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European Commission

DG for Employment, Social Affairs and Equal Opportunities

Study to support an Impact Assessment on further action at European level regarding Directive 2003/88/EC and the evolution of working time organisation.

Annexes to the Final report

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Content:

- *Annex 1: study on the health and safety aspects of working time*
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ANNEX 1:

STUDY ON HEALTH AND SAFETY ASPECTS OF WORKING TIME

1. Study on health and safety aspects of working time

Full report

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1.1. INTRODUCTION

On 2005-03-23 at 01:20 pm an explosion occurred at the BP refinery at Texas City, USA, resulting in 180 injured and 15 killed persons, and financial losses exceeding 1.5 billion US $. The responsible board operator had been working for 29 consecutive 12 h shifts, without any day off. The US Chemical Safety and Hazard Investigation Board (2007), which analyzed the accident, came to the conclusion that "fatigue was a likely contributing factor".

This does not seem to be an exception but rather the rule in such accidents. Reviewing some disastrous accidents from 1976 (Seveso) until 2010 (Deepwater horizon) (see Table 1) shows that in most of these cases one or even several characteristics related to the arrangement of working hours can be found which may have contributed to the impaired performance of the operators; e.g. working at unusual hours (nights, shifts), working long hours (12h shifts), postponing rest periods (up to 37 shifts in a sequence), or using shift systems which violate ergonomic recommendations (e.g. Wedderburn, 1991).

Although such single events do not prove anything at all, it seems remarkable that the arrangement of working hours in the BP refinery case is an expedient illustration of at least two of the central problems in the organization of working hours addressed in the working time directive (WTD): working long hours, e.g. 12 h shifts, thus reducing the daily rest period and time for recuperation, and postponing weekly rest periods – although the working hours in this case would not have been covered by the WTD. The case clearly illustrates that long hours and insufficient rest can contribute substantially to the safety of operators, the plant and its environment, as well as the general public. Although it is no proof this case nicely demonstrates the findings of our review on the effects of the organization of working time on health and safety.

1.1.1. Methods

The findings and conclusions reported in this report on the effects of working hours on safety, health and work-life-balance are based on an updated review of the effects on long work hours, a special review on more recent results on the effects of different aspects of rest periods and their postponement, a review on the effects of working at unusual times, e.g. Saturdays, Sundays, or evenings, and a summary of the findings of the effects of working shifts and/or nights and/or flexible working hours, as well as on our expertise in the field of the ergonomics of working times. In the areas of long working hours and working at unusual hours additional statistical analyses of available data sets (European Working Conditions Survey, EWCS, and national German data) have been conducted.

Table 1: Disastrous incidents and working hours

Location	Date	Unusual hours			Long working hours	Rest periods
		Shift work	During night time	Weekend or public holiday		
Seveso (Meda), Italy	1976-07-10	X	-	Saturday		
Harrisburg, USA	1979-03-28	X	X	-		
Bhopal, India	1984-12-02/03	X	X	Sunday/Monday		
Pripyat, Ukraine (Chernobyl)	1986-04-26	X	X	Saturday		
Schweizerhalle, Switzerland	1986-11-01	X	X	Saturday		
Bligh Reef, USA	1989-03-24	X	X	Good Friday		
Milford Haven, Great Britain	1994-07-24	X	-	Sunday		
Texas City, USA	2005-03-23	X	-	-	12 h shifts	29 or more consecutive days
Gulf of Mexico	2010-04-20	X	21:45	-		

The literature review on working long hours is based on the review by Wirtz (2010) in the context of her dissertation and completed by an update of the evidence published since the closing of this review in 2009 until July 2010. This also applies to the effects of working unusual hours (evenings, Saturdays and Sundays). Bases for the literature search and survey were the relevant common databases, e.g. psychinfo, medline, PubMed, ILO publications, which were searched via online access, as well as individualized backward searches based on individual publications. A number of (more specialized) studies dealing with long work hours has thus not been referenced in the reference list of this report but can be found in the reference list in the study by Wirtz (2010), which is also available online under http://oops.uni-oldenburg.de/volltexte/2010/ 996/pdf/wirlan10.pdf

The literature review on rest periods and their postponement is also based on an online search, using the same databases for the more recent findings on this topic. Since the results, as expected, were rather scarce, the argumentation and the conclusions further had to rely on "classical" ergonomics argumentations concerning the mechanisms of strain, fatigue and rest, as well as on some findings in the context of other working time problems, e.g. shift work. All of the recent publications that were accessible have been referenced in the references of this report, while for the classical evidence in general only summarizing sources have been included, together with some rather old references, in order to demonstrate that a lot of the evidence concerning rest periods has already a long history from research, but not necessary from implementation.

The results on the effects of shift work are based on research in connection with a recent implementation of an internet platform (http://inqa.gawo-ev.de/cms/), giving guidance for the design of working hours (long working hours, flexible working hours and especially shift work). This has been complemented by a survey of very recent publications, especially concerning the association of shift work with cancer, since this is a rather new topic in the context of shift work research. The survey has not addressed differential effects of different shift systems but concentrated on the more general effects of shift work, so the references are mostly of the type of a survey. A complete review of the literature on shift work was neither requested nor possible in the context of the available resources.

Also for flexible working hours the results are based on earlier work and the above mentioned platform, in conjunction with an internet search for recent research on the effects of flexible working hours. This search resulted in a very small number of relevant references, which have been included where accessible.

The review of the literature had to be performed as a narrative review, since quantitative meta-analytic approaches were not appropriate due to substantial heterogeneity between studies and the quality of the available and accessible reported results. This results in part from different methodologies used, different operationalizations of the relevant concepts and a lack of quantitative data, which would allow for a recombination of the results. The approach taken thus was to start with available theoretical considerations about the mechanisms of the effects of long working hours, working at unusual hours, and in this case with a cross check to shift work, shift work, and the mechanisms of rest breaks, again with a cross check to selected results from shift work research, in this case the distinction between shift systems with different directions of rotation. These served as a basis for the inspection of the available (new) evidence on these topics and the narrative synthesis of the results.

For long working hours and for unusual working hours additional statistical analyses of the available data material (3rd and 4th EWCS, 2000 and 2005 on the European level; Gute Arbeit, 2004; BIBB-BAUA Erwerbstätigenbefragung, 2006, on the national German level) for cross check purposes have been performed. These analyses mainly served to check some special questions, especially those of controlling for possible confounding effects. This was necessary, e.g. in the area of the accident risk associated with work on Sundays, in order to cross validate results from one survey with a different sample, and to disentangle the effects of the confounders. Working on Sundays, e.g., is associated with different types of activities and jobs (and their different a priori risks) and with a number of other characteristics of the work schedules, like shift work, working on Saturdays, or in the evening. The approach generally taken for these analyses were (stepwise) multivariate logistic regressions, in order to determine the proportion of variance accounted for by the variable in question after controlling for the effects of other, confounding variables. This represents a rather conservative estimate of the effect size, since all the common variance is attributed to those variables entering the equation before the core variable under consideration.

1.2 LONG WORKING HOURS

1.3.1. Long working hours and safety

Both early (Schneider, 1911; Vernon, 1921; Teissl, 1928) and more recent studies and reviews on the effects of long working hours on accident risk (Folkard, 1996; Hänecke et al., 1998; Lowery et al., 1998; Nachreiner, 2002; White & Beswick, 2003; Dong, 2005; Lombardi et al., 2010) show consistent results, indicating that the accident risk increases with an increase in hours worked per day and per week. The available results clearly demonstrate an exponential risk increase beyond the 7th, 8th, or 9th hour worked per day, resulting e.g. in a duplication of the risk for the 12th hour of a shift as compared to the average risk during an 8h shift, with the absolute level of the risk depending on the type of activity. Fig. 1 shows an example for such results from the study by Haenecke et al. (1998). This can be interpreted as a (fatigue based) loss of working capacity which may result in an increased risk for the whole work system, its environment or even the general public.

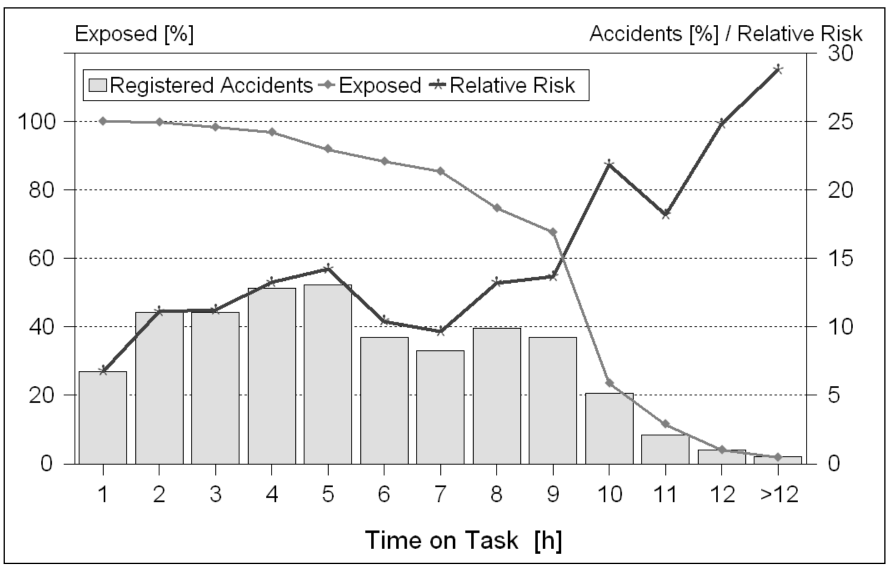

Figure 1: Relative risk of an accident with time lost as a function of hours on duty

(adapted from Haenecke et al., 1998)

The number of hours worked / week also influences the risk of occupational accidents (Vegso et al., 2007) and the probability of accidents on the way home from work (Kirkcaldy et al., 1997). As compared to employees working ≤ 40 h/week, the accident risk for workers with 65 or more h/week shows an increase of 88 % (Vegso et al., 2007). These findings are supported by results of Dembe et al. (2005) who demonstrated consistent structural trends: In a sample of 10,000 persons, representative of the U.S. population, the authors showed a clear dose-response-effect of hours worked per day and per week on the incidence of accident-based injuries or illnesses. The incidence rate per 100 worker years increased by 100 % between < 40 and ≥ 65 h/week, and between < 8 and > 14 h/day, respectively. Thus, a substantial influence of hours worked per week and per day on the accident risk could be demonstrated, before and after controlling for demographic characteristics and workplace exposures.

Folkard & Lombardi (2004, 2006) developed a "Risk Index" in order to predict the accident risk from different work schedule characteristics, based on the studies noted above and others. They reported a cumulative trend in accident risk depending on both the number of h/day and h/week (see Figure 2 and Figure 3). According to these results the accident risk increases disproportionately with each hour worked/day beyond the 8th hour and with every consecutive shift worked. The authors used 12h shifts in Figure 3, which shows that there is a substantial risk increase even within the maximum of 48 h/week in the existing EU working time directive. The accident risk decreases during times of rest and recovery (both within and between shifts) which stresses the importance of sufficient recovery periods in order to avoid an accumulation of the accident risk (see also the section on rest periods).

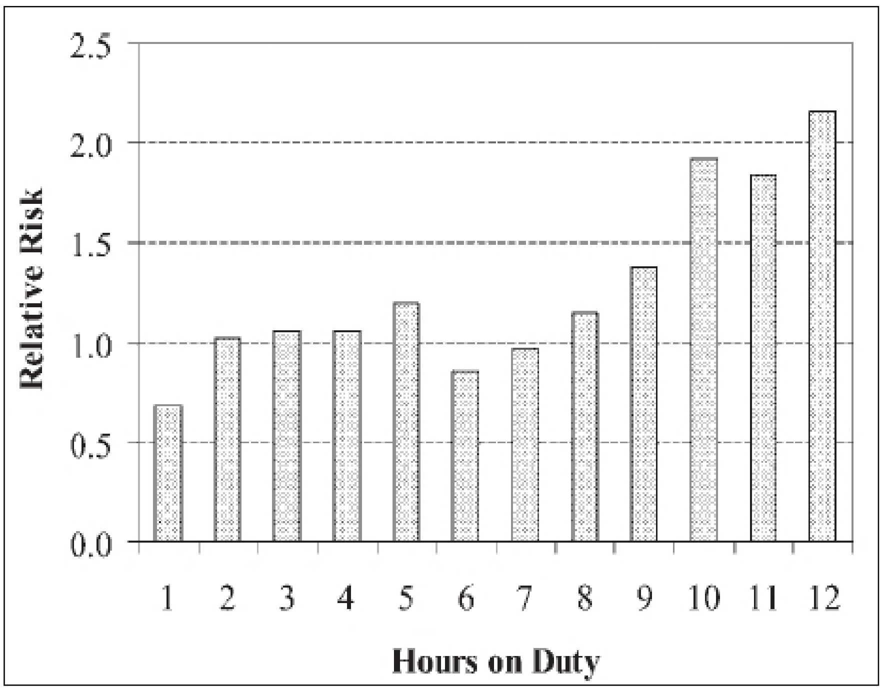

Figure 2: Mean relative accident risk over hours on duty
(Folkard & Lombardi, 2006)

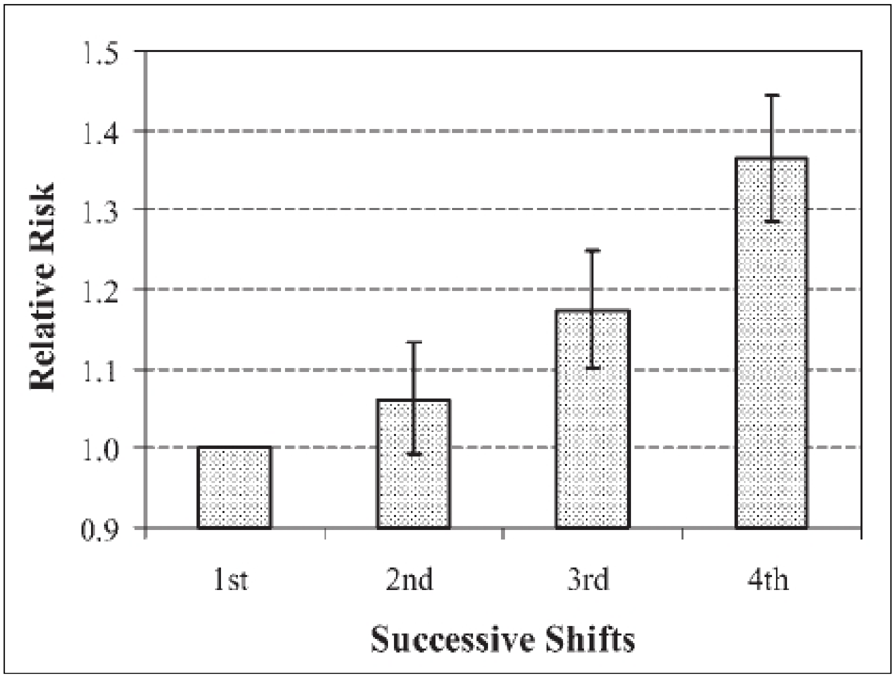

Figure 3: Mean relative accident risk over successive day shifts, 95 % CIs (Folkard & Lombardi, 2006)

However, Spencer et al. (2006) argue that predicting the accident risk from weekly working hours alone is not advisable, without taking into account other work schedule components, e.g., length of shift, type of shift, or rest breaks. Rest breaks should be considered on different dimensions, such as breaks within the shift, daily rest periods (e.g., time between two consecutive shifts), and weekly rest periods (e.g., on weekends). It is difficult to isolate the effects of such different work schedule attributes, because when the work week is extended beyond about 40 hours workers will probably also work in longer shifts, longer spans of shifts, at unusual times and therefore also at riskier times of the day or the week.

1.2.2. Long working hours and patient safety

There is evidence that not only the safety of the workers themselves can be impaired by working long hours, but that long working hours can impair product safety as well, e.g. long working hours of medical staff can negatively affect patient safety and health. In a study by Rogers et al. (2004) on nurses in the United States (n=393) it could be demonstrated that working > 12 h/day, overtime, and > 40 h/week increased the risk of errors in nurses. Logbooks over 2x2 weeks were used, measuring the scheduled and actual work hours, self reported errors and near errors, and sleep/wake patterns of nurses. The risk of errors was 1.85 times higher for nurses working 8.5-12.5h/day and even 3.29 times higher in nurses with > 12.5h/day compared to individuals working less than 8.5 h/day. Working times above 40h/week increased the risk of errors by 1.96 compared to < 40h/week.

In a review study, Weinger & Ancoli-Israel (2002) report that sleep deprivation, which can be caused by long working hours, night shift, and other work schedule factors, increases the risk of errors in medical staff and thus is another risk factor for patient safety related to long working hours.

Comparing traditional work schedules in British hospitals with intervention schedules, which were taking account of the EU working time directive, Cappuccio et al. (2009) showed an improvement regarding patient safety for the intervention schedule in comparison with the traditional schedule.

Reducing working time of junior doctors from 52.4 h/week to 43.2 h/week lead to increased time for sleep and resulted in 32.7 % fewer total medical errors. Landrigan et al. (2004) found similar effects in hospitals in the United States by changing extended (24h) shifts into shorter shifts and reducing weekly working hours from 77-81 h/week to ca. 63 h/week. Medical staff working in the intervention schedule made 36 % less medical errors than individuals on the traditional schedule. Both studies reduced not only working hours but also limited the number of night shifts and added other work schedule improvements. Therefore, it is not sufficiently clear, if the improvements in patient safety were caused by the working time reduction alone. However, it could be demonstrated, that careful work scheduling in conjunction with a work hour reduction can improve not only safety and health of employees but also of patients in hospitals and care facilities.

In a recent review Ehara (2008) analyzed the results of seven studies (5 intervention, 2 observational studies) dealing directly with work hours and patient safety (including the above mentioned Landrigan et al. study) and came to the conclusion that from these studies four suggest that a reduction in working hours had a favorable effect on patient safety indicators, three studies did not find a significant change and that no study found that reduced working hours were harmful to patient safety.

1.2.3. Long working hours and health

1.2.3.1. OVERALL HEALTH

Several reviews and empirical studies demonstrate various negative health effects of extended working hours: Long working hours are associated with poor perceived health, more illnesses, or even increased mortality (Sparks & Cooper, 1997; Spurgeon et al., 1997; Worrall & Cooper, 1999; Ettner & Grzywacz, 2001; van der Hulst, 2003; White & Beswick, 2003; Caruso et al., 2004a; Dembe et al., 2005; Kecklund, 2005; Caruso, 2006; Grosch et al., 2006; Rädiker et al., 2006; ILO, 2007; Rüters et al., 2008; Wirtz, 2010; Wirtz & Nachreiner, 2010).

In a study by Worrall & Cooper (1999) of managers in the UK (n=1,350), 21 % of managers with < 35 h/week reported a negative effect on their overall health by their work, as opposed to 40 % in the group of persons with 35-40 h/week and 75 % in persons with ≥ 60 h/week. These results are supported by findings from Wirtz (2010) who cross-validated the results of four different and independent samples, representative of the work force in Germany and the European Union. This study used the 3rd and 4th European Working Conditions Surveys (EWCS) from 2000 and 2005 as well as samples of two German surveys ("Was ist Gute Arbeit?", 2004, and "BiBB/BAuA Erwerbstaetigenbefragung", 2006); sample size ranged from n ≈ 4,000 to n ≈ 20,000 employed workers. In these studies, almost linear relationships between the amount of hours worked per week and several health impairments were observed: compared with part-time work (< 35 h/week), full-time work (35-47.9 h/week) increased the risk of reporting at least one health impairment on average by 20 % to 70 %, and long working hours (> 48 h/week) elevated the risk by 50 % to 100 % (see also Figure 4; differences in the level of complaints between samples result from a differing number of complaints covered in the various surveys and the questions asked). These findings were structurally consistent among all four samples and persisted even after controlling for several potential confounders, such as demographic variables, type and intensity of workload and additional work schedule attributes. The validity and the potential range for generalizing these results must therefore considered to be very high. Consistent results were also reported by Ettner & Grzywacz (2001) who found an increase in the risk of health problems by 25 % for employees working > 45 h/week, as compared to employees with less than 45 h/week.

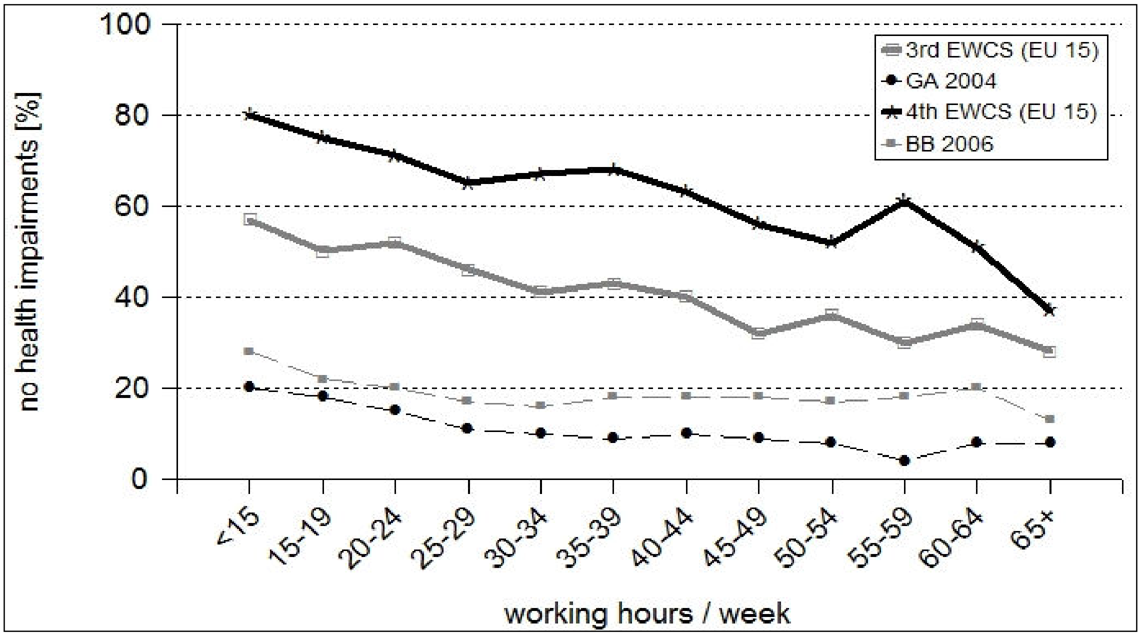

Figure 4: Frequency of reporting no health impairments over weekly working hours in four independent samples (3rd and 4th EWCS from 2000 and 2005, “Was ist gute Arbeit?” (GA 2004) and BIBB/BAuA Erwerbstaetigenbefragung (BB 2006); see also Wirtz, 2010)

1.2.3.2. PSYCHO-VEGETATIVE IMPAIRMENTS

Long working hours are associated not only with perceived overall health but also with several distinct health problems, such as psycho-vegetative impairments (e.g., mental health, different vegetative symptoms, gastrointestinal disorders, sleep problems, musculo-skeletal symptoms, or cardiovascular diseases).

Proctor et al. (1996), Baldwin et al. (1997), Rädiker et al. (2006), Rüters (2008), Artazcoz et al. (2009), Wirtz (2010), and Wirtz & Nachreiner (2010) demonstrated negative effects of long work hours on psycho-vegetative disorders and mental health. They found almost linear relationships between the number of hours worked / week and the frequency of reported psycho-vegetative impairments and depressive symptoms, which are shown in Figure 5. Furthermore, Lammers et al. (2007) showed that each additional hour worked / week increases the risk of psycho-vegetative health impairments by about 2 %, based on data of the 3rd EWCS. Remarkably, this increase in psycho-vegetative impairments, associated with an increasing number of working hours, can already be found in part-time workers (see Figure 5).

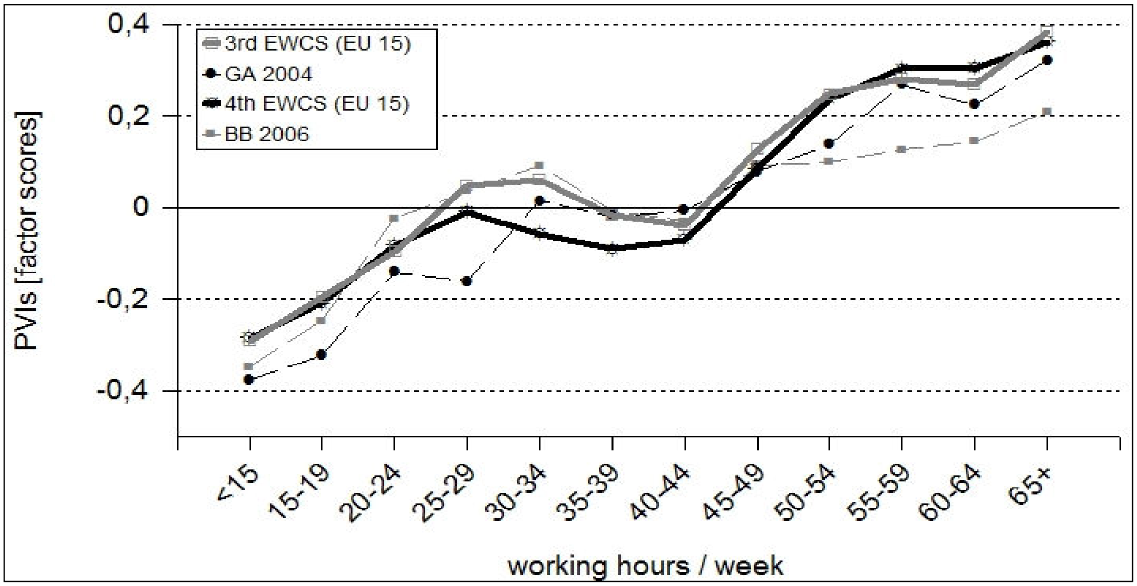

Figure 5: Psycho-vegetative impairments (PVIs) over weekly working hours in four independent samples (3rd and 4th EWCS from 2000 and 2005, "Was ist gute Arbeit?" (GA 2004) and BIBB/BAuA Erwerbstaetigenbefragung (BB 2006); see also Wirtz, 2010)

An interesting observation in Figure 5 is the drop in reported impairments from those with 30-34 h to those with 35-39 hours. This might be the result of combining two different populations, those with part time and those with full time contracts. So the group with 35-39 hours might in fact be composed of two different subgroups, those working overtime in part time and those working full time with 35-39, without overtime. If this were so, the results for that group should better be separated for both subgroups, with a higher amount of complaints for those working overtime in part time contracts and a lower amount of complaints for those working 35-39h in full time most probably, yielding two separate distinctive regression functions. If this were so this could mean that working overtime – in relation to the contractual and thus the time expected to be devoted to work – is an essential factor besides the absolute amount of hours actually worked. This, however, remains to be analyzed in more detail.

1.2.3.3. MUSCULO-SKELETAL PROBLEMS

There are only few consistent findings regarding the effects of long working hours on musculo-skeletal impairments, mostly due to lacking control of confounding factors, such as shift work, type and intensity of work load, job type, and demographic characteristics. However, several studies report a weak but consistent overall relationship between long working hours and musculo-skeletal problems (Lipscomb et al., 2002; Grosch et al., 2006; Trinkoff et al., 2006; Caruso & Waters, 2008; Wirtz, 2010).

Grosch et al. (2006) demonstrated that the risk of reporting poor overall physical health due to working hours above 70 h/week was five times higher than for persons working 35-40 h/week. The risk of reporting arm and back pain was elevated by 60 % for workers with > 70 h/week compared to full-time workers with 35-40 h/week. However, any increase in working hours between 40 and 70 h/week did not increase the risk of physical health impairments significantly. The authors used a representative sample of the U.S. population (n = 2,765) and adjusted their statistical analyses for individual characteristics, such as age, gender, and education, but did not control for work load attributes, e.g. the amount of physical work. This lack of control may be one explanation of the rather weak relations between weekly working hours and physical health.

On the other hand, Trinkoff et al. (2006) found no statistically significant effect of long work hours after controlling for physical demands, which had the strongest effect on musculo-skeletal symptoms. However, results reported by Lipscomb et al. (2002) indicate that the number of h/week has an effect on the risk of physical health problems, when combined with other potentially harmful working time attributes, such as long daily and weekly working hours, work on weekends, or other than day shift. Working > 12 h/day and > 40 h/week increased the risk of reporting musculo-skeletal problems by 230 % to 260 %, compared to working < 12 h/day and < 40 h/week.

Wirtz (2010) reported that the risk of musculo-skeletal impairments was associated with the number of hours worked per week in a linear relationship. However, the amount of weekly working hours did not have a strong impact on the risk of musculo-skeletal problems. In contrast, the type and intensity of workload, and especially high physical demands, showed a considerably stronger impact on physical health problems. Thus, employees working under physically highly demanding working conditions showed the highest amount of physical health problems. However, these health impairments increased (moderately) with an increasing amount of hours worked per week, both for employees with and without high physical work load, whereas one would have expected a steeper increase in complaints with increasing hours for those with high physical work load, i.e. an interactive effect of work load and working hours.

1.2.3.4. OTHER SYMPTOMS

Long working hours are associated with several other health symptoms. For example, cardiovascular diseases can be promoted by extended working hours, leading to an increase in hypertension, myocardial infarction, and other heart symptoms (Uehata, 1991; Hayashi et al., 1996; Liu & Tanaka, 2002; Virtanen et al., 2010). Spurgeon (2003) and Beermann (2004) conclude in their reviews that the negative effects of long work hours on cardiovascular symptoms can be regarded as substantial and reliable.

Furthermore, results of Caruso et al. (2004b) and Wirtz et al. (2009) indicate that with an increasing number of working hours, the risk of gastrointestinal problems increases. However, there is still a lack of studies examining the impact of daily and weekly working hours on these types of health impairments (van der Hulst, 2003).

Some studies report an association between long working hours and mortality (Nylen et al., 2001), diabetes (Kawakami et al., 1999; Kroenke et al., 2006), reduced sleep duration (van der Hulst, 2003; Artazcoz et al., 2009; Krueger & Friedman, 2009; Tucker et al., 2010), and maladaptive health behaviors, such as increased consumption of alcohol, cigarette smoking, or lack of physical exercise and unhealthy weight gain (Nakamura et al., 1998; Trinkoff & Storr, 1998; Shields, 1999; Artazcoz et al., 2009). Reduced sleep duration can in turn increase the risk of several other health impairments, such as cardiovascular diseases, overweight, or weakening of the immune system (Dawson & Reid, 1997; Dinges et al., 1997; van der Hulst, 2003; Caruso, 2006; Härmä, 2006; Lombardi et al., 2010). Furthermore, Nachreiner et al. (2005), Rüters (2008), and Wirtz et al. (2009) report an increasing amount of sleep problems due to an increase in hours worked / week, which may add to the negative consequences of a reduced sleep duration.

1.2.4. Long term exposure, safety and health

There are almost no studies on the effects on safety and health of working extended hours over a long period. This is due to the fact that most studies examine the impact of the current usual weekly working hours on safety and health. Thus, they do not take into account for how long these (extended) daily/weekly working hours are worked, and if they are preceded / followed / interrupted by a period of shorter working time (e.g. in order to achieve an average max. 48 h/week, as provided in the existing EU working time directive). Therefore it is not known if or how impairments to employees' health and safety (a) accumulate over an extended period of working long hours or overtime, and (b) if these impairments decrease again during a subsequent period of shorter working hours; i.e. we know nothing about the long term dynamics of working long hours. We do not know anything even for periods like one year, which can be agreed as a possible reference period between employers and unions in some countries, not to mention longer periods, e.g. extended periods during a working life or a complete working life.

This problem is very close to or connected with the problem of not allowing for or postponing adequate rest breaks, which will be dealt with below. It would, however, therefore be most important to have (or acquire) some evidence how shorter and longer periods of extended working hours affect employees' health and safety before determining certain reference periods for any maximum average number of weekly working hours. As will be shown further down, a conservative strategy would seem to restrict such reference periods for averaging peaks and troughs in order to avoid any long term accumulation of negative effects.

A prospective follow-up study in Finland investigated the impact of different working conditions on the risk of leaving work due to disability retirement (Krause et al., 1997; n = 1,038 Finnish men). The results indicate that employees working > 60 h/week have a 2.75 times higher risk of disability retirement in the following four years than employees working < 40 h/week (at the baseline assessment, but without control of the hours worked in the preceding or following years). The authors controlled for age but not for other potential confounding variables, although exposure to heavy physical work lead to a substantial risk increase and therefore probably should have been controlled for as well. The methodological problems of such an approach become quickly obvious: It is completely unknown how many hours these people worked in the following four years or until early retirement. Long term exposure and long term effects can only reasonably be addressed by longitudinal studies, preferable in a time series approach, with the number of hours worked and health problems recorded over a longer period of time.

Hoyer (2009, see also Hoyer & Nachreiner, 2010 for a condensed version) used such a time series approach with data on staffing, overtime, and time lost due to sickness and occupational accidents, collected over a period of five years (n = 1,100 German workers in an automobile production site). He demonstrated that an increase in actual and accumulated overtime lead to an increase in lost time due to sickness and occupational accidents within the next two months. In contrast, adapting staffing to production requirements reduced the amount of overtime worked and thus led to a decrease in time lost due to accidents and illnesses.

In conclusion, studies examining the concurrent and/or long term impact of long term exposure to long working hours on health and safety are urgently needed to achieve a better understanding and estimation of such dose-response effects over longer periods of time. When discussing about the extension of daily and/or weekly working hours, or the reduction of daily/weekly rest periods, it should be considered, that long daily and weekly working hours immediately increase the risk of accidents and injuries. Therefore, extending work hours over longer periods and without adequate rest will inevitably accumulate the accident risk and thus can be regarded as an important risk factor for both employee and product or patient safety and health.

1.2.5. Long working hours and work-life balance / social participation

Time for work, sleep, and leisure activities can be regarded as a zero-sum game: an increase in working hours inevitably leads to a reduction in time for sleep and / or leisure activities. Thus, the results of several studies show that family life and / or work-life balance (WLB) are being influenced by the number of working hours per week (e.g., Worrall & Cooper, 1999; Geurts & Demerouti, 2003; White & Beswick, 2003; Jansen et al., 2004; Grosch et al., 2006; Klenner & Schmidt, 2007; Geurts et al., 2009; Wirtz, 2010; Wirtz & Nachreiner, 2010). An increase in the actual number of working hours / week leads to a decrease in the reported quality of WLB (see also Figure 11 and Figure 12 below).

26 out of 30 studies support this finding in a review by Albertsen et al. (2008). Furthermore, time spent with social and leisure activities decreases with longer working hours, before and after controlling for demographic variables and other working time attributes, such as working on weekends and / or shifts (Wirtz, 2010). The relations between working hours / week and reported WLB and leisure activities are almost linear, at least until about 40 h/week, demonstrating the negative impact of increasing work hours on work-life balance – beginning already in the domain of part time. Of course, however, the negative effects of increasing working times beyond 40 h/week on social participation are stronger than for part time work with < 35 h/week (Wirtz, 2010). A closer look at Figure 12 shows that the decline in WLB increases beyond 40 h, especially for those not working Sundays, so that 40 h/ week might indicate a limit up to which (on average) an unimpaired WLB can be retained, and thus, from a perspective of avoiding social impairments, arguing for a lower limit of weekly working hours than in the existing WTD.

Results reported by Klenner & Schmidt (2007) show a structurally consistent trend with correlations of $r = -0.3$ between weekly working hours and WLB, for both men and women. In the above mentioned study by Grosch et al. (2006), an increase in working hours elevated the risk of reporting impairments to family life by 1.55 for subjects reporting 41-48 h/week, 2.28 for 49-69 h/week, and 3.75 for > 70 h/week, compared to subjects working part-time (1-34 h/week). A negative impact of long working hours on family life could also be demonstrated by Worrall & Cooper (1999). They showed that 85 % to 90 % of managers with > 60 h/week reported negative effects of their work schedule on their social life, as opposed to 54 % of the managers with 35-40 h/week and 37 % working part-time (< 35 h/week). Thus, a decrease in WLB and quality of family life with increasing working hours per week could be found in several studies in the EU and the U.S., although in general there are not many studies providing empirical evidence for this relation and at the same time controlling for important confounders.

To our knowledge, there are almost no empirical studies in the available literature examining the amount of time spent with leisure and social activities reported (see also Caruso, 2006). However, time spent with social activities is an important indicator for social participation, which is very important for developing and maintaining social values and norms within a society. Therefore, reported subjective WLB should not be considered as an adequate and sufficient operationalization of social well-being or an unimpaired social life, but also more specific indicators, e.g. time spent with families and friends should be used. It must further be kept in mind that reported work-life balance is based on a subjective evaluation of the perceived available time for non-work activities, compared to a subjective standard on what should be available, as in satisfaction with (other) working conditions. Such subjective standards, however, depend on subjective experiences and normative standards and are thus adaptable to what can be “reasonably” achieved or expected.

Results of analyses of the 3rd and 4th EWCS indicate that time for household activities, childcare, sports, cultural activities, and individual training / learning activities is reduced with an increasing amount of working hours/week (Wirtz, 2010). These findings were again structurally similar in both EWCS samples from 2000 and 2005, before and after controlling for demographic and other working time attributes, indicating again a high validity and a wide range of generalization. Furthermore, Artazcoz et al. (2007, 2009) and Popham & Mitchell (2006) demonstrated negative effects of long working hours on time for physical exercise during leisure time. However, more studies measuring work schedule attributes and assessing social / leisure activities more precisely are urgently needed. This could best be achieved by conducting diary or time budget studies, for example, or asking for actual times spent within a reference period for such activities.

1.3. WORKING UNUSUAL HOURS

In the last decades, the number of employees working in flexible and / or unsocial hours (e.g., on evenings and weekends) has substantially increased (Golden & Figart, 2000; Demetriades & Pedersini, 2008). While work on Saturdays seems to be quite common again, discussions about allowing more work on Sundays are recurring in the European Union. However, working on weekends can reduce both recovery time and the amount of socially valuable hours. Despite all the attempts towards a 7x24 hours society the social rhythm in our societies remained as a stable pattern over the last 30 years, describing it as an evening and weekend society (e.g., Neuloh, 1964; Wedderburn, 1981; Baer et al., 1981, 1984; Hinnenberg et al., 2007).

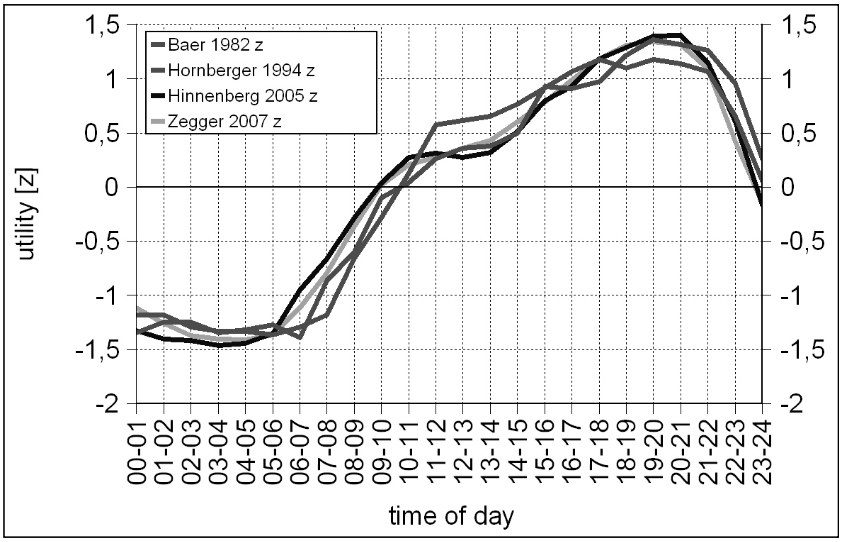

Figure 6: Utility of time across 25 years, Mondays – Thursdays

z-standardized, from Hinnenberg et al., 2007b

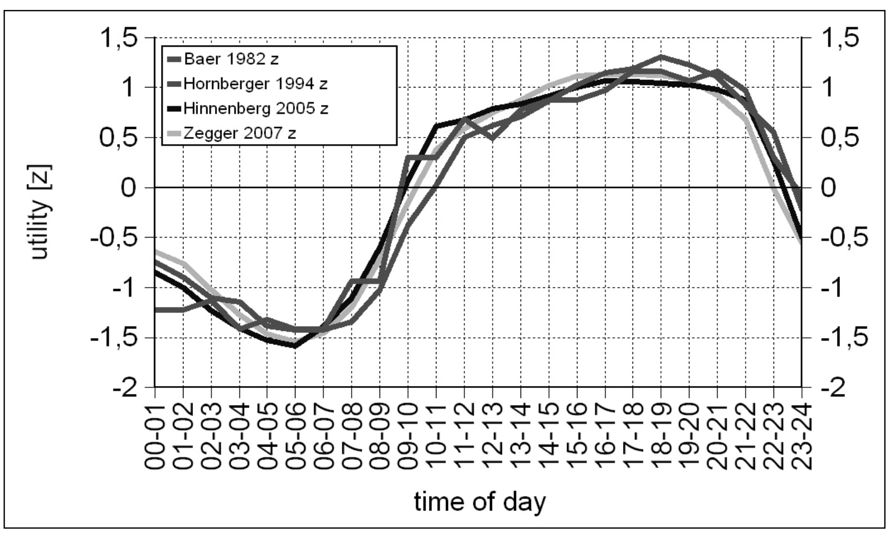

Figure 7: Utility of time across 25 years, Sundays,

z-standardized, from Hinnenberg et al., 2007b

Figure 6 (for Mondays through Thursdays) and 7 (for Sundays) show this rhythm, based on subjective utility ratings for each hour of a week from four studies conducted over the time span from 1982 until 2007 in four German samples, with scores z-standardized to achieve a common scaling. Within this rhythm, the utility of time for social and leisure activities is in general rated higher in the evenings and on weekends, with the highest values on Saturdays and Sundays. This is due to the fact that, for the majority of all society members, weekends (and especially Sundays) are in general free from work.

Thus, opportunities for social interaction are considerably increased on Saturdays and Sundays as compared to a normal work day, because nearly all the social environment, including partners for social interaction, is available for social activities / interaction on weekends. Especially family activities are most often scheduled on Sundays. This normative structure of the time enables members of a society to interact with each other and/or to take part in social activities. It is thus an important factor for active and passive socialisation activities and for developing and maintaining social norms and values.

Therefore, working at hours which are normatively devoted to social interaction, such as on evenings and weekends, and especially working on Sundays does interfere with the social rhythm, and should thus lead to severe impairments to social well-being as well as to a reduction of time for social commitments. Furthermore, quantity and quality of recovery time on weekends is most probably higher than on the other weekdays, due to this normative structure and the higher utility values of free time on weekends. Therefore, working on weekends should lead to poorer recovery and thus to a (fatigue based) loss of working capacity, which in turn could cause a higher accident risk on the following work days.

Only very few studies have addressed possible health and social effects of work on Saturdays and Sundays yet. However, there seems to be a quite common trend in the few preliminary results, indicating negative effects of work on evenings and weekends on social well-being and health and on the incidence of occupational accidents, which will be described in the following sections.

1.3.1. Safety

Using disabling and fatal accident rates in the state of Oregon, Horwitz and McCall (2003) estimated the odds ratio of a Sunday injury compared to a Tuesday injury at 3.129 and a Saturday injury compared to a Tuesday injury at 1.376. This study analysed 20,680 accepted workers' compensation claims filed by Oregon construction workers over the period of 1990-1997.

The results of our own studies (Rolfes, 2009; Nachreiner, 2009, 2010; Wirtz et al., 2010; Wirtz et al. (submitted)) on several large European (EWCS) and German samples indicate that, in accordance with the studies noted above, working on Sundays has a clear and substantial negative impact on safety, health, and the quality of work-life balance. Figure 8 shows this increased risk for occupational accidents, based on the EWCS survey of 2005 for the 31 countries included.

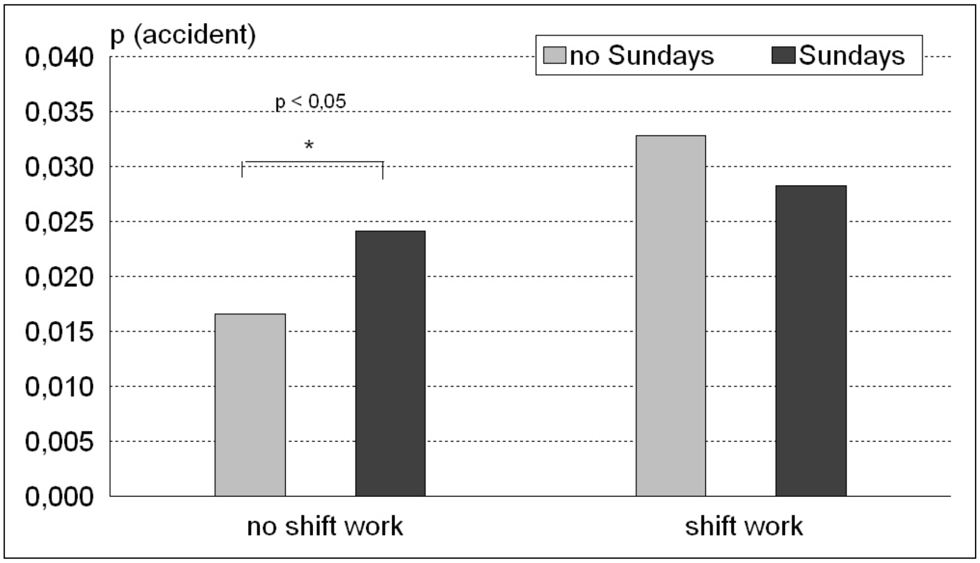

Figure 8: Accident risk for working on Sundays, controlled for working shifts (from Wirtz et al, submitted)

The probability of experiencing an occupational accident (with time lost) within the last year is clearly elevated for employees without shift work, who usually work on one or more Sundays per month, compared to workers working no Sundays. Shift work further increases the accident risk substantially. After controlling for gender, physical and mental workload, and autonomy, but not for any other working time attribute, a significant increase in the accident risk due to work on Sundays could be shown (OR: 1.238). However, controlling for workload and work schedule characteristics, work on Saturdays increased the accident risk by 1.389, whereas work on Sundays (OR: 1.087) did not have a significant influence on the occurrence of occupational accidents any more. This might be due to a methodological artefact. Since working on Saturdays is more common than working on Sundays, and working on Sundays usually includes also working on Saturdays, while the reverse is not true (i.e. those who work on Saturdays do not necessarily also work on Sundays), the variance in the accident risk that is attributable to Sundays is at least in part statistically attributed to work on Saturdays, the dominant variable. Since, in order to control for the effects of the other components, work on Saturdays had to be entered into the statistical regression equation before work on Sundays, this resulted in a substantial reduction of the variance attributable to work on Sundays. This problem has to be addressed further by testing some different and hopefully more suitable statistical control techniques.

A further and with regard to substance explanatory hypothesis is that, due to the social rhythm in European societies, time on weekends in general is most valuable for recovery, compared with all other weekdays. This might be due to the normative structure mentioned before, according to which rest and recuperation (together with social activities) are normatively associated with the weekend – and thus socially acceptable times for recuperation, whereas the same is not true for work days, which may lead to a less efficient recuperation process on such days. Rest on weekdays could thus be less recuperative that rest on Sundays.

Therefore, sufficient time for recovery on weekends seems to be an important factor for safety and health. Furthermore, results presented by Brogmus (2007) indicate a higher accident rate on Sundays than on any other weekday in a representative sample of the U.S. population. However, the relations between working on weekends and the incidence of occupational accidents need to be examined further, especially under the inclusion of more suitable data sets (most reported results are from EWCS data sets) and appropriate statistical control over confounding variables, e.g. the a priori risk of an accident for different jobs, since the distribution of working on Sundays is quite different for different sectors of the economy. In principle the accident rates across the 168 h of the week are available (at least in Germany) from the workers compensations boards (Berufsgenossenschaften), what is missing, is the exposure data for working on Saturdays and Sundays, which would have to be constructed by rather complex statistical analyses (as in Haenecke et al., 1998)

1.3.2. Health

Available results clearly indicate a negative effect on health of working unsocial hours, e.g., on Saturdays, Sundays, and evenings (Lipscomb et al., 2002; Boisard et al., 2003; Jamal, 2004; Lyonette & Clark, 2009; Nachreiner, 2009, 2010; Wirtz, 2010; Wirtz & Nachreiner, 2010). Especially the risk of psycho-vegetative and psychosomatic impairments, such as gastrointestinal impairments, sleep problems, fatigue, or irritability, is increased in individuals working unusual or unsocial hours. These working time patterns interfere with biological circadian rhythms, e.g. body temperature, thereby increasing the risk of health impairments (Giebel et al., 2008).

Accordingly, Boisard et al. (2003) used the 3rd EWCS data to demonstrate that 57 % of individuals without Sunday work reported that work affected their health, as opposed to 66.9 % of individuals working at least 1 Sunday per month. 55.8 % of individuals never working on Saturdays reported health impairments due to their work, compared to 63.4 % of individuals with regular work on Saturdays. These findings – though not controlling for any potential confounders or using any inferential statistics procedures – generally match the results of Wirtz (2010) who showed with the 3rd and 4th EWCS data that working on Sundays increases the risk of reporting at least 1 health problem by 1.2 - 1.37 times – after controlling for demographic variables, type and intensity of work load, autonomy, and other work schedule attributes. F

igure 9 shows an example of such results from the 2005 EWCS (Wirtz & Nachreiner, submitted), where it can clearly be seen that the proportion of those with a least one (work attributed) health complaint is significantly higher for those working on Sundays as opposed to those working no Sundays, adjusted for age, sex, and children as covariates; and this holds for shift and non shift workers. Furthermore, there is also evidence for negative effects of work on evenings and Saturdays on employees' health (Boisard et al., 2003; Rüters, 2008; Wirtz, 2010).

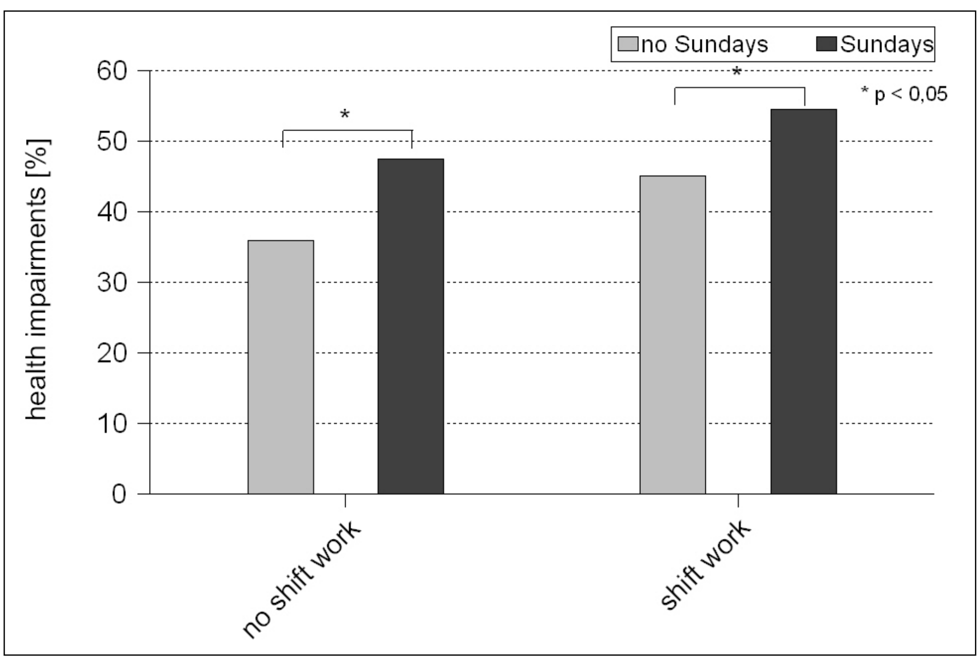

Figure 9: Proportions reporting at least one work related health complaint for working on Sundays, controlled for working shifts, EWCS 2005, 31 countries (Wirtz et al, submitted)

Kivimäki et al. (2006) in a Finnish prospective cohort study over 27 years (n = 788) showed that incomplete recovery from work during free weekends increased the mortality risk due to cardiovascular problems in initially healthy individuals. These findings were robust before and after controlling for several other risk factors and psychosocial working conditions. Although these results were based only on subjective reports on how much recovered the persons felt after a weekend without work, they indicate that insufficient recovery on weekends is an important risk factor for health and well-being.

1.2.3. Work-Life Balance

Any interference of working unusual hours with the social rhythm (by irregular working hours and work on evenings and weekends) should be associated with different social impairments, such as an impairment of family life and times for social activities (Wirtz et al., 2008). Several studies thus in fact do report a decrease in WLB due to unsocial working hours (Fagan & Burchell, 2002; Albertsen et al., 2008; Lyonette & Clark, 2009; Tucker et al., 2010; Wirtz, 2010), based mostly on data of the 3rd and 4th EWCS. The risk of reporting a poor WLB is increased by work on Sundays by 23.8 %, after controlling for demographic factors, workload, and working time attributes. As expected, working on evenings (OR: 1.84) and on Saturdays (OR: 1.49) also increases the risk of a poor WLB substantially (Wirtz & Nachreiner, 2010). Figure 10 shows an example of this impaired work-life balance due to work on Sundays (from Wirtz & Nachreiner, submitted). As can be clearly seen there is a substantial difference in work-life balance between those working on Sundays and those who do not work Sundays, even after controlling for age, sex, children and other work related variables.

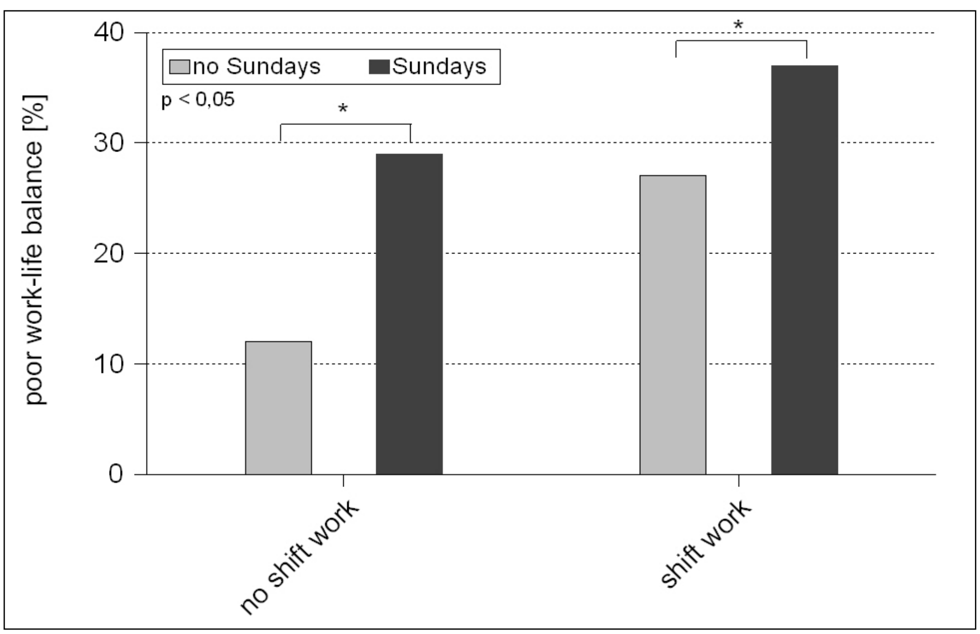

Figure 10: Proportions reporting a poor work-life balance for working on Sundays, controlled for working shifts and other confounders, EWCS 2005, 31 countries (Wirtz et al., submitted)

Fagan & Burchell (2002) reported results of the 3rd EWCS, in which 17 % of daytime only workers had a poor WLB, compared to 33 % in regular evening workers; 31 % working regular Saturdays, and 39 % with regular Sunday work reported poor WLB. However, the authors did not control for confounding factors and included no estimate of the predictive power.

Based on manager reports in a European company based survey, Kümmerling & Lehndorff (2007) demonstrated that the likelihood of sickness and absenteeism problems in European companies with work on weekends is 1.3 times higher than in establishments that do not require their staff to work on the weekend. Employee fluctuation is also reported to be increased in companies requiring weekend work.

1.4. INTERACTIONS OF WORKING LONG HOURS AND UNUSUAL HOURS WITH OTHER WORKING TIME CHARACTERISTICS

1.4.1. Long working hours and unusual working times

As indicated by previous results (Wirtz et al., 2008), work at unsocial hours, e.g. evenings and weekends, interferes with the social rhythm of the society and thus shows detrimental effects on the reported WLB. A decrease in WLB can in turn increase the risk of psycho-vegetative health impairments (Frone, 2000; Grant-Vallone, 2001; Hammer et al., 2004; Lyonette & Clark, 2009; Wirtz & Nachreiner, 2010) and sickness absence (Jansen et al., 2006). Work on evenings and weekends may therefore have an indirect effect on health impairments in addition to its direct effects.

Additive effects of long working hours and work on evenings, Saturdays, and Sundays, variable working hours, shift and night work on health impairments, work-life balance, and time for leisure activities were reported by Wirtz (2010, see
Figure 11 and Figure 12). In general, the effects on health and social well-being of working long or extended hours is increased when combined with unsocial working hours. Thus, working unusual or unsocial hours alone negatively affects health and social well-being, and these negative effects are significantly enforced when combined with long working hours. As shown in
Figure 11 and Figure 12, scores for psycho-vegetative health impairments and WLB show an increase for individuals working regular Sundays that is comparable to working 15 to 20 hrs more per week without work on Sundays. It should be remembered, that those working on Sundays had to get a compensation for working on Sundays by a day off on a workday during the week (thereby postponing the weekly rest period), in order to comply with the provisions of the existing WTD.

Thus, the negative effects of work on Sundays obviously cannot be compensated for by allowing the same amount of time off on any other weekday (see also Bittman, 2005). These preliminary results, as shown in
Figure 11 and Figure 12, thus seem to indicate that in order to achieve a comparably low impairment to people not working on Sundays, those employees working on Sundays might need additional 14-15 h of free time, and thus less working time, per week – besides the usual compensatory free weekday. Such analyses should therefore be continued to test whether this holds also for other indicators of safety, health and work-life balance.

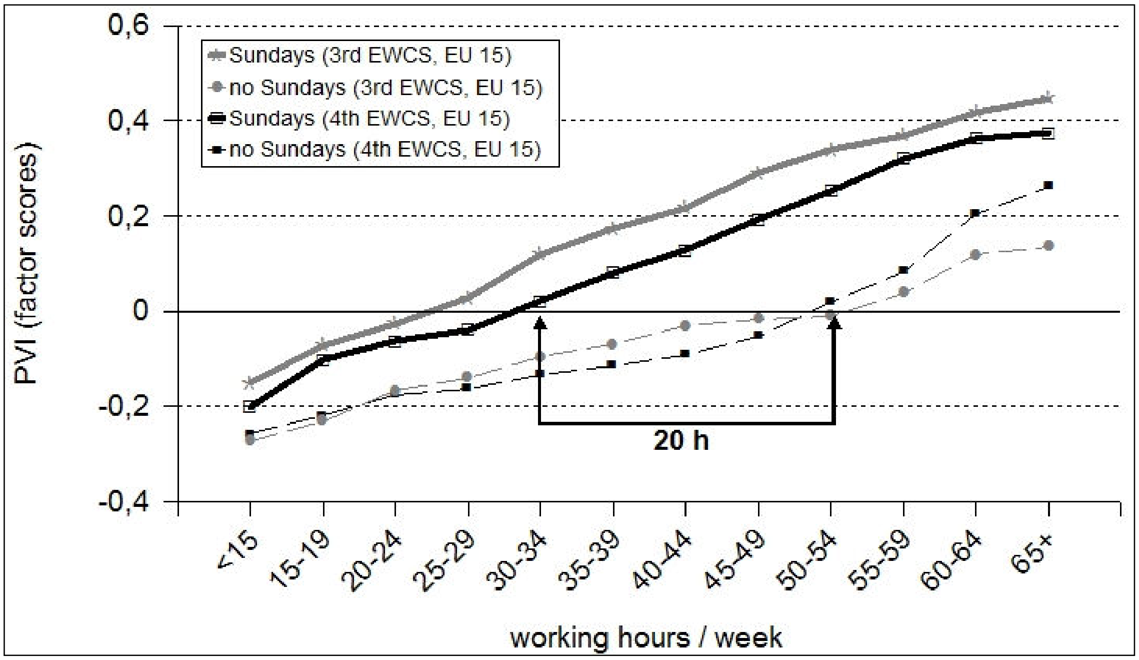

Figure 11: Psycho-vegetative impairments (PVI) for individuals with and without Sunday work over weekly working hours (based on Wirtz, 2010)

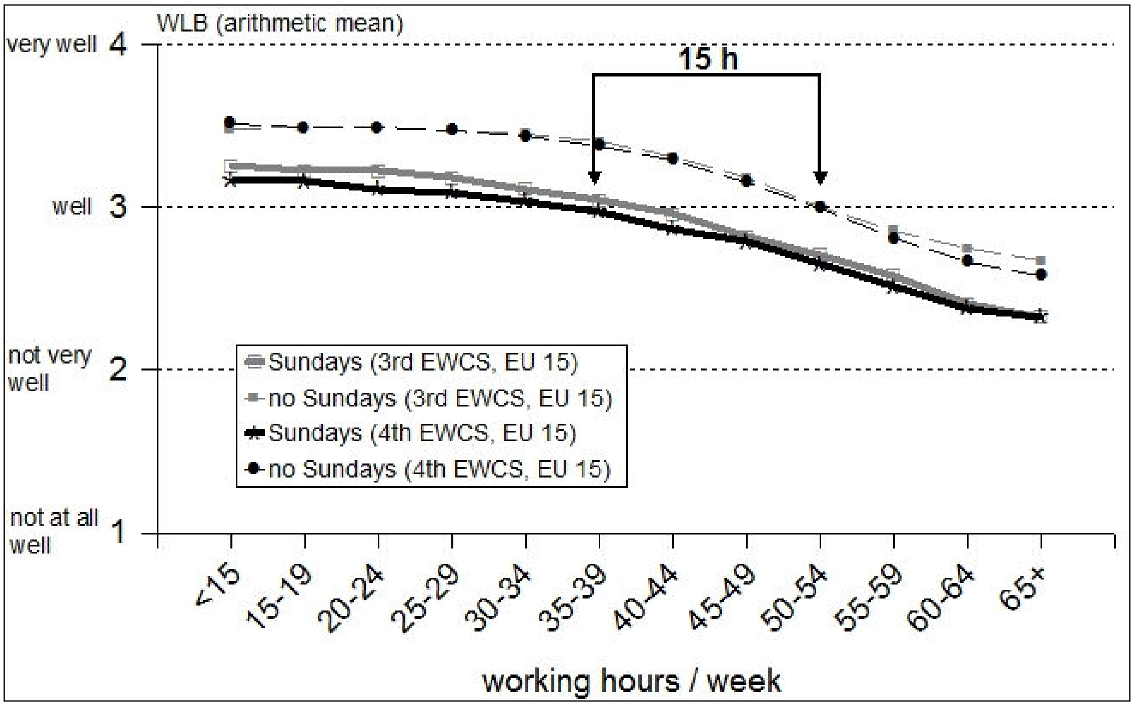

Figure 12: Subjective work-life balance (WLB) for individuals with and without Sunday work over weekly working hours (based on Wirtz, 2010)

A closer inspection of the graphs presented in Figure 12 shows that there is a clear cut difference between those working on Sundays and those working no Sundays, and that this difference and the trend over increasing working hours is remarkably stable from 2000 to 2005, which indicates that there is a quite stable difference for those working Sundays and those who do not. Besides the numerical differences per category of working hours, there is also a difference in the trends between both groups: those working no Sundays show a rather stable trend until 35-39 hours, where the beginning of a decrease in WLB can be observed, which from then on decreases substantially. For those working Sundays this decline starts definitely earlier, e.g. between 25 and 29 hours. Both trends then would suggest that there are some critical points in the number of working hours, beyond which the decline in WLB begins (and which, if combined, would suggest the above mentioned linear decrease in WLB for the total population. Taking the deviation from the stable state as an indication for beginning and to be avoided social impairments this could argue for fixing the number of hours/week at these inflection points, e.g. about 35 to 40 hours for those not working Sundays and 25 to 29 hours for those working unusual hours – at least from a perspective of avoiding social impairment.

1.4.2. Long working hours and control / autonomy over working hours

Several studies (e.g. Joyce et al., 2010a,b) demonstrate that control over and/or choice in arranging working hours by employees has a positive impact on their health and work-life balance. For example, Wirtz (2010) showed that control over different working conditions, including working time, had a positive effect on health and social well-being. However, the variable "control" showed no interactive effects with the weekly working time. Therefore, autonomy seems to have a positive impact independent of the length of the working week, (and most probably independent of other work schedule characteristics, which are – partially – controlled by the employee). However, negative effects of long working hours on health and social participation could be observed both for employees with and without control over their working hours (Janßen & Nachreiner, 2004; Burchell et al., 2007; Hughes & Parks, 2007; Valcour, 2007; Wirtz, 2010). Thus, the positive effects of having control over ones work scheduling will moderate the (reported) impairing effects to health and WLB, but do not protect against or completely compensate for the much stronger negative effects of working unusual and long hours (see Janßen & Nachreiner, 2004). The question, however, is whether there really are less negative effects, depending on a self-controlled more favorable arrangement of working hours, or whether this is a cognitive reinterpretation, since those in control of their working conditions would have, at least in part, to attribute the blame for any negative effects to themselves (because they had their choice in arranging their working hours) und thus tend to report less impairments. This, however, could only be analyzed with factual data on the working times and the impairments, which are not available at the moment.

1.4.3. Long working hours and type and intensity of workload

Exposure to high physical and mental workload increases the risk of health impairments. These effects are elevated by working long hours mostly in an additive manner (Wirtz, 2010). Thus, individuals with high (mental and/or physical) workload show a higher proportion of health impairments than individuals with lower workload, independent of the number of hours worked per week. This is true for the whole range of working hours from part-time to extended work hours. However, these results of analyses of the 3rd and 4th EWCS, and two large German samples may be due to a selection bias, where only healthy and fit individuals are able to cope with high workload for long working hours (known as healthy-worker-effect). Therefore, the negative effects of combining long working hours with high workload may have been underestimated. Support for this hypothesis can – at least in Germany – be found by a comparison of the proportion of those still working across different age groups, showing that there is such a (self-)selection process. So the results presented in the literature and in this report may be rather conservative estimates of the effects of coping with high workload for long hours.

In accordance with this hypothesis White & Beswick (2003) conclude in their review that job type and job demands can moderate the relationship between long working hours and health, although this topic was no central point in their study.

Mostly, the effects of physical and mental demands are being controlled for in the analyses of the effects of working hours by statistical analyses, and they have a demonstrable substantial impact on health. But there is a clear lack of studies examining the effects on safety, health, and WLB of combining long working hours with demanding working conditions, and controlling for a potential (self-)selection bias.

1.4.3.1. SHIFT WORK AND LONG WORKING HOURS

The effects of combining shift work with extended working hours are similar to the combined effects of unusual and long working hours. Wirtz (2010) reported additive effects on health and social well-being of combining shift and night work with long working hours. Thus, shift work increases the risk of impairments to health and WLB, and this negative effect is further increased by working extended hours (see also Rädiker et al., 2006; Rüters, 2008). In a literature review on the impact of extended work shifts, Knauth (2007) reported that it is difficult to draw firm conclusions from the available evidence due to methodological issues. Several studies comparing 8-h shifts with longer shifts report negative effects of extended work shifts on health and safety. However, there are a couple of methodological problems in the reviewed studies, such as a lack of control for confounding factors, e.g. shift start, type, and rotation, the distribution of rest periods, and the absence of comparable control groups, which prevent drawing firm generalizable conclusions.

1.5. NIGHT AND SHIFT WORK

Shift work, and especially in combination with night work, constitutes a considerable risk to safety and health (Knauth & Hornberger, 1997; Wedderburn, 2000; Shields, 2002; Spurgeon, 2003; Costa, 2003; Folkard & Tucker, 2003; Knutson, 2003, Nachreiner et al., 2006). In particular impairments and disorders based on the desynchronization of periodically, i.e. circadian, controlled body functions, e.g. the sleep/wake rhythm and digestion, can be found. A full adaptation of biological rhythms to night work has not been observed – even after a number of consecutive night shifts (Knauth & Rutenfranz, 1976). This is quite plausible as there are other Zeitgebers than just work or daylight under real life conditions, i.e. social contacts, and consciousness about time. Besides older studies and reviews also the more recent ones clearly demonstrate the negative effects of work at unusual times, including shift work, on health and safety (Wirtz, 2010; Wirtz & Nachreiner, 2010).

In addition to being subjected to biological desynchronisation (or chronodisruption or circadian disruption, as it has been called in the more recent literature on shift work and cancer, Erren et al., 2009; Straif et al., 2007; see also Costa et al., 2010) shift workers are also subjected to a social desynchronisation, a desynchronization from the social rhythm of a society (Nachreiner et al., 1985, see also above, section 3). This means that shift workers – and in this case also already those without night work, e.g. those working in fixed or rotating morning/afternoon shifts – have to work during valuable times for social interaction and participation and thus are restricted from social participation and interaction (Baer et al., 1985; Hornberger & Knauth, 1993) leading to substantial social impairments.

Shift work, and especially shift work including night work, is therefore considered a substantial risk factor for safety, health and well being, which is legally or by supreme court decisions already acknowledged in some member states of the EU (e.g. Germany; see also the current WTD).

1.5.1. Effects on safety

Generally speaking there is a consistent tendency for the risk of incidents, accidents or injuries to be higher on the afternoon shift than on the morning shift, with the highest risk on the night shift (for a detailed review see Folkard & Tucker, 2003), under otherwise comparable conditions. As this condition is often not met, e.g. through maintenance operations during the day shift, or a reduced traffic frequency during the night, leading to a change in the a priori risk probability, there are studies that report a higher risk on day than on night shifts. With a comparable or statistically controlled a priori risk, however, the evidence is clear: working at night bears a higher risk of an accident than during day work. Folkard and Lombardi (2004, 2006) have thus been able to show, that there is a circadian variation in the relative accident risk, with the maxima during the hours of the night shift and the minima in the beginning of the afternoon shift.

It must be mentioned that the increased risk is not only true for night shifts but also for late or afternoon shifts (especially in the late hours of that shift) in comparison with morning shifts, resulting in a generally higher accident risk for shift workers than for non shift workers (see results presented by Wirtz (2010) on the basis of the EWCSs; and sections 2 and 3 above, and especially Figure 8). Working at unusual times, and shift work clearly is a very special case of working at unusual times, is consistently associated with a higher risk to safety. It is thus not astonishing that the disastrous events mentioned in the Introduction were all associated with shift work, from the Seveso to the Deep Water Horizon explosion.

Furthermore, there is some reliable evidence that the relative risk of an accident increases over successive shifts (see Folkard & Tucker, 2003), and that this increase is substantially higher for successive night shifts than that for successive day shifts (Folkard & Lombardi, 2004, 2006). Whereas for both the increase follows an exponential function), pointing to a lack of (complete) recovery between shifts, this increase is definitely sharper for night shifts, resulting in a much greater difference for the fourth shift than for the first one.

Investigations have shown that with an increasing number of consecutive night shifts, but also for consecutive early shifts (Folkard & Barton, 1993; Kecklund & Akerstedt, 1995), there is an increased risk of an accumulated sleep deficit and thus increased sleepiness or decreased alertness during work hours (Knauth et al., 1983; Chan et al., 1987; Alfredsson et al., 1991; Escriba et al., 1992; Barak et al., 1995). In combination with the fatigue resulting from the actually ongoing work, especially when working long hours, this should result in an increase in the accident risk.

1.5.2. Effects on health

In general, shift work, especially that including night work, as a consequence of the circadian desynchronization increases the risk of sleep disorders (Sallinen & Kecklund, 2010), disorders of the digestive system (Costa, 1996; Knutsson & Bøggild, 2010), loss of appetite, cardiovascular diseases (Knutsson et al., 1986; Bøggild & Knutsson, 1999; Frost et al., 2009; Puttonen et al., 2010) and psycho-vegetative problems (Costa, 1995), i.e. impairments in functions that follow a circadian rhythm. In particular permanent night work thus increases the risk of health impairments to a substantial degree (Wedderburn, 2000; Knauth & Hornberger, 1997, see also Figure 9). Working shifts, whether they include night work or not, but in particular if they do, must therefore be considered as a special risk factor for health and well being.

1.5.2.1. SHIFT WORK AND CANCER

In October 2007, the International Agency for Research on Cancer (IARC) categorized shift work that involves circadian or chronodisruption as probably carcinogenic in humans (Straif et al., 2007; Erren et al., 2009; Kolstad, 2008; Costa et al., 2010). While the evidence from experiments with chronodisruption in animals is clear (leading to a classification of carcinogenic in animals), this is definitely less the case with the epidemiological evidence for humans. A few epidemiological studies show a significant but rather weak association of cancer and night work, while others do not. This is why the IARC has classified shift work including a disruption of the circadian rhythm as probably carcinogenic to humans.

Six out of eight underlying epidemiological studies show a statistically significant, albeit always only very small risk enhancement through shift work including night work, especially for breast cancer in women and prostate cancer in men (both are the most prevalent types of cancer in women and men respectively).

The problem with the available evidence in humans, however, is that it has not been clearly defined what such a "circadian disruption" really is, how it could be (quantitatively) assessed, and how this disruption is associated with working shifts – e.g. what kind of shift systems lead to which degree of disruption, and from which degree of disruption over which span of time a triggering of cancer can be expected. This is one of the reasons why the exposure to "night work" including a "circadian disruption" as the causal agent has not been adequately classified yet, so that no dose (circadian disruption? or shift work including night work leading to circadian disruption?) – response (cancer) assessments can be performed. Shift work, even that including night work, encompasses a whole lot of different shift systems with demonstrably different effects (besides cancer). So the definition of the risk factor (if it were shift work including night work) is unclear until now. If it were the circadian disruption it will be necessary to specify how this can be quantified, a yet unresolved problem. As an aside it should be mentioned that the experimental manipulations conducted with animals are in no way comparable to the effects experienced by shift workers, although they support a possible causal mechanism for the observed carcinogenity in animals and a possible causal pathway for humans.

Another methodological criticism is the lack of information concerning the exposure time in humans, e.g. duration of the exposure and breaks in the exposure, i.e. especially the dynamics of the exposure.

A further problem with the available evidence is the confounding of night work with other working conditions (e.g. work in hospitals or as cabin attendants in the air traffic sector) in the available studies, which makes it difficult to clearly attribute the effects to the night work (since circadian or chronodisruption has not been measured).

A last problem with the available evidence is that it is restricted to special professional groups, e.g. flight attendants and nurses, who probably are also exposed to other cancer promoting agents, while a broad and representative survey is still missing.

The available evidence for the association of night work and cancer must thus until today be regarded as insufficient; more valid research results, with the above mentioned methodological problems adequately addressed, are therefore urgently required to assess and to reduce any possible risk of cancer associated with night and shift work.

1.5.3. Shift work and (psycho-) social impairments

Besides the desynchronization with the circadian physiological rhythms shift work (even where it does not include night work, e.g. alternating morning and afternoon shifts) also leads to a desynchronization from the social rhythm of a society (Ernst, 1984; see also section on unusal hours). As mentioned above, social activities are concentrated in the evenings and weekends, since this normally is the time free of work– except for those working unusual hours or shifts – which makes it easier to coordinate social or family activities.

Working shifts, like working other forms of unusual hours, must therefore interfere with such activities (Ernst, 1984, Nachreiner et al., 1984) and thus result in social impairments, as can be seen from the earliest to the most recent reviews (e.g. Mott et al., 1965; Bunnage, 1981; Knauth et al., 1983; Nachreiner et al., 1984; Nachreiner et al., 1985; Walker, 1985; Colligan & Rosa, 1990; Wedderburn, 1993: Shields, 2002; Albertsen et al., 2008).

Social impairments are mostly reported in those domains which require a coordination of activities and where the social partners for the interaction are bound to the general social rhythm and cannot adapt to that of the shift worker. As families try to partially adapt to their shift working member(s) (e.g. Neuloh, 1964, Nachreiner et al., 1975) impairments, although quite considerable, are less pronounced than in those areas which do not adapt to the deviating rhythm of shift workers (e.g. organizations, public life).

Social impairments thus range from effects on the shift worker, her/his personality structure and interests (e.g. Nachreiner, 1975), the relations with primary (family) and secondary groups (friends, clubs, organizations) (e.g. Jansen et al., 2004; van Amelsvoort et al., 2004)) to the engagement in public organizations (community councils, Nachreiner et al., 1985). All reviews consistently show these social impairments, more recently dealt with under the topic of work-life balance or work-nonwork conflict. Work-life balance thus is decreased in shift workers, and due to the desynchronization more work-nonwork conflicts can be observed (Albertsen et al., 2008; see also Figure 10).

Shift work, however, does not only affect shift workers only. It also affects their partners and their children. Shift work of the partner requires some form of adaptation, connected with special efforts to manage a partnership or family life (Neuloh, 1964). Shift workers thus show a higher proportion of broken partnerships and divorces and difficulties in finding a partner/establishing a partnership (e.g. Nachreiner, 1985; White et al., 1990; Presser 2000).

It has further been shown that children of shift workers achieve lower performance at school and have a lower chance of attending higher education compared to children of day working fathers – as well as showing impairments in their social lives (Diekmann et al., 1981; Maasen, 1981; Volger et al., 1988; Lenzing & Nachreiner, 2001; Heymann & Earle, 2001; Strazdins et al., 2004).

It can thus be firmly concluded that shift work is a risk factor for the social well being of those working shifts as well as for those living together with them. It should also be observed that shift workers regularly show some kind of withdrawal from social activities, combined with a loss of interests in such activities (e.g. shift workers prefer solitary hobbies that can be performed without necessary coordination with others). The problem with this is that shift workers also withdraw form public live and the pursuit of their interest (e.g. in community councils, unions, etc.) which should also have an effect on society as a whole.

It should further be mentioned that different shift systems lead to different kinds/amounts of social impairment. For social impairment night work is not a prerequisite, these effects can also be observed with shift work not including night work, and in some instances even more than in shift work including night work, e.g. when there is a high proportion of afternoon shifts. As with health problems, some kinds of shift work tend to increase the impairments, while others show only moderate degrees of impairment (see e.g. Bonitz et al., 1987; Albertsen et al. 2008). Irrespective of such differential effects, however, shift work remains a risk factor for social participation and well being.

1.6. REST PERIODS AND THE POSTPONEMENT OF REST PERIODS

1.6.1. Introduction

There are a number of different reasons for introducing rest periods into the work process, e.g. avoiding negative consequences of work stress and work strain (e.g. physical and mental fatigue as well as other impairing effects, i.e. monotony, satiation, and reduced vigilance; see ISO 10075), recuperation and recovery from such effects, increasing performance and productivity, taking a meal, social interaction with colleagues at the work place, opportunities for sleep, leisure activities or social participation. It is obvious that these different functions require different kinds (and lengths) of rest periods, i.e. rest breaks during a shift, daily rest periods, weekly rest periods as well as longer periods of rest/absence from work. The following section will, however, cover only those kinds and aspects of rest periods that are related to avoiding and recovering from fatigue and/or other impairing effects resulting from preceding work periods.

The effects of rest breaks are a standard and traditional topic in ergonomics, dating back until the beginning of the last century (e.g. Rivers & Kraepelin, 1896; Vernon, 1921; Graf, 1922). Graf (1922, 1927) was able to show that the optimal position and length of a rest break – with a view to the "most profitable rest break", both with regard to production and fatigue – depends on the type and intensity of the work to be performed and that work including breaks, i.e. with a smaller net amount of working time, is more productive than working the same span of time, and thus more working time in absolute terms, without breaks. His results clearly showed that taking a break of the right length at the right time in order to avoid fatigue (or at least to achieve recuperation from the effects of the preceding work period) was superior to working long blocks and postponing the rest break.

This is due to the fact that – beyond a certain limit – the relation between work stress, work strain (for the terminology see ISO 10075), and its effects (e.g. fatigue) is not linear but follows an exponential function. This in turn is due to the feedback function, where the same amount of work load or work stress meets a reduced capacity for work within the individual due to its preceding coping with the preceding work load and an insufficient recovery, i.e. a lack of return of the functions under strain to their baseline or a tolerable steady state. This has been demonstrated both for physical (e.g. Rohmert, 1960a,b) as well as for mental work (Schmidtke, 1965), with exponential relations for both, the intensity of the work load and the duration of the exposure to that workload, which interact in a multiplicative way. Furthermore the function of recovery from fatigue also follows such an exponential, non-linear function, with the greatest amount of recovery occurring during the first part of a rest break, i.e. a decreasing recovery function over time. This is the reason why recovery from accumulated effects of workload, e.g. accumulated fatigue, requires disproportionately longer times for recovery than recovery from less extended deviations from the baseline (e.g. less fatigue).

This evidence has in ergonomics (but not necessarily in practice) lead to a strategy of avoiding (especially an accumulation of) fatigue by an early scheduling of short rest breaks after short periods of work (see e.g. Graf, 1922, 1927), as opposed to a strategy of recovery from (accumulated) fatigue after longer or extended periods of work. The timing of such breaks or rest periods depends, of course, on the nature and the intensity of the work load or work stress associated with the performance of the task, which means that for higher intensities of work load shorter work periods are required, whereas these can be extended for lower intensities of work load.

As a corollary from this evidence any postponement of rest periods, and thus an accumulation of impairing effects, carries the risk of decreased performance and productivity, safety and health.

Reviewing the available recent – rather scarce – evidence on the effects of rest periods and their postponement has not lead to any conflicting evidence with these well established principles – but rather to their confirmation, as shown in the following sections. For reasons of clarity we will use the terms rest breaks or rest pauses with reference to rest periods during a work shift, whereas we will use the term rest periods for longer periods, e.g. daily or weekly rest.

1.6.2. Rest periods and safety

1.6.2.1. REST BREAKS AND SAFETY

There are a number of studies which have examined the relations between rest breaks and driving. For example Stave (1977) reported that having a 4-minutes break within a 3 hours journey, in which the first errors begin to occur, is a very successful strategy in reducing / avoiding mistakes and errors. Feyer & Williamson (1995) found that tiredness / fatigue in driving, as one of the causes of an increased accident risk, can best be dealt with if the time of the break can be chosen autonomously by the drivers. However, the study does not address a postponement of rest breaks in this context which might be of great importance to safety. On the other hand there is conflicting evidence, showing that autonomously controlled breaks often lead to a postponement of rest breaks, which can result in an accumulation of fatigue (Rutenfranz & Stoll, 1966). The results by Feyer & Williamson (1995) might thus be due to the special conditions encountered (long distance driving in Australia).

However, there is also some rather confusing evidence. A study by Drory (1985) showed that a 30-minutes break after a 7 hours journey did not reduce the level of fatigue and the performance on a simulated truck driving task remained constant over time. In addition, Lisper & Eriksson (1980) found that as far as driving was concerned there was no difference whether the break lasted for 15 or for 60 minutes in an 8h driving task. Whereas the Drory (1985) results are peculiar (as is the delayed onset of the break after seven hours) the findings of Lisper & Eriksson (1980) might be due to the fact that the 15 minutes break was already long enough for a complete recovery, and the additional 45 minutes in the 60 minutes condition met a recuperated driver.

The relations between rest breaks and accidents in the industrial sector are somewhat different and more consistent with existing theory. A study by Tucker et al. (2003) showed that the accident risk during an uninterrupted 2 hours work period increased continually. The study examined 8.55 hour shifts which were interrupted by a break every 2 hours. Tucker et al. (2003) were able to show that towards the end of the uninterrupted 2 hours work period the accident risk was approximately twice as high as in the beginning of that work period and that the break reduced the risk, comparable to the initial level. It was thus concluded that fixed rest breaks at regular intervals are well suited for reducing the accident risk – especially where repetitive and machine paced work is concerned (Folkard et al., 2003, 2006). On the other hand Mitra et al. (2008) were able to show that when rest breaks were scheduled but workers were not able to take them this lead to an increase in impairments and the risk of an error.

Consistent with the results by Graf (1927) Bhatia & Murrell (1969) in their study were able to show that introducing a 10 minutes rest break after every 60 minutes of work is less tiring than a break of 15 minutes every 90 minutes, confirming that postponement of (the same relative amount of) rest breaks is not a preferable solution.

There have been numerous studies examining the effects of different rest break schedules during work with computers. Kopardekar &/ Mital (1994) for example found that working with interspersed short rest breaks every half hour or hour reduced the error frequencies as compared to continuous work. Consistent results have been found by Galinsky et al. (2000). In the same line and again in agreement with older findings Dababneh et al. (2001) found that short rest pauses are able to increase productivity. However, it was also found that too many short breaks (in this case more frequent than one break per hour) were considered unpleasant as they restricted the work flow.

Concerning the position of rest breaks within the work process Murrell (1962, 1979) was able to show that a rest break at a point in time when work performance is already decreasing does not achieve the same recuperative effect as a break taken before this point in time, supporting the preventive functions of early breaks. This has also been supported by findings from Horne & Reyner (1999) with automobile accidents in which drivers fell asleep. In this review accidents caused by drivers falling asleep were analysed as well as results from experiments on breaks, including phases of sleep, which were introduced into the driving. It has been found that not taking a break can lead to devastating consequences and that a break including sleep is a suitable means for minimizing this risk.

However, as argued before, obviously not everyone is able to determine the optimal point in time for a break, as has again been shown in the study by McLean et al. (2001) in which scheduled short breaks achieved greater effects then autonomously taken short breaks by the workers. As shown by Rutenfranz & Stoll (1966) already one of the reasons for this is that workers tend to postpone and accumulate rest breaks in order to finish earlier (or to have an accumulated longer rest period before the end of the shift). This, however, is associated with an increased risk for errors and accidents, as has been shown before.

1.6.2.2. DAILY REST AND SAFETY

Relevant studies which directly examined the aspects of work safety in connection with the duration of daily rest periods have not been found. However, when examining the aspect of long working hours and overtime, which at the same time means a postponement (and/or reduction) of daily rest periods, an increase in accident risk has been demonstrated (Folkard, 1996; Hänecke et al., 1998; Lowery et al., 1998; Nachreiner, 2002; White & Beswick, 2003; Dong, 2005), as has been shown above.

General evidence concerning critical safety effects of too short (daily) rest periods, however, can be gained from laboratory and field studies on the consequences of sleep deprivation. Results from a laboratory study by Williamson and Feyer (2000) clearly showed that sleep deprivation negatively affected the performance in the co-ordination tasks of their experiment.

A number of field studies also demonstrate safety critical effects of sleep deprivation – and this not only for the employees themselves, e.g. in the form of accidents (Marcus & Loughlin, 1996; Coplen & Sussman, 2000; Stutts et al., 2003), but also in the field of patient safety (Weinger & Ancoli-Israel, 2002; Lockley, 2007). Insufficient rest periods due to long working hours in combination with sleep loss often lead to an increased error rate, which in the field of medical care can have a strong influence on patient safety (see section on long working hours).

As shown by Folkard and Lombardi (2006), the accident risk increases with successive shifts, both for day and for night shifts, which is a clear indication that daily rest periods were not sufficient to accomplish a complete recovery from (daily) work. The increased risk on night shifts may reflect, at least in part and besides the effects of the special work load imposed by working nights, the effects of a typically reduced day sleep length (and quality) between successive night shifts. This is why Tepas & Carvalhais (1990) point to the fact that chronic sleep deprivation increases the accident risk in shift workers working night shifts.

1.6.2.3. WEEKLY REST AND SAFETY

Relevant studies which directly examined work safety in relation to weekly rest periods have not been found. Current investigations into the effects of working at unusual hours (see section above) indicate that working at weekends resp. on Sundays leads to an increased safety risk. Besides working at unusual hours this may also imply a postponement of rest periods, e.g. when working on Sundays the rest periods might well be postponed to a subsequent day of the week.

1.6.2.4. LONGER REST PERIODS AND SAFETY

A few relevant studies which directly examined safety aspects in connection with longer rest periods have been found. For offshore operations, Mikkelsen et al. (2004) were able to show that the number of injuries of Norwegian offshore workers is associated with the duration of their onshore rest periods. This study compared the effects of a 3 vs. 4 weeks rest period onshore following a 3 weeks work period on the oil rig. In this case the extended rest period, representing at the same time a reduction in average working hours, lead to a reduction in injuries. So the question remains whether the effects are due to the extended rest period or the reduced average working time.

On the other hand, until only a few years ago symmetric work/leave schedules (e.g. 1-1 / 2-2) were applied. Meanwhile 2-3 work/leave schedules are used even though there is no empirical evidence to show that longer rest periods improve fatigue, wakefulness, performance and quality of sleep (Parkes, 2010). This could be due to the fact that after 2 weeks sufficient recuperation has taken place and a longer rest period could not lead to any further recuperation. In general, however, the relationship between work/leave and safety or health effects in such situations has up to now been only inadequately investigated so that no firm conclusions can be drawn. It is assumed, however, that longer rest periods in relation to working times should reduce the accident risk, but for the time being this remains an assumption. Furthermore, Parkes (2010) reports that it is easier to recruit qualified personnel using a 2-3 work/leave schedule than using a 2-2 schedule, which may result, however, from the reduced working time and the relation of work / non-work periods.

1.6.3. Rest periods and health

1.6.3.1. REST BREAKS AND HEALTH

A number of studies suggest that having several short breaks during work reduces the increase in experienced impairments and physical complaints over the working day (Hüttges et al., 2005; Galinsky et al., 2000; Henning et al., 1997). Short breaks are thus suitable for reducing the consequences of strain (e.g. sensations of monotony), especially in monotonous and repetitive job activities (Faucett et al., 2007). Where (scheduled) breaks are not or cannot be taken this leads to increased reported impairments (Mitra et al., 2008). These investigations thus show that adequate rest breaks play an important role in safeguarding the workers health and ability to work. If rest breaks are postponed, this leads to impairments to health and well being.
Scheduling rest breaks (time, duration) is – as with safety aspects – dependent on the type and intensity of the job activities (investigated e.g. for activities requiring a standing position by van Dieen et al., 1998).

It has been shown in some studies that individual choice on breaks has a positive influence on reported health and well being (Hahn, 1989) whereas fixed breaks can lead to interruptions of the work flow (Henning et al., 1997) and furthermore to emotional impairments (Boucsein & Thum, 1997). However, self scheduled rest breaks are not always superior to scheduled ones, as shown by the study of McLean et al. (2001), reported above, most probably caused by the fact that self determined breaks are often postponed, and thus taken too late, e.g. when fatigue, monotony or satiation become sensible by the worker, or in order to finish work earlier (Rutenfranz & Stoll, 1966), with usually negative consequences for health and well being (e.g. feeling exhausted at the end of a shift).

1.6.3.2. DAILY REST AND HEALTH

Several investigations demonstrate a clear link between inadequate daily rest periods between shifts and sleep duration. Short rest periods of 8, 9 or 10 hours sometimes reduce sleep duration drastically to 3 – 5 hours (Saito & Kogi, 1978; Knauth et al., 1983; Totterdell & Folkard, 1990; Tucker et al., 2010), which must lead to insufficient recuperation and increased fatigue at the start of the next shift, providing unfavourable conditions for that shift. Such reduced rest periods also appear in, especially short, backward rotating shift systems (Tucker et al., 2010), which are usually associated with increased health complaints, as compared to forward rotating systems with the same number of work hours (e.g. Barton & Folkard, 1993; Beermann et al., 1990; Sallinen & Kecklund, 2010; van Amelsvoort et al., 2004; Viitasalo et al. 2008; Horn & Nachreiner, in preparation). Comparing backward (i.e. a sequence from night to afternoon to morning shifts, as opposed to forward rotating systems, with a reverse sequence of shifts but the same number of hours) with forward rotating shifts allows for testing the effects of the distribution of work and rest, i.e. their dynamics. This thus is an indirect test of the effects of a postponement of rest, as is the case in backward rotating systems, where rest periods are usually postponed into greater blocks of time off work. Since both for health and work-life balance backward rotation in general is inferior to forward rotation, this is also an argument against delaying rest periods.

Kurumatani et al. (1994) conclude from their investigations that more than 16 hours between work shifts are necessary to enable a sleep duration of 7 hours. However, it should be mentioned that the persons who participated in this study had considerable commuting times to and from work, which reduced their effective sleeping times. On the other hand this would argue against any backward rotation and a reduction or postponement of rest periods.

Roach et al. (2003) studied the sleeping behaviour of locomotive engineers and found that the total duration of sleep is not only dependent on the duration of the rest period between shifts but in particular also on the characteristics of the specific situation. Rest periods during the night lead, as a rule, to an increased sleep duration as compared to rest periods during the day. The study by Feyer & Williamson (1995) of long distance truck drivers also showed the importance of the timing of rest periods. For all drivers, the influence of circadian rhythms was evident in the occurrence of fatigue, with a better management of the problem being evident among drivers who were able to arrange the timing of rest to more closely coincide with periods of fatigue. In a further study, Tucker et al. (1998) also investigated the effects of rest periods between shifts. They showed that the duration of night sleep is reduced between successive shifts beginning at 06:00 as compared to those begin at 07:00. Minimum rest periods between shifts should therefore also take these time of day components into consideration, in order to ensure the possibility of sufficient sleep time.

Jansen et al. (2003) conclude from their study that higher daily and weekly work hours and especially overtime are in general accompanied by higher requirements for rest. This is not surprising since the working time is prolonged and the rest period reduced and at least partially postponed, resulting in an accumulation of negative effects.

1.6.3.3. WEEKLY REST AND HEALTH

A number of studies agree in their conclusions that one free day after a block of successive working days is often not enough to provide for sufficient rest and recuperation (Folkard & Lombardi, 2006), which may also apply for normal daily work, e.g. that of office workers (Akerstedt et al., 2000). As a general rule for shift work, scheduling two days of rest after a block of night shifts is preferable to one day off for achieving full recuperation (e.g. Totterdell et al., 1995). The validity of this principle has also been demonstrated in the medical sector by recent results from Tucker et al. (2010), who found substantially increased fatigue in medical doctors if before the next work assignment only one free day had been scheduled after a phase of night work.

In the context of 12 hour shifts in the production sector a study by Tucker et al. (1999) found that workers in such a 12 hour shift systems who had a rest period of more than 24 hours between day and night shift blocks showed slightly increased alertness during the shift, a slightly reduced rate of chronic fatigue as well as longer periods of sleep during the night shift blocks and on days off. In a study by Kandelaars et al. (2005), positive effects of longer rest periods (> 48 hours) have also been demonstrated, showing that the sleep length and thus recuperation effectiveness can be improved through longer rest periods.

Akerstedt et al. (2000) investigated rest requirements caused by different systems of non-standard working hours for selected populations using subjective alertness ratings (assessed via the Karolinska Sleepiness Scale). Comparing the data from several individual studies (train drivers with two days off after 4-5 days with irregular working hours, workers in the chemical industry with traditional three-shift work, construction workers with consecutive 7 x 12 hour day shifts, flight cabin crews with irregular working hours in connection with travelling across nine time zones) the authors conclude from the results that one day of rest after a sequence of shifts is not sufficient for adequate recuperation, two days usually are, but that for those working long shifts in long sequences three days are required for recuperation and 3-4 days are necessary after periods of severely disturbed circadian rhythms.

1.6.3.4. LONGER REST PERIODS AND HEALTH

Relevant investigations which examined the effects of longer rest periods on health are rather scarce.
A study of offshore operations (Alekperov et al., 1988) demonstrated that shorter changes in work/leave schedules (1 -1 vs. 2-2) lead to less detrimental effects on physiological functions in the operators. The postponing of the rest period thus obviously increased the biological impairments. This however does not correspond to the 2-3 work/leave schedules currently in use, which are favoured by offshore workers because of the longer off period (Parkes, 2010). It must be kept in mind, however, that for these jobs a considerable amount of time is spent in commuting between work and home locations, reducing the amount of free time substantially. It is thus comprehensible that these workers opt for a less frequent change between on and off work periods, because it leaves them more time off work. Commuting times, however, are generally not taken into consideration in such studies. Systematic investigations into accident or incident rates or reported health problems for these on/off schedules, however, have not been undertaken yet.

With regard to sabbaticals Knauth et al. (2009) argue that those which serve purposes of recovery from the effects of work during one’s working life make more sense than models in which a great deal of overtime is accumulated in order to allow for an early retirement from work – when health impairments may already exist –, the latter representing another example for the postponement of rest and its effects. Gazie (1995) in an empirical study with teachers found that a sabbatical in connection with professional training activities considerably reduced experienced burnout and intentions of leaving the profession.

There will most probably be a difference in the effects of such sabbaticals if the free period is taken either as “unpaid vacation” (without previous accumulation of overtime) or as a compensation for accumulated overtime. More serious and more frequent impairments would of course be expected where overtime hours were worked in advance and time withdrawn from the time account at a later point in time, as this would lead to a concentration of work and an accumulation of its effects during the work period and a postponement of rest periods to a later point in time.

Using bivariate time series analyses between overtime, actual and that banked on a working time account over a period of 60 months, and sick leave and accident rates (in conjunction with staffing operations) of two production units from the automotive industry Hoyer & Nachreiner (2010) were able to show that both, actual and accumulated overtime were related to lost times due to illnesses and accidents, in a complex temporal structure, with overtime preceding lost times, indicating thus that overtime (which was also related to staffing) is a causal agent for lost times due to illnesses and accidents. This study represents one of the rare examples where working long hours and the postponement of rest periods have been observed over a longer period of time (60 months), yielding insight into the complex temporal and causal structure of the effects.

1.6.4. Rest periods and work-life balance

1.6.4.1. REST BREAKS AND WORK-LIFE BALANCE

Relevant studies which directly investigated any relations of rest breaks with reported work-life balance have not been found.

1.6.4.2. DAILY REST AND WORK-LIFE BALANCE

With regard to daily rest attention must be paid to the chronological position of the rest periods because of the social rhythms in our societies (see section on unusual hours) and the differential utility of time for social interaction (Wedderburn, 1981; Baer et al., 1981, 1985; Hornberger & Knauth, 1993, Hinnenberg et al., 2007) If rest periods are postponed (and shortened) due to working long hours per day or per week into regions where social interaction becomes difficult or impossible due to either duration or chronological position this must result in a reduced work life balance, as has been shown in the section on working unusual hours.

1.6.4.3. WEEKLY REST AND WORK-LIFE BALANCE

The same reasoning as for daily rest periods applies to weekly rest periods and work life balance. A special case is postponing rest from the weekend on a weekday, which has already been dealt with under working unusual hours. Furthermore recent results from the Tucker et al. (2010) study show that young doctors working on call duties on the weekend between to consecutive working weeks experience considerably increased work–life interference.

1.6.4.4. LONGER REST PERIODS AND WORK-LIFE BALANCE

Relevant empirical studies which investigated the relations of longer rest periods with work-life balance have not been found. Differences would, however, be expected for such longer periods as a compensation for preceding overtime (i.e. postponed and accumulated rest periods) and those more closely resembling times out without any compensatory function.

1.7. FLEXIBLE WORKING HOURS

1.7.1. Introduction

During the last years there is an increasing demand for more flexibility in the arrangement of working hours. Employers want to adapt production/service times to the demands of the market in order to reduce their entrepreneurial and economic risk, and employees want to adapt their working times to their non-work, private demands in order to achieve a better work life balance. In principle this can result in a win-win situation where both parties take advantages from a more flexible arrangement of working hours. On the other hand production/service requirements and private demands/preferences are not always in accordance, so workers have to accept working times which do not coincide with their expectations or preferences. As can be clearly seen from the available literature (for a review see Costa et al., 2003; Janßen & Nachreiner, 2004a,b;) production or company interests are usually dominant in arranging flexible working hours – this is why employers opt for flexibility, and especially this kind of company controlled flexibility – and employee discretion in deciding about working times is rather restricted, as a rule within the limits of production/service requirements (although exemptions from this rule can be found).

A first problem in reviewing and reporting the effects of flexible working hours is the lack of a general accepted definition. Some consider any deviation from standard working hours as flexible working times, but that would include rigid shift systems as well and thus blur any distinction, especially also with regard to the effects. Since adaptation to changing requirements (either production or individual demands) is at the core of flexible working hours, the SALTSA group (Costa et al., 2003 has proposed the following definition: Flexible working hours involve a continuous choice on behalf of employers, employees or both, regarding the amount (chronometry) and the temporal distribution (chronology) of working hours. This is what will be considered flexible working hours in the following sections.

Flexibility in working time arrangements in the above mentioned sense can be found in a number of different forms (e.g. flexitime, several part time arrangements or working time accounts), each again with a number of different specific implementations, resulting in a number of different manifestations that cannot be reviewed in detail, because the effects will depend on the characteristics of the specific implementation, and not on the classification into a certain category (e.g. flexitime). A more promising approach is thus to extract the basic dimensions of flexible working hours arrangements (see definition) and to assess their impact on safety, health, and work-life balance. Basic dimensions for describing flexible working times arrangements are thus the variability (or irregularity) of working hours, both with regard to the chronometry and the chronology of the resulting working times, the control over the working times by employees and / or the company, and the reliability of the resulting working time arrangements.

1.7.2. Effects on safety

The effects of flexible hours on safety are not well understood. Studies dealing with this specific topic have not been found. However, if flexible hours imply working for extended times, postponing rest periods and working at unusual times, even if they are self determined, they should also be associated with higher risks to safety.

1.7.3. Effects on health

The available evidence clearly shows that a high degree of variability or irregularity of working hours has detrimental effects on health and well being, comparable in nature to that of shift workers (e.g. sleep and digestive problems, reduced social participation, see Costa et al., 2003; Janßen & Nachreiner, 2004a,b), which most probably are also due to a (partial) desynchronization of physiological and social rhythms.

Giebel et al. (2004, 2008) were able to show that the degree of irregularity or the suppression of rhythmic components in the actual working times (as analyzed by spectral analyses) was clearly associated with the amount of reported health complaints, and this applied both to full time as well as to part time workers.

Janßen & Nachreiner (2004a,b), using the data from the 3rd EWCS and a separate study of their own demonstrated that high degrees of variability of working hours (apart from that introduced by shift work) consistently lead to stronger impairments than in schedules with less variability. Figure 13 shows an example of these results, in this case the proportion of those reporting sleep problems.

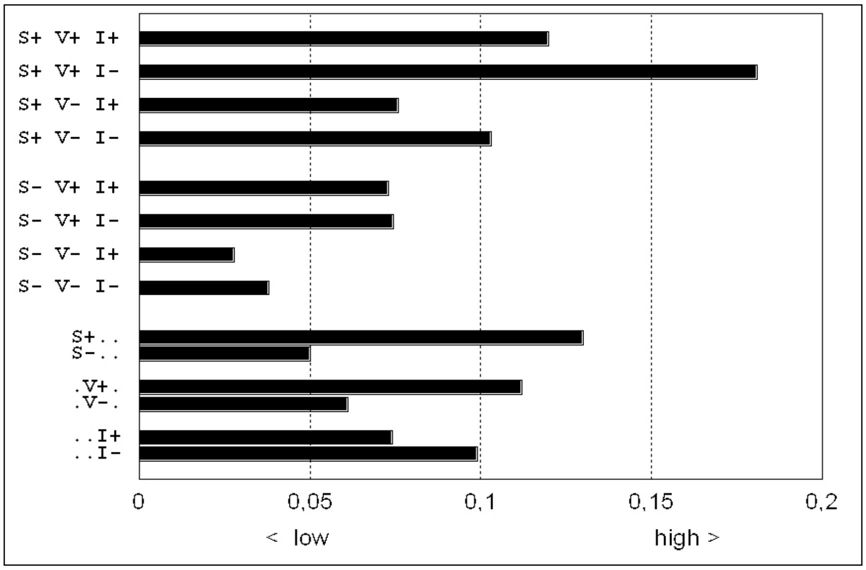

Figure 13: Proportion with sleep problems under different forms of flexible working hours

S = shift work, V = variability, I = Influence

(based on results from Janßen & Nachreiner, 2004; 3rd EWCS 2000)

As can be seen from Figure 13 there are main effects for all three dimensions: variability (V), shift work (S), and influence or autonomy (I), shown in the lower part of the graph. Variability of the working hours increased the proportion of those reporting sleep problems (and other health impairments), as is the case for shift work (both for more regular and for irregular working times). The third dimension that these authors used was the discretion of the workers in influencing the chronometry and chronology of their working hours. As would be expected, those with less autonomy had more complaints than those with more reported autonomy. The combination of the effects was mostly additive, so that the best condition emerged as a rather regular working time arrangement, without shifts, and a high degree of autonomy, whereas the worst condition was the one where shift work was combined with irregular working hours (beyond that resulting from working shifts), and with a low (or no) degree of autonomy (i.e. company controlled, flexible, irregular shift work). The latter clearly was the most disadvantageous condition with regard to health (and social participation as well).

The available evidence in general and consistently shows that company controlled variability has stronger negative effects than employee controlled variability or flexibilty, but this evidence also demonstrates that employee control over variability cannot fully compensate the negative effects of working time variability, and especially in the case of high irregularity. The results would thus indicate that variability of working times, whether self determined or company controlled, carries the risk of higher impairments to health.

This already points to the fact that autonomy on the side of the workers in controlling their working hours usually has a positive moderating effect on the reported outcomes of working flexible hours with regard to health (see also the recent review of intervention studies by Joyce et al., 2010; as well as Albertsen et al., 2008). Whether this is due to a cognitive reinterpretation (self attribution of blame for working such hours) or due to a factual different (i.e. superior) organization of working hours, however, remains to be analyzed, since most data, e.g. the EWCS, do not contain the necessary information for such analyses (e.g. the concrete schedules worked).

Besides variability the reliability of the flexibly arranged working time schedules plays an important role in the effects of flexible working hours, again both with regard to physical and to psychosocial well being. If flexibly arranged working times are unreliable, e.g. because of frequent rescheduling, emergencies or work on call, the risk of health and psychosocial complaints is increased (Janßen & Nachreiner, 2005). The causes for the detrimental effect on work-life balance (see below) are rather trivial (e.g. uncontrollable private activities), whereas the health effects will most probably be due to a temporary desynchronization with circadian and social rhythms.

This is most probably the case where flexible hours are combined with shift work so that no stable form of (an at least relative) adaptation is possible. Shift work with highly variable and predominantly company controlled working hours (besides the variability resulting from shift or night work itself) thus leads to the highest amount of physical and psychosocial impairments, as compared to other types of flexible working hours.

It has been reported already in the section on extended working hours that the combination of long and flexible working hours shows interactive effects. Whereas flexible working times can better be dealt with in the part time domain, working long flexible hours will aggravate coping with one's working hours, and exacerbate the negative effects on health.

1.7.4. Effects to work-life balance / social participation

Although flexible working hours are held and said to improve the conditions for a better work-life balance or social participation, the available empirical results in general do not coincide with these claims.

As has been shown by Janßen & Nachreiner (2004a,b) variability (in chronometry and chronology) reduces the work-life balance and social activities of the workers. Contrary to expectation workers with temporal flexibility complain more about the incompatibility of their working hours with their private life and social activities. This may be a result of the fact that most employees have only a limited amount of discretion in adapting their working times to their personal demands, whereas most of the variability and irregularity results from company control over working hours.

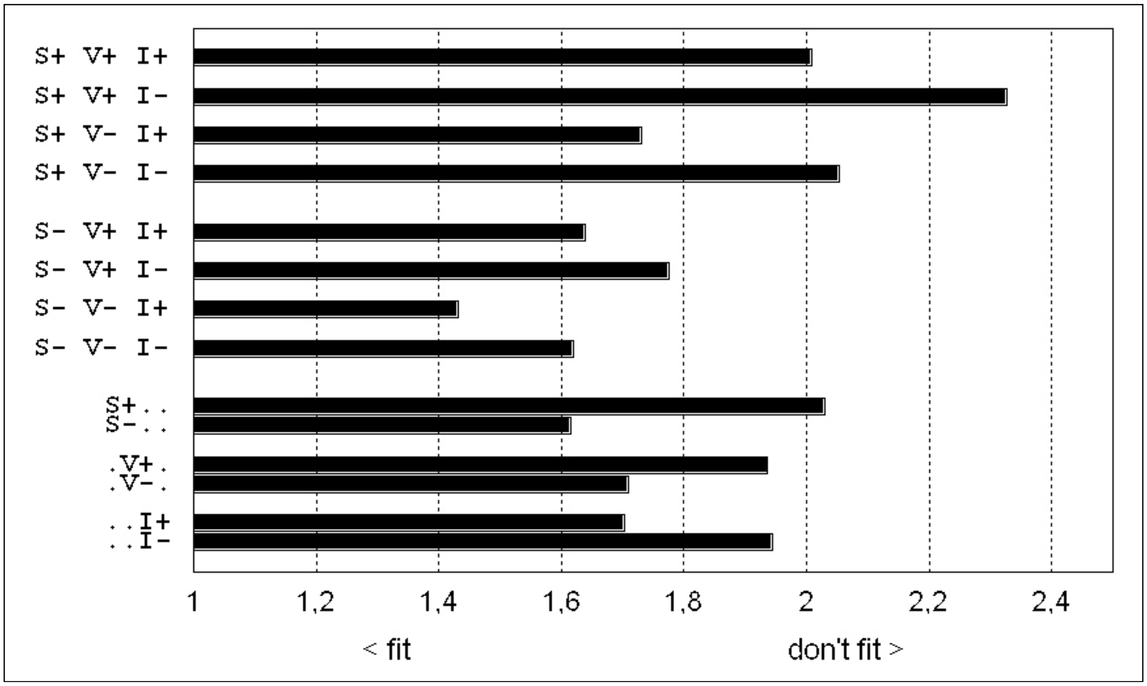

Figure 14: Work-life balance (work hours fit in with family and social life) under different forms of flexible working hours

S = shift work, V = variability, I = Influence

(based on results from Janßen & Nachreiner, 2004a; 3rd EWCS 2000)

Figure 14, as an example, shows results from Janßen & Nachreiner (2004a) on the effects of flexible hours on work-life balance (work hours fit in with family and social life). There are again the main effects for shift work, variability and autonomy, as well as the combined effects for the different combinations, completely compatible with the effects on health.

As has been shown with health effects autonomy and variability usually show additive effects, and again, as with health, working company controlled variable hours in shifts without much choice shows the most detrimental effects to work-life balance, whereas again low variability in day work with some autonomy yields the most favorable results. The same pattern of effects can be shown for a lot of different social activities, so that in general this seems to be a generalizable pattern of the effects of working flexible hours on work-life balance and social participation. It should again be noted that also in this case autonomy (partially) compensates for variability, but that full compensation cannot be achieved – with arguments similar to those on health effects to be kept in mind.

1.8. CONCLUSIONS

1.8.1. Long working hours

The available evidence clearly shows that long working hours have a detrimental impact on the safety, health, and work-life balance of the worker. Besides any direct impact on the worker there is also a negative impact of working long hours on the general public, e.g. with regard to environmental or patient safety, or the social integration of these workers.

The available data do not allow for a distinction of long term vs. short term effects of long term vs. short term exposure to long working hours. This is a gap in the available evidence that should urgently be closed by the collection of suitable data and appropriate research approaches.

Based on safety considerations a maximum number of 8 hours of working time per day can be recommended, since beyond this number of working hours the accident risk increases disproportionately. Longer hours of work per day can only be accepted if work is interrupted by adequate rest periods which avoid any accumulation of fatigue.

Based on health (as well as on safety) considerations no appropriate maximum limits for weekly working times can be specified. Since a linear increase of health impairments with increasing numbers of working hours can be observed the question of setting a limit is a question of how much impairment one is prepared to accept.

Based on the effects of long working hours on WLB, the evidence concerning the accumulation of and recovery from fatigue accumulated over subsequent work days or shifts and weekly rest periods, a reduction in the maximum number of weekly working hours would be indicated. WLB begins to decline substantially beyond 40 h/week. Weekly rest periods of one day often are not sufficient to avoid an accumulation of adverse effects and to achieve full recuperation from work – especially when there is a high work load to be dealt with. This would argue for an increased weekly rest period and thus a reduction in the number of work days to five per week. Combining this with the results from daily working time and safety yields a recommendation of 5 x 8 = 40 h per week.

The increase of the accident risk is, of course, depending on the nature and intensity of the work activities, the resulting work load and the effort and strain required. However, the reported increase in the risk with increasing hours of work has consistently been found across different jobs with different kinds and amounts of work load. Both, additive as well as interactive effects have been observed, but the effects were mostly additive. Thus for more demanding jobs shorter working hours must be considered – or a reduction in work load.

1.8.2. Rest periods

Rest periods should be taken / scheduled with the aim of avoiding impairing effects as for example fatigue, monotony, satiation, or reduced vigilance. Rest periods should thus be provided prior to the manifestation of any of these effects. This would argue against any postponement of rest periods (e.g. until to a point in time where these effects become manifest either in performance or in the perception of the worker) and any accumulation of such effects, e.g. fatigue. This would also argue for rather short reference periods for calculating averages of the exposure to work, in order to avoid any undue accumulation of impairing effects during times with high workload or extended hours within the reference period. The important thing to achieve is an appropriate dynamics in the relation of work and rest which avoids the accumulation of impairing effects, both with regard to health and WLB..

If fatigue (or other impairing effects) cannot be avoided rest periods should be scheduled so as to achieve complete recovery from fatigue (or other impairing effects). This, of course, depends on the nature and intensity of work activities. The minimum of 11 hours daily rest seems in fact to be the minimum required. Longer daily rest periods, however, would be beneficial for the maintenance of unimpaired health and safety.

1.8.3. Unusual hours

Working at unusual hours, i.e. work on Saturdays, Sundays, in the evenings and working nights or shifts, increases the risk to safety, health and work-life balance, especially in combination with long working hours. This should therefore be avoided as far as possible. Since work at unusual hours restricts the utility of the remaining hours off work, working at unusual hours would best be compensated by additional time off or a reduction in the amount of working hours. Monetary compensation cannot compensate for the adverse effects on safety, health and work-life balance.

Variability of working hours that leads to a (partial) desynchronization with the circadian as well as with the social rhythm of a society should be avoided as far as possible.

Autonomy of the workers in deciding on the arrangement of their working hours in general has a beneficiary effect in that it reduces negative outcomes. Autonomy, however, cannot compensate for violations of ergonomics principles of the design of working hours.

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Annex 2:

STUDY ON THE IMPACT ON BUSINESS: MACRO-ECONOMIC ANALYSIS

1. STUDY ON THE IMPACT ON BUSINESS

1.1. INTRODUCTION

The original objective of this work package was to provide empirical evidence on the impact of the Working Time Directive on business. The focus of the analysis will hereby lie on the implications for productivity. Administrative costs are not taken into account, as these will be examined in a separate study. Given the difficulties obtaining data which would permit the specific tracking of productivity changes related to the WTD itself, the study actually analyses the relationship between productivity and changes in the number of hours worked (whether these changes were caused by the WTD or not).

Empirical analysis of the economic impact on business is best carried out at sector level. Working time regulation is expected to have different impact on the various sectors due to difference in capital intensity, fluctuation in demand, capacity to store output, etc. Hence, a macroeconomic study of the impact of working time regulation on aggregate output or demand for factors would not lead to useful results. On the other hand, empirical microeconomic studies of the individual behaviour of producers, in response to working time regulation cannot be implemented with a EU coverage due to lack of measured data. Analysis based on case study or interviews might help understand how business react to working time regulation. However, it suffers from two drawbacks as it may not be representative of the general behaviour and may be affected by biases caused by subjective perception or unreliable data. The meso-economic level of analysis is the most appropriate level to carry out an empirical analysis of the economic impact of working time regulation on business because:

- it acknowledges the idiosyncrasies of sectors as determinant of the impact of working time of business performance ;
- data related to performance of sectors and their underlying factors are extensively available, over long period of time and across countries.

The study was conducted for six sectors which are believed to be most susceptible to productivity impact, namely Construction, Hotels & Restaurants, Financial Intermediation, Textiles, Post & Telecommunications, and Electricity, Gas & Water Supply. The focus is on service sectors or highly seasonal manufacturing sectors where a regulatory constraint put on working time could not be overcome by fluctuation of inventories. The retail sector was not included because of the widespread use of part-time work that makes the Directive less relevant to this sector. Transportation and Storage were left out of the scope since there are no detailed statistics available at subsector level that could capture the impact of the different regulations applied to road, rail, maritime transport and so on.

The study examines the specified industries across a panel of countries for the time period 1970-2007. The selection of countries takes into account both EU (old and new EU Member States) and non-EU countries, and was driven by the degree of availability of data.

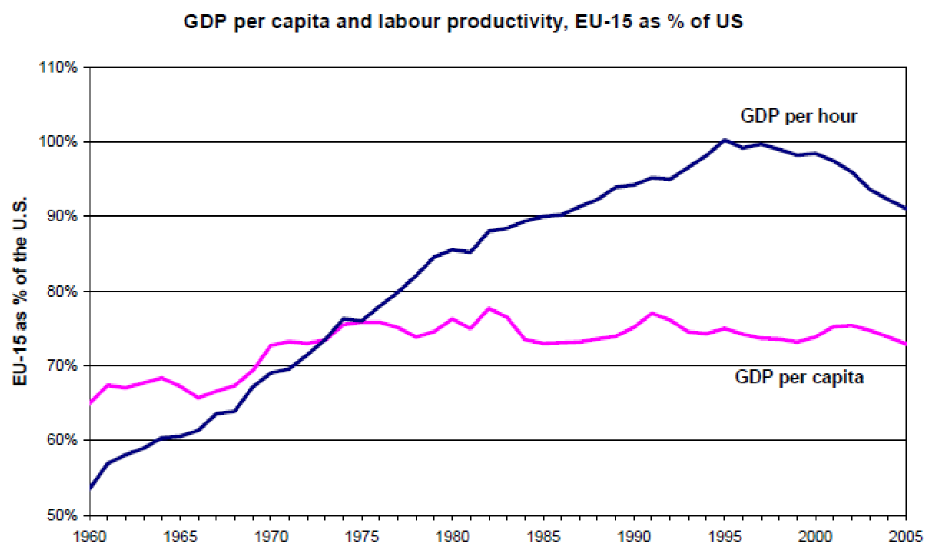
Empirical analysis is complemented by a review of specific studies from two Member States which have experienced intense debates about working time regulation, namely France and United Kingdom.

Given the scope limitations concerning the sectors, the results of the study are not to be generalized to other sectors. The data shows, for the examined sectors only, how productivity reacts on a change in the number of hours worked by an employee on a yearly average basis. Assuming the Directive has an impact on this number, these productivity changes are indirect results of the Directive. (If this assumption does not hold, the productivity changes are not to be linked to the Directive.)

1.2.1. International comparison of productivity

Concerning descriptive statistics on productivity, a lot of reports address labour productivity, expressed in terms of GDP per hour worked, in both absolute and growth terms. Mostly the aspect of European growth vis-à-vis the growth in the United States is looked at. Van Ark (2006) visualizes in his Figure 1 (reproduced below) the catching-up movement of Europe with regard to the US in terms of labour productivity. This catching-up came to a standstill around the mid 1990s. Since 1995, a new productivity gap between Europe and the US opened. In the US average annual labour productivity growth accelerated from 1.1% during the period 1987-1995 to 2.4% during 1995-2005, whereas in Europe this growth declined from 2.3% to 1.4% for the same subsequent time periods. (van Ark, 2006)

Table 1: GDP per capita and GDP per hour, 1960-2005



Note: EU refers to 15 EU membership as before 1 May 2004.
Source: Groningen Growth and Development Centre (GGDC) & The Conference Board (TCB).

Source: van Ark (2006), Figure 1, p.5

Having a look at the productivity growth rates at individual European country levels shows a lot of diversity. Tables 4 and 5 display average labour productivity growth rates for the periods 1995-2005, 2005-2009, 2007, 2008 and an estimate for 2009, along with the absolute labour productivity level compared to the US level in 2009.

Table 2: Growth and level of labour productivity, 1995-2009, Europe & Central Asia (1/2)

	Annual average growth					*GDP per person employed, % of U.S., 2009*
	1995-2005	*2005-2009*	*2007*	*2008*	*2009 (estimate)*	
World	**2.0**	**1.7**	**3.4**	**1.4**	**-1.0**	**25.8%**
Northern and Western Europe	**1.4**	**-0.1**	**1.2**	**-0.4**	**-2.9**	**80.6%**
Austria	1.5	0.2	1.7	0.1	-3.0	84.5%
Belgium	1.2	-0.1	1.3	-1.0	-2.1	91.0
Denmark	1.5	-0.9	-1.0	-2.0	-1.8	74.3
Finland	2.0	0.1	2.0	-0.8	-4.0	78.9
France	1.2	0.3	0.9	-0.2	-0.5	86.0
Germany	1.0	-0.5	0.8	-0.4	-4.9	74.5
Iceland	3.2	-2.4	1.4	0.2	-9.9	66.9
Ireland	3.0	0.3	2.2	-2.3	0.5	98.3
Luxembourg	1.2	-1.4	2.0	-4.7	-4.7	119.5
Netherlands	1.2	-0.2	1.0	0.5	-4.0	80.6
Norway	1.9	-0.8	-0.9	-1.0	0.1	110.3
Sweden	2.4	-0.2	0.4	-1.3	-2.3	80.5
Switzerland	1.1	0.0	1.7	-0.9	-2.0	75.2
United Kingdom	1.8	0.3	2.4	-0.2	-2.8	79.8
Southern Europe	**1.2**	**0.2**	**1.2**	**-0.4**	**-1.4**	**61.8%**
Cyprus	1.3	1.1	1.8	1.0	-0.5	61.9%
Greece	2.8	1.8	3.0	1.9	-0.2	74.5
Italy	0.3	-1.2	0.2	-1.4	-3.8	73.2
Malta	1.1	0.4	0.5	0.2	-1.6	57.2
Portugal	1.3	0.5	1.9	-0.5	-0.4	47.7
Spain	0.1	1.3	0.5	1.5	3.2	73.8
Turkey	3.6	1.0	3.1	-1.2	-3.2	40.3

Source: The Conference Board Total Economy Database: Summary Statistics 1995-2010, Table 9

Table 3: Growth and level of labour productivity, 1995-2009, Europe & Central Asia (2/2)

	Annual average growth					GDP per person employed, % of U.S., 2009
	1995-2005	2005-2009	2007	2008	2009 (estimate)	
Eastern Europe and Central Asia	**4.2**	**3.1**	**5.9**	**3.6**	**-3.1**	**33.0%**
Albania	7.4	4.6	6.1	6.5	0.5	24.6%
Armenia	11.4	6.6	13.6	7.2	-7.3	21.1
Azerbaijan	12.3	15.0	21.6	9.2	2.8	0.0
Belarus	6.8	4.7	6.5	7.0	-3.1	31.1
Bosnia Herzegovina	12.1	0.5	0.5	1.3	-6.3	25.6
Bulgaria	2.2	1.5	3.2	2.6	-2.5	25.3
Croatia	2.8	1.2	1.9	1.3	-3.5	52.3
Czech Republic	2.9	1.9	3.3	1.3	-1.6	53.4
Estonia	7.5	1.3	6.2	-3.8	-1.4	45.7
Georgia	6.7	8.8	14.1	8.2	4.2	18.3
Hungary	2.6	1.1	1.1	1.9	-2.0	50.5
Kazakhstan	5.1	3.0	5.5	0.3	-1.9	26.9
Kyrgyz Republic	2.2	2.9	5.5	4.6	-0.7	7.3
Latvia	6.0	1.4	6.0	-5.4	-2.0	36.6
Lithuania	6.1	2.4	6.6	3.2	-6.1	43.7
Macedonia	2.2	1.2	1.5	1.7	0.8	38.8
Moldova	4.4	3.8	3.8	6.6	-4.8	11.9
Poland	4.6	1.9	2.2	1.1	1.6	48.4
Romania	4.9	3.9	5.8	5.8	-2.9	30.5
Russian Federation	3.7	3.7	7.0	4.7	-3.8	37.1
Serbia Montenegro	0.3	1.0	0.9	5.0	-3.4	1.6
Slovak Republic	4.2	3.5	7.4	3.3	-2.4	57.2
Slovenia	3.9	1.3	3.6	0.7	-3.1	62.5
Tajikistan	2.6	8.0	6.9	13.3	6.5	10.6
Ukraine	4.3	2.2	7.7	2.3	-8.0	19.0

However, this study does not focus on labour productivity but on Total Factor Productivity (TFP). This productivity measure incorporates the efficiency with which countries are able to combine inputs into output. Hence TFP is a better measure of overall business performance. Formally, the TFP growth rate is measured as a residual as follows:

$$\Delta \ln TFP = \Delta \ln Y - w_L \Delta \ln L - w_K \Delta \ln K$$

with:

Y	Value added		
L	Labour services	w_L	Share of labour compensation in value added
K	Capital services	w_K	Share of capital compensation in value added

This base model has been further refined to take into account the change in the composition of labour force and the nature of capital assets. More details are given in section 5.3.1 below.

The average growth rates of Total Factor Productivity in the time periods 1995-2005, 2005-2008, 2007 and 2008 are presented per country in the table below.

Table 4: Total Factor Productivity Growth, 1995-2008, Europe, Central Asia and North America

	1995-2005	2005-2008	2007	2008
World	**0.6**	**1.2**	**1.9**	**0.1**
Northern and Western Europe	**0.6**	**0.3**	**0.5**	**-1.0**
Austria	0.2	0.3	0.9	-1.1
Belgium	0.3	-0.3	0.7	-1.9
Denmark	-0.3	-1.5	-1.9	-3.3
Finland	1.6	1.1	1.7	-1.4
France	0.4	-0.1	-0.6	-0.9
Germany	0.8	0.7	0.6	-0.7
Iceland	2.7	-0.5	-0.1	-0.2
Ireland	1.8	-1.4	0.8	-4.9
Luxembourg	1.3	-0.1	1.9	-4.4
Netherlands	0.4	1.0	1.4	0.2
Norway	0.2	-1.8	-1.6	-2.0
Sweden	1.1	-0.4	-0.7	-2.6
Switzerland	-0.1	0.8	1.4	-0.9
United Kingdom	0.5	0.6	1.2	-0.5
Southern Europe	**-0.1**	**-0.3**	**0.3**	**-1.7**
Cyprus	1.1	0.8	1.5	0.2
Greece	1.4	1.0	2.8	0.1
Italy	-0.3	-0.4	-0.1	-1.3
Malta	0.4	0.8	0.1	-0.3
Portugal	0.0	0.1	2.0	-2.0
Spain	-0.6	-0.4	0.1	-1.0
Turkey	0.0	-1.5	-1.0	-4.2
Eastern Europe and Central Asia	**3.1**	**4.2**	**4.9**	**2.3**
Albania	1.9	2.6	2.7	3.1
Armenia	6.1	3.6	5.6	-0.1
Azerbaijan	10.8	16.5	18.8	7.1
Belarus	4.4	-0.4	-1.5	-0.7
Bosnia Herzegovina	3.9	-1.9	-2.4	-3.3
Bulgaria	-0.2	0.9	0.8	0.3
Croatia	1.7	1.2	1.0	-0.4
Czech Republic	1.2	2.5	3.4	-0.1
Estonia	6.0	1.0	3.7	-5.1
Georgia	5.1	6.9	10.7	3.2
Hungary	1.4	0.6	-0.3	-0.1
Kazakhstan	5.1	0.2	0.9	-3.6
Latvia	1.3	-1.7	1.7	-8.6
Lithuania	3.2	1.9	3.2	-1.2
Moldova	4.2	4.0	1.4	4.5
Poland	2.9	2.0	2.0	0.3
Romania	2.2	2.1	1.3	0.9
Russian Federation	4.3	6.8	7.6	5.1
Slovak Republic	3.4	4.6	6.3	2.7
Slovenia	0.0	0.6	1.4	-1.5
Tajikistan	6.4	4.9	3.5	7.0
Ukraine	3.4	6.0	8.3	2.7

	1995-2005	2005-2008	2007	2008
North America (NAFTA)	**0.5**	**0.0**	**0.3**	**-0.5**
Canada	0.7	-0.9	-0.6	-1.8
Mexico	0.2	-0.3	0.2	-2.6
United States	0.6	0.1	0.5	0.0

Source: The Conference Board Total Economy Database: Summary Statistics 1995-2010, Table 12

Looking at the period from 1995 till 2005 gives a good overview on where to position each country. Spain has the lowest average growth rate of -0.6, Ireland has the highest rate of the early EU-members with 1.8 and the US had an average growth rate of 0.6 in the period 1995-2005. When we have a look at the rates in 2007 and 2008, we see a general fall-back for 2008. This is not surprising, given the worldwide financial crisis. This implies however that the rates for the 2005-2008 time period are influenced by this event. Together with the rather short time span of 2005-2008, we prefer not to make general statements on the productivity evolution across the two periods 1995-2005 and 2005-2008.

Large-cross country variations in TFP are caused both by the business cycle and long run trends in production efficiency caused by technical change, economies of scale, improvements in allocative and technical efficiency. Aside from technical innovation, institutional and regulatory factors are also likely determining factors of variations in TFP. In the section below we review empirical studies that have investigate the possible link between productivity and labour market regulations.

1.2.2. Empirical analysis of labour market policies and productivity

There have been some empirical analyses of labour market policies and productivity. An in-depth study of the OECD in 2003 (covering 23 industries in manufacturing and business services in 18 OECD countries over the period 1984-1998) finds evidence that stringent regulatory settings in the product market, as well as strict employment legislation, have a negative bearing on productivity at the industry level (Nicoletti et al.,1999).

Bassanini and Venn (2007) assess the impact of four labour market policies on productivity in 18 OECD countries over the years 1982-2003. The labour market policies under investigation are employment protection legislation, minimum wages, parental leave and unemployment benefits. The clearest result from the analyses is that strict statutory employment protection for regular contracts appears to dampen productivity growth (Bassanini and Venn, 2007, Bassanini et al., 2008). The results for the three other policies are less clear.

Scarpetta and Tressel (2002) also present a study on the impact of institutional settings on the productivity across a panel of 23 industries in 18 OECD countries. Again, the authors find a negative impact of stringent employment protection legislation on productivity growth.

1.2.3. Case studies

1.2.3.1. FRANCE AND THE 35-HOUR WORKWEEK

There has been an intense debate about the impact of the laws limiting working time introduced following the 1997 elections. Empirical studies focus on the ex-post impact on employment, which was the stated objective of the policy, and to a much lesser extent on output and productivity. They rely on micro data that compared companies that adopted the 35-hour workweek with a control population of companies that kept the 39-hour workweek regime. Crépon, Leclair and Roux (2004) analysed the impact on TFP. They found out that the shift from 39 to 35 hours, a 10% decrease, had a negative impact of 3.7% on TFP. In their study, TFP is defined by labour input measured in terms of number of employees instead of number of hours worked. Hence they conclude that the reduction in working time would have increased TFP, when measured on an hourly basis, by as much as 6.3%. This study demonstrates that a decrease in hours worked, when combined with sticky wages, is likely to trigger efficiency improvements to offset the direct negative effects of higher hourly wage rate on competitiveness.

1.2.3.2. UNITED KINGDOM, REGULATORY IMPACT ASSESSMENT

The only quantifications that could be found in the UK are ex ante regulatory impact assessments (RIA). They mainly focus on compliance costs and recognize that even these costs vary largely from business to business. In these regulatory impact assessments, although the benefits of the working time regulation are identified, there is no attempt of quantification. Ex post empirical estimates of the overall impact of working time regulation could not be found in the literature and this is probably due to the opt-out and extensive use of derogations experienced in the UK. Apart from the RIAs, two studies (Neatley, 2003 ; Neatley & Arrowsmith, 2000) based on a case study approach conclude generally that in the majority of cases the working time regulation has only marginal impact on organisations covered by the research. Where a negative impact was cited, it was most commonly in relation to increased labour costs but other companies reported positive operational benefits arising from changes made to comply with the working time regulation.

In sum, there is a clear distinction to be made between the compliance costs and the overall impact on business of working time regulation. This demonstrates the relevance of the econometric approach adopted in this study.

1.3. SPECIFICATION

1.3.1. Total factor productivity as dependent variable

To measure the impact of the WTD on productivity, a productivity variable must serve as dependent variable. For this, we apply the neoclassical growth accounting framework, pioneered by Solow (1957). This framework, which is based on an aggregate production function in growth rates, makes it possible to assess the contribution of various inputs (labour, capital and intermediate goods) to GDP growth and to measure the residual, the Total Factor Productivity (TFP). The output growth contribution of a specific input is measured by the growth rate of that input, weighted by its income share. Following the neoclassical framework, the income shares reflect the output elasticities and sum to one, representing constant returns to scale. (Senhadji (2000), van Ark et al. (2008), Nicoletti and Scarpetta (2003))

The basic idea of TFP is that any output growth that is not accompanied by a growth of inputs must be due to a more efficient use of inputs, hence due to a growth in productivity (Nicoletti and Scarpetta, 2003). This measure has been taken as a proxy for productivity in several studies, e.g. in Scarpetta and Tressel (2002), Nicoletti and Scarpetta (2003), Bassanini and Venn (2007) and Bassanini, Nunziata and Venn (2008). Senhadji (2000) explains why it is important to look at TFP as source of economic growth instead of looking at GDP growth as a whole or any other source.

Working time may be associated with labour productivity. However, working time may equally impact the capital intensity and hence the overall efficiency companies have to employ in allocating their inputs. As explained before, this is exactly what TFP measures, and qualifies it as the appropriate dependent variable.

'Output growth' can be interpreted in two ways: growth of gross output or growth of value added. Gross output decompositions are most meaningful at the lowest level of aggregation (firm level), since it is highly sensitive to intra-industry deliveries. Value added as a measure for output on the other hand, does not show this sensitivity and is better suited for aggregation at industry level. (EU KLEMS, 2007)

Research shows that more accurate estimates for TFP are gained when both the contributions of labour services and of capital services are further split. The contribution of labour services is therefore split into the contributions of hours worked and of changes in the labour composition in terms of educational attainment, age or gender. In the contribution of capital services a distinction is made between ICT capital and non-ICT capital.TFP will therefore be calculated as follows:

$$\Delta \ln TFP = \quad \Delta \ln Y - w_{LC}\Delta \ln LC - w_H \Delta \ln H - w_{KIT}\Delta \ln KIT - w_{KNIT}\Delta \ln KNIT \quad (Eq.1)$$

with:

Y	Value added		
LC	Change in labour composition	w_{LC}	Share of labour composition change in value added
H	Hours worked	w_H	Share of hours worked in value added
KIT	ICT capital services[1]	w_{KIT}	Share of ICT capital in value added
KNIT	Non-ICT capital services	w_{KNIT}	Share of non-ICT capital in value added

The way TFP is measured in the growth accounting framework results in identifying the growth rate of TFP. The growth of TFP is the difference in TFP from one year to the next. In our analyses, we use these annual growth rates to calculate a TFP index, with a value of 100 in the base year (1995). We control for differences in the absolute value of TFP across countries in the base year by including a set of country dummies in the specification.

[1] ICT: Information and Communication Technology

1.3.2. Average hours worked per employee (yearly) as proxy for the Directive impact

Examining the impact of the Directive on productivity, one needs a variable representing the impact of the Directive. A straightforward variable would be the dates of transposition of the Directive into the national legislation for all countries and sectors under consideration. There are however limits in the availability of this information. The most important restriction is the availability of the information at country and industry level. Also, apart from the availability of the data, one can argue that by merely looking at the date of formal implementation of legislation would not take into account a) whether the legislation was actually fully in practice and b) whether the Directive was more or less restrictive than the legislation in place prior to the transposition of the Directive Taking these limits into consideration, 'transposition' was not retained as a reliable variable, which in turn obliged us to seek a qualitative proxy.

A proxy for the impact of the Directive implied the following two requirements. The proxy needed to measure the impact and not merely the existence of the Directive. In other words, if a Member State was already compliant with the provisions of the Directive, adopting the Directive would not have any relevant impact. Hence adoption as such should not be reflected in the proxy variable. The second requirement of the proxy was that it covers as many aspects of the Directive as possible, since the Directive covers multiple aspects of working time regulation (average weekly hours, reference period, annual leave…).

These requirements, along with the restrictions on data availability concerning country, period and sectors, led to the use of the ***average yearly hours worked per employee*** (HPE) as a proxy for the Directive. This choice embodied the assumption that implementing the Directive or equivalent legislation would be translated into a change of HPE. Hereby meeting our first requirement. Since HPE is also likely to be influenced by weekly working time, annual leave, resting time and in some way the reference period, the second requirement is also met.

1.3.3. Sector, country and time effects

Productivity, measured by TFP, varies greatly across countries (Nicoletti and Scarpetta, 2003; Mourre, 2009), but is also very sector-specific. This study required us to conduct the study by analysing different relevant industries. The focus is on service sectors or highly seasonal manufacturing sectors where regulatory constraints placed on working time could not be overcome by fluctuation of inventories. A drawback of this focus is that service sectors have in common that the measurement of output is not as straightforward as in goods-producing industries. However, a distinction should be made between services which are traded in a market, known as market services, and non-market services. Given the efforts made by national statistical offices in measuring market services output, a fairly accurate internationally comparable picture of development in market services exists. (O'Mahony and Timmer, 2009) Aside from the output measurement issue in non-market services[2], there is also the neoclassical assumption in the growth accounting framework, which does not hold in non-market services. Accordingly, the selection of industries for the study is limited to market sectors only, leading to the exclusion of the health care sector and the following final selection:

- Construction,
- Hotels & Restaurants,
- Financial Intermediation,
- Textiles,
- Post & Telecommunications, and
- Electricity, Gas & Water Supply.

As mentioned above, TFP by itself varies greatly across countries and also over time. To take this into account a fixed country and time effect is included in the model.

[2] van Ark et al. (2008) state that *"...the scope of measurement problems [in service output] should not be overestimated...there is no evidence that differences in measurement practices bias international comparisons of productivity growth rates across countries."*

1.3.4. Control variables

TFP, as a residual measure, is by itself already controlled for by several aspects such as the labour composition and the measurement of capital input. The way capital services are measured, for instance, makes TFP measure disembodied technological change[3]. (Embodied technical change in new capital goods is captured by the measure of capital input, as explained in van Ark et al. (2008)) However, we include one extra control variable (two where data available). The control variable we include in the entire study is Employment Protection Legislation (EPL hereafter). EPL is the set of mandatory restrictions governing the recruitment and dismissal of employees in a country, and has been studied in a variety of contexts. For example Autor et al. (2007) and Bassanini et al. (2008) link EPL to productivity. We therefore include this variable as a control variable[4]. In order to test whether the effects of EPL and HPE on productivity are additive or not, we also include a variable built as the multiplication of these two variables.

Another link to productivity that has been investigated and confirmed in literature is the impact of R&D intensity, as reported by Scarpetta and Tressel (2002) in an OECD Working Paper[5]. Following their results, we intended to include this variable as a control variable in this study. However, the availability of the data did not show a strong match with the country-sector-period selection of our study, which allowed us to include this control variable in only two out of the six sectors under investigation (Construction and Electricity, Gas & Water Supply). Although the use of the ANBERD data is preferred, the issue of R&D or innovation is partly captured in the measurement of TFP by a) the split of capital services into ICT and non-ICT capital services, and b) the way capital services are measured, including embodied technology.

1.3.5. Model Specification

The model for our study, built according the specifications described above, is as follows:

$$\log TFP\_I_{it} = \alpha + \alpha_i + \alpha_t + \beta_i \log HPE_{it} + \gamma EPL_{it} + \delta\left(EPL_{it} * \log HPE_{it}\right) + \varepsilon_{it} \qquad (Eq.2)$$

Where:

$\log TFP\_I_{it}$	Log of TFP (industry value added based) index (1995=100) in country *i* at time *t* in the considered industry
$\log HPE_{it}$	Log of actual average hours worked per employee per year in country *i* at time *t* in the considered industry
EPL_{it}	Employment protection legislation in country *i* at time *t* (same for all considered industries)
ε_{it}	Error term – potentially with heteroskedasticity and autocorrelation
Α	Overall intercept
α_i	Country specific intercept
α_t	Year specific intercept

[3] Embodied technical change refers to improvements in the design or quality of new capital goods or intermediate inputs while disembodied technical change is not incorporated in a specific factor of production. In the EU KLEMS database, capital services are measured on basis of investment series by asset type; ICT assets are deflated using a quality-adjusted investment deflator; and aggregation is done using weights that are related to the user cost of each asset. This approach is based on the assumption that marginal costs reflect marginal productivity. Higher user cost reflects higher productivity of assets that is due to their improved design or quality.

[4] For a literature review on EPL and productivity the reader is referred to Bassanini et al. (2008).

[5] For their study, the authors used the OECD ANBERD database for data on R&D intensity.

As mentioned above, R&D intensity is also taken into account for the Construction and Electricity, Gas & Water Supply industries, but is not specified in the general model.

The model as stated in Equation 2 investigates whether there is a substitution effect between 'total hours worked per employee' and 'number of employees'. Combined, these are the factors that constitute the labour input (when measured as the total hours worked). If there is a perfect substitution among the factors, β_i would be equal to zero. This would imply that one can for instance decrease the number of employees and increase the hours that each remaining employee works (HPE), without having an effect on productivity. However, if $\beta_i < 0$, the suggested increase in hours worked per employee would decrease productivity, providing proof that the additional hours worked per employee are less productive. Conversely, $\beta_i > 0$ suggests that the additional hours are more productive than the 'basic' hours.

The country fixed effects (α_i), capture the base level of TFP for each country. This is required since we are using an index[6]. Not introducing a country fixed effect would imply all countries being at the same base level of TFP, which of course does not represent reality.

[6] EU KLEMS database provides only index series of TFP, no series of absolute value of TFP is available.

1.4. DATA AND METHODS

1.4.1. Country and sector scope

The EU KLEMS database is the main source for our data. This database, containing growth and productivity accounts, was created to analyse productivity in the European Union and provides (amongst other measures) TFP at the industry level for European Union Member States from 1970 onwards. The measures are developed for individual European Union Member States, and are linked with 'sister' KLEMS databases in the United States of America and Japan.

With regard to the country scope for this study, data on both EU and non-EU countries were aspired, and both founding and acceding Member States were included in the EU group. The availability of TFP data in those countries was the only criterion to determine whether to include a country in the panel or not. This resulted in the following list of countries:

EU Member States	Non-EU countries
Austria	Australia
Belgium	Canada
Czech Republic	Japan
Denmark	United States of America
Finland	
France	
Germany	
Hungary	
Ireland	
Italy	
Netherlands	
Slovenia*	
Spain	
Sweden	
United Kingdom	

**Slovenia is not represented in every analysis due to lack of data.*

With regard to the industries in the EU KLEMS database, the European NACE revision 1 classification is applied (although the level of detail varies across countries, industries and variables due to data limitations). The classification codes referring to the selected industries are the following:

Industry	Code
Textiles	Code 17-19
Hotels & Restaurants	Code H
Financial Intermediation	Code J
Post & Telecommunications	Code 64
Electricity, Gas & Water Supply	Code E
Construction	Code F

1.4.2. Productivity data

As stated before, the TFP index, based on value added (as opposed to gross output), is taken as the dependent variable. The measure takes into account the above mentioned splits of labour and capital services. The indices used have 1995 as base year.

This is variable TFPva_I in the EU KLEMS database.

1.4.3. Working time data

The explanatory variable of interest, the average hours worked per year per employee (HPE), is created by dividing the total hours worked by employees in a particular industry per year by the number of employees in that same industry and year. These are the variables labelled H_EMPE and EMPE in the EU KLEMS database. These variables have been preferred, as proxy to the impact of the Directive, to the corresponding statistics calculated on basis of number of persons engaged because they exclude self-employed and family members -two categories of labour that are not subject to working time regulation. The way the number of employees was measured is described in the source documents of EU KLEMS (www.euklems.net). All countries in this study used the number of persons working to define an employee, rather than using Full Time Equivalents. For some countries and industries, the real average yearly hours worked per employee was given in the EU KLEMS database (as opposed to the calculated ratio). However, the coverage of our panel with this variable was very limited. Also, comparing this data with the calculated ratio as described above did not show significant differences (as expected).

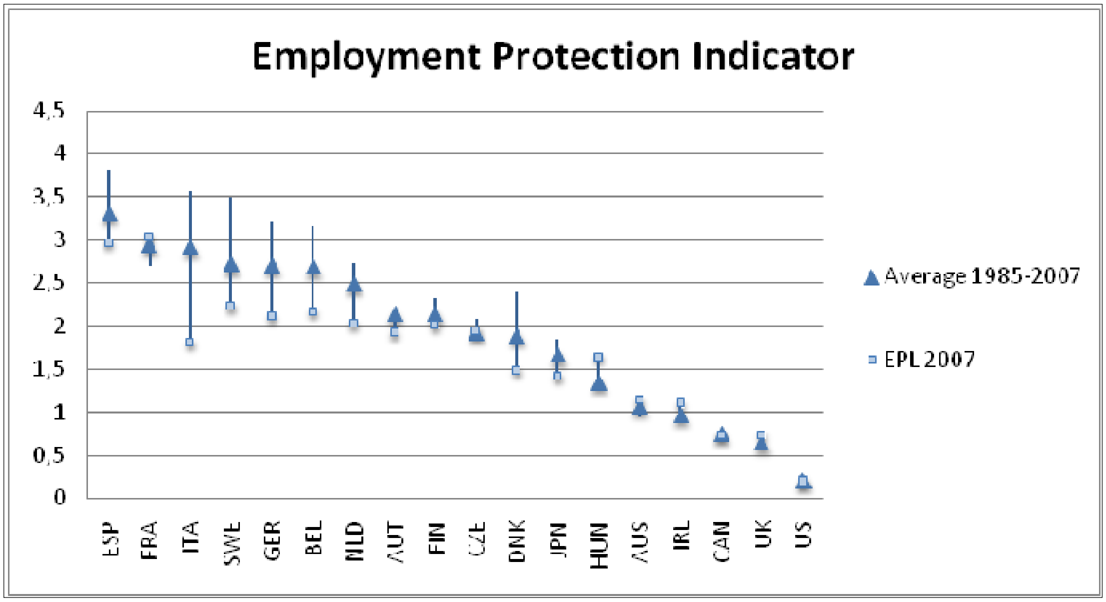
1.4.4. Employment protection legislation

The degree of stringency of EPL is quantified using the overall indicator of EPL provided by the OECD STANS database. This indicator measures the procedures and costs involved in dismissing individuals or groups of workers and the procedures involved in hiring workers on fixed-term or temporary work agency contracts. (OECD, 2004) The overall EPL indicator, scaled from 0 to 6 with 6 being the most restrictive, is available on country level from 1985 onwards, but not on industry level. Accordingly, this variable will have the same values in all industries. Also, by including this variable in our model later on, we will lose a great part of our time series (1970-1985) and hence a lot of information. This has to be taken into account when interpreting the results.

Figure 5 displays the indicator per country. The bars depict the minimum-maximum range of the indicator value in the reported period. The triangles show the average value over this period. We can see that the EPL in the non-EU countries in our sample (Japan, Australia, Canada, and US) is far less restrictive than in the rest of the countries in our panel. Only Hungary, Ireland and UK position themselves at this low level of employee protection.

As extra information, but of lesser importance for the analysis, the latest EPL index is shown.

Figure 15: The overall OECD Employment Protection Indicator – range and average over the period 1985-2007, and the EPL in 2007:



There are two restrictions on using the EPL data in our model. The first restriction concerns the country scope. There is no EPL index for Slovenia. Slovenia is therefore omitted when EPL is included in the regressed model. The second restriction concerns the time-series. The EPL index is only available from 1985 onwards, 15 years after the start of our original time-series. We overcame this large loss of data by using the 1985 value for all years from 1970 until 1985. We call this variable EPL_extended. The descriptives of EPL_extended, along with the descriptives of the original EPL, are provided in annex 2, showing no large deviations from each other. Also, most countries remained at their original level of 1985 for several years before moving to another index score. The possible negative effect of having estimates for EPL from 1970 until 1984 is believed to be outweighed by the advantage of having a longer time-series in total.

1.4.5. R&D Intensity

R&D intensity is the ratio of R&D expenditure to value added. This data is provided in the OECD ANBERD database. The availability of data for this variable does not however cover our country-period panel for all six sectors under investigation. As a result, for the Construction and Electricity, Gas & Water Supply industries, we have 'sufficient' data to incorporate the variable. Furthermore we lose a lot of our time-series (data from 1987 onwards) and some of our country observations. The inclusion of this control variable is reported and critically discussed per industry at the Results section.

1.4.6. Model estimation

1.4.6.1. PREPARATORY ACTIONS

For each industry, we start by running an endogeneity test between the explanatory variable logHPE and our dependent variable logTFP. For testing endogeneity, an instrumental variable is needed. Such an instrumental variable needs to be correlated with its endogenous variable, but may not be correlated to the error term in the explanatory equation. For our equation where logHPE might be endogenous, we used as the instrumental variable the log of HPE lagged one period, divided by the country average. (Note that in case of autocorrelation, the quality of this instrumental variable decreases.) After fitting the explanatory variable based on the instrumental variable, both the predicted and the original value were used in the specified model. Next, a Hausmann test was used to compare the estimators between the two regressions to test whether logHPE is an endogenous variable or not.

The result of the endogeneity test is reported for each industry. In five of the six industries (all except Post & Telecommunication), there was no endogeneity. In case of endogeneity, replacing the endogenous variable by the instrumental variable is a possible way of dealing with the endogeneity issue. However, this is only a proper solution if a qualified instrumental variable exists. In the case of Post & Telecommunications, as reported below, there was evidence of autocorrelation, which would diminish the quality of the instrumental variable and hence using the instrumental variable instead of the endogenous variable would imply a trade-off between efficiency and consistency in measuring the estimators. We opted to use the original variable.

After testing for endogeneity, tests were run to check for possible heteroskedasticity and autocorrelation. If heteroskedasticity and/or autocorrelation were detected, this was taken into account in the final estimation of the model.

After running the tests on endogeneity, heteroskedasticity and autocorrelation, a panel data analysis was performed, pooling cross-country and time-series data. For the regression the feasible Generalized Least Square (GLS) method was applied. Depending on the outcome of our heteroskedasticity and autocorrelation tests, the GLS estimation was applied with the necessary alterations to take care of any issues. The details of running the estimations are explained in the following paragraphs.

1.4.6.2. REGRESSION ANALYSES

We specified the model to estimate in Eq. (2). We will however, in each industry, arrive at this model in four steps, responding to four models. In the two industries where R&D intensity is taken into account, a fifth model will be estimated too. The four/five models to be estimated per industry are the following:

$$\log TFP\_I_{it} = \alpha + \alpha_i + \alpha_t + \beta \log HPE_{it} + \varepsilon_{it} \quad (1)$$

$$\log TFP\_I_{it} = \alpha + \alpha_i + \alpha_t + \beta_i \log HPE_{it} + \varepsilon_{it} \quad (2)$$

$$\log TFP\_I_{it} = \alpha + \alpha_i + \alpha_t + \beta_i \log HPE_{it} + \gamma EPL_{it} + \varepsilon_{it} \quad (3)$$

$$\log TFP\_I_{it} = \alpha + \alpha_i + \alpha_t + \beta_i \log HPE_{it} + \gamma EPL_{it} + \delta \left(EPL_{it} * \log HPE_{it}\right) + \varepsilon_{it} \quad (4)$$

$$\log TFP\_I_{it} = \alpha + \alpha_i + \alpha_t + \beta_i \log HPE_{it} + \gamma EPL_{it} + \delta \left(EPL_{it} * \log HPE_{it}\right) + \xi \log R\&D + \varepsilon_{it} \quad (5)$$

The four models will be estimated subsequently for each industry. The α_i, which captures the country fixed effects by means of country dummies, is each time tested for its significance. This test checks if $\forall\, \alpha_i = 0$. The same has been done for the year dummies. The year effect is comprised in α_t and in each model $\forall\, \alpha_t = 0$ is tested. The outcome of these tests is reported in the results section.

The first model takes an overall logHPE as the only explanatory variable for logTFP. Model (2) replaces this overall logHPE by country specific logHPE's. A joint F-test on the inclusion of these interaction variables is performed and reported. This test checks if $\forall\, \beta_i = \bar{\beta}$. In the following two models the EPL is included as control variable: in one case as a standalone variable (model (3)), and in the other in interaction with the overall logHPE (model (4)).

For the two sectors with sufficient data on R&D intensity, model (5) is also included. Model (5) builds further on model (4) by adding the R&D variable, also in a log-variant, representing elasticities.

Apart from the estimations for $\alpha, \beta_i, \gamma, \delta, \xi$ and the results of the tests described before (tests for significant year dummies, significant country dummies and significant country effect in logHPE), a goodness-of-fit measure is also provided for each estimated model. In case of an Ordinary Least Squares estimation, the R-squared statistic is often used as a goodness-of-fit measure. Using the Generalized Least Square method, the standard R-squared cannot be computed. Hence a pseudo R-squared is constructed by calculating the correlation between the observed response and the predicted response, and then squaring it. To adjust this measure so that it takes into account the number of explanatory variables, we calculate an adjusted pseudo R^2, which is done as follows:

$1 - adjR^2 = [(n-1)/(n-k-1)] \times (1 - R^2)$ where k is the number of regressors

1.4.6.3. INTERPRETATION COEFFICIENTS

When reading the estimations, the reader should look at whether or not the estimates represent elasticities.

The β_i will represent a double elasticity, since it estimates the influence of the logarithm of HPE on the logarithm of TFP. For example: an estimation of 2 for a specific β_i means that for that country i, an increase in the hours worked per employee (HPE) of 1% would result in an increase in TFP of 2%. So asking employees to work 1% more on an average yearly basis, would increase productivity by 2%.

The estimations of γ give information on the effect a 1 point index increase in the Employment Protection Index would have on productivity, expressed as a percentage. An estimated parameter of value .03 implies a 3% increase in TFP, given a 1 point index increase in EPL. So this estimation needs to be multiplied by 100.

If model (4) is used, both the effect of HPE and EPL is not captured by the previous estimators (β_i and γ) alone. They need to be combined with the interaction effect. If we are interested in a country effect of HPE in model (4), we need to combine the effect expressed in β_i with the effect expressed in δ using a fixed EPL. The most logical value to use for EPL is the average for that country across the time period. In this case (fixing EPL and looking at the effect of HPE) we are dealing again with double elasticities and the resulting number of (β_i + 'mean EPL' * δ) is simply to be read as the percentage increase in TFP, given a 1 percent increase in HPE.

If we want to deduce the effect of a 1 point index increase in EPL on TFP, we have to combine γ with δ using a fixed logHPE. Although γ and δ are not country-specific, fixing logHPE requires a country-specific level as it varies significantly across countries. As a result we end up with an EPL effect per country, using the mean value of logHPE for each country as a fixed value for interpreting the δ estimator. As with γ, we are not dealing with double elasticities and we have to multiply the combination of (γ + 'mean logHPE'* δ) by 100 in order to receive the percentage change in TFP as result of a one point index increase in EPL.

Interpreting ξ about the effect of R&D on productivity is again a double elasticity where a 1% increase in R&D intensity results in a ξ% increase in TFP.

1.5. EMPIRICAL RESULTS

1.5.1. Textiles Sector

Using the preparatory test, evidence of heteroskedasticity and autocorrelation was found. This will be taken into account in the GLS estimation. The estimated parameters for the four models are reported in Table 7.

Table 5: Results Textiles

Dependent variable: logTFP				
	(1)	**(2)**	**(3)**	**(4)**
Intercept	7.926013***	10.05237***	(omitted)	32.20067***
	0.8350059	*2.160797*		*4.191238*
logHPE	-0.5146228***			
	0.1122681			
$logHPE_{AUS}$		-2.237704***	-2.285939**	-3.705563***
		0.8442906	*0.8973265*	*0.9978902*
$logHPE_{AUT}$		-1.425553***	-1.023625**	-3.786023***
		0.3710927	*0.4022907*	*0.5210078*
$logHPE_{BEL}$		-0.5267131	-0.3192732	-4.068754***
		0.868286	*0.8355325*	*0.8542184*
$logHPE_{CAN}$		-0.8275525*	-1.089423**	-1.9846***
		0.4412749	*0.4658027*	*0.4685564*
$logHPE_{CZE}$		-0.3619225	-0.037579	-2.786293
		1.896522	*1.745024*	*1.870375*
$logHPE_{DNK}$		-0.3822481	-0.5788801	-2.646074***
		0.4770195	*0.5574391*	*0.54808*
$logHP_{ESP}$		3.466391***	3.950029***	0.0422351
		0.5817119	*0.7837103*	*0.7758755*
$logHPE_{FIN}$		-0.3464708	-0.3161887	-2.824962***
		0.31851	*0.2985*	*0.4283882*
$logHPE_{FRA}$		-0.8039896***	0.577255***	-3.827628***
		0.2921723	*0.0068597*	*0.5706821*
$logHPE_{GER}$		-0.5357921*	0.5792323***	-3.330574***
		0.2915327	*0.0062265*	*0.4169812*
$logHPE_{HUN}$		-1.044696	-0.202228	-1.90009
		0.9005995	*0.9712541*	*1.246455*
$logHPE_{IRL}$		-0.546565	-0.9482196**	-2.116026***
		0.4035665	*0.3712756*	*0.3849911*
$logHPE_{ITA}$		0.2250836	0.508002	-3.102992***
		0.4905187	*0.5727288*	*0.6842973*

Dependent variable: logTFP				
	(1)	(2)	(3)	(4)
$logHPE_{JPN}$		0.3808117	0.7486085	-1.386473**
		0.6450551	*0.722424*	*0.6300415*
$logHPE_{NLD}$		-0.7605061**	-0.4845722	-3.505344***
		0.3865258	*0.3575365*	*0.5436563*
$logHPE_{SVN}$		9.368892*	(omitted)	(omitted)
		5.212022		
$logHPE_{SWE}$		-0.3482478	-0.6227973	-2.797268***
		0.6583936	*0.8211377*	*0.7834874*
$logHPE_{UK}$		-1.870967***	-1.926857***	-2.603082***
		0.4801938	*0.4594346*	*0.4885449*
$logHPE_{US}$		0.2305724	-0.1234983	-0.3327622
		0.493195	*0.5252026*	*0.4794057*
EPL			-0.0561298***	-8.068135***
			0.0112412	*1.012734*
EPL*logHPE				1.100647***
				0.1390046
Country dummies?	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)
Year dummies?	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)
Joint F-test on country interaction with logHPE		P=.000		
Pseudo R²adj	0.049	0.725	-0.163	0.731
Df	56	74	73	74
Number of observations	498	498	486	486

Notes:

Dependent variable logTFP (index with value 100 in base year 1995).

Standard errors in gray italics.

***, **, *: significant at the 1%, 5% and 10% level respectively.

logHPE: logarithm of average hours worked per employee.

$logHPE_{ABC}$: interaction between the logarithm of average hours worked per employee and country dummy ABC.

EPL: Employment Protection Legislation, measured by the OECD overall EPL indicator.

Country abbreviations: AUS: Australia, AUT: Austria, BEL: Belgium, CAN: Canada, CZE: Czech Republic, DNK, Denmark, ESP: Spain, FIN: Finland, FRA: France, GER: Germany, HUN: Hungary, IRL: Ireland, ITA: Italy, JPN: Japan, NLD: Netherlands, SVN: Slovenia, SWE: Sweden, UK: United Kingdom, US: United States of America

Slovenia is omitted in models (3) and (4) because of lack of EPL data for this country.

All models include unreported country and time fixed effects.

All models are estimated using a feasible GLS method, correcting for heteroskedasticity across panels and AR1 autocorrelation within panels.

Comparing the four models, we see that including the EPL control variable on its own has a very negative effect on the R^2 and omits the intercept because of multicollinearity. However, including both EPL on its own and in interaction with logHPE restores and even slightly increases the goodness of fit and yields more significant estimators. The two variants of the control variable itself are also highly significant. We therefore interpret the results of model (4).

As explained before, deducing the effect of HPE on TFP from the estimators in model (4) requires a combination of the logHPE country estimates with the estimate of the interaction variable EPL*logHPE. We therefore fix EPL at its mean value per country (this is the same for each industry since this index is only known per country at an aggregate level). So for Australia, with a mean EPL value of 1.017895, the effect of a 1% increase of HPE would result in a -2.59% effect on TFP, being -3.705563 + (1.017895 * 1.100647).

The effects are calculated for each country and presented in Table 8. The insignificant country effects are left out.

Table 6: Impact (%) on TFP of one percent increase in HPE, ceteris paribus

Country	%
Australia	-2.59***
Austria	-1.39***
Belgium	-0.91***
Canada	-1.16***
Czech Republic	-0.68
Denmark	-0.34***
Spain	3.91
Finland	-0.38***
France	-0.65***
Germany	-0.15***
Hungary	-0.46
Ireland	-1.07***
Italy	0.39***
Japan	0.52**
Netherlands	-0.66***
Slovenia	-
Sweden	0.53***
United Kingdom	-1.91***
US	-0.10

*(The significance level of .01, .05 and .10 (***, **, and * respectively) is the significance level of the country specific effect.)*

In general, we see a negative effect of HPE on TFP, with the strongest effect in Australia (a 2.59% decrease in TFP when HPE is increased by 1%). In **Italy, Japan and Sweden** we find **a limited positive effect** of HPE on TFP (.39 to .53%). Aside from the significant effects of HPE on TFP, the following countries show no country specific significant effect: Czech Republic, Spain, Hungary and the US.

A negative effect of increasing HPE on TFP represents a positive effect of the WTD on TFP, if we assume that the WTD restricts HPE and therefore induce an increase in productivity.
The effect of EPL, our control variable, is also not to be read in one parameter but needs to be constructed by combining both EPL related estimators, using a fixed value of logHPE. For this fixed value we take the country mean logHPE in this industry, as stated before. In that case we could say that, for Australia with a mean logHPE of 7.549915 in Textiles, an increase of 1 index-point in EPL would result in a 24 percent increase in TFP. This is calculated as follows: -8.068135 + (7.549915*1.100647) = 0.24. This is expressed in percentage format, so needs to be multiplied by 100.

Using the mean logHPE values per country it is possible to also calculate all country specific impacts of EPL on productivity. This concerns however the impact of the control variable, is not part of the main research question for this study and is accordingly included in Annex.

1.5.2. Hotels & Restaurants Sector

For this sector, there was evidence of heteroskedasticity and autocorrelation. This will be taken into account in the GLS estimation. The estimated parameters for the four models are reported in Table below.

Table 7: Results Hotels & Restaurants

Dependent variable: logTFP				
	(1)	**(2)**	**(3)**	**(4)**
Intercept	6.400668***	-0.6465998	-2.420268	-3.856326
	0.5184693	*2.303911*	*2.261235*	*2.354521*
logHPE	-0.1710619**			
	0.0689821			
$logHPE_{AUS}$		-0.9719183**	-1.003578**	-0.9693614**
		0.443971	*0.440255*	*0.445558*
$logHPE_{AUT}$		-0.8182781***	-0.7720298***	-0.6844698***
		0.1623524	*0.1700116*	*0.193038*
$logHPE_{BEL}$		-0.3061381	-0.3853037**	-0.3270591
		0.2134791	*0.1728958*	*0.1999361*
$logHPE_{CAN}$		1.52925***	2.073261***	2.108871***
		0.5011458	*0.4974087*	*0.4856182*
$logHPE_{CZE}$		1.213976	1.209137	1.288109
		1.540063	*1.574385*	*1.585002*
$logHPE_{DNK}$		-0.9073799*	-0.9667507*	-0.8744757
		0.5386823	*0.5482477*	*0.5707449*
$logHP_{ESP}$		0.4455415**	0.2931842	0.4569766*
		0.1910747	*0.208343*	*0.2680813*
$logHPE_{FIN}$		-2.601451***	-2.567119***	-2.561149***
		0.5860463	*0.5613657*	*0.5668914*
$logHPE_{FRA}$		0.7695147**	0.9880261***	1.181837***
		0.3107969	*0.3045732*	*0.3178022*
$logHPE_{GER}$		0.4492937	0.2330715	0.2987248
		0.3237489	*0.2306936*	*0.209656*
$logHPE_{HUN}$		1.843488***	2.026394***	2.128501***
		0.4952998	*0.5458534*	*0.5354275*
$logHPE_{IRL}$		-0.4885713	-0.4977858	-0.4506234
		0.3839269	*0.3363725*	*0.3296141*
$logHPE_{ITA}$		-0.152591	-0.1582306	-0.0816354
		0.1620925	*0.1545311*	*0.1948753*
$logHPE_{JPN}$		0.2843066*	0.3099031*	0.3725429**
		0.1684724	*0.1672903*	*0.1812573*
$logHPE_{NLD}$		-0.0356602	-0.05134	0.0379671
		0.0940236	*0.105972*	*0.1641739*
$logHPE_{SVN}$		-2.464301***	(omitted)	(omitted)
		0.5713095		
$logHPE_{SWE}$		-0.4528763	-0.4518113	-0.3650084
		0.3477127	*0.357291*	*0.3648232*

Dependent variable: logTFP				
	(1)	**(2)**	**(3)**	**(4)**
$logHPE_{UK}$		-0.027276	0.0202836	0.0377337
		0.2462488	*0.2493428*	*0.2580072*
$logHPE_{US}$		-1.304767***	-1.482038***	-1.597186***
		0.3728178	*0.3512488*	*0.3491957*
EPL			0.0439711***	0.3353658
			0.014288	*0.3071195*
EPL*logHPE				-0.039143
				0.0419657
Country dummies?	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)
Year dummies?	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)
Joint F-test on country interaction with logHPE		P=.000		
Pseudo R² adj	0.663	0.745	0.759	0.763
df	56	74	73	74
Number of observations	498	498	486	486

Notes:

Dependent variable logTFP (index with value 100 in base year 1995).

Standard errors in gray italics.

***, **, *: significant at the 1%, 5% and 10% level respectively.

logHPE: logarithm of average hours worked per employee.

$logHPE_{ABC}$: interaction between the logarithm of average hours worked per employee and country dummy ABC.

EPL: Employment Protection Legislation, measured by the OECD overall EPL indicator.

Country abbreviations: AUS: Australia, AUT: Austria, BEL: Belgium, CAN: Canada, CZE: Czech Republic, DNK, Denmark, ESP: Spain, FIN: Finland, FRA: France, GER: Germany, HUN: Hungary, IRL: Ireland, ITA: Italy, JPN: Japan, NLD: Netherlands, SVN: Slovenia, SWE: Sweden, UK: United Kingdom, US: United States of America

Slovenia is omitted in models (3) and (4) because of lack of EPL data for this country.

All models include unreported country and time fixed effects.

All models are estimated using a feasible GLS method, correcting for heteroskedasticity across panels and AR1 autocorrelation within panels.

Models (2) till (4) show similar estimates, pointing at the robustness of the model. Model (3) and (4), the models that control for EPL, have a similar pseudo R². The significance of the control variable and of some other logHPE variables however falls away when including the interaction between EPL and logHPE. Accordingly we base the discussion on model (3).

In the Hotels & Restaurants sector **the effects of HPE vary greatly across countries**. The strongest negative effect on TFP would be reached in Finland (-2.56%). The strongest positive effect of an increase of HPE would be attained in Canada and Hungary (2.13% and 2.11% respectively).

There is an overall positive effect of 4% on TFP in case of a one point increase in EPL, *ceteris paribus*.

1.5.3. Financial Intermediaries Sector

For the Financial Intermediaries industry there was evidence of both heteroskedasticity and autocorrelation. This will be taken into account in the GLS estimation. The estimated parameters for the four models are reported in Table 6.

Table 8: Results Financial Intermediaries

Dependent variable: logTFP				
	(1)	**(2)**	**(3)**	**(4)**
Intercept	11.29874	11.46492***	10.62883***	28.48672***
	1.19611	*2.57746*	*2.684878*	*7.32825*
logHPE	-0.8802222***			
	0.1603224			
$logHPE_{AUS}$		1.752363**	1.413409**	0.1162136
		0.6932164	*0.6538327*	*0.6980759*
$logHPE_{AUT}$		-0.8864849**	-0.8805779**	-2.608291***
		0.3984021	*0.4119435*	*0.8067439*
$logHPE_{BEL}$		-3.44972*	-3.337607*	-5.929834***
		1.99541	*2.008942*	*2.095738*
$logHPE_{CAN}$		-0.8983149	-0.8110691	-1.383166*
		0.7454428	*0.7581918*	*0.7866823*
$logHPE_{CZE}$		0.0906131	0.1704802	-1.256561
		0.7096944	*0.6899814*	*0.8833984*
$logHPE_{DNK}$		-4.776015***	-4.804747***	-5.882649***
		0.7643446	*0.7873558*	*1.042726*
$logHP_{ESP}$		-1.675144***	-1.698509***	-4.59279***
		0.6533193	*0.6434412*	*1.326221*
$logHPE_{FIN}$		-0.7746903	-0.7587309	-2.399053**
		0.7316239	*0.7307024*	*0.9924502*
$logHPE_{FRA}$		-0.8939483**	-0.7874089**	-3.20613***
		0.350152	*0.3630332*	*0.9927186*
$logHPE_{GER}$		2.081836**	2.029206**	0.3213032
		0.8212338	*0.8192691*	*1.052181*
$logHPE_{HUN}$		-7.860217***	-7.98764***	-9.936484***
		2.231418	*2.222183*	*2.139004*
$logHPE_{IRL}$		2.791179	2.841426	2.387904
		2.222391	*2.236101*	*2.275129*
$logHPE_{ITA}$		-0.8883801*	-0.9060298*	-3.346747***
		0.5191749	*0.5246774*	*1.117054*
$logHPE_{JPN}$		-2.066555	-2.081432	-3.698034**
		1.319487	*1.31904*	*1.469823*
$logHPE_{NLD}$		0.031811	0.008905	-1.956424**
		0.3064774	*0.3226601*	*0.8328005*
$logHPE_{SVN}$		-2.04649**	(omitted)	(omitted)
		0.9744843		
$logHPE_{SWE}$		-0.6310337	-0.5738056	-2.381922***

Dependent variable: logTFP				
	(1)	(2)	(3)	(4)
		0.4510541	*0.4534436*	*0.8408458*
$logHPE_{UK}$		-0.9805454*	-0.9760967*	-1.444112***
		0.5397268	*0.5193229*	*0.5599101*
$logHPE_{US}$		-3.792764**	-3.900152**	-3.877311**
		1.692109	*1.68013*	*1.681241*
EPL			0.0187479	-5.599509**
			0.0246257	*2.265062*
EPL*logHPE				0.7608083**
				0.3069733
Country dummies?	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)
Year dummies?	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)
Joint F-test on country interaction with logHPE		P=.000		
Pseudo R^2adj	0.347	0.440	0.436	0.437
df	56	74	73	74
Number of observations	498	498	486	486

Notes:

Dependent variable logTFP (index with value 100 in base year 1995).

Standard errors in gray italics.

***, **, *: significant at the 1%, 5% and 10% level respectively.

logHPE: logarithm of average hours worked per employee.

$logHPE_{ABC}$: interaction between the logarithm of average hours worked per employee and country dummy ABC.

EPL: Employment Protection Legislation, measured by the OECD overall EPL indicator.

Country abbreviations: AUS: Australia, AUT: Austria, BEL: Belgium, CAN: Canada, CZE: Czech Republic, DNK, Denmark, ESP: Spain, FIN: Finland, FRA: France, GER: Germany, HUN: Hungary, IRL: Ireland, ITA: Italy, JPN: Japan, NLD: Netherlands, SVN: Slovenia, SWE: Sweden, UK: United Kingdom, US: United States of America

Slovenia is omitted in models (3) and (4) because of lack of EPL data for this country.

All models include unreported country and time fixed effects.

All models are estimated using a feasible GLS method, correcting for heteroskedasticity across panels and AR1 autocorrelation within panels.

Based on the pseudo R^2 adjusted and the large number of significant estimates, along with the inclusion of EPL as control variable, model (4) is selected to interpret the effects of HPE on TFP.

As explained before, in order to look at the effect of HPE on TFP in model (4), the estimates of all country specific logHPE parameters need to be combined with the estimate of the EPL*logHPE parameter using a fixed EPL. Using per country the average EPL across time, the final country effects of HPE on TFP are calculated in Table 7.

Table 9: Impact (%) on TFP of one percent increase in HPE, ceteris paribus

Country	%
Australia	0.89
Austria	-0.95***
Belgium	-3.75***
Canada	-0.81*
Czech Republic	0.20
Denmark	-4.29***
Spain	-1.92***
Finland	-0.71**
France	-1.01***
Germany	2.52
Hungary	-8.94***
Ireland	3.11
Italy	-0.93***
Japan	-2.38**
Netherlands	0.01**
Slovenia	-
Sweden	-0.08***
United Kingdom	-0.97***
US	-3.72**

*(The significance level of .01, .05 and .10 (***, **, and * respectively) is the significance level of the country specific effect.)*

Aside from the positive effect in the Netherlands (.01%), there is **a general negative effect of HPE on TFP**, with Hungary having the strongest effect of -8.94%, followed by Denmark and Belgium (-4.29% and -3.75% respectively).

Also the effect of EPL has to be constructed by combining the stand alone variable with the interaction variable. This has been calculated and reported in the Annex.

1.5.4. Post & Telecommunications Sector

Concerning heteroskedasticity and autocorrelation the tests showed evidence of autocorrelation but no heteroskedasticity. This will be taken into account in the GLS estimation. The estimated parameters for the four models are reported in Table 12.

Table 10: Results Post & Telecommunications

Dependent variable: logTFP				
	(1)	**(2)**	**(3)**	**(4)**
Intercept	6.731228***	32.47519***	30.75984***	36.36855***
	1.131567	*2.607621*	*2.818997*	*5.373377*
logHPE	-0.3634894**			
	0.1555989			
$logHPE_{AUS}$		-0.1836844	-0.2214606	-0.4793023
		0.6612129	*0.6498778*	*0.6860008*
$logHPE_{AUT}$		-0.4108358	-0.3952628	-0.824123
		0.9414526	*0.9366494*	*1.020112*
$logHPE_{BEL}$		1.289319	1.11088	0.3407664
		1.713809	*1.704933*	*1.79166*
$logHPE_{CAN}$		-0.3807836	-0.410086	-0.6137821

Dependent variable: logTFP				
	(1)	**(2)**	**(3)**	**(4)**
		1.092409	*1.083119*	*1.093705*
$logHPE_{CZE}$		0.9184046	1.067507	0.5717201
		1.053839	*1.045706*	*1.114402*
$logHPE_{DNK}$		-0.3127273	-0.4201428	-0.9020347
		0.4068018	*0.4169946*	*0.5726514*
$logHP_{ESP}$		1.371581***	1.299881***	0.2857339
		0.507715	*0.5050453*	*0.9098402*
$logHPE_{FIN}$		2.87496***	2.833664***	2.19267***
		0.6309543	*0.6229779*	*0.7652595*
$logHPE_{FRA}$		-3.918704***	-3.694554***	-4.45312***
		0.3595243	*0.3849516*	*0.7297415*
$logHPE_{GER}$		-1.326721***	-1.39386***	-1.59081***
		0.5011576	*0.4673119*	*0.3434156*
$logHPE_{HUN}$		-0.4286145	-0.5514396	-0.6552631
		2.18149	*2.174968*	*2.155522*
$logHPE_{IRL}$		1.320493***	1.306388***	1.059059**
		0.4255869	*0.4214716*	*0.4583223*
$logHPE_{ITA}$		-0.444741	-0.4834761	-1.167476*
		0.4490134	*0.4352749*	*0.7055088*
$logHPE_{JPN}$		-1.280063	-1.221943	-1.596303*
		0.8688207	*0.8591338*	*0.9047675*
$logHPE_{NLD}$		-0.5237992	-0.4959796	-1.199107
		0.657323	*0.654576*	*0.8658604*
$logHPE_{SVN}$		59.87538***	(omitted)	(omitted)
		9.983783		
$logHPE_{SWE}$		0.5036876	0.6732318	0.1481508
		0.6400487	*0.6324418*	*0.7888246*
$logHPE_{UK}$		-1.296264	-1.224054	-1.401675*
		0.814845	*0.8068395*	*0.8132133*
$logHPE_{US}$		2.170883**	2.243642**	2.149073**
		1.061347	*1.049561*	*1.047877*
EPL			0.0296146	-1.726974
			0.0278552	*1.416569*
EPL*logHPE				0.2374691
				0.1917065
Country dummies?	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)
Year dummies?	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)
Joint F-test on country interaction with logHPE		P=.000		
Pseudo R^2adj	-0.124	0.775	0.774	0.778
df	56	74	73	74

Dependent variable: logTFP				
	(1)	**(2)**	**(3)**	**(4)**
Number of observations	498	498	486	486

Notes:

Dependent variable logTFP (index with value 100 in base year 1995).

Standard errors in gray italics.

***, **, *: significant at the 1%, 5% and 10% level respectively.

logHPE: logarithm of average hours worked per employee.

$logHPE_{ABC}$: interaction between the logarithm of average hours worked per employee and country dummy ABC.

EPL: Employment Protection Legislation, measured by the OECD overall EPL indicator.

Country abbreviations: AUS: Australia, AUT: Austria, BEL: Belgium, CAN: Canada, CZE: Czech Republic, DNK, Denmark, ESP: Spain, FIN: Finland, FRA: France, GER: Germany, HUN: Hungary, IRL: Ireland, ITA: Italy, JPN: Japan, NLD: Netherlands, SVN: Slovenia, SWE: Sweden, UK: United Kingdom, US: United States of America

Slovenia is omitted in models (3) and (4) because of lack of EPL data for this country.

All models include unreported country and time fixed effects.

All models are estimated using a feasible GLS method, correcting for AR1 autocorrelation within panels.

Concerning the Post & Telecommunications sector the "late" liberalisation of the sector might have an influence on the dynamics between HPE, EPL, and TFP, since the behaviour is assumed to deviate from market industries. Also, the two sub-industries, post and telecommunications, are in se very different industries: post is a labour-intensive service while telecommunications is a capital-intensive service. The weight of these two industries in the aggregated industry might vary greatly across countries, as can also be the case with liberalisation timing.

The control variable EPL does not show any significant impact and the pseudo R^2 is similar in models (2), (3) and (4). Model (2) is selected for interpretation.

Slovenia is an outlier in this model. Regressing the same model without Slovenia (not reported) showed similar estimators and pseudo R^2 adjusted.

For the Post & Telecommunications sector, **the effect of HPE is not consistent across countries**, which might be explained by the issues of different liberalisation timing or different weighting of post and telecommunication sub-sectors. 12 countries out of our 18 country sample do not show a significant relationship between HPE and productivity**. In Spain, Finland, Ireland and the US an increase of HPE would result in a higher productivity, where in France and Germany this would result in a lower productivity.**

1.5.5. Electricity, Gas & Water Supply Sector

Concerning heteroskedasticity and autocorrelation in this industry, both tests were positive. This will be taken into account in the GLS estimation. The estimated parameters for the five models (R&D Intensity is included as control variable for this sector) are reported in Table 13.

Table 11: Results Electricity, Gas & Water Supply

Dependent variable: logTFP					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Intercept	6.973818***	18.50186***	18.70415***	-0.9029061	(omitted)
	0.9838602	*3.128354*	*3.15426*	*7.328204*	
logHPE	-0.340505***				
	0.1310579				
$logHPE_{AUS}$		0.1951532	0.3012226	1.2974***	1.065945**

Dependent variable: logTFP					
	(1)	(2)	(3)	(4)	(5)
		0.3002156	*0.2993044*	*0.4380842*	*0.5279491*
$logHPE_{AUT}$		-3.6456***	-3.591105***	-1.639657**	0.4595509***
		0.5142355	*0.5182714*	*0.8355627*	*0.0224824*
$logHPE_{BEL}$		-0.7030383	-0.7153907	2.055532*	(omitted)
		0.7435781	*0.7414196*	*1.163898*	
$logHPE_{CAN}$		-0.548985	-0.5330574	0.1671376	2.055645
		0.545832	*0.5242697*	*0.5680104*	*1.423653*
$logHPE_{CZE}$		0.9663268	0.9143722	2.595577	0.4383469
		1.645713	*1.644787*	*1.770776*	*1.90143*
$logHPE_{DNK}$		2.5358***	2.821783***	4.979643***	5.305448***
		0.9195065	*0.9128987*	*1.061943*	*1.124658*
$logHP_{ESP}$		-0.6422585**	-0.5851475**	2.211629**	-0.0313079
		0.2542592	*0.2514807*	*1.046338*	*0.3651833*
$logHPE_{FIN}$		-0.4324972	-0.4902816	1.510376*	(omitted)
		0.6334999	*0.6315341*	*0.9146507*	
$logHPE_{FRA}$		-1.905598***	-1.928508***	0.7170754	(omitted)
		0.4257309	*0.4282993*	*0.9888928*	
$logHPE_{GER}$		-1.338798**	-1.129612*	0.5544323	-1.162172**
		0.5457436	*0.5992669*	*0.8195849*	*0.5430239*
$logHPE_{HUN}$		0.2899124	0.0652981	1.361417	2.922745***
		0.8074733	*0.7240289*	*0.8457419*	*0.5311753*
$logHPE_{IRL}$		0.6693963	0.4405948	1.375363	20.86157***
		2.861789	*2.857966*	*2.892152*	*3.142119*
$logHPE_{ITA}$		-0.6659873	-0.7496262	1.479872	1.593928**
		0.6829934	*0.7662932*	*1.06812*	*0.8030185*
$logHPE_{JPN}$		-0.7960053	-0.7559354	1.039416	0.6400757
		0.6797453	*0.6876547*	*0.9063733*	*0.5086625*
$logHPE_{NLD}$		0.3283605	0.2852261	2.673016**	0.7943726
		0.9032762	*0.9329722*	*1.230505*	*1.422411*
$logHPE_{SVN}$		8.09342**	(omitted)	(omitted)	(omitted)
		4.032683			
$logHPE_{SWE}$		0.3370125	0.488411	2.283315**	(omitted)
		0.8142304	*0.8206353*	*1.042774*	
$logHPE_{UK}$		-1.110897*	-1.151357*	-0.6124436	(omitted)
		0.5994951	*0.6175006*	*0.6446764*	
$logHPE_{US}$		1.181673	1.264286	1.559391	0.3124638***
		1.108306	*1.093525*	*1.096641*	*0.0272426*
EPL			-0.0090459	6.672741***	(omitted)
			0.0217525	*2.213972*	

Dependent variable: logTFP					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
EPL*logHPE				-0.901789***	-0.016390***
				0.2983965	*0.0023032*
logR&D					0.1077118***
					0.0103861
Country dummies?	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)
Year dummies?	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)	Yes (P=.000)
Joint F-test on country interaction with logHPE		P=.000			
Pseudo R²adj	0.039	0.474	-0.173	0.290	0.484
df	56		73	74	45
Number of observations	498		486	486	203

Notes:

Dependent variable logTFP (index with value 100 in base year 1995).

Standard errors in gray italics.

***, **, *: significant at the 1%, 5% and 10% level respectively.

logHPE: logarithm of average hours worked per employee.

$logHPE_{ABC}$: interaction between the logarithm of average hours worked per employee and country dummy ABC.

EPL: Employment Protection Legislation, measured by the OECD overall EPL indicator.

Country abbreviations: AUS: Australia, AUT: Austria, BEL: Belgium, CAN: Canada, CZE: Czech Republic, DNK, Denmark, ESP: Spain, FIN: Finland, FRA: France, GER: Germany, HUN: Hungary, IRL: Ireland, ITA: Italy, JPN: Japan, NLD: Netherlands, SVN: Slovenia, SWE: Sweden, UK: United Kingdom, US: United States of America

Slovenia is omitted in models (3) and (4) because of lack of EPL data for this country.

All models include unreported country and time fixed effects.

All models are estimated using a feasible GLS method, correcting for heteroskedasticity across panels and AR1 autocorrelation within panels.

Looking at the volatility of the estimated parameters across the models, we can conclude that models (4) and (5) are not robust anymore. In model (5), where R&D intensity is introduced as control panel, five countries are omitted from the model because of collinearity (this is without Slovenia which is omitted when EPL is included because of lack of EPL data for Slovenia), Ireland behaves as an outlier, and EPL is omitted because of collinearity.

Considering model (2) and (3), with stable country parameters for logHPE, the inclusion of the EPL variable in model (3) does not improve the model.[7] Accordingly we discuss the results of model (2).

In model (2), Slovenia shows again (as in Post & Telecommunications) an extreme effect of HPE on TFP. Rerunning the regression without Slovenia (unreported) yields similar results.
Apart from Denmark which shows a relatively high positive effect on TFP in case of an HPE increase (2.5%), the other countries with a significant effect on TFP would react negatively. These countries are Austria, Spain, France, Germany and the UK. The other countries do not show a significant productivity effect of a change in HPE.

[7] This is the same situation as in the previous sector, Post & Telecommunications, another sector of late liberalisation.

1.5.6. Construction Sector

The tests on heteroskedasticity and autocorrelation show evidence of autocorrelation, but not of heteroskedasticity. This will be taken into account in the GLS estimation. The estimated parameters for the five models (R&D Intensity is included as control variable for this sector) are reported in Table 14.

Table 12: Results Construction

Dependent variable: logTFP					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Intercept	7.781798***	8.455765***	8.891001***	14.6922***	10.8021
	0.7058594	*3.03378*	*3.023577*	*4.476402*	*9.662379*
logHPE	-0.4311239***				
	0.0932447				
$logHPE_{AUS}$		-0.8693206	-0.7366784	-1.047692	-0.8571852
		0.6597045	*0.6628302*	*0.6980885*	*0.9117428*
$logHPE_{AUT}$		-1.341967***	-1.259593***	-1.846448***	-2.002251**
		0.4411827	*0.4455138*	*0.5795851*	*0.8340391*
$logHPE_{BEL}$		0.0514017	0.05255	-0.8270124	(omitted)
		0.2961934	*0.2994747*	*0.6081156*	
$logHPE_{CAN}$		-1.528224**	-1.529846**	-1.759293***	-0.3750556
		0.655566	*0.66488*	*0.6808152*	*0.9793846*
$logHPE_{CZE}$		-0.648436	-0.6448748	-1.197578*	-1.096844
		0.6255925	*0.627402*	*0.7096423*	*0.8297197*
$logHPE_{DNK}$		-0.7132704**	-0.7143736**	-1.245054**	-1.021785*
		0.3462261	*0.3421613*	*0.4943308*	*0.588313*
$logHP_{ESP}$		-1.623592***	-1.64789***	-2.691616***	-2.097901*
		0.4942089	*0.4961335*	*0.775271*	*1.133281*
$logHPE_{FIN}$		-0.6950061	-0.752556	-1.417444**	(omitted)
		0.45921	*0.4594489*	*0.6106295*	
$logHPE_{FRA}$		-0.5227535	-0.5801354	-1.36423**	(omitted)
		0.4041108	*0.4010832*	*0.6003634*	
$logHPE_{GER}$		0.346388	0.3003556	-0.4181773	-1.008556
		0.6047219	*0.5857481*	*0.7441227*	*0.7888639*
$logHPE_{HUN}$		0.1138248	0.2719467	0.1392478	0.1663293
		0.9401781	*0.9431151*	*0.9474583*	*1.047121*
$logHPE_{IRL}$		-0.1767925	-0.1322298	-0.3821251	-0.2941782
		0.3431936	*0.3462346*	*0.3792184*	*0.3952653*
$logHPE_{ITA}$		-0.60898	-0.5135221	-1.344491*	-1.854968*
		0.5225049	*0.5388698*	*0.7433147*	*0.9923712*
$logHPE_{JPN}$		1.157903***	1.079796***	0.5461075	0.2991537
		0.4088977	*0.3970366*	*0.5296493*	*0.7748976*
$logHPE_{NLD}$		-0.4021082**	-0.3964535**	-1.154367**	-1.086147

Dependent variable: logTFP					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
		0.1736208	*0.1763525*	*0.4992699*	*0.7260786*
$logHPE_{SVN}$		-0.3327626	(omitted)	(omitted)	(omitted)
		0.7164808			
$logHPE_{SWE}$		-0.2677722	-0.2419004	-0.9681493	(omitted)
		0.4850556	*0.5167245*	*0.6069093*	
$logHPE_{UK}$		-0.4672959	-0.5964104	-0.7828839*	(omitted)
		0.4147544	*0.4108343*	*0.4213092*	
$logHPE_{US}$		-1.889241*	-1.891201*	-2.055562**	-0.8139852
		0.9763299	*0.9819496*	*0.9802083*	*1.267789*
EPL			0.0057193	-2.047137	-2.110424
			0.0173841	*1.271898*	*1.757984*
EPL*logHPE				0.2773141	0.2880718
				0.1717758	*0.2377353*
logR&D					0.0004029
					0.0079196
Country dummies?	Yes (P= .000)	Yes (P= .0877)	Yes (P= .0042)	Yes (P= .0006)	No (P= .1702)
Year dummies?	Yes (P= .000)	Yes (P= .0226)	Yes (P= .0027)	Yes (P= .0010)	Yes (P= .0687)
Joint F-test on country interaction with logHPE		P= 0.0101			
Pseudo R²adj	0.174	0.497	0.498	0.511	0.577
Df	56	74	73	74	48
Number of observations	498	498	486	486	197

Notes:

Dependent variable logTFP (index with value 100 in base year 1995).

Standard errors in gray italics.

***, **, *: significant at the 1%, 5% and 10% level respectively.

logHPE: logarithm of average hours worked per employee.

$logHPE_{ABC}$: interaction between the logarithm of average hours worked per employee and country dummy ABC.

EPL: Employment Protection Legislation, measured by the OECD overall EPL indicator.

Country abbreviations: AUS: Australia, AUT: Austria, BEL: Belgium, CAN: Canada, CZE: Czech Republic, DNK, Denmark, ESP: Spain, FIN: Finland, FRA: France, GER: Germany, HUN: Hungary, IRL: Ireland, ITA: Italy, JPN: Japan, NLD: Netherlands, SVN: Slovenia, SWE: Sweden, UK: United Kingdom, US: United States of America

Slovenia is omitted in models (3) and (4) because of lack of EPL data for this country.

All models include unreported country and time fixed effects.

All models are estimated using a feasible GLS method, correcting for AR1 autocorrelation within panels.

As in the previous industry, model (4) and (5) are not robust anymore. The inclusion of R&D intensity is here also not an added value. Model (2) and (3) are very similar and could both be used. Although the inclusion of EPL does not result in a significant parameter, it is believed this variable might take away some omitted variable bias. Accordingly we prefer model (3) slightly over model (2).

Except for Japan where HPE has a positive effect on TFP in the Construction industry, the significant effects found in other countries are all negative. There is a negative effect of HPE on TFP in Austria, Canada, Denmark, Spain, Netherlands and the US.

1.6. CONCLUSIONS

The study examined the impact of changes in Working Time on a country's productivity. This examination was conducted in six industries which are believed to be most susceptible to productivity impact, namely Construction, Hotels & Restaurants, Financial Intermediation, Textiles, Post & Telecommunications, and Electricity, Gas & Water Supply.

Measuring the possible impact of the WTD is approached by measuring the impact on productivity of the average number of hours an employee works in a year. This number is believed to be directly influenced by the WTD in those Member States where the Directive imposes a more restrictive regime than before. The productivity of a specific sector in a country is measured by Total Factor Productivity. The required data for this study comes from the EU KLEMS database and the following 19 countries are included in the study:

Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Netherlands, Slovenia, Spain, Sweden and UK as EU countries, and Australia, Canada, Japan and US as non-EU countries.

Table 15 presents an overview of the country-specific impact on productivity of the hours worked per employee, per investigated sector. Only the significant effects are displayed.

In **Textiles** and in **Financial Intermediation**, there is a general positive impact of decreased yearly working hours on productivity. If one assumes the Directive would decrease the average yearly working hours per employee, this would imply **a general positive effect of the WTD on productivity** in these two sectors. There are **however differences in the country-specific impacts** when comparing these two sectors. For instance in Hungary, Spain and the US, the WTD might be presumed to have had a high impact in the Financial Intermediaries industry, but no impact in Textiles. (These are also the only two sectors where a country-specific significant effect of the control variable EPL was found.)

The **Hotels & Restaurant** industry show very scattered results from +2.57 to -2.07, meaning that decreasing the number of hours worked per year by one percent would result in a productivity change ranging from a increase of 2.57% to an decrease of 2.07%. Nine of the 19 countries display no effect. We can conclude that there is **no clear impact in this industry**.

For the **Post & Telecommunications** and **Electricity, Gas & Water Supply** industries**, a significant impact** on productivity of decreasing yearly hours worked per employee was found in only six (Post & Telecommunications) and seven (Electricity, Gas & Water Supply) of the 19 countries. The six, respectively seven, countries are: Spain, Finland, France, Germany, Ireland, and US for Post & Telecommunications, and Austria, Denmark, Spain, France, Germany, Slovenia, and United Kingdom for Electricity, Gas & Water Supplies. Not only are these small portions of the sample investigated, but there is also **no clear line in the effects**. In Post & Telecommunications, the 6 significant effects range from +3.92 to -2.87. In Electricity, Gas & Water Supply 5 countries (out of the 7) showed a positive effect, while in Denmark and Slovenia a negative effect was found. France, Germany and Spain showed a significant effect in both industries. Note that Spain showed however both a negative and a positive effect on productivity of decreasing average working hours, while the other two countries showed consistently a positive effect over the two sectors.

In **Construction** also, **only seven countries showed a significant impact** of decreasing hours worked on TFP, namely Belgium, Canada, Denmark, Spain, Japan, Netherlands, and US. Six countries displayed a increase in productivity when HPE was decreased. Japan was the only country where a negative effect of decreasing hours worked on TFP was identified.

If one compares the country effects over the industries, there is no pattern that can be distinguished. A country may display a strong impact of a change in yearly hours worked per employee in one industry, while remaining stable in another industry with the same change in hours per employee.

The table below shows the percentage change in productivity, given a 1% decrease in HPE. For the Textiles and Financial Intermediaries sectors these are effects, calculated from both a standalone variable and an interaction variable on HPE. For the other sectors, only the HPE variable on itself is represented (because this was the selected model for these industries).

The table shows the percentage change in productivity, given a 1% decrease in HPE.

Table 13 Overview of significant country impacts on productivity from decreasing average yearly hours worked per employee (HPE) (%)

The table shows the percentage change in productivity for each 1% decrease in HPE. (***, **, *: significant at the 1%, 5% and 10% level respectively)

	Textiles	Hotels & Restaurants	Financial Intermediation	Post & Telecommunications	Electricity, Gas & Water Supplies	Construction
Australia	2.59***	1.00**				
Austria	1.39***	0.77***	0.95***		3.65***	1.26***
Belgium	0.91***	0.39**	3.75***			
Canada	1.16***	-2.07***	0.81*			1.53**
Czech Republic						
Denmark	0.34***	0.97*	4.29***		-2.54***	0.71**
Finland	0.38***	2.57***	0.71**	-2.87***		
France	0.65***	-0.99***	1.01***	3.92***	1.91***	
Germany	0.15***			1.33***	1.34**	
Hungary		-2.03***	8.94***			
Ireland	1.07***			-1.32***		
Italy	-0.39***		0.93***			
Japan	-0.52**	-0.31*	2.38**			-1.08***
Netherlands	0.66***		-0.01**			0.40**
Slovenia	-		-		-8.09**	
Spain			1.92***	-1.37***	0.64**	1.65***
Sweden	-0.53***		0.08***			
United Kingdom	1.91***		0.97***		1.11*	
US		1.48***	3.72**	-2.17**		1.89*

Source: Deloitte calculation

ANNEX 3:

STUDY ON THE IMPACT OF BUSINESS: SURVEY ANALYSIS

Study on the impact of business: survey analysis

1 Introduction

This report provides the results of Deloitte's analysis of two surveys performed by the Commission to consult EU businesses on their views on the current impact of the WTD and possible courses of action on working time regulation at European level in the context of the impact assessment of further action at EU level on the working time directive:

- the Listen SME Working Time Directive survey (LSME survey);
- the European Business Test Panel Review of EU minimum rules on organization of working time (EBTP survey).

The analysis is an annex to "Study to support an Impact Assessment on further action at European level regarding Directive 2003/88/EC and the evolution of working time organisation" and highlights the salient results of the surveys with some cross-analysis provided where most relevant. It is structured according to 4 key themes corresponding to 4 key issues linked to the WTD which are detailed in the section below.

2 Survey questions, participants and respondents

2.1 Survey Questions

The questions in both surveys were almost identical and aimed at gaining insights into businesses' views on possible courses of action on working time regulation at European level, focussing mainly on four key issues linked to WTD:

- the measurement of weekly working time;
- the treatment of on-call time;
- average working hours;
- minimum rest periods.

Given the minimal differences between the survey questions (highlighted in Table 1 below), the results of our analyses are presented together, allowing for easier comparison and cross-analysis.

Nonetheless, while the analyses, and particularly the cross-analysis between these, allow us to gain certain insights into businesses' views on possible courses of action on working time regulation at European level, limitations on the statistical robustness of certain statements made below should be borne in mind due to the different number of participants and sizes of sub-groups, the different data collection methods applied across the two surveys (e.g. ability to respond with several answers to certain questions in the EBTP survey vs. a singly answer in the LSME survey), and the fact that not all respondents answered all questions (e.g. certain questions in the surveys were to be skipped based on the answer to previous questions).

Table 2: Comparison of EBTP and LSME survey questions

LSME		EBTP	
Meta Informations Identification of the Enterprise Europe Network partner A. PROFILE OF YOUR COMPANY	1.1 In which country is your company based?	BACKGROUND	Country
	1.3 How many workers does your company employ?		Number of employees in your company
	1.2 In which sector does your company operate?		Indicate your main sector of activity
			Apart from your country, in how many countries of the European Union do you regularly sell products and services?
			0. Would you like to participate in this consultation?
		A. PROFILE OF YOUR COMPANY	1. Is the organisation of working time in your company decided partly or wholly by collective bargaining?
B. Measuring weekly working time	2. Does your company keep records of workers' weekly working time (excluding senior managers)?	B. MEASURING WEEKLY WORKING TIME	2. Does your company keep records of average weekly working time, for some or all workers (excluding senior managers)?
	3. Over what period does your company calculate workers' average weekly working time?		3. Over what period does your company calculate those workers' average weekly working time?
	4. Is your business subject to strong fluctuations in its activity during the year?		4. Is your business subject to strong fluctuations in its activity during the year?
	(included above)		4.1. What type of strong fluctuations is your business subject to in its activity during the year?
	5. Does your company face significant difficulties in recruiting temporary staff to cover a period when demand is at a peak?		5. Does your company face difficulties in recruiting temporary staff to cover a period when demand is at a peak?
	6. Suppose that the rules were changed, so that any company had the option of calculating average working time over up to 12 months. How would this affect your company?		6. Suppose that the rules were changed, so that any company had the option of calculating average working time over up to 12 months. How would this affect your company? (Please select all that apply)
C. Treatment of 'on-call' time	7. In your company, do any of the workers undertake periods of 'on-call time'?	C. TREATMENT OF "ON-CALL" TIME	7. In your company, do any of the workers undertake periods of 'on-call time'?
			7.1. Where do the workers of your company undertake periods of 'on-call time'?
	8. Which of the following best describes the level of attention required during on-call at the workplace in your company?		8. Which of the following best describes the level of attention required during on-call time at the workplace in your company?
	9. If all on-call time at the workplace had to be fully counted as working time (counted towards the 48-hour limit), how would this affect your company? 		9. If all on-call time at the workplace had to be fully counted as working time (counted towards the 48-hour limit), how would this affect your company? (Please select all that apply)
D. Average working hours	10. Do any workers in your company (excluding senior management) work more than 40 hours per week on average ('overtime work')? Please include in 'overtime work' any on-call time at the workplace.	D. AVERAGE WORKING HOURS	10. Do any workers in your company (excluding senior management) work more than 40 hours per week on average ('overtime work')? Please include in 'overtime work' any on-call time at the workplace.
	10. a) How many workers in your company normally work more than 40 hours per week on average?		
	12. How is overtime (including on-call at the workplace) compensated in your company?		11. How is overtime (including on-call time at the workplace) compensated in your company? (Please select all that apply)
	11. Taking the workers who work the longest hours, what is their average weekly working time, including overtime and on-call time at the workplace? 		12. Taking the workers who work the longest hours, what is their average weekly working time, including overtime and on-call time at the workplace?
	13. Where some workers are working longer than 48 hours per week on average, please explain why?		13. Where some workers are working longer than 48 hours per week on average, please explain why? (Please select all that apply)
	14. Does your company ask workers to give an individual written consent (agreement to 'opt-out') before they can work more than 48 hours per week?		14. Does your company ask workers to give an individual written consent (agreement to 'opt-out') before they can work more than 48 hours per week?
	15. How many workers in your company have given such an agreement?		15. How many workers in your company have given such an agreement?
	16. In your company, do any of the following conditions apply, if a worker gives such an agreement? 		16. In your company, do any of the following conditions apply, if a worker gives such an agreement? (Please select all that apply)
	17. If the rules were changed so that workers could not agree to work longer average hours than the 48 hour limit; which reply best matches the likely effect on your company?		17. If the rules were changed so that workers could not agree to work longer average hours than the 48 hour limit; which reply best matches the likely effect on your company?
F. Minimum rest periods	18. In your company, can workers (other than senior management) always take their daily and weekly minimum rest when it is due, or is there sometimes a need to delay minimum rest hours for any workers?	E. MINIMUM REST PERIODS	18. In your company, can workers (other than senior management) always take their daily and weekly minimum rest when it is due?
			18.1. How often is there a need to delay minimum rest hours for any workers? (Please select all that apply)
	19. What is the main reason your company sometimes needs to delay minimum rests?		19. What is the main reason your company sometimes needs to delay minimum rests?
G. Other working time rules	20. Has any of the following EU working time rules had an important impact on your company? If so, please indicate which one(s).	F. OTHER WORKING TIME RULES	20. Has any of the following EU working time rules had an important impact on your company? If so, please indicate which one(s). (You can explain more about this impact, if you wish, in your answer to question 21.)

2.2 Participants & Respondents

The LSME survey on the Working time directive was performed from 18.06.2010 – 06.09.2010. A total of 1581 respondents answered, all of whom were willing to answer the detailed survey questions. Companies from Germany and Poland were well represented, with Austria equally strongly accounted for, while France was underrepresented. It is worth noting that countries with and without the opt-out system were represented in both surveys. SME's formed the largest part of the surveyed population (1335) although 246 large enterprises were also questioned. Furthermore, the highest number of respondents were from the manufacturing (30.2%), wholesale & retail trade (12.8%), and construction (9.4%) sectors.

The EBTP (European business test panel) survey on the Working Time Directive was carried out from 14.07.2010 – 13.08.2010. A total of 531 respondents answered out of the some 3,600 companies of different sizes and sectors located in all EU Member States and EEA countries of which the EBTP is composed (given the lower number of participants compared to the LSME survey, results from the LSME survey should be somewhat more grounded). 493 of the respondents were willing to answer the detailed survey questions with particularly strong representation for Germany, the Czech Republic, Denmark, Poland and Luxembourg, while France was again underrepresented. The bulk of respondents were SME's (409), while only 122 respondents were large enterprises, making it interesting to compare the results of the survey with those of the LSME survey. Furthermore, the highest number of respondents were from the manufacturing (23%), real estate (17.9%), and wholesale & retail trade (13.6%) sectors.

We provide details of the respondents to the two surveys in the tables below:

Table 2: Participation in the LSME survey by country

Country	Participants	(%)
Germany	317	20.1%
Poland	249	15.7%
Austria	152	9.6%
Hungary	112	7.1%
Estonia	107	6.8%
Slovenia	92	5.8%
Italy	83	5.2%
Ireland	63	4.0%
Slovakia	58	3.7%
United Kingdom	58	3.7%
France	54	3.4%
Denmark	50	3.2%
Spain	42	2.7%
Belgium	38	2.4%
Portugal	38	2.4%
Bulgaria	21	1.3%
Lithuania	18	1.1%
Czech Republic	13	0.8%
Sweden	6	0.4%
Greece	4	0.3%

Country	Participants	(%)
Luxembourg	2	0.1%
Romania	2	0.1%
Finland	1	0.1%
Malta	1	0.1%
Cyprus	0	0.0%
Latvia	0	0.0%
Netherlands	0	0.0%
Other	0	0.0%

Source: LSME survey

Table 3: Participation in the EBTP survey by country

Country	Participants	(%)
Germany	96	18.1
Czech Republic	44	8.3
Denmark	40	7.5
Poland	40	7.5
Luxembourg	38	7.2
The Netherlands	27	5.1
United Kingdom	26	4.9
Hungary	21	4.0
Romania	20	3.8
Spain	18	3.4
Finland	18	3.4
Austria	16	3.0
Italy	15	2.8
Belgium	11	2.1
Estonia	11	2.1
Greece	11	2.1
Ireland	11	2.1
France	9	1.7
Portugal	9	1.7
Bulgaria	8	1.5
Latvia	8	1.5
Cyprus	7	1.3
Lithuania	7	1.3
Sweden	6	1.1
Malta	4	0.8
Norway	4	0.8
Slovenia	3	0.6
Island	2	0.4
Slovak Republic	1	0.2

Source: EBTP survey

For the cross-analyses contained within this document, readers should bear in mind all necessary safeguards in terms of the statistical validity of the results given the relatively small number of respondents to the surveys, especially when considering sub-groups.

Furthermore, it is important to state that, as can be seen in the tables above, responses of companies from some countries are very much over-represented and those from other countries very much underrepresented in comparison to what we would expect from the countries' share of the EU GDP or share of number of companies. For this reason, it is difficult to draw representative conclusions at EU level from the analyses.

3 Results

3.1 Measurement of weekly working time

The majority of companies surveyed measure weekly working time, but it is worth noting that this is nonetheless not the case of 49.3% of companies responding to the LSME survey[8], and 35.1% of companies responding to the EBTP survey.

Of those who do calculate weekly working time, most use a reference period of up to 4 months (in both the LSME and EBTP surveys):

3. Over what period does your company calculate workers' average weekly working time?	Responses (%)[8]
Up to 4 months	46.2%
4-6 months	10.0%
6-12 months	23.7%
Longer than 12 months	20.1%

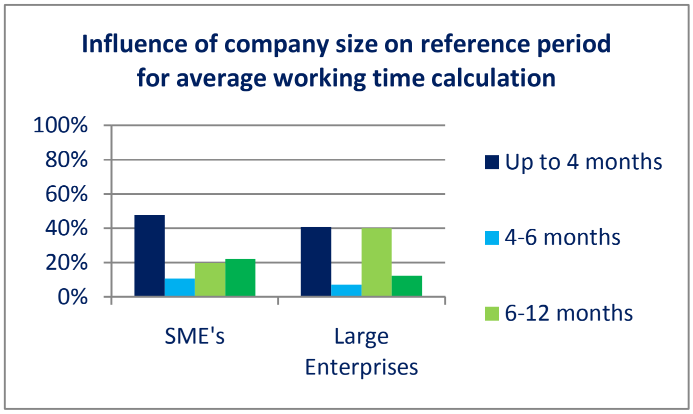
Source: LSME survey

3. Over what period does your company calculate those workers' average weekly working time?	Responses (%)
Up to 4 months	50.6%
4-6 months	11.2%
6-12 months	29.7%
Longer than 12 months	8.4%

Source: EBTP survey

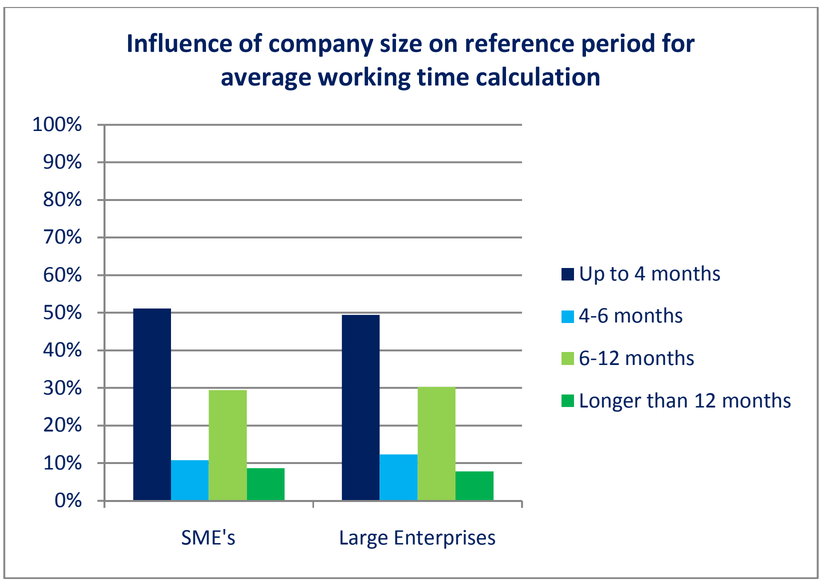
8 Based on companies specifying a period over which working time is measured in the LSME survey

According to the LSME survey a higher proportion of SME's than large enterprises do not track average weekly working time, and a significantly lower proportion use a reference period of 6-12 months for this, where track is kept at all.



Source: LSME survey

This is in contrast to the results of the EBTP survey, in which the reference period for companies measuring average weekly working time is not dependent on their size, with SME's and large enterprises showing similar results:



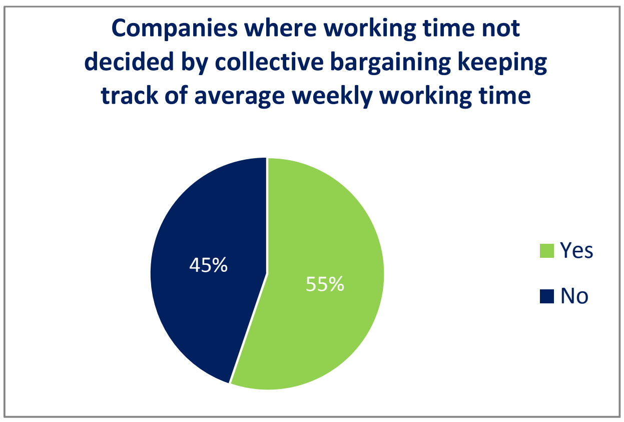
Source: EBTP survey

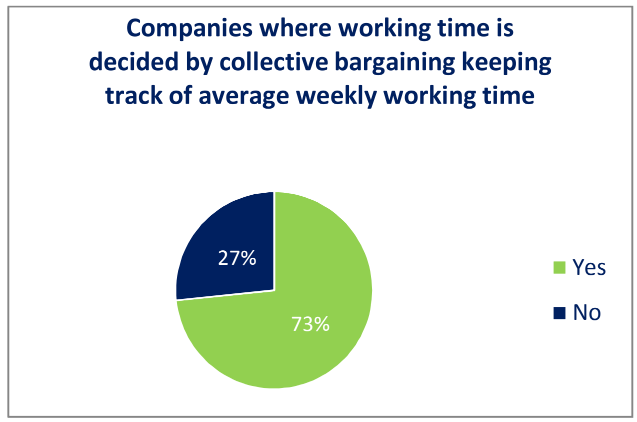
Furthermore, many of the companies that responded to the EBTP survey (46.7%) mentioned that collective bargaining does not define working time in their company, meaning that they could potentially benefit from an adaptation to the working time directive in order to allow the extension of the reference period for measurement of weekly working time to 12 months through national legislation.

1. Is the organisation of working time in your company decided partly or wholly by collective bargaining?	Responses (%)[9]
No, not at all	46.7%
Yes, by collective agreement(s) at national level applying to several sectors	12.8%
Yes, by collective agreement(s) at sectoral level	19.7%
Yes, by collective agreement(s) at the enterprise level	14.4%
Yes, by collective agreement(s) at more than one of these levels	6.5%

Source: EBTP survey

However, among those companies responding that working time is not decided by collective bargaining, 45% do not keep records of working time as opposed to only 27% in companies where working time is decided by collective bargaining:





Source: EBTP survey

A majority of the respondents to the LSME survey (51.4%) mentioned that changing the rules so that any company had the option of calculating average working time over up to 12 months by law would be useful to them10. Given the fact that some companies already use a reference period of 12 months, the overall split of responses in terms of the usefulness of a regulation change to have the option to calculate average working time over up to 12 months can be summarized as follows:

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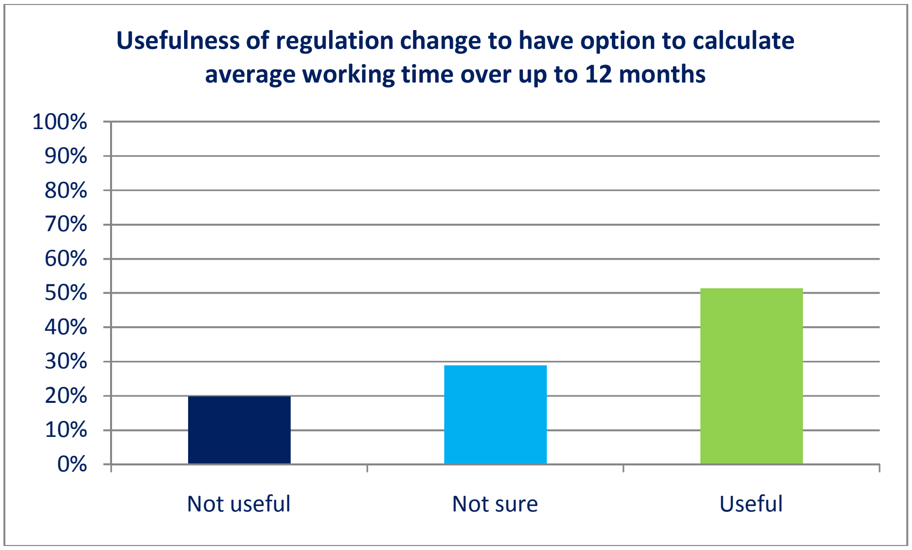
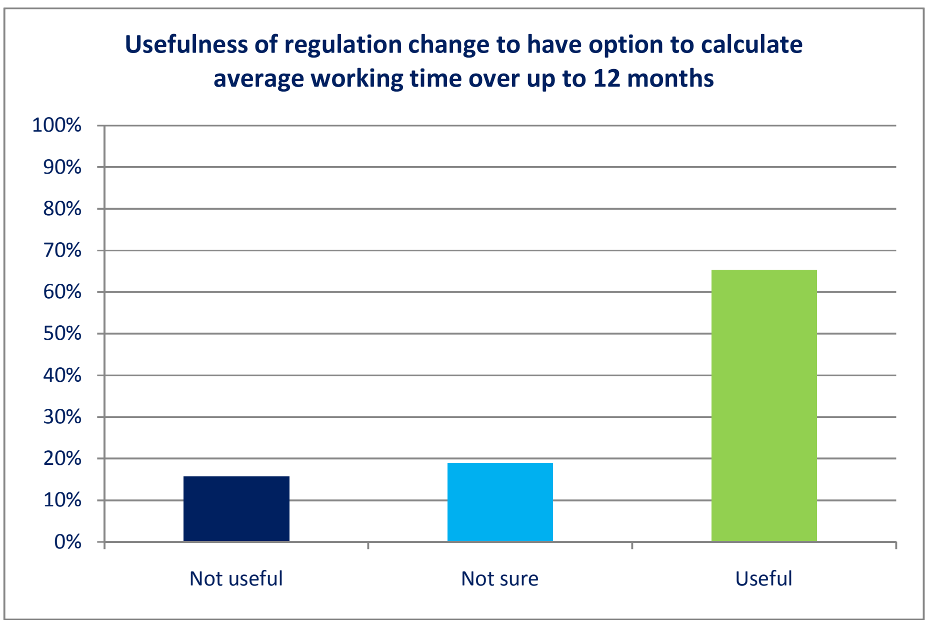
9 Meaning responses to the given question – this is the approach taken in all subsequent mentions

10 Useful includes companies mentioning that they already use a 12 month reference period



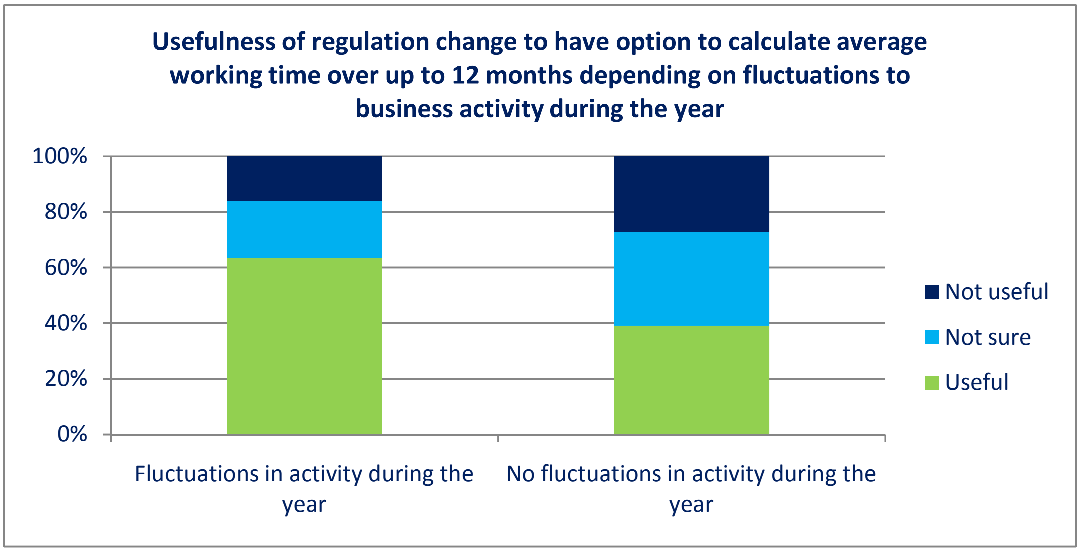
Source: LSME survey

This is confirmed by the EBTP survey in which 65% of respondents responded likewise.



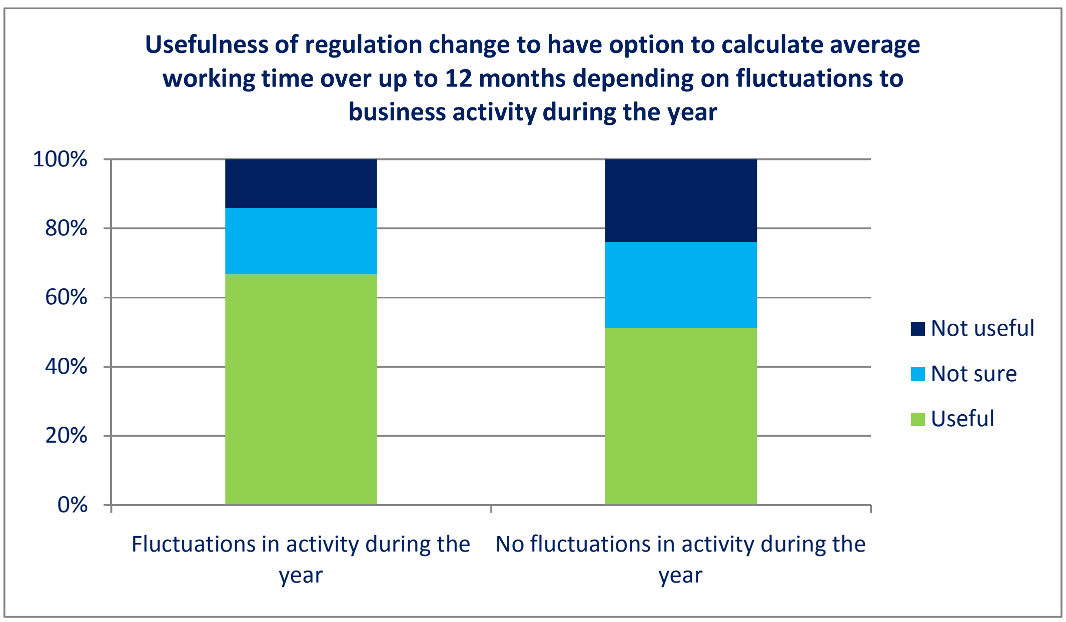
Source: EBTP survey

The proportion of companies finding a change in the regulation useful seems even higher for companies facing fluctuations in activities during the year in the LSME survey:



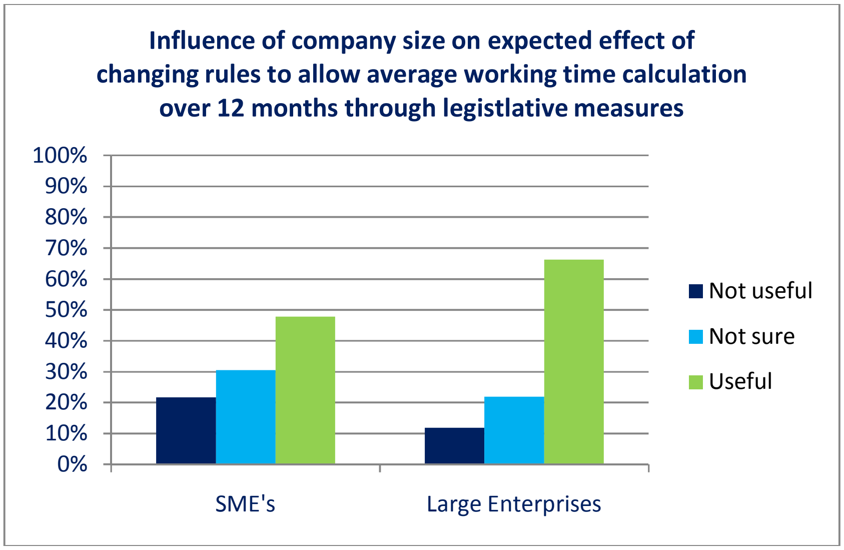
Source: LSME survey

This is again confirmed by the EBTP survey:



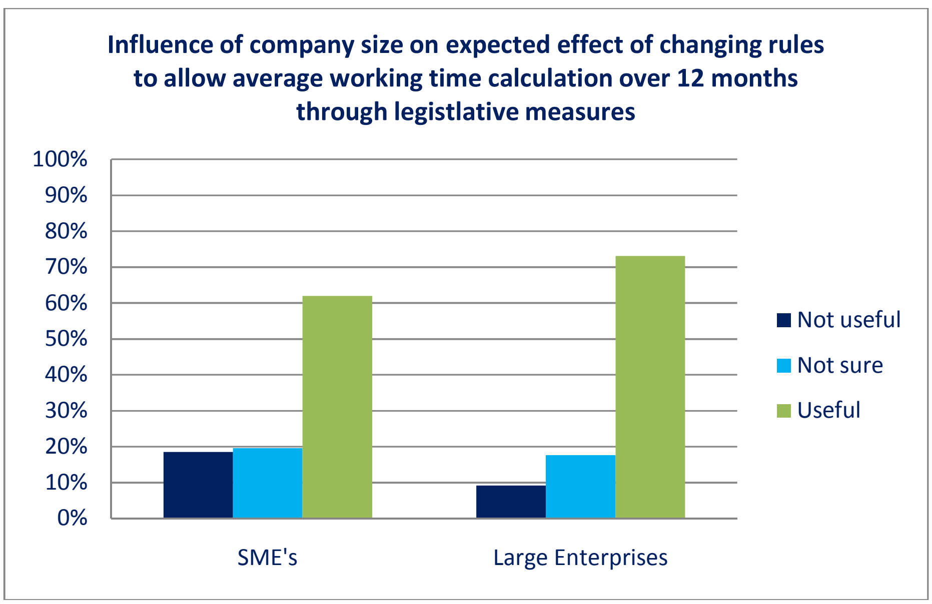
Source: EBTP survey

Furthermore, we note in the LSME survey that SME's were more sceptical than large enterprises on the effects of such a change in regulation:



Source: LSME survey

This is confirmed by the EBTP survey although it shows a higher proportion of SME respondents (also closer to the proportion of large enterprises) expecting that such a change in the rules would be useful compared to the LSME survey.



Source: EBTP survey

3.2 Treatment of "on-call" time

When treating "on-call" time it is first necessary to ensure clarity with some definitions, given that the surveys coupled both real "on-call" time and "stand-by" time under this term:

- "On-call" time is time during which workers must remain at the workplace or a place chosen by the company even though they are not actively working;
- "Stand-by" time is time during which workers can remain at home or at another place of their choice, but must be contactable to work within a defined number of minutes if needed.

32.9% of respondents to the LSME survey had workers undertaking periods of "on-call" time or "stand-by" time, with 3.8% of respondents obliging workers to remain at the workplace or a place chosen by the company.

7. In your company, do any of the workers undertake periods of 'on-call time'?	Responses (%)
Yes: during on-call time they must remain at the workplace or a place chosen by the company	3.8%
Yes: during on-call time they can remain at home or at another place of their choice, but must be contactable to work if needed	23.2%
Yes, both on-call at the workplace and on-call at home	6.1%
No	66.9%

Source: LSME survey

This closely corresponds to the EBTP survey in terms of the number of respondents using "on-call" time or "stand-by" time (31%), but somewhat differs in terms of the number of companies obliging their employees to remain at the workplace or a place chosen by the company (true "on-call" time), with only 9.2% of respondents from the EBTP survey having indicated workers from their company perform "on-call" or "stand-by" time mentioning these must remain at the workplace or a place chosen by the company.

The following breakdown in terms of required level of attention[11] during "on-call" time at the workplace was observed:

Which of the following best describes the level of attention required during on-call at the workplace in your company?	Responses (%)
High	10.3%
Low	53.6%
Variable	36.1%

Source: LSME survey

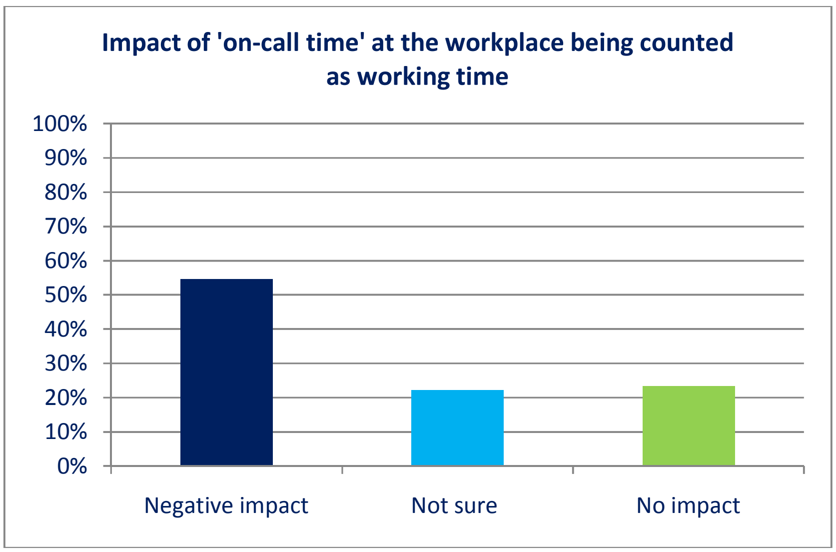
The EBTP survey found that less workers need to maintain a high level of attention during "on-call" time:

[11] The levels of attention required high, low, variable and don't know are based on the responses "Must remain active/attentive over long periods, with no or limited opportunity to rest", "the employee is rarely called to intervene in practice, can rest or relax for long periods", "either is possible, depending on the job" and "don't know"

8. Level of attention required during on-call time at the workplace in your company	Responses (%)
Low	46.4%
Variable	43.1%
High	2.6%
Don't know	7.8%

Source: EBTP survey

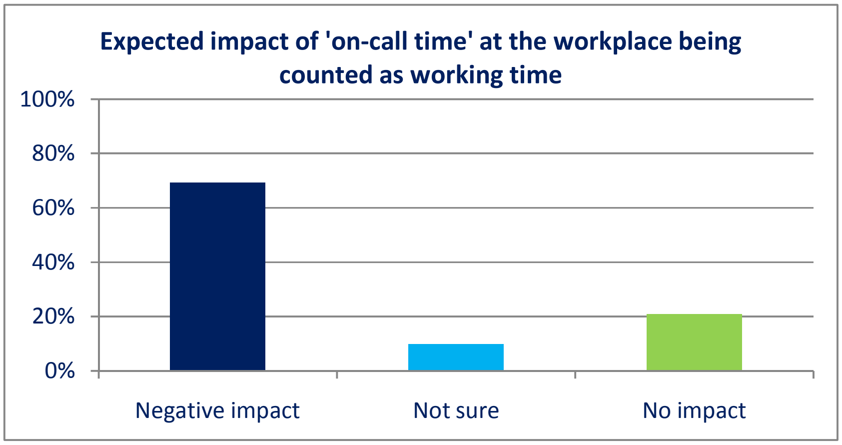
The WTD – as confirmed by SIMAP-Jaeger rulings - considers all “on-call” time as working time. Nevertheless, when the surveys raised the question of the “expected” impact of counting all “on-call” time at the workplace as working time on the companies using this[12], the responses clearly showed a negative “expected” impact among respondents[13] (as well as the fact that many companies do not seem to be aware of the WTD rules), with substantial problems requiring a major reorganization of work patterns being the most often cited impact:



Source: LSME survey

[12] All “on-call time” at the workplace already is counted as working time (as per the SIMAP – Jaeger rulings)

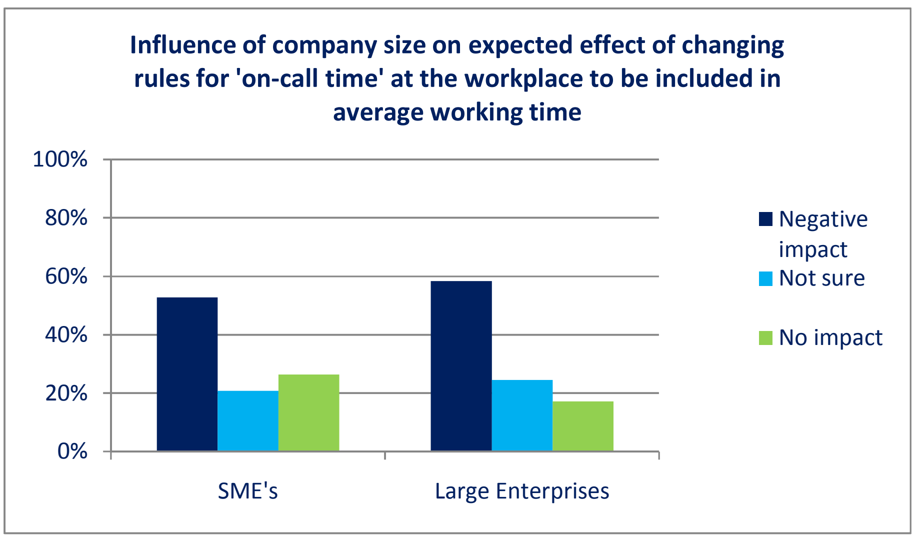
[13] Negative impact covers all responses mentioning minor or substantial expected problems; No impact covers all responses mentioning no problem – other impacts are not covered



Source: EBTP survey

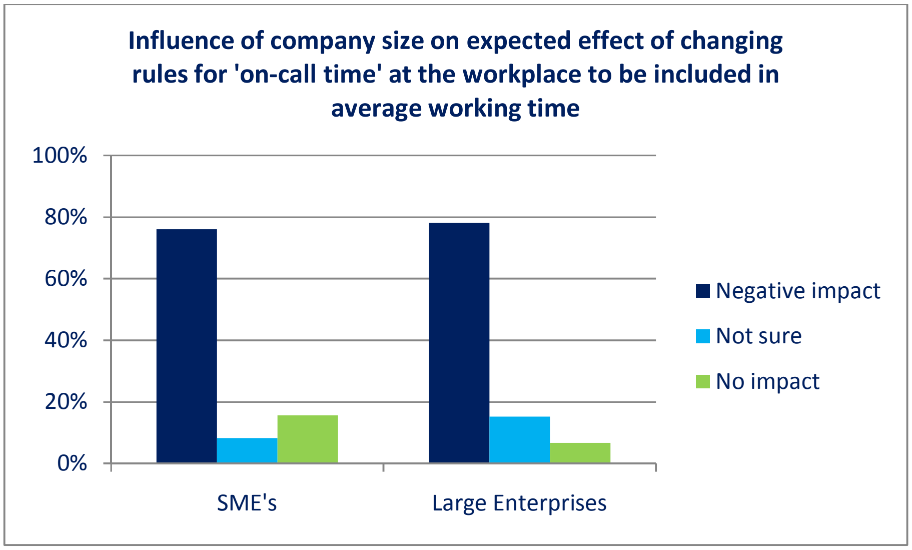
Results from the EBTP survey were even more emphatic on this point.

The LSME results were similar for SME's and Large Enterprises, with SME's being slightly less negative about the impact of such a change.



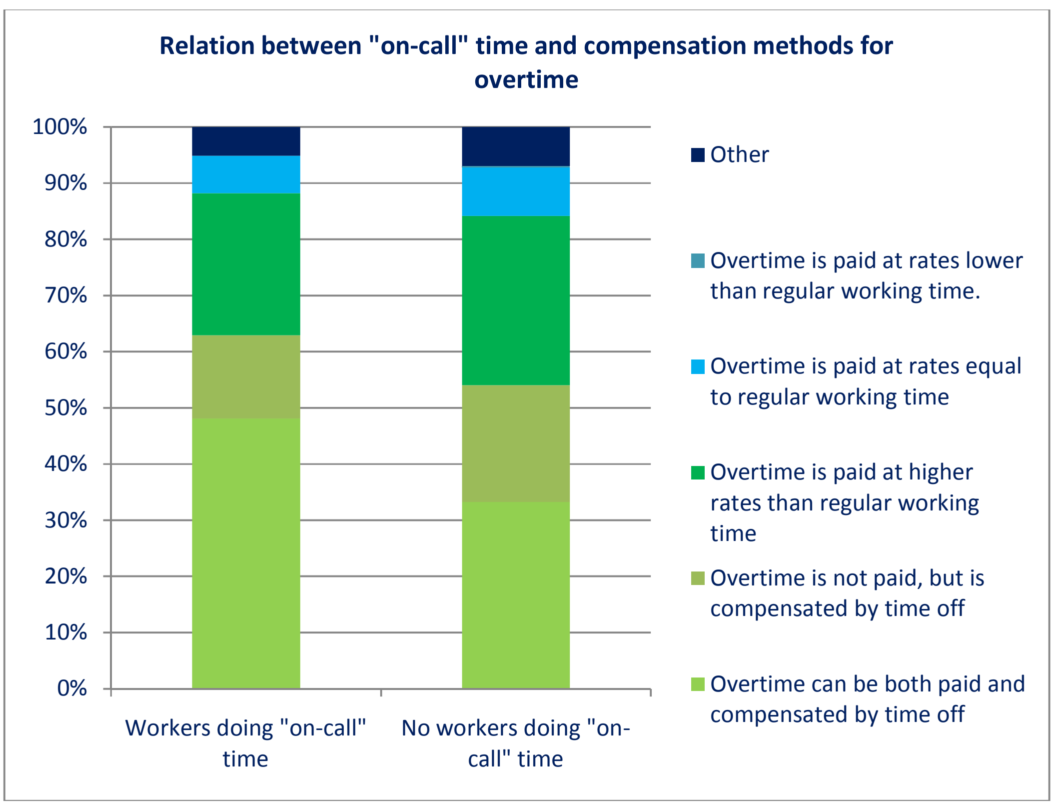
Source: LSME survey

The EBTP results showed the same, but results were closer:



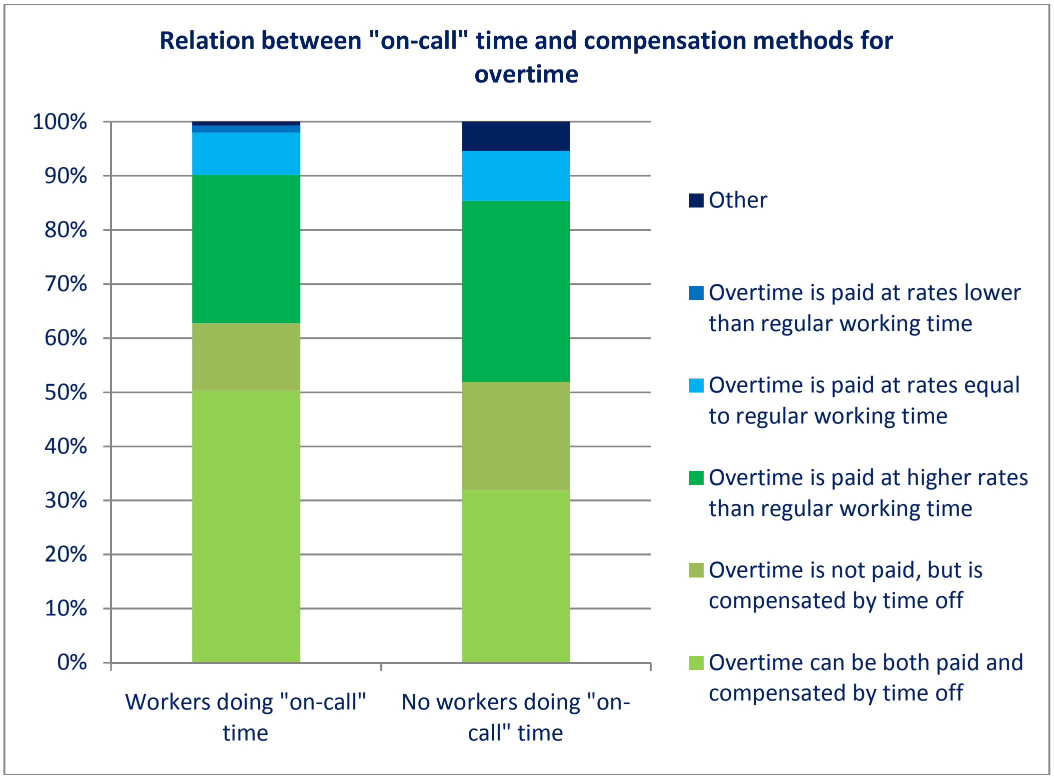
Source: EBTP survey

It is also interesting to analyse "on-call" time in relation to the compensation methods for overtime[14]. In this respect, in both studies we note a higher proportion of companies with workers performing "on-call" time where overtime can be compensated both financially and by the recovery of the worked time, and a lower proportion where overtime is not paid, but is simply compensated by recovery of the worked time.



Source: LSME survey

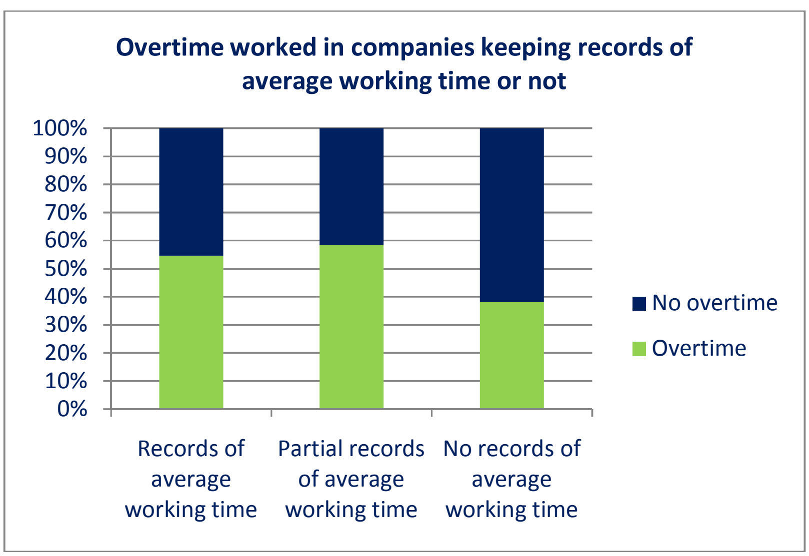
[14] Where several compensation methods are provided in the EBTP survey, all are taken into account.



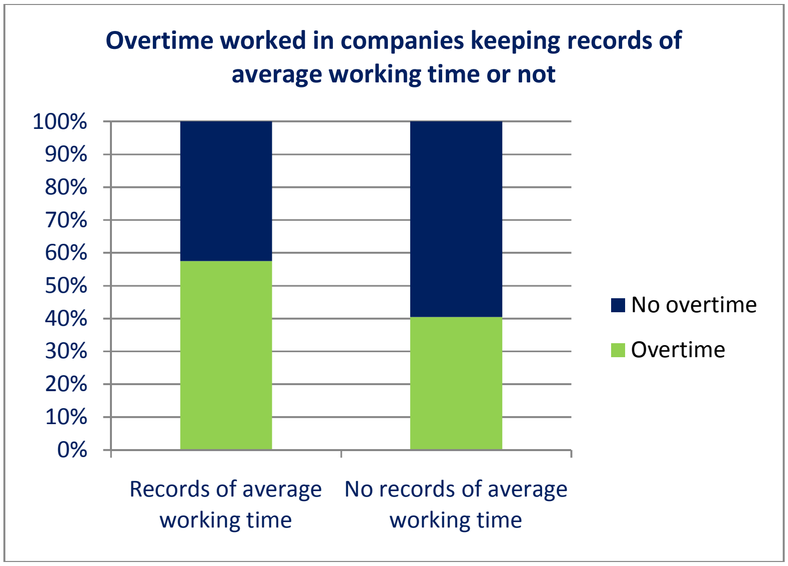
Source: EBTP survey

3.3 Average working hours

51.4% of LSME and 51.5% of EBTP responses identified workers other than senior management working more than 40 hours per week on average (including "on-call" time at the workplace), with companies recording average weekly working time reporting a higher proportion of overtime:

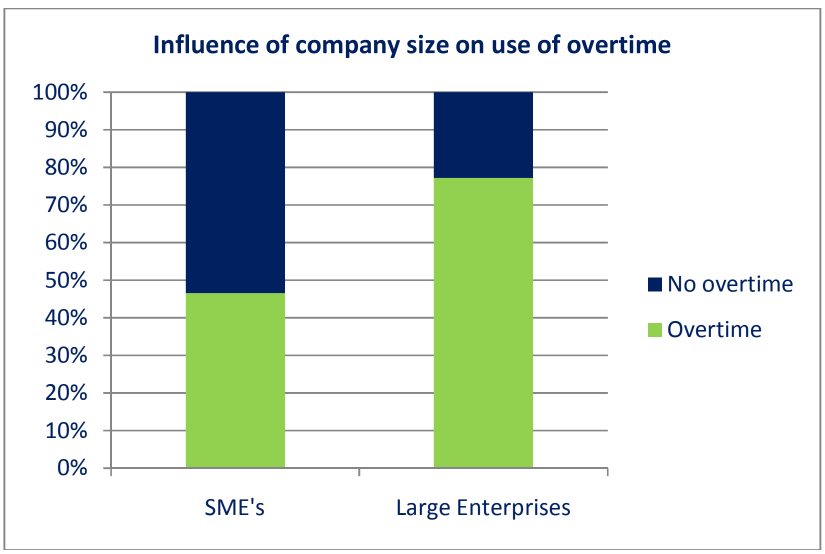


Source: LSME survey

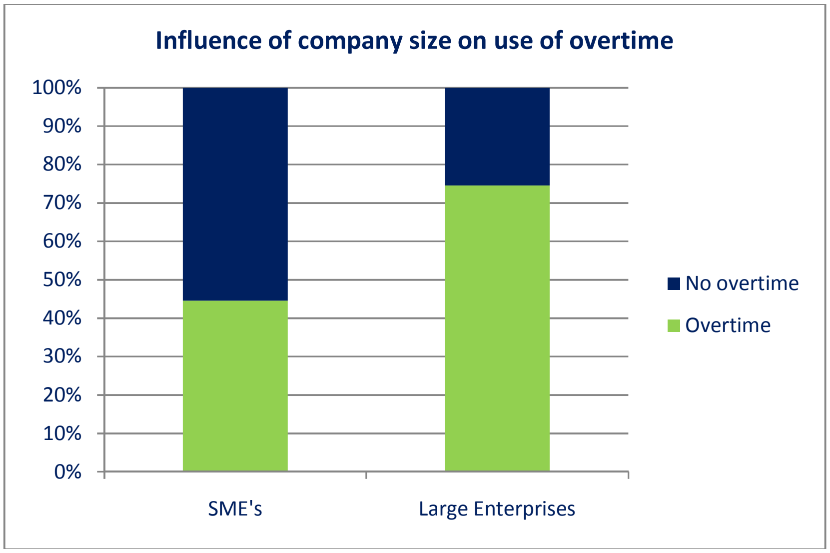


Source: EBTP survey

Furthermore, LSME and EBTP results clearly converged in showing that overtime is more often present in large enterprises than in SME's:

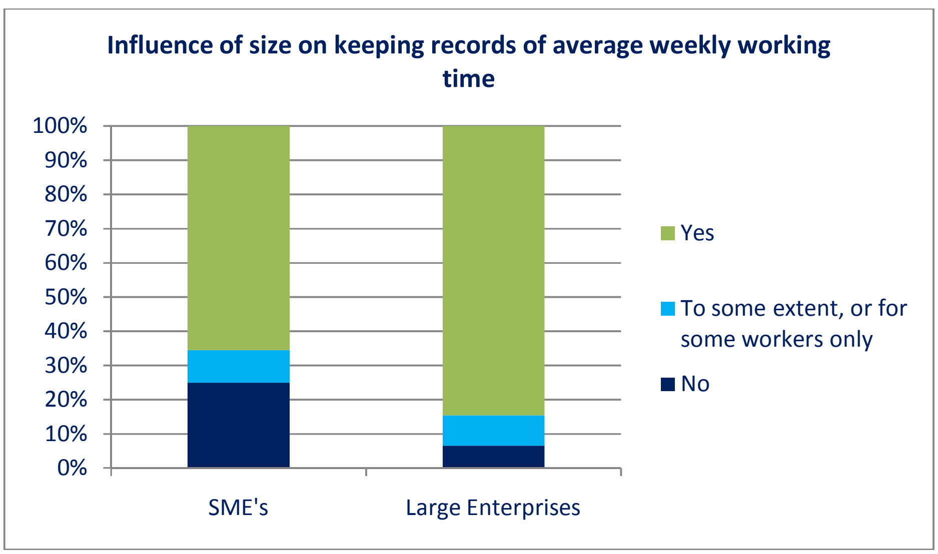


Source: LSME survey

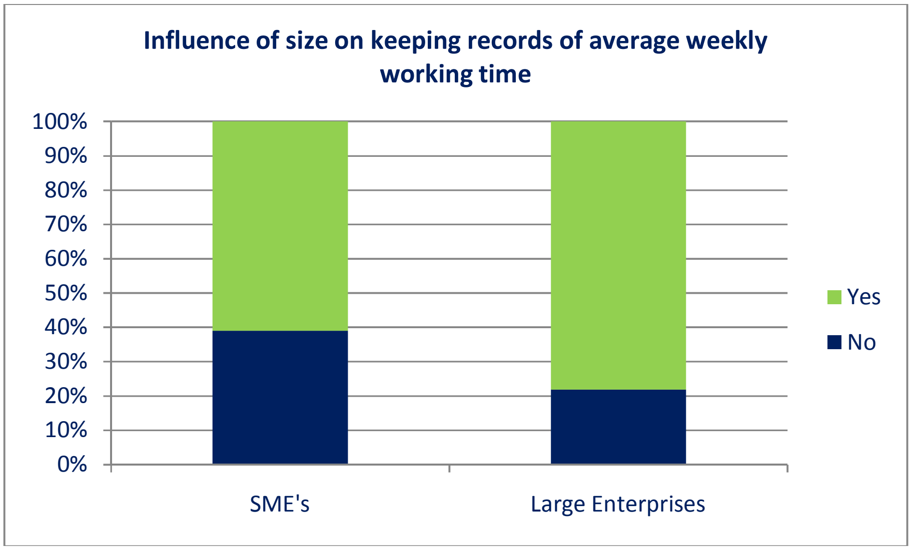


Source: EBTP survey

This may to a certain extent be explained by the fact that a higher proportion of large enterprises than SME's measure average weekly working time as shown below:

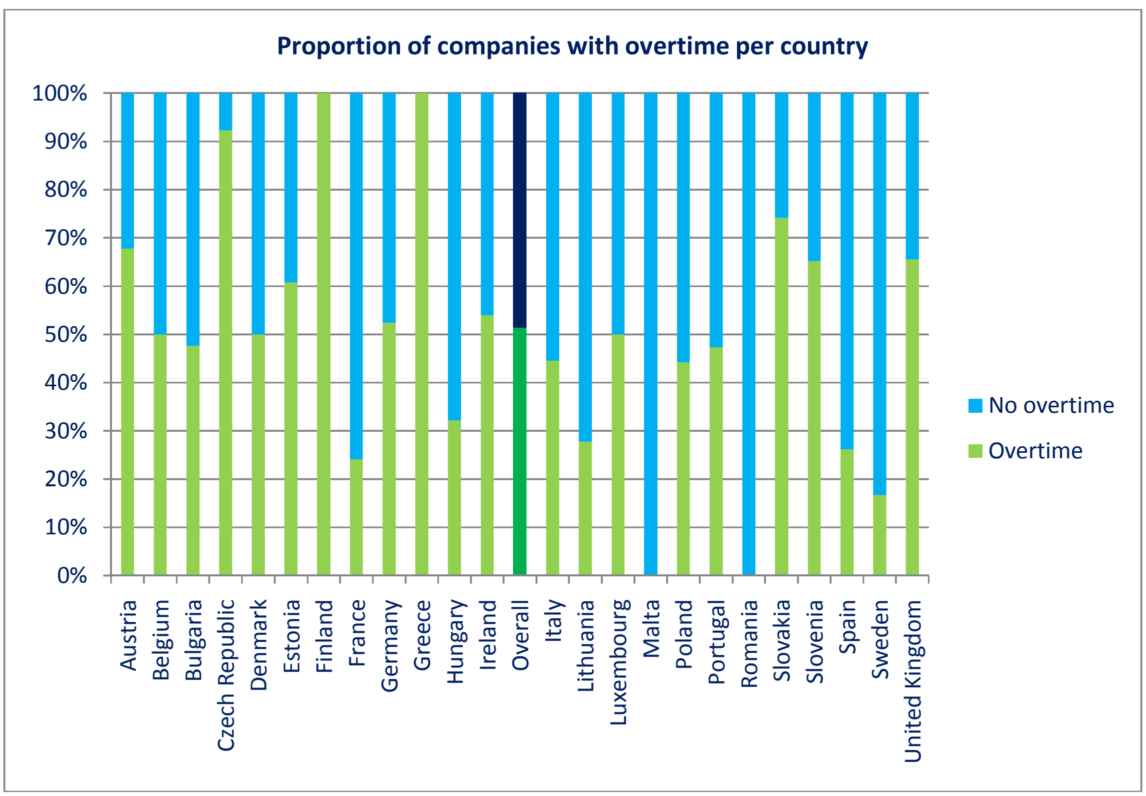


Source: LSME survey

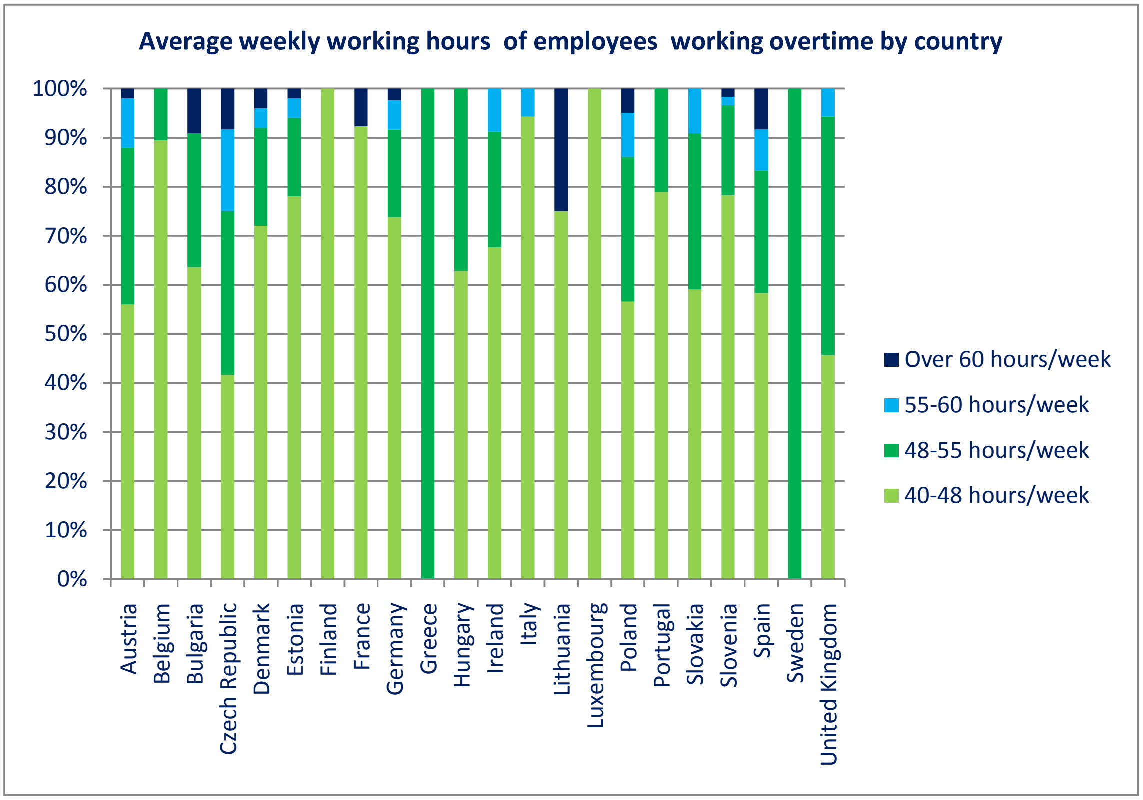


Source: EBTP survey

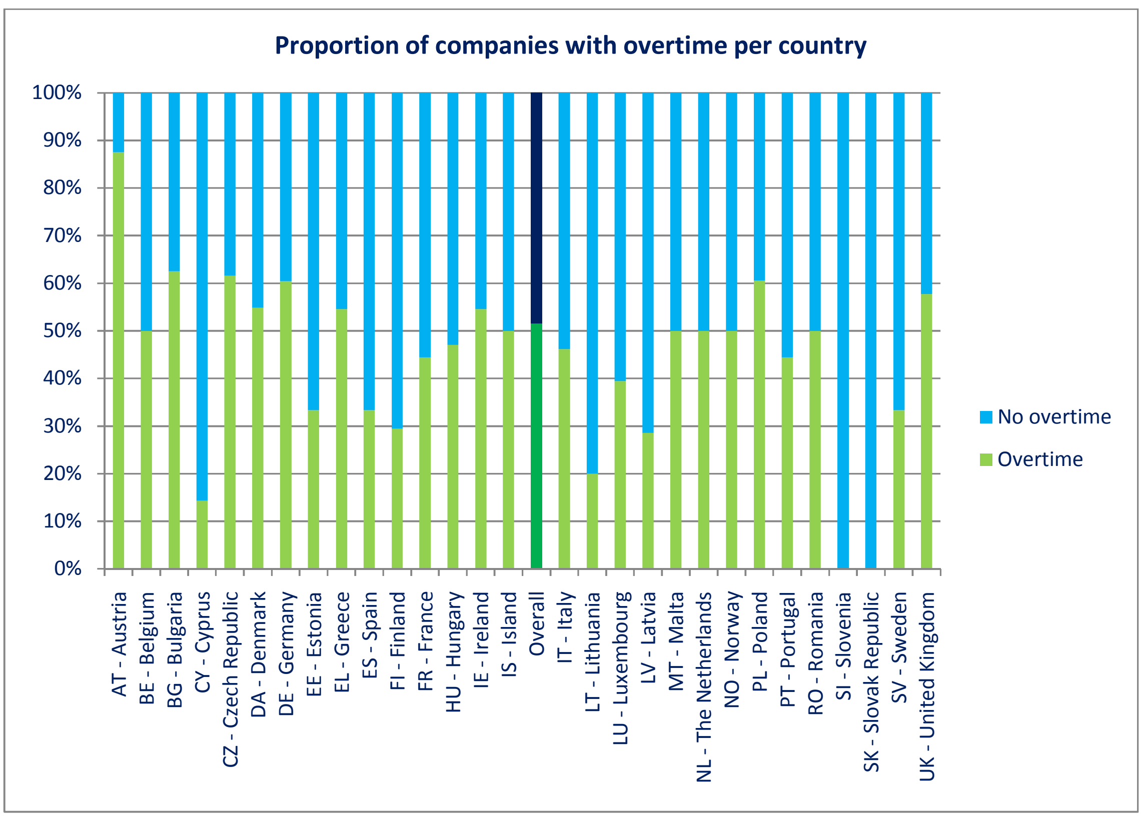
Besides company size, the existence of an opt-out system may influence average weekly working time of employees working overtime. However, the link to the opt-out system which is only applicable in certain EU countries does not seem clear although this may be due to the small sample size at country level (in reading the graphs below, the reader should bear in mind that not all countries of companies represented in the surveys are represented as companies from certain countries did not answer this question).



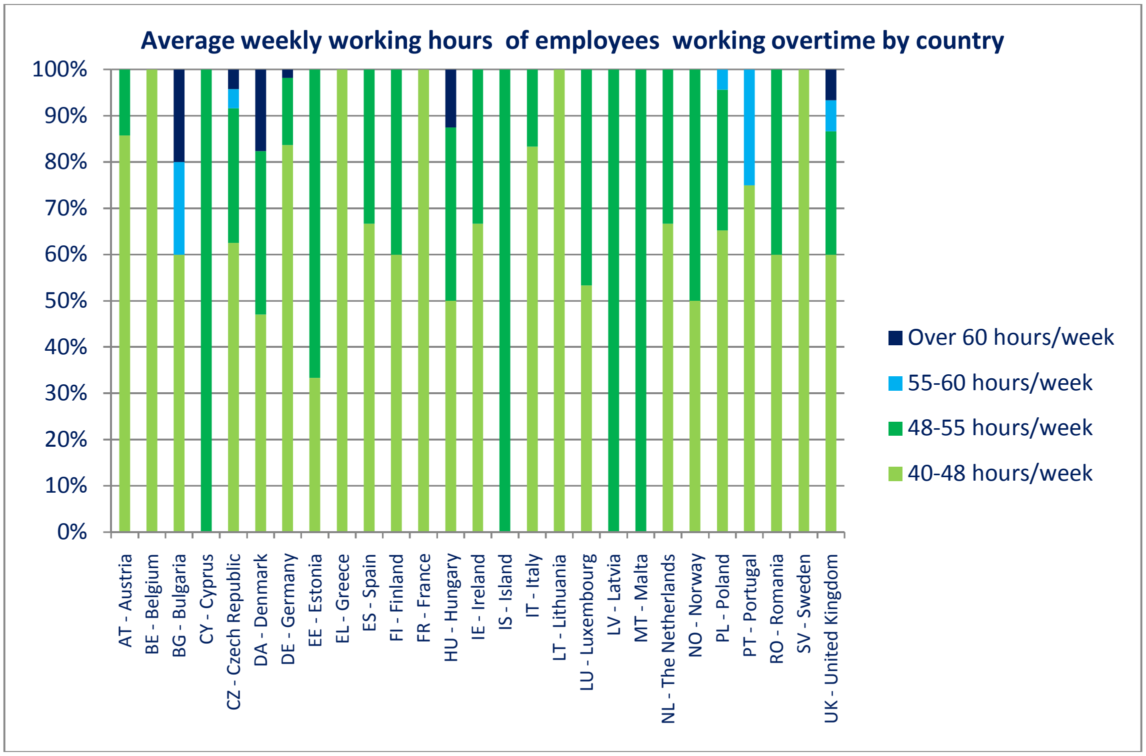
Source: LSME survey



Source: EBTP survey

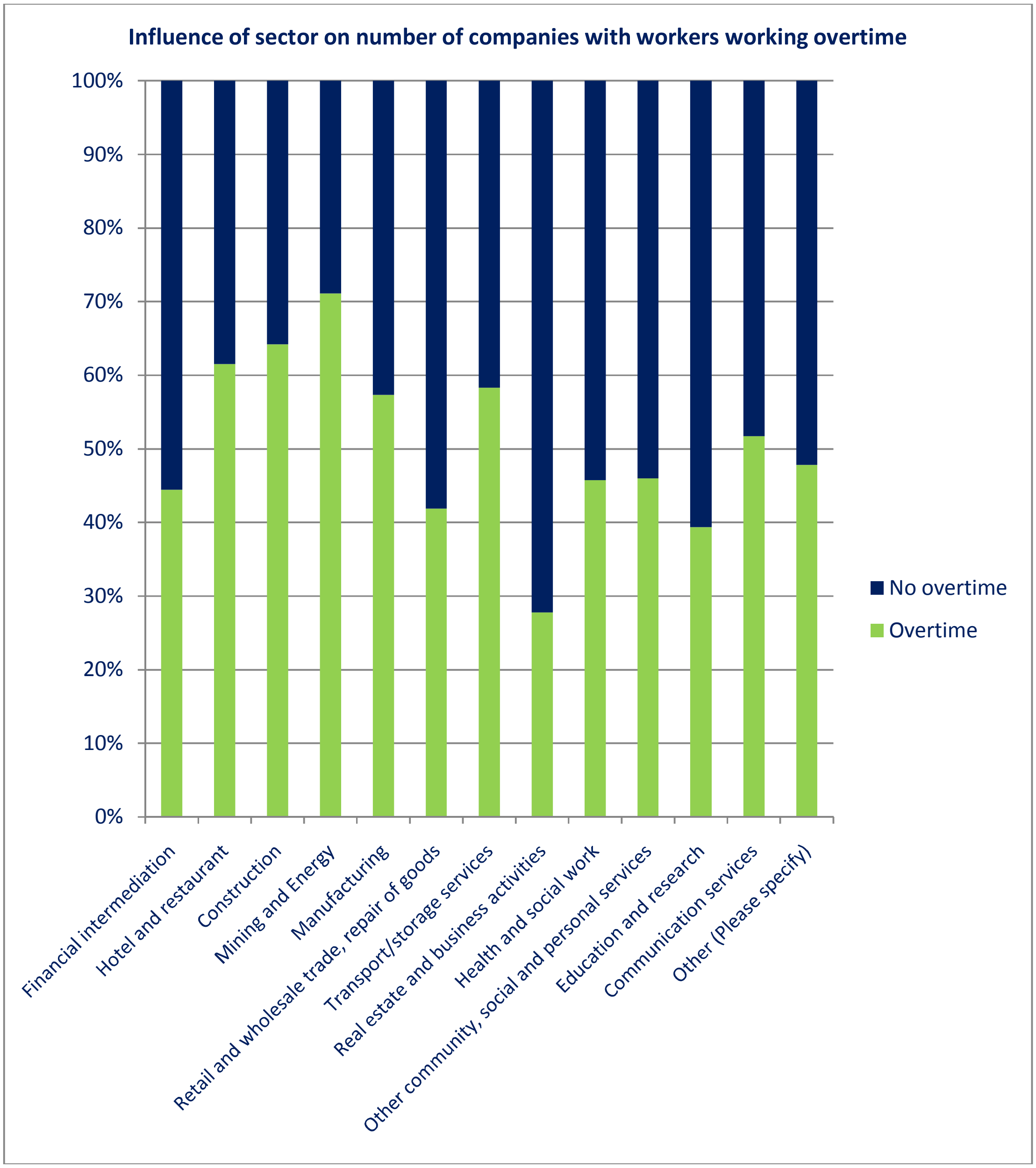


Source: LSME survey

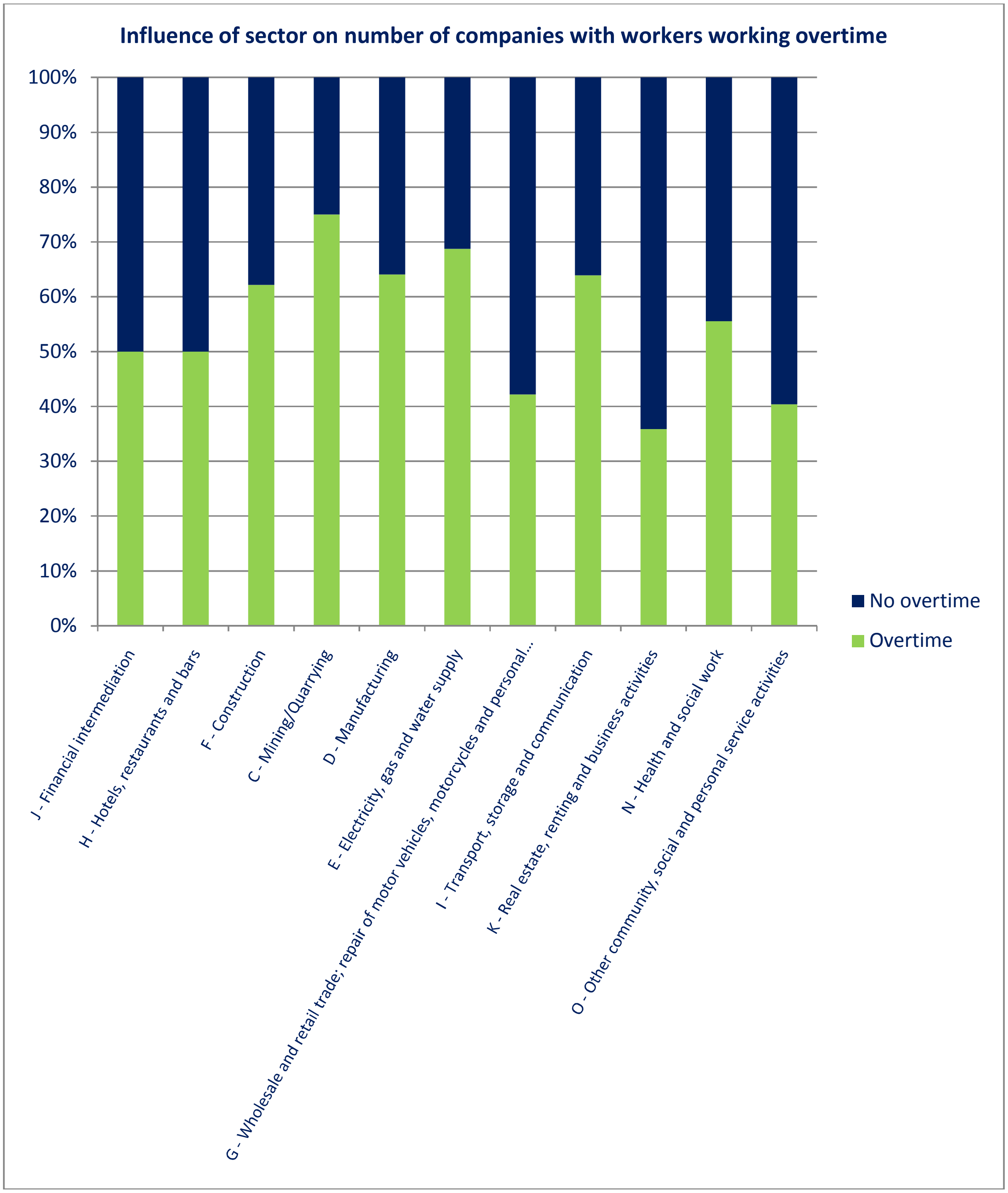


Source: EBTP survey

We also note that the distribution of companies using overtime amongst sectors is relatively homogeneous, with some sectors having a slightly higher reliance, although the small number of responses per sector means that yet again these results are to be treated with caution:



Source: LSME survey



Source: EBTP survey

Results of the LSME survey showed a slightly higher proportion of workers working the longest hours working between 55 and 60 hours/week as opposed to between 48 to 55 hours/week than the EBTP survey in which most workers with the longest weekly working hours work average weekly hours between 40 and 48 hours. The ranges of average working hours are distributed as follows:

11. Taking the workers who work the longest hours, what is their average weekly working time, including overtime and on-call time at the workplace?	Responses (%)
40-48 hours/week	67.2%
48-55 hours/week	24.2%
55-60 hours/week	6.1%
Over 60 hours/week	2.5%

Source: LSME survey

12. Taking the workers who work the longest hours, what is their average weekly working time, including overtime and on-call time at the workplace?	Responses (%)
40-48 hours/week	68.1%
48-55 hours/week	26.8%
55-60 hours/week	2%
Over 60 hours/week	3.1%

Source: EBTP survey

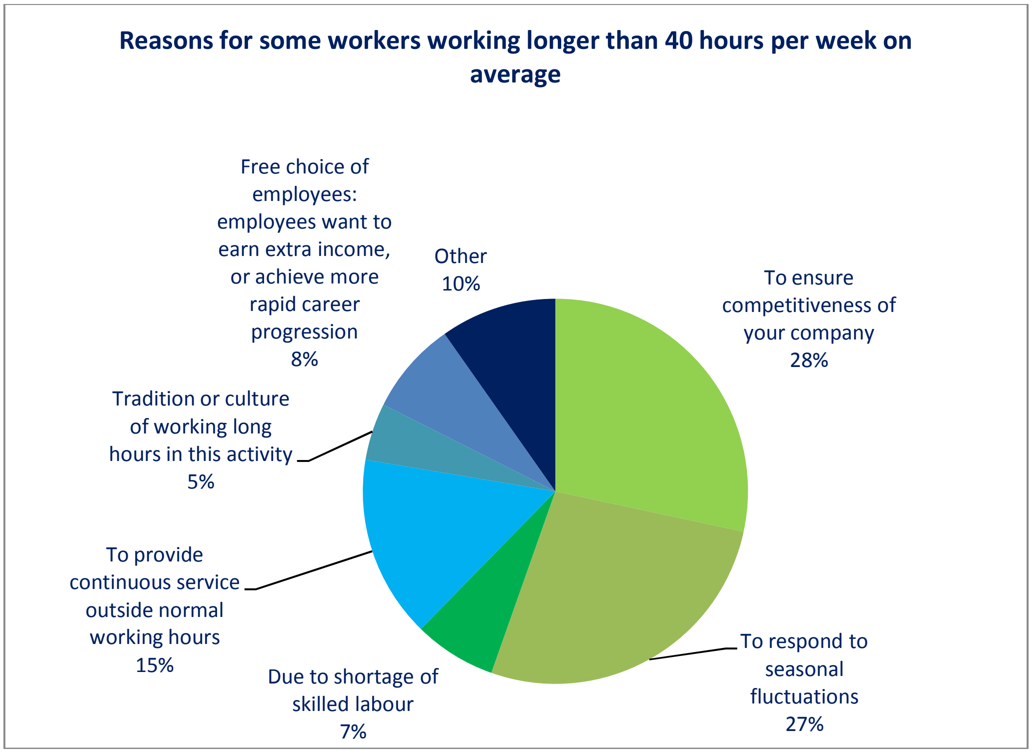
Of the main reasons cited for the existence of these long average weekly working hours, a number were relatively well aligned between the EBTP and LSME surveys:

- responding to seasonal fluctuations (27% for the LSME survey and 25% for the EBTP survey);
- providing continuous service outside business hours (15% for both the LSME survey and the EBTP survey).

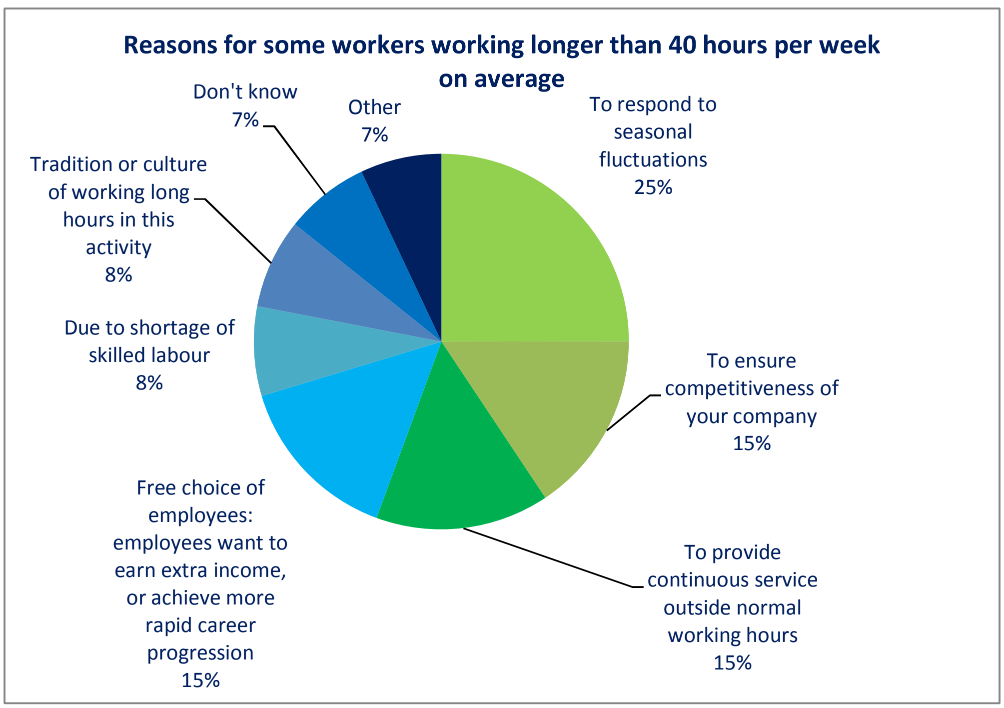
Others were significantly different between the two surveys:

- ensuring competitiveness (28% for the LSME survey but only 15% for the EBTP survey): LSME responses clearly considered this factor as more important;
- free choice of employees in order to progress faster or earn more (only 8% for the LSME survey but 15% for the EBTP survey): the LSME responses identified a much lower proportion of "voluntary overtime".

The pie chart below presents details of the various reasons for the long average weekly working hours.



Source: LSME survey

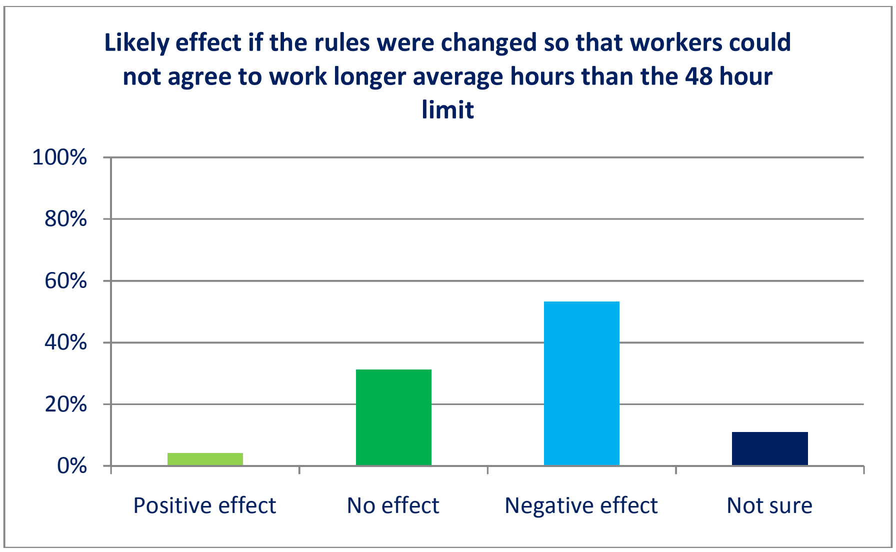


Source: EBTP survey

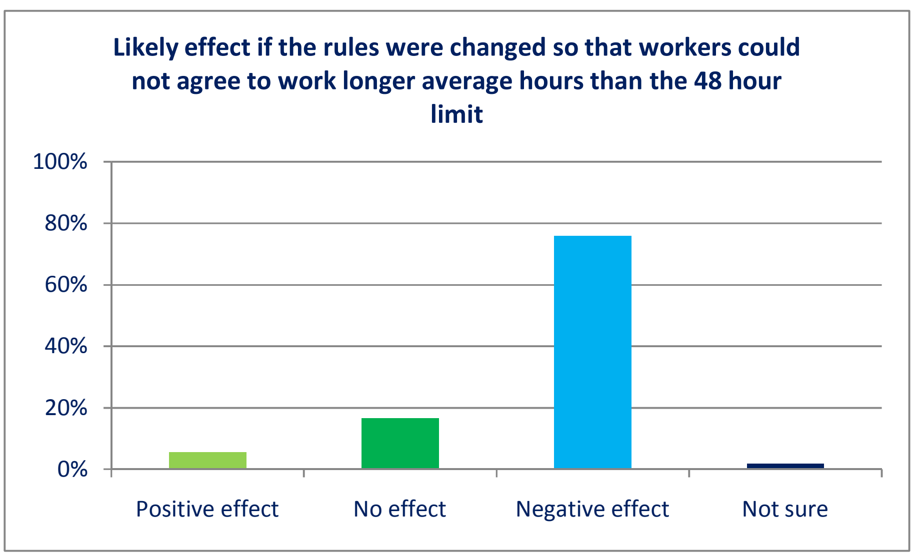
The overtime in most companies is compensated for either by pay at higher rates than regular working time (40.9% of responses) or a combination of pay and compensating time off (53.5% of responses).

In opt-out and partial opt-out countries the expressed agreement to opt-out from the workers is required by the WTD. In both surveys the highest proportion of companies mentioning they are under this regime have over 40% of workers providing such a written consent (38% of LSME respondents having mentioned workers are asked to provide the written consent before working more than 48 hours per week, and 44.4% of EBTP responses where this is the case).

When asked *what would be the effect of changing the rules so that workers could not agree to work longer average hours than the 48 hour limit*, the vast majority of surveyed companies in opt-out and partial opt-out countries (53.4% of LSME respondents using opt-out, and 75.9% of EBTP respondents using opt-out) responded that the impact would be negative, showing that the companies in these countries clearly value this regime[15].



Source: LSME survey



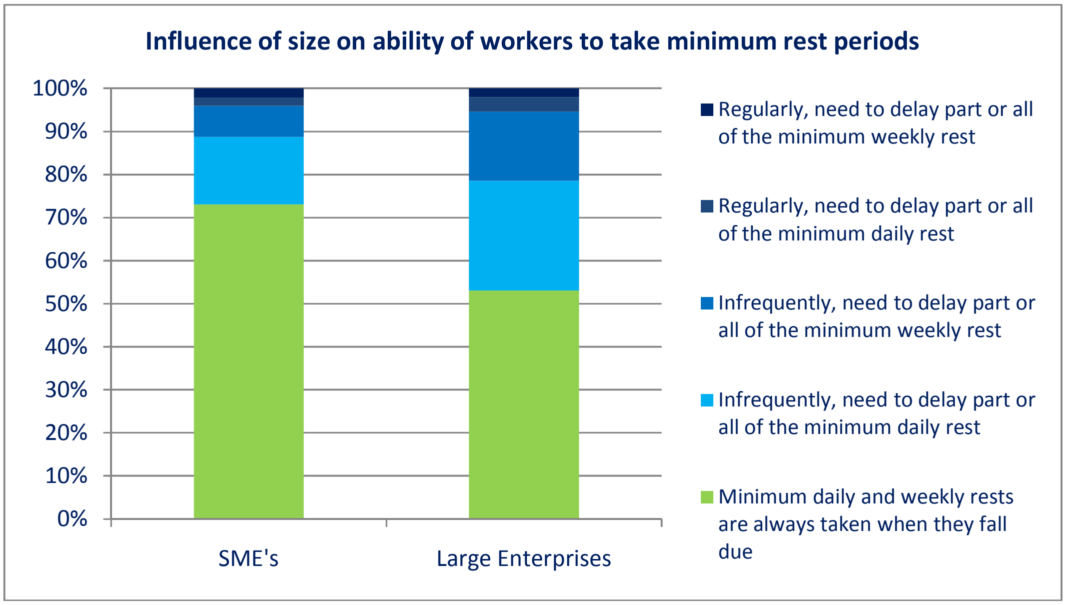
Source: EBTP survey

[15] Negative impact encompasses all responses mentioning a problem whether significant or not; Positive impact only takes into account responses where a positive impact is explicitly mentioned and no problem is mentioned.

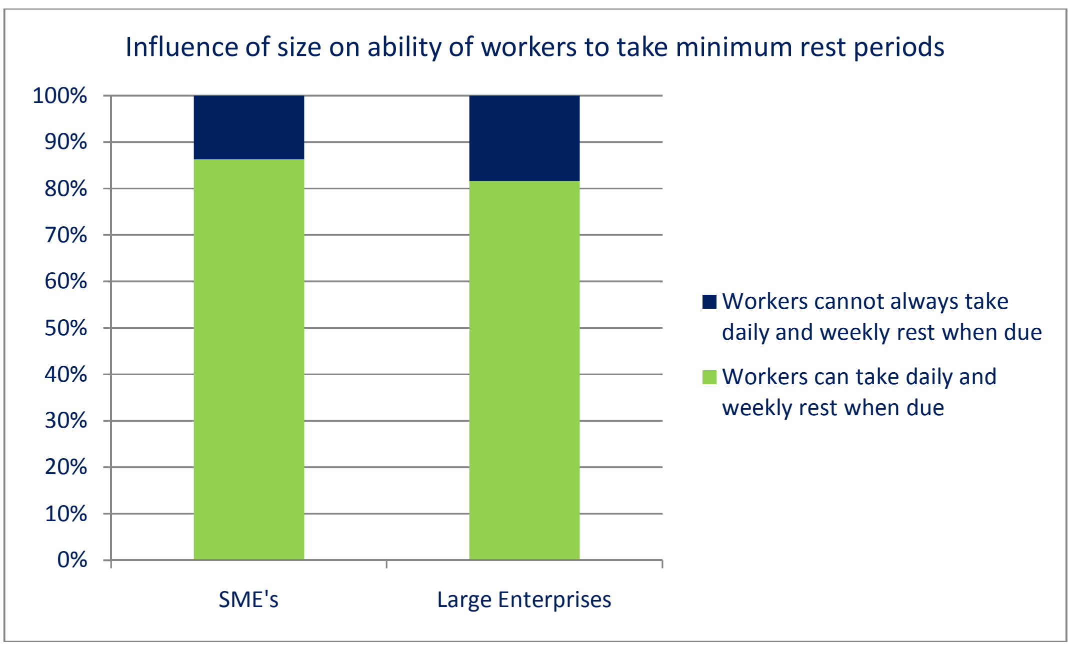
3.4 Minimum rest periods

According to both the LSME and EBTP surveys, workers are always able to take their daily and weekly minimum rest when it is due in the vast majority of cases (68.6% of LSME responses and 85.2% of EBTP responses). When this is not the case, minimum daily rest is affected more than minimum weekly rest (64.4% of cases where minimum rest periods cannot be taken affect minimum daily rest in the LSME survey vs. 35.6% which affect minimum weekly rest in the same survey), although generally infrequently in both cases.

Furthermore, both surveys show that minimum rest periods are always taken when due in a larger proportion of SME's than large enterprises:



Source: LSME survey



Source: EBTP survey

The main reasons given by companies to sometimes delay minimum rest periods are the following:

19. What is the main reason your company sometimes needs to delay minimum rests?	Responses (%)
Unpredictable fluctuations in level of demand for our product or service	44.3%
Seasonal variations in demand for our product or service	17.4%
Unable to recruit additional staff with the necessary skills or experience	6.6%
Extra costs of recruiting more staff	4.9%
Staff preference for more flexible timing of rest periods	12.7%
Other	14.0%

Source: LSME survey

19. Main reasons companies sometimes needs to delay minimum rests?	Responses (%)
Unpredictable fluctuations in level of demand for our product or service	46.6%
Seasonal variations in demand for our product or service	15.1%
Staff preference for more flexible timing of rest periods	13.7%
Unable to recruit additional staff with the necessary skills or experience	4.1%
Other	20.5%

Source: EBTP survey

In both surveys unpredictable fluctuations in the level of demand for the product or service was by far the most frequent reason to delay the minimum rests.

3.5 Other working time rules

Finally, most surveyed companies (67.4% of LSME responses and 64.9% of EBTP responses) responded that other EU working time rules (all workers are entitled to at least four weeks' paid annual leave; normal hours of work for night workers should not exceed 8 hours per night on average; in particularly stressful or dangerous work, night workers should not work longer than 8 hours in any night; night workers suffering from health problems linked to their night work may transfer where possible to suitable daytime work) have no important impact on them. The two tables below clearly show this:

20. Has any of the following EU working time rules had an important impact on your company? If so, please indicate which one(s).	Responses (%)
All workers are entitled to at least four weeks' paid annual leave	22.0%
Normal hours of work for night workers should not exceed 8 hours per night on average	5.1%
In particularly stressful or dangerous work, night workers should not work longer than 8 hours in any night	1.9%
Night workers suffering from health problems linked to their night work may transfer where possible to suitable daytime work	3.7%
No important impact	67.4%

Source: LSME survey

20. Important impact of other EU working time rules	Responses (%)
All workers are entitled to at least four weeks' paid annual leave	25.2%
Normal hours of work for night workers should not exceed 8 hours per night on average	8.5%
Night workers suffering from health problems linked to their night work may transfer where possible to suitable daytime work	6.9%
In particularly stressful or dangerous work, night workers should not work longer than 8 hours in any night	3.7%
Other	5.5%
No important impact	64.9%

Source: EBTP survey

Nonetheless, between 22% and 25% of respondents to both surveys consider that the rule imposing four weeks' paid annual leave has an important impact on their company. This is indeed obviously the rule with the broadest and most significant financial impact on respondents.

We can interpret these results as a positive integration of the health and safety rules in the surveyed companies.

4 Conclusions

Overall, the results of the LSME and EBTP surveys show much the same thing, and are globally in line with the Commission's previous proposals to adapt the WTD. The main conclusions on the topics covered are:

- For the **measurement of weekly working time**:
  - the majority of companies measure weekly working time, although a non-negligible minority do not;
  - the highest proportion of companies tracking average weekly working time use a reference period of 4 months;
  - most companies believe that a regulation change to have the option to calculate average weekly working time over up to 12 months by law would be useful;
- For the **treatment of "on-call" time**:
  - the "expected" impact on the companies using this of counting all "on-call" time at the workplace as working time (which is already the case as per the SIMAP-Jaeger rulings) is negative, with substantial problems requiring a major reorganization of work patterns being the most often cited impact. This tends to indicate companies are not fully in line with the current regulation;
  - "on-call" time seems to be linked to a greater flexibility in the compensation of overtime as a higher proportion of companies using "on-call" time allow compensation both financially and by the recovery of worked time. This may also indicate potential focus areas for other adaptations to WTD rules for companies using "on-call" time.
- For **average working hours**:
  - a significant proportion of companies use overtime. While there are sectoral differences, there does not seem to be a country effect in this, linked to the opt-out system which is only applicable in some EU countries;
  - the most often cited reasons for having workers work average weekly hours above 48 are to ensure competitiveness and to respond to seasonal fluctuations. There are sectoral differences which tend to fit the findings on the inverse link between long hours and productivity in the financial intermediation sector as less companies mention ensuring competitiveness through the longer hours in this sector;
  - Companies in countries using the opt-out or partial opt-out perceive its potential elimination negatively, showing they value this measure and would potentially be against its' abolishment.
- For **minimum rest periods**: minimum rest periods can be taken when due in most cases tending to indicate further flexibility might not be a priority for businesses;
- For **other working time rules**: most companies do not have significant impacts from other working time rules of the WTD. The other working time rule with the most impact is the rule entitling all workers to at least four weeks' paid annual leave.

ANNEX 4:

STUDY ON THE USE OF THE OPT-OUT

1. USE OF THE 'OPT-OUT'

BIBLIOGRAPHY

A number of literature sources were consulted as part of the review of the impact of the opt-out. It should be noted that there was much more extensive literature available in some EU countries, notably the UK, on the opt-out (including survey-based opinion data on the opt-out). Moreover, there was almost no literature available on the opt-out in those countries only using the opt-out for limited activities (e.g. healthcare services) such as France. In some of the new member states using the opt-out across all sectors, because the opt-out has only been used for a relatively short period of time, and in some cases has not been that widely used, there was an absence of empirical research on the extent of usage of, or impact of the opt-out. It should be noted that the responsible national authorities in some countries such as Bulgaria, Cyprus and Estonia, do intend to carry out some research on the opt-out in future.

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Poland

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