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Eva Gutiérrez-i-Puigarnau • Jos N. van Ommeren

Start Time and Worker Compensation: Implications for Staggered-Hours Programs

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German Socio-Economic Panel Study (SOEP)
DIW Berlin
Mohrenstrasse 58
10117 Berlin, Germany

Contact: Uta Rahmann | urahmann@diw.de

Start Time and Worker Compensation: Implications for Staggered-Hours Programs

Eva Gutiérrez-i-Puigarnau

VU University, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands
egutierrez@feweb.vu.nl

Jos N. van Ommeren

VU University, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands
jommeren@feweb.vu.nl

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Abstract

There is little known about the effects of staggered-hours programs that affect workers' working schedules to mitigate peak congestion. We examine the effect of workers' morning start times on their wages for Germany. In contrast to previous work based on cross-section data, we demonstrate that wages are not, or, may be, a slight inverse U-shaped function of start time suggesting that staggered-hours programs might be welfare enhancing.

Keywords: work start time, wage, productivity, staggered work hours, congestion
JEL codes: J2, J3, R41

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1.0 Introduction

Traditionally, most of the labour supply has been structured following a set worktime pattern under which all workers start and end work at the same time. Henderson (1981) reports that, in 1979, 75 per cent of workers arrive within a time interval of 15 minutes. This situation causes a large volume of traffic around work start and end times. One way to mitigate the lengthening of the commute time due to peak congestion has been by diversifying start times.[1] Nevertheless, heavy morning and evening peak congestion (for example, Arnott et al., 1993) are still a major worry not only for policymakers, but also for employers as it increases the travel costs of workers to arrive at work.

Commute time induced by traffic congestion is directly related to the workers' distribution of start (and therefore end) times (Vickrey, 1969; Henderson, 1974; Chu, 1995; Fosgerau, 2008). When workers' start times spread out, peak congestion is flattened. The present paper examines workers' compensation through variation in wages related to spread in morning start times, allowing us to get more insight about the effects of mandatory staggered-hours programs, which induce firms, and therefore workers, to vary the time workers arrive at and leave from the workplace.[2] The number of firms adopting staggered work hours has been increasing in recent years in many countries (see, for example, Mun and Yonekawa, 2006). In Germany, which is the focus of our analysis, staggered work hours are a matter of great interest and have become widespread, utilised by one out of three firms (Bauer et al., 2007). Arnott (2007) argues that it is a priori not clear that the government's intervening to internalize only the negative externalities of congestion would be welfare-enhancing. It is therefore key to understand the effect of mandatory staggered-hours

[1] Other ways to diversify work schedules include a compressed week work, where a worker works her usual number of hours over a fewer number of workdays, or flextime, where a worker has some choice in establishing her work schedule.

[2] A small number of dominant (extremely large) employers may voluntarily internalize the external costs of commuting by staggering work hours (see, for example, Safavian and McLean, 1975; Giuliano and Golob, 1990).

programs on welfare. By focusing on the effect of start times on wages, we are able to see whether these programs affect productivity and workers' disutility.

The large empirical labour economics literature focusing on the effect of job attributes on wages, known as hedonic wage theory, has largely ignored workers' start time. See Cahuc and Zylberberg (2004) for an exposition of hedonic wages theory. In the urban transportation literature, the relationship between workers' departure time, travel time and work start time has received much attention (for example, Small, 1982; Arnott et al., 1993). This relationship has become more relevant with the increasing popularity of flexible work-hours (Yoshimura and Okumura, 2001; Li, 2007). However, this literature ignores compensation in the labour market for the chosen start time by taking the wage as given (an exception is Wilson, 1989). Furthermore, the bulk of transport literature generally takes the start-time of the job as given. The urban transport literature focuses on travel time valuation and activity-scheduling behaviour. In this literature, the start-time of the job is a key variable of interest and assumed to be (endogenously) determined by (endogenous) activity preferences and (exogenous) employer restrictions. This paper aims to reduce the existing divergence between labour and transport economics literature by using the insights about start time of the job (importance), as studied in detail in the transport literature, and apply them into the field of labour economics.

The relationship between wages and start times is the result of the effect of start time on workers' preferences and productivity (assuming a constant workday, so workers' schedule is fully described by start time, see Wilson, 1989). With preferences, we refer to the worker's utility derived from start time which may involve *scheduling preferences* for the timing of leisure activities (for example, family responsibilities – to have breakfast together – or socializing with friends after work; see Mahmassani and Chang, 1990; Wang, 1996)) and *commuting time preferences*, as there is a strong relationship between start time and time length of the commute due to congestion (see Chu, 1995; Wang, 1996).

Commuting time costs are always higher at peak congestion, but a priori, it is not clear how scheduling preferences relate to peak congestion.[3] Some workers may prefer to start working before the peak, whereas others may prefer to start after the peak.[4] It is, however, plausible that most workers prefer to synchronize leisure activities with others, and therefore synchronize work times (Bernheim, 1994). This is consistent with the study of Emmerink and van Beek (1997) where respondents report that they travel at peak times, and not at non-peak times, (mainly) due to their own scheduling preferences, and not due to constraints set by employers. So, workers' scheduling preferences likely cause peak congestion.

Worker's productivity may also depend on the worker's start time (Golembiewski et al., 1974; Shepard et al., 1996). It is usually assumed that workers' productivity increases with the number of workers that are active at a certain time within a firm or even within the economy (Henderson, 1981; Arnott, 2007). For example, workers that start on different times may reduce opportunities for scheduling meetings, workers interaction and inhibits responsiveness to clients (Weiss, 1996). Examples of jobs for which this may be relevant are classroom teaching, police and fire services and emergency-medical services. If productivity depends on the number of workers outside the firm, then this implies the existence of an externality (Mills, 1967; Brainard, 1997). So, start times will be concentrated during the day and wages will be higher at peak times. Another reason that worker's productivity may depend on start time is due to diminishing marginal returns of labour when capital costs are fixed, see Lucas (1970). Examples of such jobs include assembly-line manufacturing. If workers prefer to start working at peak hours, the number of workers hired will then be lower

[3] Work start time has been traditionally set by external factors such as daylight and temperature, which may affect current preferences (Weiss, 1996).

[4] The relationship between scheduling preferences and peak congestion is much clearer though given the assumption of identical preferences.

outside peak hours, so wages outside peak hours will then be higher (such that wage equals marginal productivity).

So, in a competitive labour market, a variety of start times may be offered to workers at different wages reflecting preferences and productivity of workers varying by work start time and an equilibrium locus of wages and start times exists (see Henderson, 1981). We aim to estimate this equilibrium locus. In equilibrium in a competitive market, by assumption, workers maximize their utility and firms maximize profits, and wages equal marginal productivity. We focus now on two possible (stereotype) equilibria that may arise. In the first equilibrium, wages are a U-shaped function of start time, and wages obtain a minimum at peak time. In this case, workers prefer to start at peak time but accept jobs outside the peak because they are compensated by higher wages (so, the worker's productivity is increased enough to compensate for inconvenient start times). In the second equilibrium, wages are an *inverse* U-shaped function of start time. Thus, workers prefer to work at non-peak times (for example, because of large savings in commuting time), and demand higher wages at peak times (so, workers must be more productive at peak times, for instance due to the nature of their job, as otherwise employers are not willing to pay a higher wage).

The only empirical study of wages and start time we are aware of reports that the relationship between wages and start time is *strongly inverse U-shaped* Wilson (1988). So, workers starting at a peak time are paid *much* more than those starting later or earlier. However, this interpretation is controversial, because the study does not control sufficiently for worker characteristics (for example, the study does not control for weekly hours which is important, at least theoretically, see Kinoshita, 1987) and relies on cross-section data. As argued by Arnott (2007, p.190): "Wilson found that … the daily average wage is on average twice as high for workers with a peak work start-time … than for those with an off-peak work start-time. Intuition suggests that this difference is too large to be explained by intra-day productivity effects alone, and that sorting of workers across start times, on the basis of ability attributes observable to employers but not to the empirical researcher, must play an important role too. No empirical work has been done that attempts to distinguish between the two effects".

One contribution of the present paper is that we use panel data and control for many worker characteristics and unobserved time-invariant worker characteristics using a workers' fixed-effects methodology. So we are able to examine the effect of changes in start time on wages which are induced by hypothetical policies that encourage off-peak start times to mitigate traffic congestion (see, for example, Giuliano and Golob, 1990; Arnott et al., 2005). The first-best policy to reduce peak congestion is by road pricing, which may be infeasible in practice. As a second-best policy, governments may induce firms to stagger work hours.

The outline of the paper is as follows: in Section 2 we provide information on data employed, introduce the econometric model of wages and present empirical results; Section 3 concludes.

2.0 Worker Compensation Analysis for Start Time

2.1 The data

Our study is based on information from the German Socio-Economic Panel (SOEP) survey for the years 2004, 2006 and 2008.[5] Our dataset contains 14,108 annual observations for 8,364 workers of which 7,355 are observed in two years and 6,524 in three years. The sample is restricted to workers aged 20-60, who (usually) work at least 10 hours per week and between 4 to 12 hours per day.

A work schedule is either flexible or fixed (when it does not change from day to day). When it is fixed, which applies to the large majority (77 per cent), then we know the start

[5] For details of these data, see Haisken-DeNew and Frick (2005).

time. We focus on morning start times between five and twelve o'clock (which applies to 97 per cent of those with a fixed schedule). The choice of a 5–12 a.m. interval or a smaller one does not appear to be essential. We prefer the former to capture the whole relevant distribution of start times.

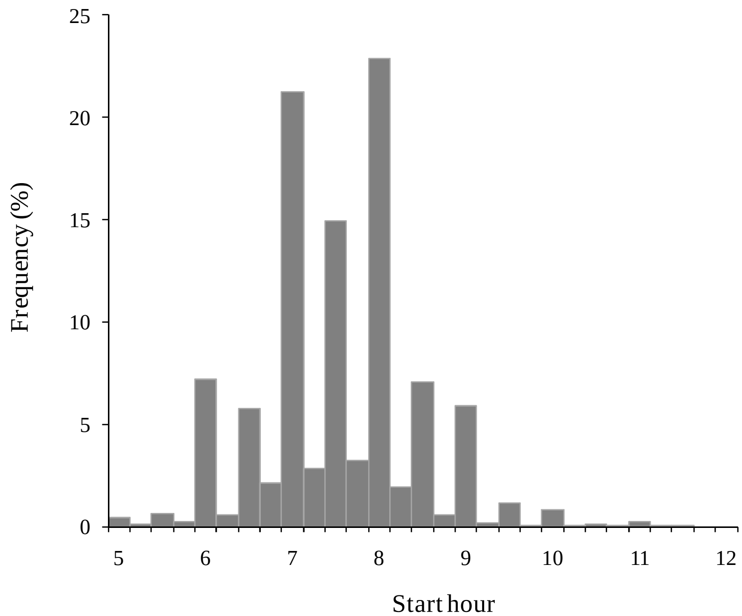

Figure 1. *Frequency distribution of start time (SOEP 2004, 2006, 2008)*

Figure 1 shows the frequency distribution of morning start times. Although start time is, in principle, a continuous variable, most workers report to start work at a whole or half hour. Many workers report that they start at exactly 8:00 a.m. (23 per cent), 7:00 a.m. (20 per cent) and 7:30 a.m. (14 per cent); most workers start within a one hour interval: 63 per cent start between 6:59 and 8:01 a.m., which we call *the peak interval*. The proportion of workers that starts before the peak is roughly the same as after the peak (17 per cent respectively 18 per cent). The mean and median start times occur at 7:32 and 7:30 a.m. respectively, so in the middle of the peak interval. The maximal rounding error in the start time value is small and only five minutes, since start time is measured in ten-minute intervals. We therefore may assume that rounding does not affect the consistency of the estimates.

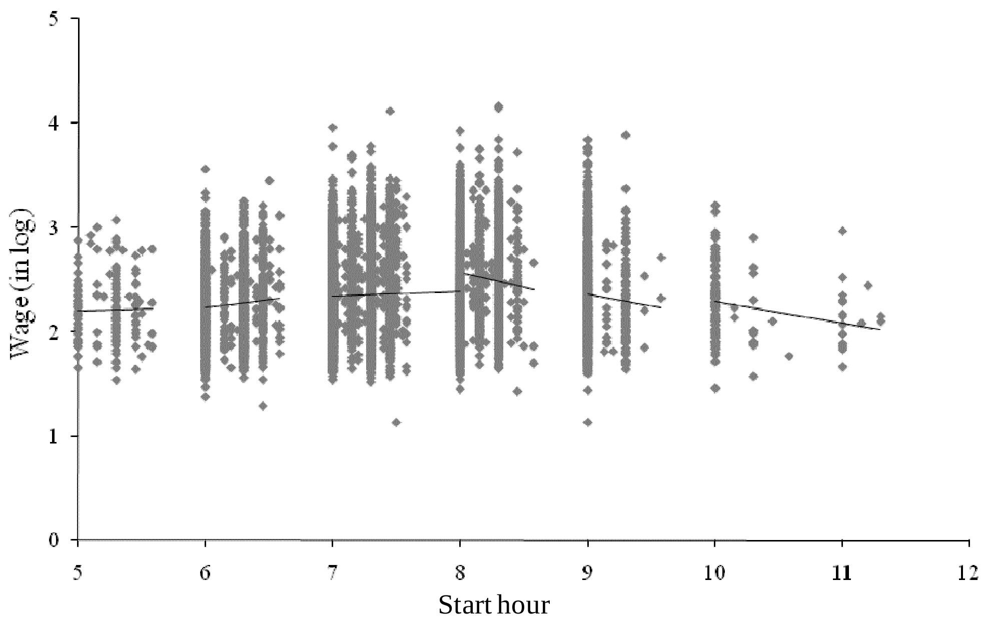

Figure 2. *Wage levels (in log) by start hour (SOEP 2004, 2006, 2008)*

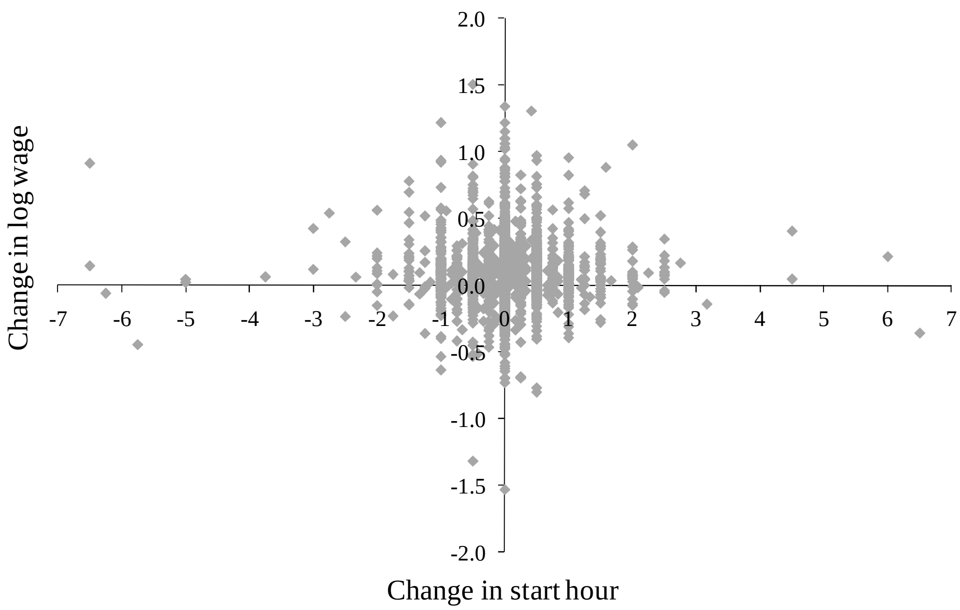

Figure 3. *Bi-annual change in log wages by change in start hour (SOEP 2004, 2006, 2008)*

In our analyses we focus on the workers' (bi-annual) change in start times. Many workers do not change their start time (substantially), but 4.8 per cent change their morning start time by more than one hour. Hourly wage, our main dependent variable, is calculated by dividing net monthly earnings by monthly contractual hours of work. It ranges from €3 to

€64, with a mean of €11.2. Figure 2 plots wage levels (in log) by start hour. It clearly shows that wage levels strongly decrease at non-peak times, but it can be easily seen that this relationship is largely spurious: Figure 3 plots workers' (bi-annual) change in log wages by change in start hour, and shows that the change in wages is rather independent of changes in start hour. In Figure 2, wages and start hour seem correlated with each other possibly because they are both correlated with a third causal variable that is unobserved such as unobserved ability characteristics of the worker.

2.2 Econometric model

The approach we use to estimate the effect of start time on wages is standard in the hedonic wage literature (see, for example, Duncan and Holmlund, 1983). This wage equation is not an explicit supply or demand wage equation (Rosen, 1974), but rather the wage change associated with any given start time change is a market-determined compensating differential. The hedonic wage literature assumes a competitive labour market, so the variables (including start time) can be assumed to be exogenous in the estimation procedure, because employers set wages as a function of work start time.

We estimate the *logarithm* of the wage, *W*, as a function of start time and control variables. For example, we control for the size of the firm, which captures variation in productivity. We further control for other variables, such as presence of a child, which may be correlated with omitted variables (for example, childcare start time) that are correlated with our main variable of interest, work start time. Start hour changes may include observations where the worker's occupation also changes. So, by not controlling for occupation we allow that occupation is an endogenous choice.

Because the hedonic wage literature generally allows wage rates to vary with hours of work (Kinoshita, 1987; Trejo, 1991; Hartog and Oosterbeek, 1993; Dustmann and van Soest, 1998), we control for (contractual) *weekly hours*. Hourly wage rates are calculated by dividing monthly earnings by monthly hours.[6] Such a calculation introduces a well-known form of measurement error, known as 'division bias', because measurement error in hours enters both the left and right hand-sight of the equation that we will estimate. This results in a spurious negative correlation between hours and the wage rate (Hartog and Oosterbeek, 1993; Dustmann and van Soest, 1998), because overreporting of hours would lead to an underreporting of the hourly wage rate. So, we calculate the wage rate using *contractual* hours instead of usual hours, because the division bias in hourly wage rates using contractual hours is substantially less than using usual hours.

We emphasize that we also include (the usual) *daily hours of work* (in line with Zhang et al., 2005), so start time captures the effect of start and end times (because end time equals start time plus daily hours). Because we control for daily hours and weekly hours, we also control for number of days worked per week (as the number of days worked is fully determined by the number of daily and weekly hours). Furthermore, by controlling for daily hours of work and weekly hours, we also control for work flexibility over the week, which may be relevant from a transportation perspective as the literature points out a relationship between type of workweek and commuting (see, for example, Hung, 1996).

Using control variables may not be sufficient to generate consistent estimates of start time (Arnott, 2007). So, we include worker fixed effects, which controls for unobserved time-invariant worker characteristics. In the estimation procedure, only within-worker's differences in variables are employed.

2.3 Empirical results

We focus on the effect of the morning start time (measured in hours), which we observe for

[6] This variable is the average hourly wage during one year. We set €3 as minimum hourly wage, though no general legal minimum wage exists in Germany (Immervoll, 2007).

fixed schedules. We control for other work schedules by including dummies for flexible schedules, evening work (starting after 12:00 a.m.) and night work (starting before 5:00 a.m.). As emphasized in the introduction, it is plausible that the wage is a non-linear function of start time, so we employ a range of non-linear specifications (quadratic and piecewise linear functions; interval dummies).

The results given a quadratic specification (see Table 1, column 1a) indicate that the relationship between wages and start time is inverse U-shaped: the effect of start time on wage is positive and the square of start time is negative, with a maximum around 7:41 a.m. (s.e. 1.29). The use of a quadratic specification may not be appropriate, because it allows for an (inverse) U-shaped function, but it does *not* allow for any other functional form. Therefore, we also estimate a model using six morning start time dummies: two before the peak (5:00–5:59 a.m. and 6:00–6:59 a.m.) and three after the peak (8:01–8:59 a.m., 9:00–9:59 a.m. and 10:00–12:00 a.m.), where peak time (6:59–8:01 a.m.) is the reference category. The results (see column 2) suggest that wages are slightly lower before 7 a.m. and after 9 a.m., but these effects are statistically insignificant using a F-test, reported at the bottom of the table.

One disadvantage of a time-interval dummy specification is that it ignores variation *within* intervals. This seems restrictive, as the difference in congestion or scheduling preferences within these intervals may be quite large. So, we also use a piecewise linear specification with four predefined knots at 5:00, 6:59, 8:01 a.m. and 12:00 a.m., so we estimate three different slopes (Pindyck and Rubinfeld, 1991, pp. 126–7). The piecewise linear function we estimate is standard and has three different time intervals ruling the effect of start time on wage by specifying the model, in general notation, in the following way: $\beta_1(S-5)D_1+\beta_2(S-5)D_2+\beta_3(S-5)D_3 \; +2\beta_1(D_2+D_3)+\beta_2 D_3$, where β_i, i = 1, 2, 3, refers to the coefficient to be estimated in interval i, S is start time (in hours) between 5:00 and 12:00 a.m., D_1, D_2 and D_3 are before-peak, peak and after-peak start time dummies. As can be seen from the F-test at the bottom of Table 1, column 3, this specification also does not support any relationship. We also examined other knots, but the results are the same.

Table 1. *Estimates of net hourly wage in log (in euros) (SOEP 2004, 2006, 2008)*

	[1a]	[2]	[3]	[1b]
		Worker fixed effect		OLS
	Quadratic function	6 start time dummies	Piecewise linear function	= [1a] except no fixed effect
Morning start time variables				
Start time (hours)	0.089 (0.035)**			0.225 (0.033)**
Start time squared (hours)	–0.006 (0.002)**			–0.013 (0.002)**
Start time 5:00–5:59		–0.015 (0.020)		
Start time 6:00–6:59		–0.006 (0.008)		
Start time 8:01–8:59		0.001 (0.008)		
Start time 9:00–9:59		–0.022 (0.011)**		
Start time 10:00–12:00		–0.023 (0.027)		
Start time (hours)/10 (before peak)			0.002 (0.016)	
Start time (hours)/10 (peak interval)			0.008 (0.011)	
Start time (hours)/10 (after peak)			–0.014 (0.019)	
Start time control variables				
Flexible schedule	–0.007 (0.006)	–0.004 (0.006)	–0.004 (0.006)	0.012 (0.006)**
Night work	–0.028 (0.038)	–0.027 (0.038)	–0.025 (0.038)	–0.145 (0.034)**
Evening work	–0.049 (0.021)**	–0.046 (0.021)**	–0.045 (0.021)**	–0.036 (0.019)*
Other controls				
Daily working hours in log	0.158 (0.018)**	0.157 (0.018)**	0.158 (0.018)**	0.422 (0.017)**
Weekly working hours in log	–0.532 (0.018)**	–0.533 (0.018)**	–0.532 (0.018)**	–0.252 (0.015)**
Self-employed	0.025 (0.016)	0.025 (0.016)	0.025 (0.016)	0.170 (0.015)**
White collar	0.030 (0.010)**	0.030 (0.010)**	0.030 (0.010)**	0.144 (0.006)**
Civil servant	0.038 (0.019)**	0.038 (0.019)*	0.038 (0.019)*	0.347 (0.011)**
Firm size < 20	0.013 (0.008)	0.012 (0.008)	0.012 (0.008)	–0.165 (0.011)**
Firm size from 20 ≤ 200	0.002 (0.007)	0.002 (0.007)	0.002 (0.007)	–0.107 (0.010)**
Firm size from 200 ≤ 2000	0.004 (0.007)	0.004 (0.007)	0.003 (0.007)	–0.047 (0.010)**
Firm size unknown	0.018 (0.012)	0.018 (0.012)	0.018 (0.012)	–0.006 (0.018)
Other household income in log	–0.036 (0.003)**	–0.036 (0.003)**	–0.036 (0.003)**	–0.037 (0.003)**
Other household income unknown or zero	0.089 (0.007)**	0.089 (0.007)**	0.089 (0.007)**	0.104 (0.008)**
Partner	0.056 (0.008)**	0.056 (0.008)**	0.056 (0.008)**	0.072 (0.006)**
Child	0.060 (0.008)**	0.060 (0.008)**	0.061 (0.008)**	0.133 (0.007)**
Female × child	–0.061 (0.015)**	–0.061 (0.015)**	–0.062 (0.015)**	–0.089 (0.011)**
Primary and lower education				–0.286 (0.010)**
(Upper) secondary education				–0.258 (0.006)**
Post-secondary non tertiary education				–0.213 (0.010)**
First stage of tertiary education				–0.189 (0.009)**
Education unknown				–0.242 (0.022)**
Age/10				0.081 (0.003)**
Female				–0.177 (0.006)**
Constant				1.526 (0.137)**
Worker fixed effect	Yes	Yes	Yes	
p-value (F-test start time)	0.011	0.117	0.838	0.000
Adjusted R^2	0.917	0.917	0.917	0.520
No. observations	14,108	14,108	14,108	14,108
No. workers	8,364	8,364	8,364	8,364

Notes: Year, industrial sector and firm location controls included. Usual daily hours of work, contractual weekly hours of work, firm size is number of workers. ** and * indicate that estimates are significantly different from zero at 0.05 and 0.10 level. Standard errors are in parentheses.

These results do not support the conclusion of Wilson (1988), who reports that the relationship between wages and start time is *strongly* inverse U-shaped, as our results indicate that there is maybe a weak inverse U-shaped relationship. This may not even be true, as in the flexible specifications, we are not able to find any statistically significant effect. The results of an analysis without fixed effects can be compared to the results of Wilson (1988), who does not use these effects. The results without fixed effects (see Table 1, column 1b) imply that the relationship between wages and start time is strongly inverse U-shaped (with a *maximum* at 8:40 a.m.), in line with Wilson (1988) (and Figure 2). As emphasized above, it is plausible that relevant unobserved variables are correlated with start time, and these estimates are therefore spurious.

We also estimated separate models distinguishing between workers *with* and *without* young children (aged below 14 years), because the inconvenience of work schedules may be different for these different groups (see Table 2). For example, workers with young children may have a higher level of family responsibility to meet child-care schedules in the morning or family gatherings in the evening (another motivation could be that the presence of *children* is the main determinant of start times, as shown in separate analysis not reported here). In our data, 31 per cent of workers have a young child.[7]

Given a quadratic specification of start time (columns 1 and 4), the results suggest that the relationship between wages and start time is *U-shaped for workers with children* (with a minimum at 7:19 a.m.; s.e. 6.36), and *inverse U-shaped for workers without children* (with a maximum at 7:35 a.m.; s.e. 6.05). The results suggest therefore that workers with a child have to be compensated by higher wages if they start work at an off-peak time. However, the estimated minimum and maximum start times are not well-identified due to the large standard errors. Therefore, one may raise doubt on the validity of this interpretation.

[7] It is not possible to identify effects based on models of workers with children *with* and *without* a partner due to too small sample sizes.

Table 2. *Estimates of net hourly wage in log (in euros) by workers with and without children (SOEP 2004, 2006, 2008)*

	[1]	[2]	[3]	[4]	[5]	[6]
	Child			No child		
	Quadratic function	6 start time dummies	Piecewise linear function	Quadratic function	6 start time dummies	Piecewise linear function
Morning start time variables						
Start time (hours)	–0.124 (0.067)*			0.103 (0.041)**		
Start time squared (hours)	0.009 (0.004)**			–0.007 (0.003)**		
Start time 5:00–5:59		0.068 (0.046)			–0.021 (0.021)	
Start time 6:00–6:59		0.008 (0.014)			–0.003 (0.009)	
Start time 8:01–8:59		–0.007 (0.015)			0.012 (0.010)*	
Start time 9:00–9:59		0.023 (0.021)			–0.041 (0.013)**	
Start time 10:00–12:00		0.095 (0.048)**			–0.046 (0.032)	
Start time (hours)/10 (before peak)			0.011 (0.030)			0.010 (0.020)
Start time (hours)/10 (peak interval)			–0.011 (0.021)			0.001 (0.013)
Start time (hours)/10 (after peak)			0.046 (0.034)			–0.012 (0.022)
Start time control variables						
Flexible schedule	0.021 (0.011)*	0.019 (0.011)*	0.016 (0.011)	–0.010 (0.007)	–0.008 (0.007)	–0.005 (0.007)
Night work	0.026 (0.070)	0.024 (0.070)	0.022 (0.070)	–0.050 (0.045)	–0.051 (0.045)	–0.046 (0.045)
Evening work	0.065 (0.034)*	0.063 (0.034)*	0.029 (0.034)*	–0.112 (0.030)**	–0.118 (0.030)**	–0.115 (0.030)**
Other controls						
Daily working hours in log	0.180 (0.033)**	0.180 (0.033)**	0.178 (0.033)**	0.175 (0.022)**	0.176 (0.022)**	0.177 (0.022)**
Weekly working hours in log	–0.599 (0.035)**	–0.598 (0.035)**	–0.596 (0.035)**	–0.605 (0.024)**	–0.604 (0.024)**	–0.602 (0.024)**
Self-employed	–0.016 (0.027)	–0.016 (0.027)	–0.017 (0.027)	0.069 (0.020)**	0.069 (0.020)**	0.069 (0.020)**
White collar	0.012 (0.018)	0.013 (0.018)	0.012 (0.018)	0.032 (0.012)**	0.032 (0.012)**	0.033 (0.012)**
Civil servant	0.015 (0.036)	0.015 (0.036)	0.014 (0.036)	0.062 (0.024)**	0.061 (0.024)**	0.062 (0.024)**
Firm size < 20	0.020 (0.016)	0.021 (0.016)	0.020 (0.016)	0.016 (0.010)	0.016 (0.010)	0.015 (0.010)
Firm size from 20 ≤ 200	–0.005 (0.013)	–0.005 (0.013)	–0.005 (0.013)	0.018 (0.008)**	0.019 (0.008)**	0.019 (0.008)**
Firm size from 200 ≤ 2000	–0.006 (0.013)	–0.006 (0.013)	–0.005 (0.013)	0.016 (0.008)*	0.016 (0.008)*	0.016 (0.008)*
Firm size unknown	–0.001 (0.023)	–0.000 (0.023)	0.000 (0.023)	0.027 (0.014)*	0.027 (0.014)**	0.027 (0.014)**
Other household income in log	–0.046 (0.005)**	–0.046 (0.005)**	–0.046 (0.005)**	–0.027 (0.003)**	–0.027 (0.003)**	–0.026 (0.003)**
Other household income unknown or zero	0.111 (0.013)**	0.110 (0.013)**	0.111 (0.013)**	0.077 (0.008)**	0.077 (0.008)**	0.077 (0.008)**
Partner	–0.007 (0.025)	–0.009 (0.025)	–0.007 (0.025)	0.062 (0.009)**	0.061 (0.009)**	0.061 (0.009)**
Worker fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
p-value (F-test start time)	0.065	0.021	0.198	0.012	0.040	0.952
Adjusted R^2	0.925	0.966	0.925	0.921	0.921	0.921
No. observations	4,410	4,410	4,410	9,698	9,698	9,698
No. workers	2,831	2,831	2,831	6,016	6,016	6,016

Notes: Year, industrial sector and firm location controls included. Usual daily hours of work, contractual weekly hours of work, firm size is number of workers. ** and * indicate that estimates are significantly different from zero at 0.05 and 0.10 level. Standard errors are in parentheses.

A specification using six dummies (columns 2 and 5) also suggest a different relationship by worker: a U-shaped for workers with children and inverse U-shaped for workers without children. A U-shape relationship implies that, at least for some jobs, workers are more productive when they start outside the peak (as it is implausible that employers compensate for an inconvenient work schedule unless the worker is more productive); in addition, the benefits of starting at a non-peak time are relatively lower (for example, because higher inconvenience in scheduling times) and workers therefore demand higher wages. However, these results are only suggestive as they are not statistically significant. Furthermore, given a piecewise linear function (columns 3 and 6) – which is our preferred specification due to above-mentioned arguments – effects are also statistically insignificant. So, overall, our findings suggest that the relationship between wages and start times do not strongly differ by workers with and without children.

As sensitivity analyses, we re-estimated all models using a more narrow definition of morning start time (between six and ten o'clock) and added controls (commuting distance, job tenure and interactions of start time with self-employed), but the results remain the same. In our main analyses, we do not control for commuting distance because commuting distance does not affect the workers' productivity and therefore wages in a competitive labour market. However, according to the job search theory literature, distance is positively correlated to wages (see Manning, 2003). Excluding weekly hours, the signs of the effect of start time on wage are the same for all specifications, but the sizes of these effects are somewhat smaller than the ones discussed above, so all effects are statistically insignificant. We find a negative effect of weekly hours of work. A negative effect is also found in other German studies (Dustmann and van Soest, 1998). Excluding any other variable than weekly hours (including daily hours) generates almost identical results.

The welfare effects of a program that requires firms to stagger work hours (for example, the government may regulate the distribution of firms' start times) are theoretically unclear. The benefits of these programs (a reduction in external congestion costs) are relatively easy to determine; for example, the *external* savings in commuting time by starting at 9 a.m. instead of 8 a.m. (peak time) are estimated to be €2.45 per day.[8] However, there is little or no information on the costs in terms of productivity losses (or gains) and workers' disutility, so that the net effect is unknown.

Our results imply a weak (or no) relationship between wages and start time, which indicates that start time of workers has relatively little effect on wages (and therefore productivity and workers' disutility) suggesting that staggered-hours programs that induce workers to start work at non-peak times are welfare-enhancing due to the reduction in external costs. This is in contrast to Arnott et al. (2005) who, on theoretical grounds, conclude that it is better that governments do not interfere with the work schedules of firms.

Now suppose that governments impose a staggering-work-hours program for some industries or type of firms (for example, large firms) and also impose that wages remain fixed (which may be feasible in the short-run). For example, staggering can be done by regulating the distribution of work start times of firms with at least 1,000 employees. Alternatively, governments may stagger the work start times of civil servants.[9] If one believes the difference suggested by our results by type of worker, such programs enhance the surplus of workers without children, but decrease the surplus of workers with children, but induce opposite effects on the firms' surpluses.[10]

[8] The latter estimate has been based using an external congestion cost of 0.068€ per km (see Small and Verhoef, 2007, p. 99) and a mean one-way commuting distance of 18 km. This estimate is likely a maximum as it is based on the assumption that a commute for job starting at 9 a.m. does not induce any congestion.

[9] This is a second-best policy so that it is not clear a priori what happens at the peak period to trips that are made for other purposes than commuting.

[10] This suggests that these programs may enlarge the negative effect of having children on female's labour supply (Gutiérrez-i-Puigarnau and van Ommeren, 2010).

3.0 Conclusion

Transport economists have been interested in workers' work start time for many years, as start (and therefore end) times are closely related to morning (afternoon) peak congestion. Staggered-hours programs to mitigate congestion also affect worker's preferences and productivity, and are then an interesting policy tool. Little is known about the effect of these programs on productivity and workers' preferences (Arnott, 2007). One (indirect) way to get more information about this is to estimate the effect of start time on wages. In this paper, we examined the effect of workers' morning start (and end) time on wages for Germany.

Arnott (2007) emphasized that it is important in hedonic wage studies to control for worker sorting based on unobserved variables. We take this issue into account by estimating worker fixed-effects models. Wages are a slight inverse U-function of start time, although some specification may imply that wages are constant when work starts before peak time (7–8 a.m.) and only *slightly* lower after peak time. However, wages are more likely U-shaped for workers with a child when work starts after peak time.

It has been emphasized that staggering of work hours by governments in order to mitigate congestion must be well designed in order not to reduce social welfare (Arnott, 2005). The benefits of staggering work hours are clear (a reduction in external congestion costs), but there is little or no information on the costs in terms of productivity losses and workers' disutility. Although our data does not allow us to distinguish between productivity and workers' disutility effects of start times on wages (since data on worker productivity is required), we still can speculate. Our results imply that the start time of workers has relatively little effect on wages (and therefore productivity and workers' disutility) suggesting that staggered-hours programs that induce workers to start work at non-peak hours, maybe even when introduced on a large scale, may be beneficial. So, in this respect, we are slightly more optimistic than Arnott et al. (2005) who recommend that governments should not use these programs.

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