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ABSTRACT

Cues for Coordination: Light, Longitude and Letterman*

Market productivity is often greater, and leisure and other household activities more enjoyable, when people perform them simultaneously. Beyond pointing out the positive externalities of synchronicity, economists have not attempted to identify exogenous causes that affect timing. We develop a theory illustrating conditions under which synchronicity will vary and identify three factors – the amount of daylight, the timing of television programming, and the benefits of coordinating work schedules across a large country – that can alter timing. Using the American Time Use Survey for 2003 and 2004, we first show using a natural experiment that abstracts from the impacts of daylight hours and television timing that an exogenous shock to time in one area leads its residents to alter their work schedules to coordinate more closely with people elsewhere. We then show that both television timing and the benefits of coordinating across time zones in the U.S. generally affect the timing of market work and sleep, the two most time-consuming activities people undertake. These impacts do not, however, differ greatly by people's demographic characteristics, suggesting that longitude and television establish social norms that affect everyone.

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1 Introduction

Coordination is central to economic behavior. The production of goods and services typically requires the services of complementary inputs, including the services of workers of different types. Firms often cooperate with others in order to maximize their joint profits. Generating satisfaction in the household requires purchasing goods and using one's own and rented time to create a commodity that yields utility (Becker, 1965). Policymakers must take into account how their choices affect the choices of other policymakers, so that coordination typically underlies their thinking too. The study of these various types of coordination has formed the basis for much of microeconomic theory, and testing them and inferring the values of the parameters describing parts of the theories has occupied a substantial proportion of empirical economists' time for at least half a century.

That every activity implicitly must have a time subscript has entered theoretical analyses only rarely (but see the excellent exception in Winston, 1982). Using capital services alone from midnight to noon and labor services alone from noon to midnight will lead to much less (zero?) output than if both are utilized in the same twelve hours of the day; and production will probably be higher if workers of different types are on the job at the same time than if each one works at different times. Firms that cooperate do so in a time dimension; and the extent of the temporal coordination has macroeconomic impacts (Cooper, 1999). For most people the services of an automobile are more valuable if they are combined with the simultaneous inputs of drivers' and passengers' time when the auto is on hand; and the utility gained by the people involved is usually higher if enjoyed simultaneously. Finally, policymakers need to take into account both what other policies are being undertaken and when their effects will be felt.

When activities take place matters, as does the extent of temporal coordination in generating them. Despite the importance of when cooperating agents engage in various activities, there has been remarkably little empirical study of the temporal nature of activities and even less of temporal patterns of coordination. One study (Cooper and Haltiwanger, 1993) demonstrated how government policies can induce firms to undertake decisions about product design at the same time. Others (Hamermesh, 2002; Hallberg, 2003) showed that spouses prefer to work (and engage in household production) at the same times of the day, and that such coordination is a superior activity. Jenkins and Osberg (2005) demonstrated how an increase in the fraction of people in a region who engage in a particular leisure activity has positive ceteris paribus impacts on individuals' choices of leisure activities.

Very little other empirical study of the timing of coordination appears to have been done. Perhaps part of the reason is that, while it is clear that the people's synchronization of their work activities is important (Weiss, 1996), as is their coordination in timing their non-market activities, it is very difficult to identify factors that might cause the extent of synchronization to differ among different groups of workers and consumers. Indeed, it is difficult to find any external cue that might generate greater or lesser coordination. In this study we do exactly that—identify several determinants of temporal coordination that are clearly external to the agents making the decisions to coordinate. We thus show that the degree of synchronization does not just happen—it results from the gains to coordination of activities. Temporal coordination partly results because of these welfare gains, but it also can be affected by cues, both natural and artificial. The artificial cue we examine here is the timing of television programs, while the natural cue is circadian rhythm as modified by daylight (Wever, 1982). We also examine the importance of coordination that is induced by the gains to simultaneous production across geographic areas where the nominal time of day differs. We refer to these as light, television, and work cues, respectively.

In the next section we write down a simple model that allows us to illustrate some trade-offs involved in temporal coordination and to identify instances where we might expect cues for coordination to be more or less powerful. In Section 3 we describe the nature of the institutions that generate these cues, while in Section 4 we present the data used to analyze their importance. Section 5 offers the central results of the paper, both the results of a natural experiment that demonstrates the empirical importance of work cues as induced by time zones and the estimates of models that show the independent importance of all three cues. Section 6 explores how the impacts of these cues vary across demographic groups.

2 Theoretical Model

Scheduling choices will very likely depend on individual preferences for the timing of activities as well as for synchronization with parties who are both internal and external to an individual's geographic area. Our model takes into account the coordination trade-offs associated with the timing of activities and then predicts which individuals will be most responsive to the coordination cues that influence the choices of others.

Assume that there are two periods of equal length in each day and that a representative worker must engage in market production during one period and household production during the other. The labor market productivity of worker i is determined both by individual characteristics unrelated to time of day as well as by coordination effects arising from the timing of his activities. To take the first into account, assume that each worker can earn a wage of $w_i \geq 0$ in the absence of any coordination effects. Coordination effects are introduced by assuming that productivity is enhanced by both local and distant market activity. Let N be the number of local workers, and let p be the proportion of these workers who choose to work during Period 1. Then worker i's productivity is increased by a factor of $\beta_i Np$ during Period 1, where $\beta_i \geq 0$. In addition, labor complementarities with workers outside of the local region also enhance worker i's productivity. Assume that extra-regional workers choose to work during Period 1 and that worker i's productivity increases by a factor of $\alpha_i \geq 0$ if he chooses to engage in market work during that period.[1] Finally, we allow for some

[1]Note that the sequential choice of scheduling in which external workers have selected to engage in market

time preferences for our worker that can account for, say, a desire to coordinate household production with a non-working spouse during Period 1.

Suppose that labor productivity changes by a factor of θ_i during Period 2 as a result of worker preferences for the timing of activities. Combining these individual-level parameters that affect temporal productivity, let be z_{1i} be the earnings of worker i if she chooses to engage in market production during Period 1 and z_{2i} be her earnings if she works during Period 2. Then

$$z_{1i} = w_i(1 + \alpha_i + \beta_i N p) \tag{1}$$

and

$$z_{2i} = w_i(1 + \beta_i N(1 - p) + \theta_i) \tag{2}$$

where

w_i = worker i's base wage

α_i = worker i's increased productivity due to external coordination outside of the region

β_i = worker i's increased productivity due to internal coordination within region

N = the number of workers in the region

p = the proportion of workers in the region who work during Period 1

θ_i = worker i's increased productivity due to a preference for working during Period 2.

Worker i will choose to work during Period 1 if his earnings are higher during that period, that is, if $z_{1i} - z_{2i} \geq 0$. Hence, worker i will choose to work in Period 1 if $\alpha_i + \beta_i N[2p(\boldsymbol{\alpha}, \boldsymbol{\beta}, \boldsymbol{\theta}) - 1] - \theta_i \geq 0$. Worker i's decision depends not only on his own coordination parameters, but, because $p(\boldsymbol{\alpha}, \boldsymbol{\beta}, \boldsymbol{\theta}) = \frac{1}{N}\sum_{i=1}^{N} y_i(\alpha_i, \beta_i, \theta_i)$, also on the preferences of others in his region. For

activity during Period 1 is purely a modeling convenience. Similar predictions are obtained by modeling workers in the regions as making simultaneous scheduling choices but having differences in inter-regional cues such as light.

$(y_1^*, y_2^*, ..., y_N^*)$ to be a Nash equilibrium, for each i, y_i^* must satisfy the individual decision rule given what all other individuals have chosen. Hence, the Nash equilibrium choice of outcome for arbitrary worker i satisfies

$$(3) \qquad y_i^* = \begin{cases} 1 \quad if \quad \alpha_i + \beta_i[2\sum_{j=1}^{N} y_j^*(\boldsymbol{\alpha}, \boldsymbol{\beta}, \boldsymbol{\theta}) - N] - \theta_i \geq 0 \\ 0 \quad if \quad \alpha_i + \beta_i[2\sum_{j=1}^{N} y_j^*(\boldsymbol{\alpha}, \boldsymbol{\beta}, \boldsymbol{\theta}) - N] - \theta_i < 0 \end{cases}$$

Although it is not possible to characterize this equilibrium by solving the set of N discontinuous equations, we can characterize the nature of equilibrium coordination as a function of individual parameters. Because β, the benefit of internal coordination, is positive, workers in this region will prefer to synchronize their schedules, all else equal. In other words, if the likelihood that worker i will select Period 1 increases, then the likelihood that other workers will follow suit increases as well, meaning that individual direct effects are only amplified in magnitude by the indirect effect via $p*$. Given this result, we can conclude that individual i is more likely to choose to work in Period 1 as α_i, his return to external coordination, increases. He is less likely to work in Period 1 as θ_i, his preference for working in Period 2, increases. Examining the effect of local coordination, he is more likely to work in Period 1 as the number of other local workers choosing this time slot increases. As his own return to internal coordination, β_i, increases, he is more likely to work in Period 1 if $p \geq \frac{1}{2}$,that is if the majority of local workers are employed during this period.

The theoretical model thus far has omitted the issue of "cues," instead looking simply at preferences for timing and synchronization. We view "cues" as the exogenous signals that influence timing decisions. For instance, time zones may serve as external cues to those who are coordinating with other regions. Those in the Central time zone may go to work at 8 a.m. because the easterners have just arrived at 9 a.m. in their region.

While measuring responsiveness to cues will shed light on the degree to which the need for coordination affects scheduling decisions, it is not possible to identify the individual parameters at work here. This model implies that individuals who benefit more from external synchronization of activities are more likely to coordinate with those outside of their region. It also indicates that even individuals who derive very small direct benefits from such coordination may also end up synchronizing with the external region because of the need to coordinate with other local residents. Hence, a waitress may have a small α_i because her productivity is not directly dependent on workers in other regions, but a large β_i because her productivity is influenced by other local residents, such as call center workers. So she may end up getting up early because others in her area are doing so. The observer, however, can only identify that she is responding to a cue for inter-regional coordination, not the underlying parameter that is driving this response. One interesting way in which insight might be gleaned, however, is by examining the impact of the cue of television scheduling. Because we can identify viewers and non-viewers, any impact that television cues have on non-viewers can be assumed to enter through the need for local coordination.

As a final note, if we consider θ_i as accounting for personal preference for working in Period 2, then factors that tend to diminish this preference will increase the level to which our worker is driven by coordination concerns. For instance, to the extent that household production by an unmarried individual depends less on others, he may be more likely to coordinate externally.

3 Background on Time Zones and Television

The discussion above suggests that we might observe coordination arising from local external cues, such as television programming and sunlight, and from inter-regional external cues, such as decisions made elsewhere about when production will take place. In this section we discuss how these cues are determined exogenously. From early childhood every American knows that the United States is divided into time zones. What is less known to most Americans is that until the growth of railroad traffic after the Civil War scheduling was not uniform, and different areas, even those in close proximity, operated on different times (O'Malley, 1990). With the Standard Time Act of 1918 the current four (contiguous) U.S. time zones (Eastern, Central, Mountain and Pacific), were established and have been in effect since then, with minor changes at the edges of the zones. The current division of the country is shown by the state-county map reproduced in Figure 1. The nominal times in the other three time zones differ from that in the Eastern zone at the same real time by one, two and three hours respectively.

Twelve of the 48 states are in more than one time zone, as is Alaska (most of which is one hour behind the Pacific zone). All of Hawaii is two hours behind Pacific time. Most of the United States goes on daylight saving time (DST) in early spring and goes off it (onto standard time–hereafter ST) in mid-autumn. Certain areas, particularly the entire states of Arizona and Hawaii, and many parts of Indiana (including the Indianapolis metropolitan area) remain on standard time all year.

Most young children in the United States also learn the mantra announcing prime-time television shows, "10 p.m. Eastern and Pacific, 9 p.m. Central and Mountain:" Television shows from late afternoon onwards appear one nominal hour earlier in the middle two time zones than in the other two zones. This difference is a relic of the technology of radio transmission (Winston, 1998). During the late 1920s, when the radio networks were being developed, the technology was such that the signals could not be sent across the whole country. Thus one broadcast was produced and performed live to serve both the Eastern and Central time zones, appearing at the same real time in both zones, but an hour earlier in nominal time in the Central zone. For the other two zones (which encompassed at that time only tiny fractions of the population) the shows were transmitted recorded at different times. The essential point is that the television time-zone mantra precedes television and was dictated by technological limitations in the broadcast of radio signals that are no longer relevant but that still influence the timing of presentations in radio's main successor medium.

4 Time-Use Data and the Distribution of the Population by Time Zone

Most of the analyses that we present are based on the American Time Use Survey, an on-going Bureau of Labor Statistics effort that began in 2003 and that currently collects roughly $13,000$ time diaries per year, 1100 each month, from recent participants in the Current Population Survey (see Hamermesh et al., 2005, for a description). Each of the selected respondents (one per CPS household) is asked to complete a diary for the most recent day (4 a.m.-3:59 a.m.) in which s/he lists when each activity undertaken began and what it was. The activities are coded into 406 separate categories. We use data from the twenty-four months of diaries collected in 2003 and 2004, which yield 20,790 and 13,973 observations respectively. Because the observations are chosen from recent respondents to the Current Population Survey, all the usual CPS demographic information is available on the respondents and their spouses and children (if any). In addition to information from the ATUS and CPS, sunrise and sunset data were collected from the United States National Observatory website and matched to the day and location of each observation.

We focus here on three activities: market work, sleeping and watching television. These activities comprise a large fraction of the typical respondent's day: On a representative day they totaled 226, 509 and 158 minutes respectively, thus accounting for 62 percent of the available time on the days surveyed. They are undertaken by 39.7, 99.9 and 78.5 percent of the sample respectively on the representative day. In addition, these three activities are by far the most important single activities undertaken, with even television-watching accounting for over twice as much time as the next most time-consuming activity.

While our use of residents in a particular time zone as first-movers in our model was an expositional convenience, in reality the Eastern zone is and has been dominant. As Table 1 shows, nearly half the country's population is currently in the Eastern zone (and not in

Indiana). That is true today, and its importance was even greater in 1920, the Census year nearest the date when time zones became more or less fixed by statute. The major change in the past 85 years is that the relative importance of the Eastern and especially the Central time zone has diminished, with the increase taken up by the Pacific zone. Nonetheless, the Eastern zone remains dominant.

Choosing a sample for the analysis is rendered difficult by the inability to classify exactly in what time zone each respondent in the ATUS resides. In the samples used in most of the analyses for the U.S. we include only those individuals in the contiguous states whose time zone can be identified with certainty from the state or metropolitan area where they are located, and for whom DST applies during part of the year. The distribution of the sample is shown in Table 1. Of all the respondents 6.0 percent cannot be classified, and 0.1 percent are in Alaska. 91.2 percent can be classified into zones that switch from DST to ST, while 2.7 percent are in identifiable zones that remain on ST all year.

5 Do Cues Matter?

As a set of initial examinations we consider whether the ATUS data show evidence that the cues of work spillovers, television and daylight matter.[2] Finding differences in the timing of activities across time zones would not demonstrate the importance of coordination and its determinants through external cues. Rather, inferring their existence is possible only if we see behavior that is consistent with the generation of differential cues across time zones arising from the timing of television broadcasts, variation in daylight, and the relation of real to nominal times across the zones.

[2]We ignore differences in timing that may arise from variations in the weather. These may affect very high-frequency behavior (see(Connolly, 2005)), but are hardly likely to alter long-term differences across regions. Average climates across time zones in the contiguous United States do not differ greatly, in any event, as the time zones run north to south.

5.1 A Natural Experiment

As we noted above, Arizona, Hawaii and much of Indiana remain on ST throughout the year. Thus while the rest of the nation is on DST, these areas are respectively 3, 6 and 1 hours behind Eastern time; while the rest of the nation is on ST, they are respectively only 2, 5 and 0 hours behind Eastern time. Moreover, in each of the non-daylight saving locations, as in the rest of the nation, the nominal time at which television broadcasts appear does not change during the year in response to nominal time changes. So, Arizona is essentially on Mountain time during the winter but Pacific time during the summer when it does not "spring forward" with the rest of the Mountain time zone. However, its television schedules remain at the nominal Mountain times. This allows us to construct a double-difference estimator of the effect an hour shift in time zone, holding nominal television times constant:

$$\Delta^2 = (p_{DST} - p_{ST})_{exper} - (p_{DST} - p_{ST})_{control} \tag{4}$$

where p is the proportion of individuals performing a particular activity during a 15 minute period and *exper* indicates "experimental" locations that do not observe DST while *control* locations do. Δ^2 is a measure of the impact of the exogenous shock to cues in Arizona, Hawaii, and Indianapolis that occurs when most of the U.S. resets their clocks for daylight saving time. This shock, moreover, does not involve a change in the television cue. Table 2 presents the estimated single- and double-differences describing sleep, work and television time for the quarter-hour 7:30-7:45 a.m. and for sleep and television time at 10:30-10:45 a.m.. (The differences look quite similar at the quarter-hours adjacent to these two.) People in these three unusual localities are roughly 50 percent more likely to be working early in the morning when the rest of the country is on DST than when the entire nation is on ST. Moreover, in the rest of the country there is no seasonal difference in the propensity to work at this early hour. Together these single-differences generate a double-difference that is large and highly significant statistically.

The ability of workers in these areas to shift their schedules is generated mainly by their choosing to alter their sleep patterns. The fraction of respondents who are still asleep at 7:30 a.m. in these areas is much lower when the rest of the country is on DST than when it is on ST. The fraction asleep at 10:30 a.m. is only slightly higher on those days, but in the rest of the country fewer people are asleep when DST is in effect than during ST. Thus the double-differences on the timing of sleep are statistically significant, and they too indicate the role of the benefits of coordinating work activities with the rest of the country.

While the rest of the country is slightly (but significantly) more likely to watch television in the late evening during DST, the special areas are less likely to watch than when DST prevails elsewhere. Since the nominal timing of television programs does not change over the year, this shifting of viewing habits is also consistent with the changed cue resulting from the benefits of external coordination of work timing.

The work cue clearly changes differentially between the area that remains on ST all year and the rest of the country. Given the more southerly location of the areas that are always on ST, whether the effects of the daylight cue change differentially over the year depends on the timing of these activities in response to changes in the amount of daylight. It is unclear a priori in what direction these effects might go. To examine whether the results are being generated by the benefits of coordinating work inter-regionally or from cues from daylight, we restricted the sample to the 106 days in the two years during ST when the amount of daylight was the same as that on the 106 days when most of the nation was on DST. We then recalculated Δ^2 for this reduced sample.

While the quartering of the sample reduces the significance levels of these double-differences, the point estimates hardly change. In order of the estimates listed in the final column of Table 2 they become -0.056, 0.085, -0.034, for the early morning quarter-hour, and 0.059 and -0.056 for the late evening quarter-hour. The changes in behavior in the areas that do not switch to DST result from the benefits of coordinating work schedules with the rest of the country, not from differences in available daylight between ST and DST (and clearly not from television schedules, since the latter do not change over the year).

5.2 Separating the Cues

While our double-difference estimates of the effect of not following daylight saving time suggest that coordination with other regions is a significant determinant of schedules, they do not address the impact of local cues on coordination. In order to take the three cues (time zone, television zone, and sunlight) into account simultaneously, we use probit models for each of the 96 fifteen-minute periods into which we can use the ATUS to divide the day. The cue variables are: *workcue*, which is 0 for the Eastern time zone, 1 for Central, 2 for Mountain, and 3 for Pacific; *tvcue* which is 0 for the two coasts and 1 for the middle of the country (where television schedules are an hour earlier nominally); and, *sunrise* and *sunset*, which measure the minute of the observation day when the National Observatory calculates each occurred.[3] We also include various demographic variables as well as one-digit occupation and industry indicators in the work probits. Finally, we control for the total number of minutes in the day devoted to a given activity, allowing us to isolate the impact of these cues on scheduling, holding total consumption of the particular activity constant.[4]

Table 3 reports average marginal effect estimates from representative probits for television viewing, sleeping, and working, Monday through Friday. Note that the sample in the work probits is restricted to those who worked at some point during the observation day in order to further isolate the effect of scheduling. Not surprisingly, the more time in the day a person devotes to television, sleep, or work, the more likely he is to be performing each activity at

[3]The variables *tvcue* and *workcue* describe the four time zones. If we replace these two by indicator variables for three time zones, likelihood ratio tests do not imply an improvement in our ability to describe variations in the probabilities.

[4]The central results change only slightly if these totals are not held constant.

the given time. However, holding total consumption constant, we find that the probability that an individual is watching television between 11 and 11:15 p.m. decreases with age, while the probability that he is awake between 7 and 7:15 a.m. and at work between 8 and 8:15 a.m. increases until retirement age. In addition, as education levels increase, individuals appear to be more likely to be watching television at a late hour, more likely to sleep in, and less likely to be at work early.

Marital status, and children don't appear to have any impact on the scheduling of television viewing at 11 p.m., but married individuals are less likely to be sleeping at 7 a.m. and more likely to be at work at 8 a.m., an effect that is magnified considerably for married males. Finally, to save space, indicator variables for industry and occupation are not reported for the work probits, but their estimated coefficients suggest the expected results. Individuals whose occupation is maintenance, management, business, or financial-related tend to be at work early, while those who are in sales and services are less likely to be at work at 8 a.m.. By industry, those employed in agriculture, mining, construction, and public administration are more likely to be at work at 8 a.m. than workers in other sectors.

Turning to the cues, individuals who are in the early television zones are about 5 percentage points less likely to be watching television between 11 and 11:15 p.m. than those who are in later television zones (for whom the late news is just beginning). Given that about 17 percent of people in the East are watching television at this time, this corresponds to nearly a one-third drop in the proportion viewing television in the middle of the country, bolstering our assertion that television schedules serve as a local coordination cue, as people in earlier television zones will tend to watch television earlier. Moreover, for a one hour shift to the west in the work cue, individuals are about 1 percentage point less likely to be watching television at this time. Finally, as sunset gets later, people are more likely to still be up watching television at 11 p.m., but the magnitude of the effect is quite small. A quick linear approximation suggests that if sunset is pushed back by an hour, the probability of watching television at 11 p.m. only increases by about half a percentage point.

While the effects of sunrise and sunset cues are minimal for all three activities, those of work and television cues continue. Individuals in the early television zones are 3.9 percentage points less likely to be asleep at 7 a.m. and 3.5 percentage points more likely to be at work at 8 a.m. In addition, for a one–hour increase (shift west) in the work cue, the probability of being asleep drops by 1.6 percentage points, although there is no significant effect on work. Within each time zone, both the television cue for local coordination and the time zone cue for external coordination help to determine scheduling. As a linear approximation, compared to the Eastern time zone, an individual in the Central zone is, on average, 5.4 percentage points more likely to be awake at 7 a.m. and an individual in the Mountain zone is 7.0 percentage points more likely to be awake. While the television cue for those in the Pacific time zone is identical to that in the East, the effect of being three hours earlier leaves residents there 4.7 percentage points more likely to be awake at this time than those in the East. These effects are quite large relative to the roughly 34 percent of easterners who asleep between 7 and 7:15 a.m. Central time zone inhabitants differ from the East primarily because of their earlier television schedule, while residents in the Pacific time zone differ in their schedules due to the combined effects of the work cue across three time zones.

Turning to all 96 periods in the day, the estimated average marginal effects and 95–percent confidence bands for the cues are presented in Figures 2 and 3. Figure 2 summarizes how both natural and artificial cues affect sleep schedules. Sunlight and circadian rhythms have the anticipated effects on sleep scheduling. If sunrise occurs one hour later, sleep probabilities are higher in the morning and lower in the evening as people shift their schedules later. Similarly, if sunset occurs one hour later, people again rise earlier and go to sleep later. It is artificial rather than natural cues, though, that have the largest effects. Being in the early television zones of the United States makes one significantly more likely to be awake in the morning and less likely to be awake in the evenings. The relative probability of being asleep in the evening for the early TV zones begins to spike at 10 p.m. with the end of prime time there, but it peaks at 11 p.m. as prime time ends on the coasts. At this time, people in the center of the country are 10 percentage points more likely to be asleep than people on the coasts, demonstrating the importance of television cues to sleep schedules. Turning to work cues, we see that for a shift one time zone west (to an earlier nominal schedule), individuals are less likely to be sleeping in the morning and more likely to be sleeping in the evening, holding television schedules constant. While the effects of this cue for coordination with other regions are significant, they tend to be about half the magnitude of the television cue for local coordination.

Figure 3 shows the marginal effects of the same cues on work. Although the trends for sunlight cues are again as anticipated— later sunrises or sunsets result in later starting times and ending times of work— the individual effects are insignificant. Similarly, a hour shift west to an earlier time zone leads to being at work earlier and leaving earlier; but, again, most of the individual effects are insignificant. Estimates of the effect of the television cue on work, however, show an interesting pattern. Individuals in the middle of the country are as much as 3.5 percentage points (at 8 a.m.) more likely to be working in the morning and as much as 3 percentage points (at 5:30 p.m.) less likely to be working in the evening. However, there is a dramatic downward spike in the middle of the workday. People in early television zones, it would appear, are far less likely to be working at lunch time than people on the coasts. One possible explanation is that people in the center of the country may work closer to home or to other locations where they take a non-working lunch break, while people on the coasts may be more likely to live in large cities where commuting home for lunch is difficult.

6 Are Some Groups More Responsive to Cues?

Thus far we have observed average sleep and work coordination both within and between regions of the country for the population as a whole. As our theoretical discussion implied, however, the returns to coordination may vary across demographic groups. We ask three questions about demographic differences in cue sensitivity: Do single people respond differently to coordination cues than people who share a household with somebody? Are the effects of work cues on sleep scheduling stronger for the employed than for those who are not working? Are people who do not watch television still responsive to television cues?

6.1 Household Status

Our model assumes that scheduling decisions are influenced by returns to both local and inter-regional coordination as well as by taste factors such as a desire to be at home with family at certain times. Individuals who have fewer personal or household scheduling demands may therefore be more strongly influenced by cues for intra- and inter-regional coordination. Figure 4 shows the relative impacts of television and work cues on scheduling decisions by people who are married and/or who have children under 17 living in the household ("non-singles") and for "singles," who are not married and do not report living with children. Looking at sleep scheduling, we see that the effect of work cues on sleep are virtually identical throughout the day for both singles and non-singles. The effect of television cues tends to be stronger for non-singles than for singles, however. As an example, at 7 a.m., there is no significant difference in the proportion of singles who are sleeping on the coasts and in the center of the country. Married people in the center of the country are a significant 2.8 percentage points less likely to be sleeping at this time. It seems plausible that non-singles are engaging in greater household coordination and that, in particular, they are more likely to watch television with others, amplifying the effects of television cues rather than dampening them.

Turning to the work schedules of singles and non-singles, for much of the day we see little difference in responses to cues. At certain key times, however, there is some evidence that singles are more responsive to cues for intra- and inter-regional coordination than are non-singles. In particular, note that at 7 a.m. there is no significant effect of television cues on work probabilities for non-singles, while singles are 3.7 percentage points more likely to be at work if they live in the early television zones. Looking at work cues, at 5 p.m. there is no significant effect of work cues on work probabilities for non-singles, while singles are 1.8 percentage points less likely to be working at this time.

6.2 Employment Status

We have referred to the cue generated by time zones— by the individual's longitude— as a "work cue" throughout this paper, with the implicit assumption that it is the need for work coordination across time zones that drives scheduling differences with each hour shift in time zone. If this is indeed the case, then we would expect that individuals who are currently employed will be more responsive to the work cue than individuals who are not working. Figure 5 presents the marginal effect of the work cue on sleep probabilities for both groups of individuals. Contrary to our expectations, it is not uniformly true that employed persons are more responsive to longitudinal cues. In particular, between about 6 and 10 a.m. employed persons are notably less responsive to work cues than those who are not working. Perhaps this is because longitudinal cues operate through more than returns to inter-regional work coordination and those with jobs have relatively less scheduling flexibility than those who are not working. This would also be consistent with the smaller effects of cues on sleep schedules than on work schedules.

6.3 Television Viewership

The television cue is particularly interesting because it may directly affect scheduling for viewers but, because of a need for local coordination, it may alter non-viewers' schedules as well. By examining the relative responsiveness of viewers and non-viewers to television cues, we begin to separate the direct effect of the cue on scheduling from the indirect effect that it provides through local coordination concerns. We divide our sample into "viewers," who watch half an hour or more of television on the reference day (77 percent of the sample) and "non-viewers," who watch less than half an hour of television. Figure 6 shows the relative responsiveness to television cues in work and sleep scheduling by these two groups.

Looking first at the effect of television cues on sleep schedules, we see that viewers tend to be more influenced by these cues, but non-viewers are responsive as well. For example, at 11 p.m., the peak of the spike induced by differences in prime time television schedules, television viewers in the middle of the country are 6.6 percentage points more likely to be asleep than those on the coasts. The non-viewers in the middle of the country are 4.2 percentage points more likely to be sleeping than those on the coasts.

Turning to the effect of television cues on work schedules by the two groups, there is less discernable pattern in the differences. When some pattern does seem manifest, it suggests that non-viewers are actually more responsive to television cues in their morning work schedules. Most of the differences between the two, though, are not significant.

7 Conclusion

We have investigated how the synchronicity that generates cooperation among factors of production and among consumers can arise through external cues. Of course, synchronous behavior will be productive because of complementarities in generating output and consuming goods and services; but the exact nature of the jointness of timing does not simply arise randomly— it may be affected by natural factors and may be altered by man-made changes in its determinants. These latter may arise from decisions that were made independent of any considerations of their impacts on the timing of activities, or they can be instruments through which policy might operate to alter behavior.[5]

These issues can be examined in areas where the possibility of both types of variations can be discerned. Because of its vast distances, both north-south and east-west, and because of political decisions taken nearly a century ago, examining the timing of the three most important (in terms of time spent) activities that people undertake— sleep, work and television-watching—in the U.S. offers the opportunity to analyze these issues. Our results, using the first large-scale data set providing information on how Americans spend their time, indicate that the natural cue of sunlight has some effects, and that the entirely artificial cue of the timing of television programs has still larger effects on the coordination of activities. Even larger impacts of the benefits of coordinating the timing of activities, particularly work in the market, at the same real time but different nominal times are apparent throughout.

While the roles of these three cues for coordination are evident, there is little sign that their importance differs greatly across individuals who differ in their marital status, employment status or even their occupation/industry. By inference one must conclude that the social norms that are established by natural cues, by the benefits to inter-regional coordination of employment, and by television programming dominate any consistent individual variations.

Prompted by the recent rapid growth of surveys offering large samples of individuals whose timing of activities is now available, research on the nature of temporal coordination should burgeon in the next decade. Examining the synchronicity of activities is the obvious complement to the vast literature on the quantity of different activities, particularly those

[5]For example, the decision early in the existence of the People's Republic of China to have one time zone covering a country whose expanse would, if it were governed by a Western model, justify three time zones, was clearly political and designed to enhance the cohesiveness of the population.

in the market, that has been such a huge component of labor economic and macroeconomic research.

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Figure 1: **Time Zones within the Contiguous United States**

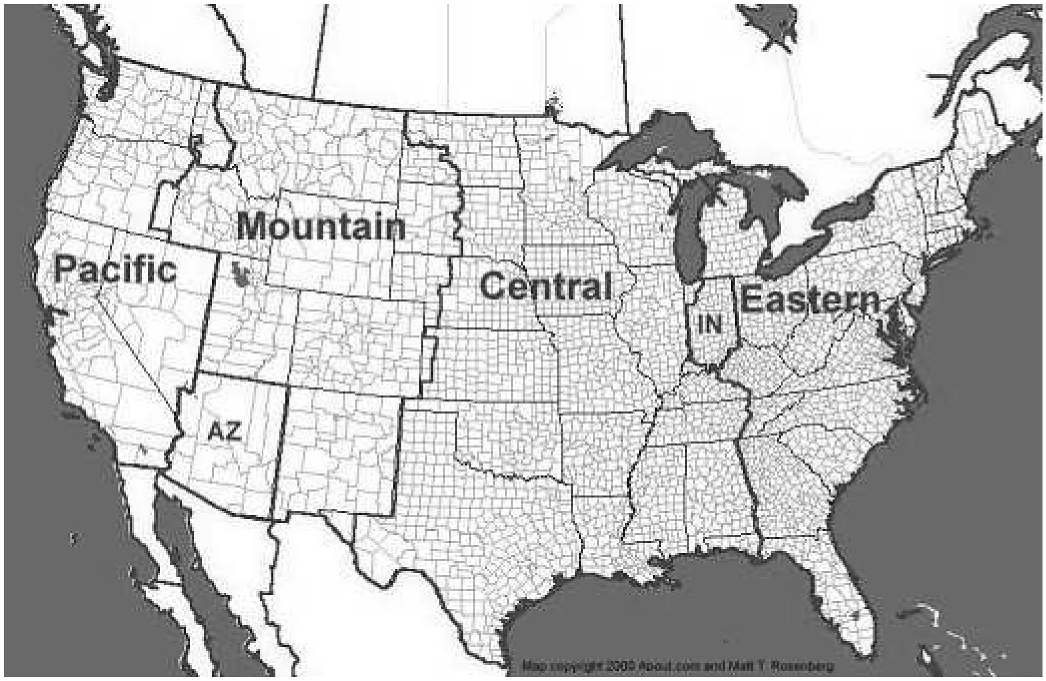


Table 1: **Population Distribution by Time Zone**

Time Zone	Census Bureau 1920	Census Bureau 2004	ATUS 2003-2004
Eastern	50.07	44.72	45.9
Central	33.40	26.52	27.4
Mountain	3.36	4.25	4.7
Pacific	5.32	16.35	13.2
Non-Classifiable	7.85	8.16	6.1

* *Non-classifiable states are AK, AZ, HI, IN, KY, and TN*

Table 2: **Double–Difference Estimates of the Effect of a Shock to the Time Zone Cue on Proportion Sleeping, Working, and Watching Television**

	Experimental Locations (don't observe DST)			Control Locations (observe DST)			
Time	ST	DST	Δ	ST	DST	Δ	Δ^2
7:30-7:45 a.m.							
Sleep	**0.3026**	**0.2466**	-0.0560	**0.3183**	**0.3234**	0.0051	**-0.0611**
	(0.0214)	(0.0195)	(0.0289)	(0.0037)	(0.0035)	(0.0051)	(0.0153)
Work	**0.1703**	**0.2523**	**0.0820**	**0.2142**	**0.2174**	0.0032	**0.0788**
	(0.0175)	(0.0196)	(0.0266)	(0.0033)	(0.0031)	(0.0045)	(0.0135)
Television	**0.0461**	**0.0351**	-0.0110	**0.0406**	**0.0349**	**-0.0057**	-0.0053
	(0.0098)	(0.0088)	(0.0128)	(0.0016)	(0.0014)	(0.0021)	(0.0063)
10:30-10:45 p.m.							
Sleep	**0.5670**	**0.5878**	0.0208	**0.5306**	**0.4977**	**-0.0329**	**0.0537**
	(0.0231)	(0.0222)	(0.0320)	(0.0040)	(0.0037)	(0.0055)	(0.0164)
Television	**0.1884**	**0.1620**	-0.0264	**0.2114**	**0.2223**	**0.0109**	**-0.0373**
	(0.0182)	(0.0166)	(0.0246)	(0.0033)	(0.0031)	(0.0045)	(0.0135)
number obs.	460	491		15,589	18,153		

* *Bold difference estimates are significant at 5% level. Standard errors are in parentheses.*

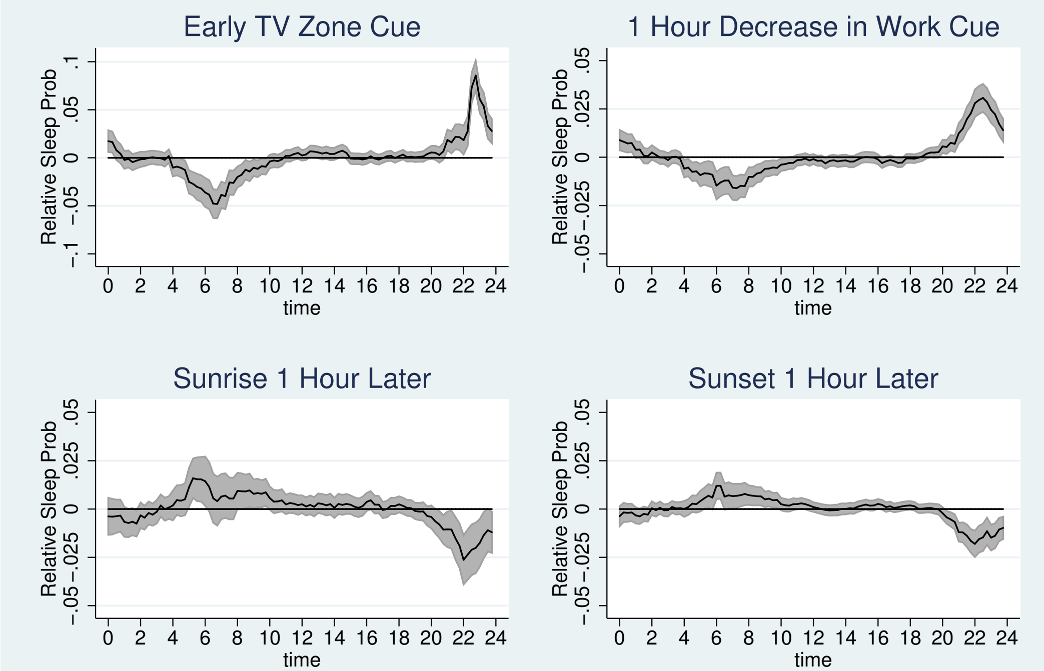
Table 3: **Average Marginal Effects for Select Television, Sleep, and Work Weekday Probits**

	Pr(Television) 11-11:15p.m.		Pr(Sleeping) 7-7:15a.m.		Pr(Working) 8-8:15a.m.	
	coef	*se*	*coef*	*se*	*coef*	*se*
hours tv	**0.0318**	0.0089	-	-	-	-
hours sleep	-	-	**0.0701**	0.0042	-	-
hours work	-	-	-	-	**0.0625**	0.0015
age 20–29	-0.0235	0.0132	**0.0462**	0.0183	**0.1389**	0.0280
age 30–39	**-0.0297**	0.0131	**-0.0427**	0.0168	**0.1909**	0.0281
age 40–49	**-0.0329**	0.0129	**-0.0556**	0.0165	**0.1780**	0.0295
age 50–59	**-0.0418**	0.0120	**-0.0714**	0.0157	**0.1856**	0.0277
age 60–69	**-0.0437**	0.0119	-0.0072	0.0173	**0.1689**	0.0268
age >70	**-0.0537**	0.0109	-0.0065	0.0164	**0.1336**	0.0356
educ 12	**0.0604**	0.0107	**0.0384**	0.0116	-0.0048	0.0200
educ 13–15	**0.0725**	0.0114	**0.0538**	0.0120	**-0.0470**	0.0208
educ 16	**0.1186**	0.0140	0.0238	0.0131	**-0.0484**	0.0227
educ >16	**0.1321**	0.0166	**0.0316**	0.0150	**-0.0689**	0.0255
married	-0.0034	0.0074	**-0.0243**	0.0092	**0.0399**	0.0136
male	0.0125	0.0078	0.0072	0.0098	-0.0148	0.0152
married∗male	-0.0039	0.0104	**-0.0371**	0.0132	0.0231	0.0192
kids age 0-5	-0.0105	0.0072	-0.0044	0.0090	**-0.0485**	0.0114
kids age 6-17	-0.0020	0.0061	**-0.0709**	0.0081	0.0168	0.0096
black	0.0109	0.0082	0.0145	0.0106	-0.0138	0.0156
other	-0.0104	0.0164	**0.0814**	0.0227	**-0.0781**	0.0289
hispanic	-0.0099	0.0088	0.0105	0.0112	-0.0133	0.0161
year 2004	-0.0056	0.0052	**-0.0136**	0.0066	0.0045	0.0094
Cues						
tv cue	**-0.0519**	0.0053	**-0.0385**	0.0070	**0.0354**	0.0099
work cue	**-0.0128**	0.0025	**-0.0157**	0.0032	0.0069	0.0046
sunrise	0.0001	0.0001	0.0001	0.0001	-0.0001	0.0001
sunset	**0.0001**	0.0000	**0.0001**	0.0000	-0.0001	0.0001
number obs.	16,604		16,604		8,249	

* *Bold coefficients are significant at 5% level.*

** *Work probits also included indicator variables for industry and occupation.*

Figure 2: **Marginal Effects of Coordination Cues on Sleep Schedules**



*95% confidence bands surround marginal effect estimates.

Figure 3: **Marginal Effects of Coordination Cues on Work Schedules**

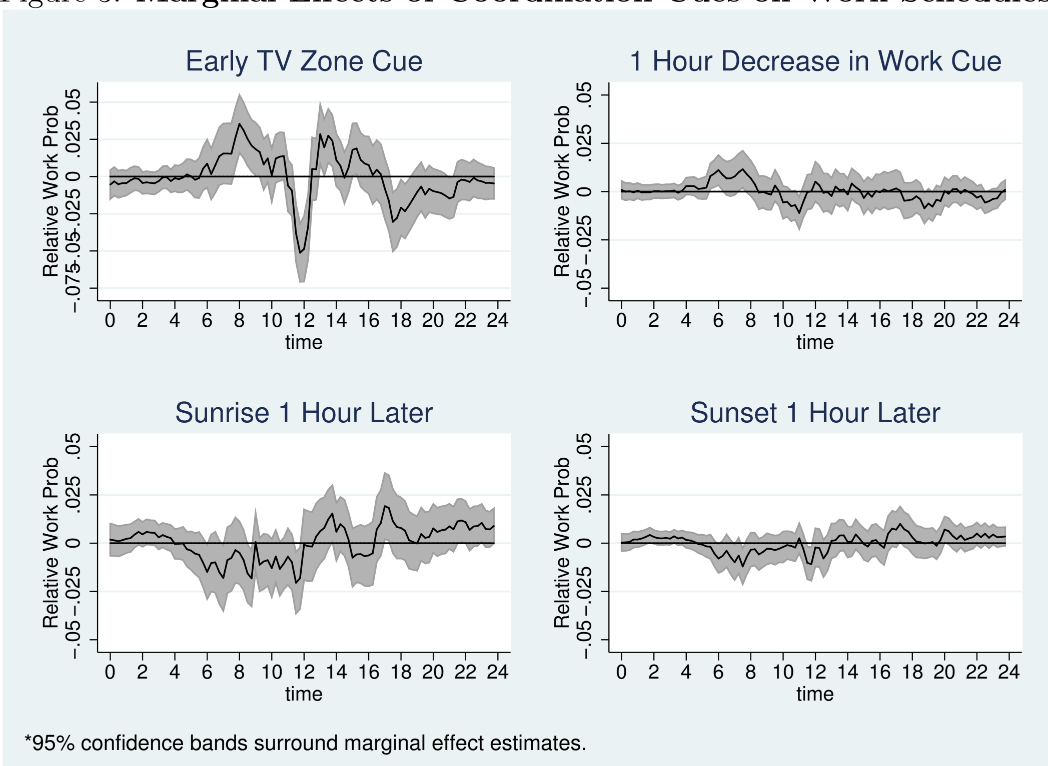


Figure 4: **Marginal Effects of Coordination Cues by Household Status**

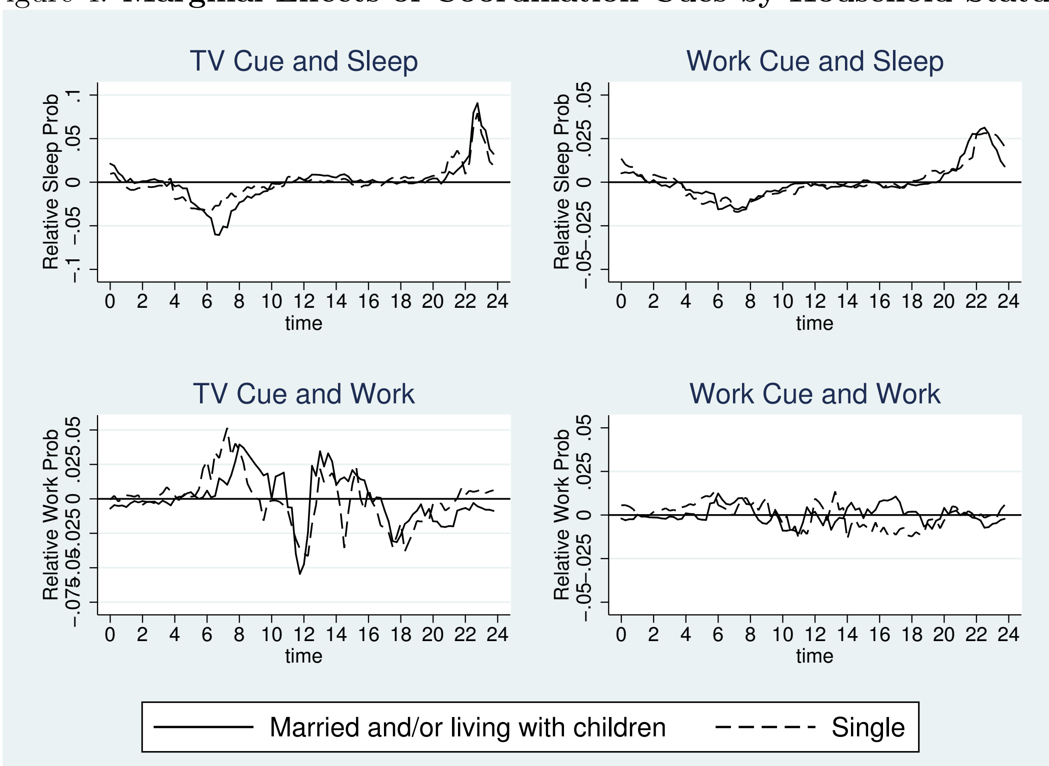


Figure 5: **Marginal Effects of Coordination Cues on Sleep by Employment Status**

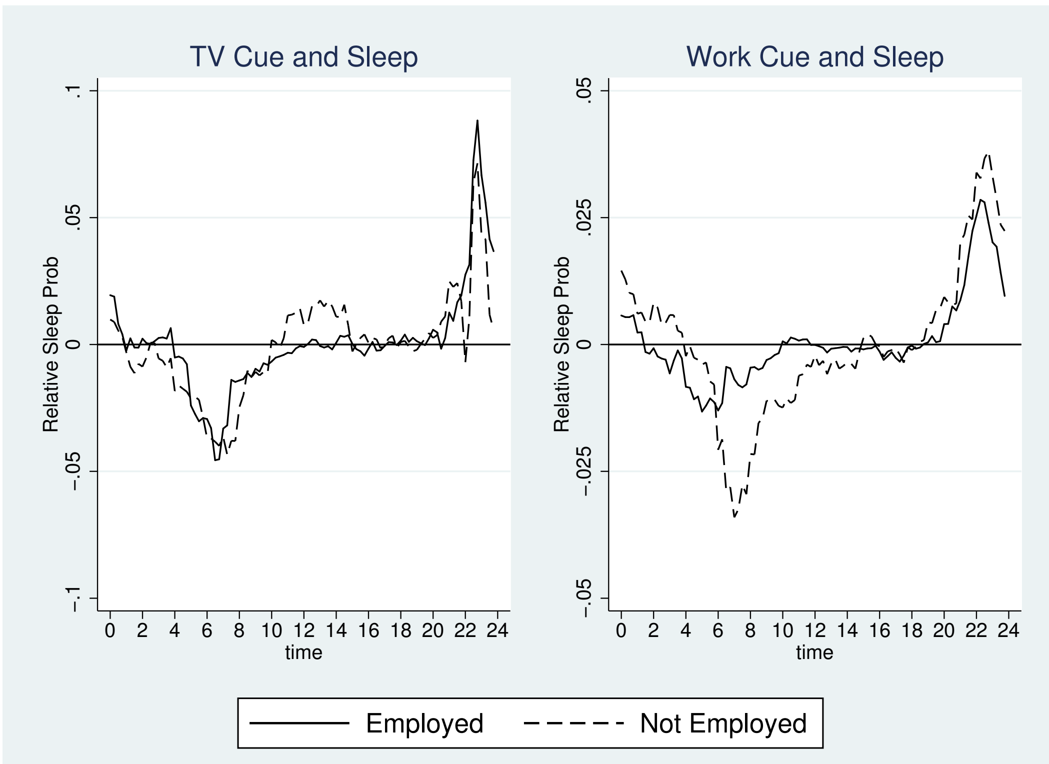


Figure 6: **Marginal Effects of Television Cues by Viewership Status**