishing SMWT, as the results in this paper indicate.

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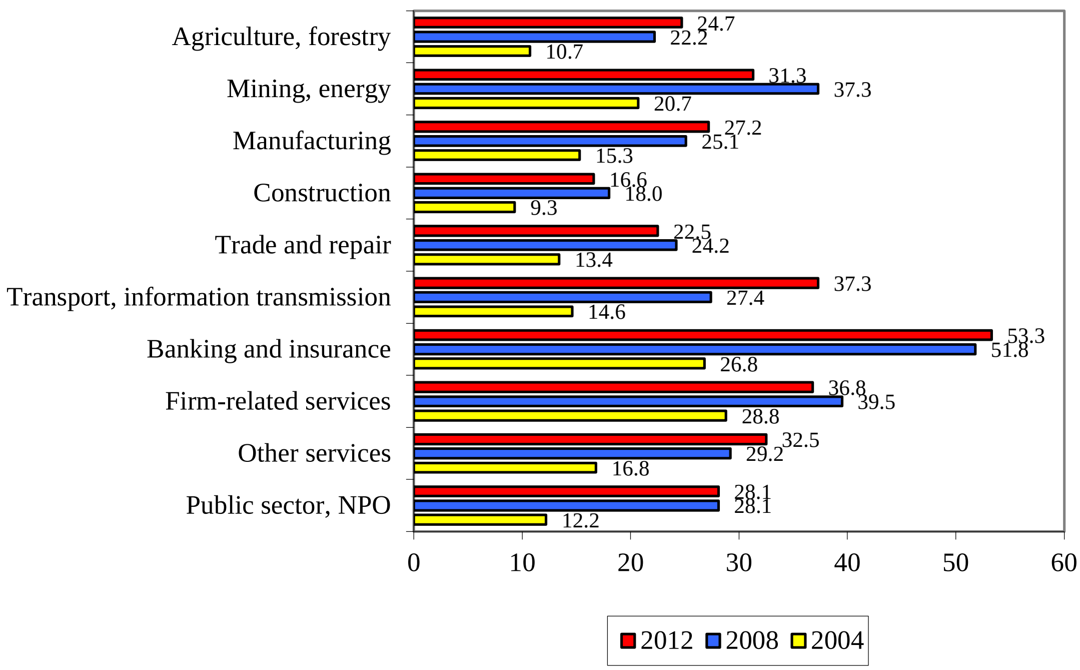

Figure 1. Incidence of SMWT by sector affiliation

Note: The displayed values are percentages. Sample size in 2004/2008/2012 is 15,588/15,380/15,325.

Source: IAB Establishment Panel 2004, 2008, 2012, own calculations.

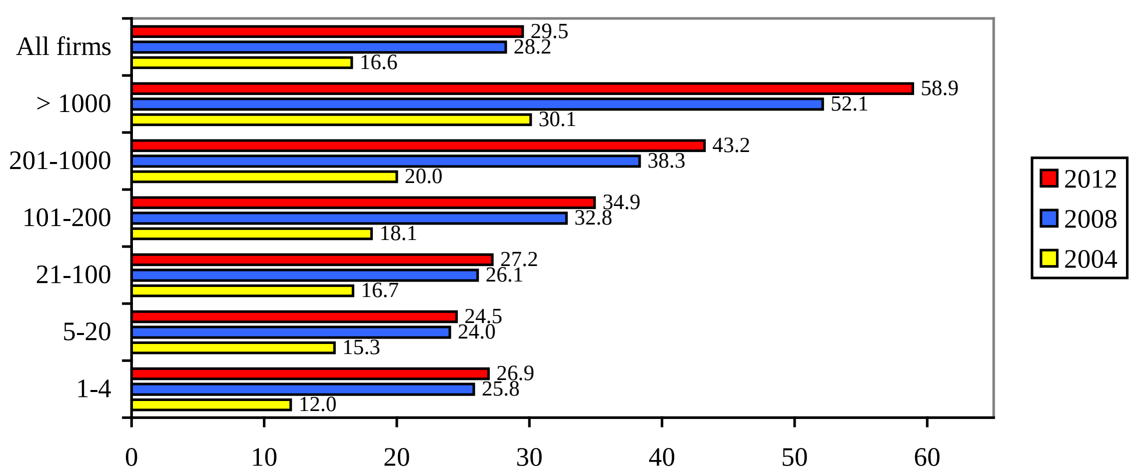

Figure 2. Incidence of SMWT by establishment size (number of employees)

Note: The displayed values are percentages. Sample size in 2004/2008/2012 is 15,588/15,380/15,325.

Source: IAB Establishment Panel 2004, 2008, 2012, own calculations.

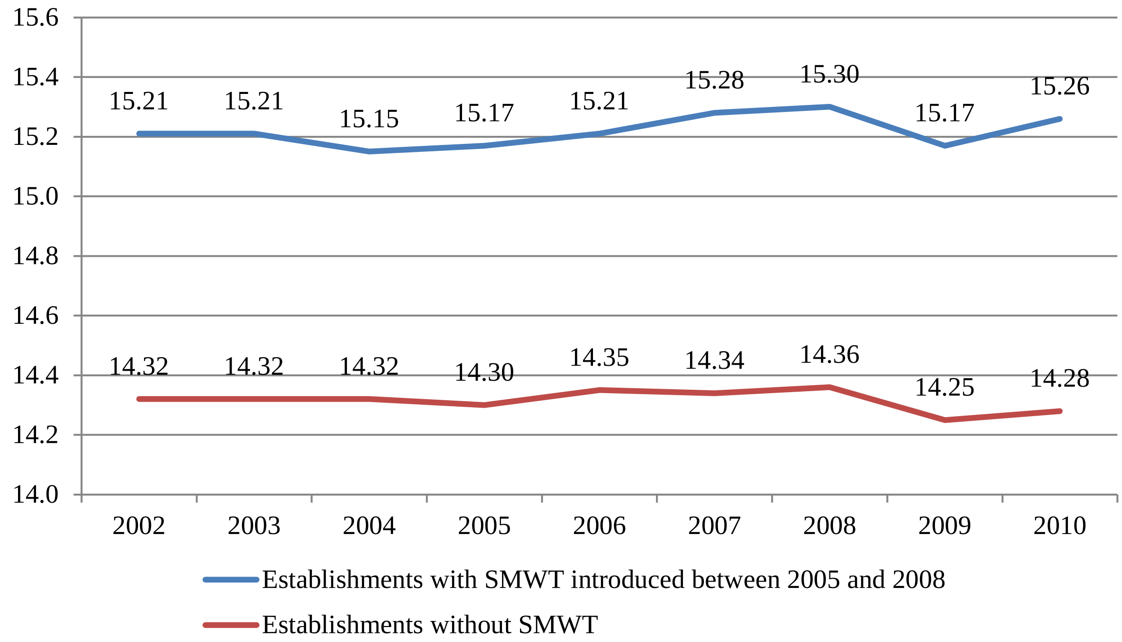

Figure 3. Total sales (logged, GDP-deflated) in SMWT and non-SMWT establishments

Note: Sample size: 82 (SMWT establishments), 623 (non-SMWT establishments).

Source: IAB Establishment Panel, own calculations.

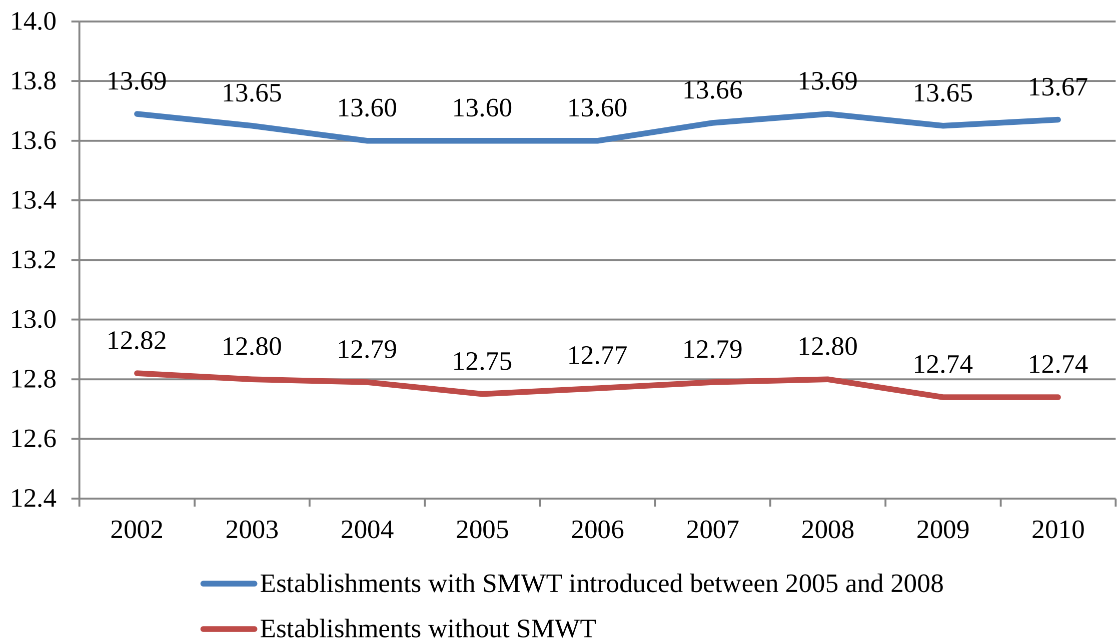

Figure 4. Wage bills (logged, GDP-deflated) in SMWT and non-SMWT establishments

Note: Sample size: 82 (SMWT establishments), 623 (non-SMWT establishments).

Source: IAB Establishment Panel, own calculations.

Table 1. The impact of SMWT on firm performance

Estimation strategy		OLS DID	FE DID	OLS DID (weighted)	FE DID (unweighted)	FE DID (weighted)
Dependent variable	Explanatory variables	(1)	(2)	(3)	(4)	(5)
$\ln Y$	$TREAT$	-0.121** (0.057)		-0.131** (0.065)		
	$TREAT \times POST$	0.135** (0.059)	0.115** (0.046)	0.130** (0.065)	0.108** (0.045)	0.091** (0.046)
	$TREAT \times PRE_1$	0.055 (0.056)	0.052 (0.052)	0.056 (0.061)	0.054 (0.053)	0.047 (0.056)
	$TREAT \times PRE_2$	0.106 (0.072)	0.081 (0.061)	0.048 (0.076)	0.064 (0.060)	0.044 (0.061)
$\ln W$	$TREAT$	-0.103** (0.041)		-0.088** (0.042)		
	$TREAT \times POST$	0.106** (0.053)	0.091** (0.045)	0.097* (0.051)	0.083* (0.044)	0.087** (0.042)
	$TREAT \times PRE_1$	0.029 (0.048)	0.029 (0.042)	0.012 (0.050)	0.015 (0.042)	0.003 (0.043)
	$TREAT \times PRE_2$	0.084* (0.047)	0.067 (0.046)	0.035 (0.050)	0.048 (0.046)	0.019 (0.045)
$\ln(Y/W)$	$TREAT$	-0.018 (0.052)		-0.043 (0.057)		
	$TREAT \times POST$	0.029 (0.055)	0.024 (0.043)	0.033 (0.060)	0.025 (0.043)	0.004 (0.043)
	$TREAT \times PRE_1$	0.026 (0.060)	0.023 (0.054)	0.044 (0.064)	0.039 (0.057)	0.044 (0.059)
	$TREAT \times PRE_2$	0.022 (0.071)	0.014 (0.065)	0.013 (0.074)	0.016 (0.065)	0.025 (0.066)
	Input / control variables	Yes	Yes	Yes	Yes	Yes
	Time fixed effects	Yes	Yes	Yes	Yes	Yes
	Firm fixed effects	No	Yes	No	Yes	Yes
n		705	705	425	425	425
N		3,525	3,525	2,125	2,125	2,125

Note: The values in parentheses represent robust standard errors clustered at the firm level. N (n) is the number of observations (firms). All specifications additionally contain an identical set of covariates described in Section 4. The estimates displayed in columns (3)–(5) are based on a matched sample using propensity score matching. The matching algorithm is nearest neighbor matching with 10 neighbors and replacement. In columns (3) and (5) the observations of the control group (non-SMWT firms) are weighted using analytical weights. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Source: IAB Establishment Panel, waves 2002-2011; own calculations.

Table 2. Descriptive statistics by treatment status before and after matching

Covariate	Before matching Treatment group	Control group	$p > \|t\|$	%bias	After matching Treatment group	Control group	$p > \|t\|$	%bias
$\ln K$	8.881	7.209	0.014**	28.5	8.881	8.905	0.967	-0.4
$\ln L$	3.680	3.041	0.000***	38.0	3.680	3.672	0.966	0.4
$\ln M$	14.414	13.518	0.000***	38.5	14.414	14.409	0.986	0.2
Skilled workers	72.855	66.824	0.031**	26.8	72.855	72.229	0.774	2.8
Apprentices	3.765	5.836	0.045**	-26.5	3.765	3.836	0.906	-0.9
Freelancers	2.024	0.660	0.312	12.5	2.024	2.314	0.874	-2.6
Technical status	0.743	0.663	0.145	17.6	0.743	0.750	0.885	-1.3
Exports	9.817	3.640	0.000***	41.5	9.817	8.795	0.555	6.9
Works council	0.414	0.197	0.000***	48.3	0.414	0.426	0.800	-2.7
Foreign ownership	0.109	0.037	0.003***	27.9	0.109	0.125	0.613	-6.1
Private company	0.268	0.412	0.012**	-30.7	0.268	0.292	0.577	-5.2
Independent company	0.768	0.889	0.002***	-32.6	0.768	0.785	0.673	-4.6
Working time changes for part-timers	0.158	0.056	0.001***	33.2	0.158	0.160	0.945	-0.8
Working time corridors	0.182	0.089	0.008***	27.5	0.182	0.202	0.611	-5.7
Delegation of decision rights to lower hierarchical levels	0.158	0.085	0.034**	22.3	0.158	0.175	0.638	-5.2
Reorganization of departments and/or functions	0.317	0.113	0.000***	51.0	0.317	0.301	0.724	4.0
Parental leave offer	0.170	0.090	0.023**	23.8	0.170	0.173	0.947	-0.7
Product innovations	0.548	0.331	0.000***	44.6	0.548	0.539	0.840	2.0
Service sector	0.414	0.328	0.122	17.8	0.414	0.448	0.478	-7.1
$\ln Y$	15.199	14.317	0.000***	41.8	15.199	15.231	0.881	-1.5
$\Delta \ln Y$	-0.057	-0.002	0.174	-12.9	-0.057	-0.024	0.434	-7.9
$\ln W$	13.605	12.805	0.000***	39.0	13.605	13.604	0.996	0.1
$\Delta \ln W$	-0.092	-0.029	0.193	-14.5	-0.092	-0.065	0.504	-6.2
n	82	618			82	343		

Note: n is the number of firms. %bias denotes the standardized percentage bias. The propensity score matching algorithm is nearest neighbor matching with 10 neighbors and replacement. The pre-treatment period is 2004. The observations of the control group (non-SMWT firms) in the matched sample are weighted using analytical weights. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Source: IAB Establishment Panel, waves 2002-2011; own calculations.

Table 3. Sensitivity analysis

Estimation strategy		FE DID	FE DID	OLS	FE	OLS
Model specification		(2)	(3)	(4)	(5)	(6)
Regres-sand	Explanatory variables	(1)	(2)	(3)	(4)	(5)
$\ln Y$	$TREAT \times POST$	0.108*** (0.040)				
$\ln(Y/L)$	$TREAT \times POST$		0.076** (0.037)			
$\Delta \ln Y$	$INTRO$			0.098** (0.046)		
$\ln Y$	$SMWT$				0.015** (0.007)	
$\Delta \ln Y$	FM					0.028 (0.041)
	$INTRO$					0.102** (0.047)
	$ABOLISH$					-0.044 (0.045)
$\ln W$	$TREAT \times POST$	0.100** (0.047)				
$\ln(W/L)$	$TREAT \times POST$		0.024 (0.030)			
$\Delta \ln W$	$INTRO$			0.073* (0.044)		
$\ln W$	$SMWT$				0.013* (0.007)	
$\Delta \ln W$	FM					0.071 (0.047)
	$INTRO$					0.077* (0.045)
	$ABOLISH$					-0.100** (0.049)
n		705	705	1,156	13,129	1,313
N		2,115	3,525	1,156	25,786	1,313

Note: The values in parentheses represent robust standard errors clustered at the firm level (columns (1), (2), (4)) or heteroscedasticity-robust standard errors (columns (3), (5)). N (n) is the number of observations (firms). The specifications contain the same covariates that have also been applied in the regressions displayed in Table 1. The model displayed in column (1) additionally controls for the pre-treatment variables $\Delta \ln Y$ and $\Delta \ln W$. The pre-treatment interaction terms $TREAT \times PRE_1$ and $TREAT \times PRE_2$ are not displayed in column (2). They are always insignificant, so the hypothesis $\delta = 0$ cannot be rejected. The models in columns (3), (4) and (5) additionally control for a series of working time arrangements (work at weekends, working time changes for part-timers, working time accounts, employment-securing working time reduction) and include a product innovation dummy (except the FE model in column (4)). * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Source: IAB Establishment Panel, waves 2002-2011; own calculations.

Table 4. Incentive and selection effects of SMWT

Estimation strategy	Tobit ML	FE	FE	FE	FE
Model specification	(7)	(7)	(8)	(8)	(8)
Dependent variable	H_SK	H_SK	$\ln Y$	$\ln Y$	$\ln Y$
Explanatory variables	(1)	(2)	(3)	(4)	(5)
$SMWT$	4.256*** (1.309)	2.425** (0.980)	0.039*** (0.012)	0.037*** (0.012)	0.039*** (0.014)
H_SK				0.039*** (0.011)	0.041*** (0.012)
$SMWT \times H\_SK$					-0.005 (0.021)
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	Yes	Yes	Yes
n	14,010	14,010	8,650	8,650	8,650
N	23,709	23,709	12,229	12,229	12,229

Note: The values in parentheses represent robust standard errors clustered at the firm level. N (n) is the number of observations (firms). The parameter estimates for H_SK and the interaction term are multiplied by 100. The specifications contain the same set of covariates that has also been applied in column (4) of Table 3. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Source: IAB Establishment Panel, waves 2008-2012; own calculations.