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The Effect of Unreliable Commuting Time on Commuter Preferences



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# The Effect of Unreliable Commuting Time on Commuter Preferences

DISSERTATION

submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in Economics

by

Pia Maria K. Koskenoja

Dissertation Committee:

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1996

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"Socio-Economic Attributes and Impacts of Travel Reliability: A Stated-Preference Approach," (with Kenneth Small and Robert Noland), a report (#MOU-117) for the PATH Program of the University of California, September 28, 1995.

"A Discrete Choice Simulation Model of Urban Highway Congestion Incorporating Travel Reliability," (with Robert Noland and Kenneth Small), a paper presented at Regional Science Association meetings 1994, and at the Transportation Research Board meetings, 1996.

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"Socioeconomics of the Individual and the Costs of Driving: New Evidence for Demand Modelers," (with A. P. Talvitie), *Transportation Research Record* 1328: 58-68. Presented at the Transportation Research Board Meeting 1990. This paper makes refined estimates over socioeconomic groups of the fixed and variable costs to the motorist of automobile ownership and usage.

"Transportation Demand Model of Work Tours," Report 741, Technical Research Centre of Finland, 1989. This report is an empirical investigation of how individuals chain their daily journeys by car, transit, and other modes.

"Environmental Effects of Studded Snow Tires," Technical Research Centre of Finland, 1990 (in Finnish). In this report I discussed the various damaging consequences of the use of metal studs in snow tires. These damages include pavement deterioration, health hazards from road dust, and excessive noise.

ABSTRACT OF THE DISSERTATION

**The Effect of Unreliable Commuting Time on Commuter Preferences**

by

Pia Maria Koskenoja

Doctor of Philosophy in Economics

University of California, Irvine, 1996

Professor Kenneth A. Small, Chair

Unreliable travel time is defined to mean a distribution of possible commute durations. This dissertation identifies occupational groups and shows how an individual's occupation can be expected to indicate how that person is going to behave in risky commuting situations.

Individual occupations attract a certain personality type. Also, individual occupations require different amounts of team work and pose idiosyncratic supervisory requirements for the employer. These effects create systematic variations among employer imposed work rules concerning employee's time use and employee expectations and reactions to the rules. The outcome is both personality driven and situation specific response to risky commuting situations.

A psychological construct -- locus of control -- draws a boundary between what an individual believes is influenced by her own actions and what is caused by factors external to her. A person with an internal locus of control is optimistic about

her possibilities to influence the outcomes of risky situations, while a person with an external locus of control tends to see the cause of events as random or influenced by some powerful others.

Commuters with an external locus of control take fewer planned risks, reserving more slack time between planned arrival and official work start time. If something unanticipated throws them off the habitual path, they are less likely to go out of their way to maintain the planned arrival time. The commuters with more internal locus of control are more willing to take planned risks and are more committed to see that the risk pays off.

I use occupational classification developed by John Holland and resource exchange theory of Uriel Foa to establish a partial order from most external to most internal occupational groups.

The dissertation also includes models where the commuter trades off different elements of unreliable travel time: expected mean travel time, expected schedule delay early, and expected schedule delay late. Occupations affect these tradeoffs even when income and family composition are controlled.

# 1. INTRODUCTION

How does unreliability of the morning commuting time affect how people choose to commute? How are these choices connected to the commuter's socio-economic characteristics, especially the occupation and other work life incentives, demands and restraints?

I hypothesize that the type of work has an impact on how the commuter chooses to commute. Aside from the monetary remuneration, which enables more costly commuting habits in well paying occupations, different occupations have characteristic demands and restrictions for punctuality and flexibility. The demands and restrictions come partly from the production technology, and partly from the individual company policies. Additional to the work requirements, the commuter has her own preferences for the daily choices concerning commuting time and unreliability trade-offs. This study investigates hypotheses about work related factors that systematically influence responses to unreliable morning commuting time.

The topic of this dissertation refers to a surprisingly small intersection of two well established academic fields: choice under uncertainty and transportation demand. To understand the effects of unreliable travel time on commuting decisions I will first discuss the risk concept and then relate the general tendencies of risk behavior to the commuting context. First I review the literature about the employer's needs for reliable transportation for employees defined by team work intensity of the work. Then I introduce the expected commuter risk when to the requirements for punctual arrival are strict. I review briefly what expected utility and prospect theory say about describing risky behavior.

Stress affects the way an individual sees the decision situation. I present the conflict theory of Janis and Mann, which classifies decision making modes under different levels of stress. I combine this theory with two motivational theories: Atkinson's achievement model and Loomes and Sudgen's Regret theory, which incorporate the emotions of the decision maker to explain her behavior. To differentiate between commuter groups I describe the concept of locus of control at the end of the fourth chapter. Locus-of-control and stress offer a bridge between theories of behavior and the empirically defined socio-economic groups that behave differently, and allow me to combine the effects of the theories and hypotheses to find predictably different risk preferences in different commuter groups.

In the fifth chapter I discuss the use of personality variables in empirical models and I introduce a classification of occupational groups by Holland as a cross-sectional description of all these effects on behavior. To deepen the understanding of the occupational classification I compare them with the resource exchange theory of Foa. I use the occupational groups to empirically identify the groups with different locus of control and present testable hypotheses about the commuting risk preferences of the different groups.

The sixth chapter starts with the issues concerning operationalization of perception of reliability and reviews the previous empirical findings of travel behavior related to unreliable travel time. The seventh chapter collects the hypotheses to be tested in this study. The eight chapter discusses the modelling of the choices.  It discusses the benefits and deficiencies of attidunal and stated preference data, and describes the SP question design and the data collection process.

Chapters nine and ten present the data and test some of the hypotheses. Chapter nine is mainly descrptive, but chapter ten combines the data in a sequential manner, starting from modeling the need for reliable arrival time to modeling a habit of reserving slack time before work start and willingness to pay to ensure timely arrival when an unexpected delay happens on the way to work.

Chapter eleven presents the choice models based on stated preference data. After first determining the model format, I interact different socio-economic modifiers with the elements of unreliable travel time.  A concuding discussion finishes the dissertation.

# 2. RISK AND RISK TAKING

## 2.1 What constitutes risk?

Risk is usually defined as the possibility of loss. Yates and Stone (1992) agree with the common definition, and add that the critical elements of a risk construct are (a) potential losses, (b) the significance of those losses, and (c) the uncertainty of those losses. They also note that if risk is defined this way, risk is not an objective feature of the alternative. Instead, it represents an interaction between the alternative and the decision maker. In other words, risk is an inherently subjective construct. What is considered a loss is peculiar to the person concerned, and so is the significance of that loss and its chance of occurring. This notion is often pushed aside in empirical economics, when the experiments are defined so that probabilities are assumed objective, and the choice behavior can be classified as risk averse or risk preferring with respect to the probabilities and outcomes the experimenter defines as pertinent. As we'll see later on, when risk is defined in the expected utility theory, an alternative can be risky even when its all outcomes are positive. In that context the possibility of a loss is with respect to a competing alternative, which would give a positive, but lesser outcomes for sure. Yates and Stone elaborate further on the theme:

(a) Losses

When risk is defined as the probability of attaining losses, the losses are implicitly defined with respect to a *reference outcome* (Kahneman & Tversky 1979). Any outcome that is prefererred to the reference is a gain; the less preferred is a loss.

The reference point is often status quo, but Yates and Stone (1992) list a number of ways for formulating reference points: Personal average reference, situational average reference, social expectation reference, target reference, best possible reference, and regret reference[1]. Yates and Stone recount that often all acts with uncertain outcomes are defined as risky. To define risk that way, the reference point has to be above the worst outcome.

(b) Significance of the losses

The significance of a risk is measured by the curvature of the value function[2]. If the value function is linear, an additional loss of endowment of equal size brings about equal loss of utility. With convex loss function, an additional loss of

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[1] A regret reference is the outcome the individual would have attained - or thinks he would have attained - had a competing alternative been selected.

[2] A value function maps the value of one commodity to another commodity when no uncertainty is involved.

endowment of equal size brings about a lesser loss of utility, while the opposite is true for a concave loss function.

(c) Uncertainty of the losses

People may face more fundamental uncertainties than just the amount of loss. They can face uncertainties about categories of losses, and which of those loss categories will occur. And there may be ambiguity about the probabilities of different outcomes.

Frank Knight (1921) made a difference between uncertainty and risk along the decision maker's knowledge about the outcome probabilities: if the probabilities are known, the decision maker faces a risky decision, if the probabilities are not known, he faces a decision under uncertainty. Luce and Raiffa (1957) labeled the extreme uncertainty a state of 'ignorance', and maintained the state of known probabilities as 'risk'. Ellsberg (1961) established the term 'ambiguity' to refer to the intermediate cases between risk and ignorance.

### 2.1.1 Measures of risk

Risk can be measured only when the probabilities of outcomes are known. Yates and Stone note that this type of measurement ignores the uncertainty about loss classes, ambiguity about the probabilities, and also implicitly assumes that consecutive risks can be reduced into a one-time risk.

Bearing this in mind, the conventional way is to measure the expected loss, but also semivariance over the negative outcomes and variance over all outcomes are used. If one wants to stick to the definition of risk as possibility of negative outcomes, variance is in many cases a flawed measure as it includes also positive outcomes.

Yates and Stone (1992) note that empirical measurement of risk is often marred by the illusion that the outcomes can be totally defined. They maintain that people are always risk averse, in the sense that nobody prefers bad outcomes. Rather, the benefits of the lucky outcome and the auxiliary benefits not explicitly mentioned in the task simply outweigh the bad ones. They mention the exhilaration of escaping the bad losses, or a social prestige from the tolerance of risk as examples of the auxiliary good outcomes.

## 2.2 Risk of unreliable commuting time

The commuter can avoid negative consequences of uncertain travel time by choosing to depart early, to travel a less congested route, or to change the travel mode to a more reliable one. Conventional wisdom says that these choices are habitual. Many commuters have a consistent preference about the size of a safety margin between arrival time at work site and work start time[3], and quickly develop a habit of taking particular means of transportation or route. The habit does not have to be based on daily commute: some people seem to develop weekly or monthly routines[4]. Or the habit may include listening to traffic radio in the morning and choosing daily form several alternative routes.

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[3] See Small (1982), Caplice and Mahmassani (1992).

[4] In the panel study conducted by David Brownstone and Tom Golob at the Institute of Transportation Studies, Irvine, many respondents indicated that they carpooled at

The commuting habit can be explained by several factors. Most obvious is work requirements: at what time the work starts and how often is it crucial to arrive punctually at work. These requirements vary between occupations. Other factors, such as available commuting alternatives, need to carpool with family members to school or day care, and personal preferences influence the emerging commuting routine.

2.2.1 Employers's need for punctual commuters: team work

There are not many empirical studies explaining how companies set their requirements of arrival time punctuality. Hansen (1990) discusses the effect of uncertain commuting time on productivity. He claims that *team work* is the key concept explaining how crucial prompt arrival of employees is on productivity.

Team work has many definitions. Hanson defines the broadest concept of teamwork to imply that the joint output of a group of workers is greater than the output those same individuals could produce working separately. He quotes Radner and Marschak (1972) definition that a company is using teamwork-intensive technology whenever a laborer's work-in-progress requires inputs from another laborer, the lack of which will delay the completion of the output. Alchian and

---

certain days. Hall (1982) also indicates habituality.

Demsetz (1972, p. 779) define teamwork to happen whenever the production function of two or more inputs is not separable into functions each involving only one input.

Depending on the teamwork-intensity, lateness of one worker may halt the whole production process if the work technology is arranged according to Just-On-Time (JOT) philosophy, or not slow the work process at all, if the work can be done later after hours. Thus the effects of late arrival to company productivity may vary intensely depending on the production technology.

Hansen notes that flexitime has two totally opposite effects: on one hand flexitime is promoted as a way to reduce congestion and the harrowing experience of commuting, and thus increase productivity. On the other hand flexitime reduces productivity by reducing the agglomeration effects, which can be gained only when all the employees are working at the same time accessible to each other. Hansen refers to Lee and Young (1978), who have developed an empirical measure of teamwork intensity. It is an index of three factors: interdependence, interchangeability, and criticality of output.

*Interdependence* is the degree to which workers in the same production unit rely on one another for parts or material to continue working.

*Interchangeability* is the extent to which one worker can substitute at another's job. *Criticality* is defined as the amount of time a production unit (B) downstream of the one being examined (A) can continue functioning without being disrupted by a drop in output at A.

Lee and Young suggest that the index can be used to estimate a technology's ability to tolerate flexitime without great risk of productivity loss. The technology has high degree of teamwork-intensity when interdependency is high, interchange-ability is low and criticality is high. Hansen notes that the concerns of flexitime can be directly applied to unreliable travel time, since a company operating in a congested environment is forced to operate on *de facto* flexitime.

When a company is using staggered work hours, the commuters face as strict arrival time requirements as with traditional hours, and all workers of the company can interact with each other the maximum time, but the window for interaction between employees of different companies or between employees and customers may be reduced. On the other hand, a non-traditional starting time allows commuting through less congested streets leading to shorter and more reliable commutes.

### 2.2.2 Commuter’s risk: arriving too late or too early

Commuting offers a peculiar type of risk - intended arrival time is usually the optimal point: any other arrival time is worse. The commuters response to uncertain commuting time to work depends on the expectations, penalties and rewards she faces at work, and her other activities.. There is a whole spectrum of work rules. At one extreme when no team-work is required, the expectation may be just delivering the finished product at a given time with no concern on the time usage in the process. At the other extreme is a strict requirement to be present every day at official work start time. In the first case the commuter has probably only minor disutility from arriving earlier or later than the intended arrival time. In the latter case it would be natural to assume that the commuter faces more disutility from arriving either earlier or later than the intended arrival time, perhaps experiencing a discontinuity at the target time. The reason for more disutility from arriving late is obvious: there are some penalties from that. The disutility from arriving earlier is also intuitive: time will be wasted if there is no alternative use for it.

The commuter's disutility functions in these two stylized extreme cases are depicted in Figures 1 and 2, respectively.

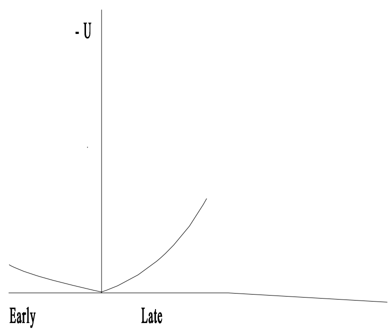


Figure 1. Arrival time preferences with ample lateness tolerance

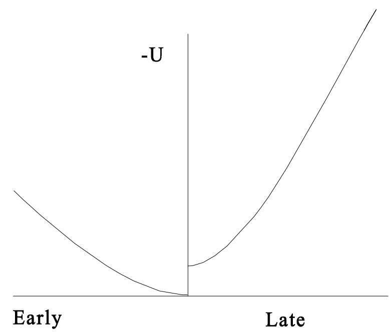


Figure 2. Arrival time preferences with little lateness tolerance

In Figure 1 the disutility is smooth and practically flat around the intended arrival time indicating that small deviations from the intended arrival time do not cause additional disutility. Larger deviations do, but there are no discreet threshold values.

Figure 2 depicts a more industrial view of time constraints. Compared to Figure 1 the disutility descends steeper on the early arrival side, indicating that too early arrival causes additional disutility to the commuter. After the intended arrival time the disutility jumps as a lateness penalty kicks in. Any additional minute after that brings increasingly more disutility.

## 2.3 Risk taking in economic theory

There are three main approaches to explaining individual choices: 1) theories explaining non-specific risk behavior due to reasons originating from the biological nature of our existence, capturing the general principles of behavior, and assigning the individual differences to lower importance, 2) individual personality differences, and 3) theories explaining behavior due to reasons originating from the choice situations. These approaches are used in economics, psychology, and in decision making theories.

In economics, the marginal utility theory treats risk taking as an outcome of the psychophysical nature of our existence: the significance of an additional unit of resource is less than the significance of the first unit, leading to diminishing marginal value as a function of the total amount of the resource. This valuation leads to curvature in the utility function, which has also been interpreted as an indicator of risk preference. Stricktly speaking this is not correct, since the value function reflects the valuation of the resource under certainty. Unfortunately both of these two separate effects -- marginal utility and risk preference -- are confounded in the curvature of the utility function.

Individual differences are recognized in the expected utility theory by von Neuman and Morgenstern (1947). The theory treats risk taking or risk averse behavior as a given individual idiosyncracy, which can be described, but not explained, through the shape of the person's expected utility function. The function can be numerically derived by presenting a person a series of choices, where she specifies her willingness to gamble versus receive a price of certain value for sure. If the derived function is convex the person is risk preferring. A person is generally defined to be risk preferring when she prefers to gamble instead of getting for sure a price equal to the expected outcome of the gamble. For instance, a person may be choosing between A: a gamble of 50% chance of winning $ 8.00 and 50% chance of winning $12.00 versus B: $10.00 for sure. If he chooses A, he is defined risk preferring. This can be expressed as $E[u(x)] > u(E[x])$, where $u(x)$ is the von Neuman-Morgenstern utility function. The strength of risk preference (or risk aversion) can be measured by Arrow-Pratt measure $-u''(x)/u'(x)$. In most situations individuals are found to be risk averse, which corresponds to a concave utility function and $E[u(x)] < u(E[x])$.

## 3. SITUATION SPECIFIC RISK TAKING

Empirical findings in fields other than transportation suggest that a person's risk attitude depends on situational factors. March and Shapira (1992) summarize empirical findings of situational risk behavior by five observations:

1. We react to threatening situations by two opposing ways: by taking increasingly larger risks in order to avoid the danger or by extreme forms of risk aversion and rigid behavior.
2. Slack resources increase our risk taking.
3. We tend to be risk taking below an aspiration point but risk averse above it.
4. We tend to be more risk taking with newer resources or resources we assimilate to somebody else, than with resources we consider old or our own.
5. If we are successful risk takers, we tend to believe the success is due to our better skills and not luck.

### 3.1 Prospect theory

To encompass the systematical violations of expected utility Kahneman and Tversky (1979) defined the utility of a prospect in terms of the change in endowment that it brings about, not the total endowment. This makes the theory comparable with the risk construct discussed earlier, with outcomes lower than the reference point defined as losses, higher ones as gains. A natural reference point is the status quo, since it implies no change in endowment. Other reference points are also compatible with the theory. Utility at the reference point is defined as u(0).

Kahneman and Tversky further hypothetized that people are risk averse in the positive domain of outcomes, but risk takers in the negative domain. This behavior has been found in laboratory experiments, usually involving monetary gains (Payne et al 1980, 1981). The utility function is be concave in the positive domain, but convex and steeper in the negative domain. Since the utility function is defined on the change of endowment, the curvature of this type of utility function does not suffer from the earlier mentioned double interpretation.

Prospect theory seems to fit well into two of the five observed behavioral patterns. The theory explicitly states that we are risk preferring below the aspiration point and risk averse above it. It accommodates the notion that we are more risk averse with the resources that are closer to our reference point: comparing equal losses and gains from the reference point indicates that a loss of x units of any good yields far more disutility than gain of x units of the same good. But if the x units are added or removed at equal distances from the reference point, the utility changes are more equal. Prospect theory utility function is pictured in Figure 3.

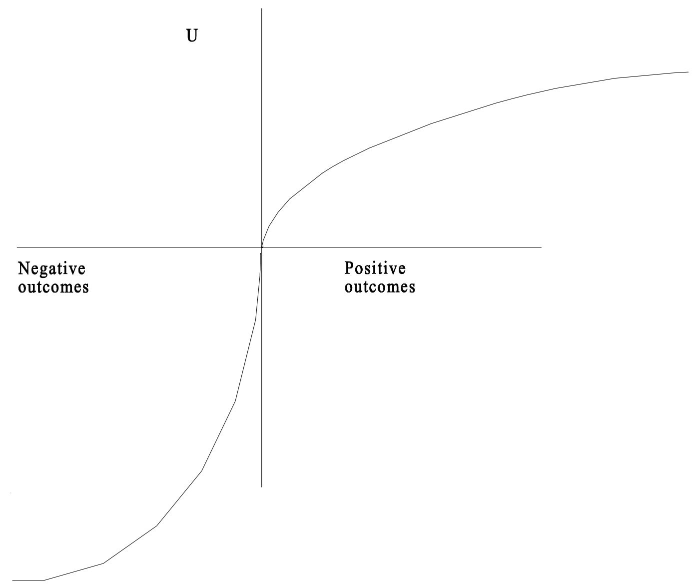


Figure 3. Utility function according to Prospect theory.

If we analyze arrival time according to prospect theory, the natural reference point can be assumed to be the intended arrival time. The positive outcome in this case would be to arrive earlier than planned. However, an early arrival may also be considered worse than the target arrival time, which would make the "positive" range of outcomes to also have a negative value. Unlike in the case of monetary gains it is hard to say if the commuters are looking at the earlier arrival times as 'better' outcomes than arriving on time, or if these arrival times are regarded as inferior to spending the time in traffic.

It is more intuitive to present the time increasing from left to right and use the more common disutility function of travel time than utility function, which leads to a presentation like the one in Figure 4. Note, that the concavity of the curves indicates that according to Prospect theory people would be risk preferring on both sides of the target arrival time, more on the late side than the early side. This is consistent with the notion of risk preferring behavior below the target outcome.

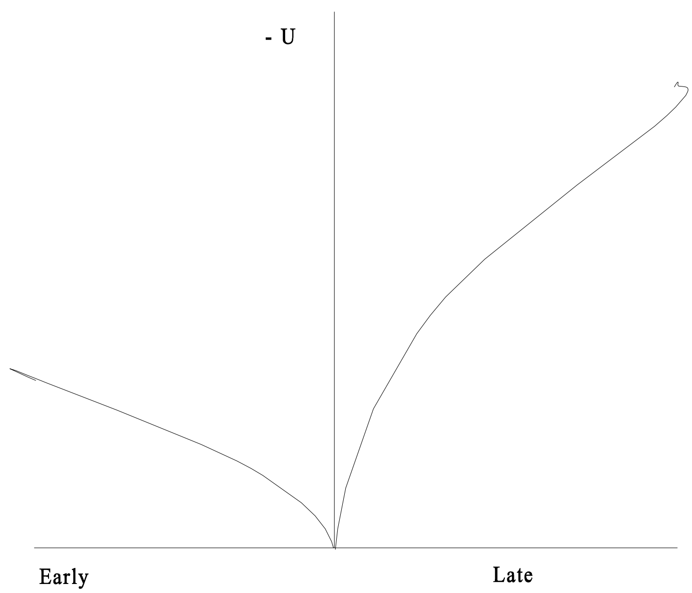


Figure 4. Utility function of early and late arrivals according to Prospect theory.

Expected utility theory does not have any particular hypothesis about the shape of the utility function. Expected utility theory can be applied to commuting in several ways. It can be applied to the total travel time assuming that less time used is always better. This would be in accordance with the assumption that utility depends on the total endowment of the resource, not the change of it. If one allows the reference point approach into the analysis, the expected utility part could be applied to the separate parts of early and late arrivals.

# 4. THE EFFECT OF STRESS ON RISK TAKING

The commute to work may be stressful. Novaco et al (1990) finds that commuting stress increases with the number of freeways traveled, the number of road exchanges, percentage of miles on freeways, and percentage of travel time on freeways. These factors are also positively related to work-absence due to illness, sick days, and bouts of common cold or flu.

Novaco et al finds support for the assumption that psychological consequences of environmental conditions in one life domain (home, commuting, work, or recreational) transfer to another. In particular, they confirm earlier findings that mood-affecting consequences of the commute to work carry over to midmorning, and that these effects are modified by job involvement, which in turn is linked to personality variables.

## 4.1 Stress conflict model

Janis and Mann (1977) studied how stress affects behavior and found five distinguishable patterns of decision making: unconflicted adherence, unconflicted change, defensive avoidance, hypervigilance, and vigilance. The first two decisions involve no conflict and are made almost automatically, while the last three involve a conflict of goals and are harder to make. Mann (1992) describes the patterns as follows (p. 209-210):

1. *Unconflicted adherence*: The decision maker complacently decides to continue whatever he or she has been doing, ignoring information about the risk of losses. Because the person believes there is very little or no risk from continuing with his present course of action, there is no decisional conflict and, accordingly, little or no stress.

2. *Unconflicted change*: The decision maker reacts to a challenge or threat by precipitously changing to a new course of action without giving the matter much thought. The decision maker uncritically adopts whichever new course of action is most salient or most strongly recommended. Because the person believes there is no risk involved in moving directly to a new policy, there is no conflict regarding alternatives and, accordingly, little or no stress.

3. *Defensive avoidance*: The person believes that there are serious risks involved both in staying with the current course of action and in moving to a new course of action. Hence there is a classic state of conflict. Stress aroused by the conflict is compounded by pessimism about finding a good solution to the dilemma. In that case the person becomes motivated to reduce the distressing state of high emotional arousal by one or another of the three mechanisms of defensive avoidance. Procrastination enables the person to postpone the decision, turning his attention away from the conflict to other, less distressing matters. Shifting responsibility to someone else ("buckpassing") enables the person to evade the dilemma and provides him a handy scapegoat should the decision turn out poorly. The invention of fanciful

rationalizations in support of one of the choice alternatives is another mechanism for escaping conflict. Stress is warded off by selectively attending to only the good aspects of that alternative and by ignoring or distorting negative information about it. All three forms of defensive avoidance enable the decision maker to escape from worrying about the decision.

4. *Hypervigilance*: The decision maker recognizes that there are serious risks entailed in the competing courses of action. He believes that a better solution might be found. But because he also believes there is insufficient time to search for and evaluate that solution, he experiences a high degree of psychological stress. The person in hypervigilant state is frantically preoccupied with the threatened losses that seem to loom larger every minute. He searches anxiously for a way out of the dilemma in order to put an end to the stress. He impulsively seizes a hastily contrived solution that seems to offer immediate relief, overlooking the full implications of his choice. The behavior of the decision maker in this type of crisis is marked by a very high rate of vacillation. Other symptoms of hypervigilance include a high degree of emotionality, reduced memory span, and simplistic, repetitive thinking. In its most extreme form, hypervigilance is equivalent to "panic".

5. *Vigilance*: The vigilant decision maker is in a state of conflict, in that he recognizes that there are serious risks associated with competing alternatives. However, the conditions surrounding the conflict confine psychological stress to a moderate level. The person has confidence about finding an adequate solution and believes there is ample time to do it. The decision maker is accordingly motivated to

confront the dilemma head-on. He searches painstakingly for relevant information, assimilates it in a relatively unbiased manner, and evaluates alternatives carefully before making a choice.

In summary, the conflict model assumes that extremely low stress and extremely intense stress induce poor decision making, while moderate stress helps to bring about the best decisions.

This study uses data from mail-in surveys. The questions present conflict situations to the respondent. Therefore I do not expect to receive answers that are given in a state of unconflicted adherence or unconflicted change. On the other hand hypervigilance is such an extreme state that it is not likely that a hypervigilant person would care to answer survey questionnaires. Consequently, in this study I assume that there are no respondents in a hypervigilant state, either. I expect to get answers from people who are either in a state of vigilance or in a state of defensive avoidance.

### 4.2 Empirical findings on time stress impact on decision making

Mann (1992) refers to Keinan (1987), who studied how stress affected the decision making of Israeli undergraduates. The students were all instructed to solve problems and choose among six alternative answers. One group of students was also told that painful, but harmless electric shocks might be administered if they chose the wrong answer. Another group was told that the electric shocks might be administered randomly while they were solving the problems. The third group was not told anything about electric shocks. Subjects in the two stress groups had a higher tendency to choose before they had seen all alternatives, to scan the alternatives in a disorganized fashion, and to choose incorrectly. Even in the first group, where the 'punishment' was strictly connected to the performance, the existence of the threat from failure increases the failure rate.

Mann (1992) mentions a number of studies about decision making under time pressure: Abelson and Levi (1985) identify two effects of time pressure, a tendency to rely on one or two salient attributes in making the choice and a tendency to attach greater weight to unfavorable information about choice alternatives and therefore to become more cautious. Wallsten (1980) found that subjects under time pressure typically focus their attention to a few salient cues as they process information before making a choice. Wright (1974) predicted -and found - that subjects under time pressure simplify decision making by focusing on unfavorable information. This enables them to use a simple choice strategy such as to rule out all alternatives with any flaw or impediment.

In these experiments the time pressure and/or stress deteriorates decision making. It is not a concave function of stress level like in Janis and Mann's conflict theory. The findings do not necessarily disagree with the theory: the observed stress levels in the experiments may have been only moderate and high.

It is noteworthy that the stress behaviors described by conflict theory are in accordance with the first observation of situational risk behavior by March and Shapira. Defensive avoidance represents behavior that is extremely rigid by staying put with the chosen behavior when the situation worsens. In hypervigilance the decision maker focuses on avoiding the perceived risk to a degree that she ignores other risks that this avoiding causes. This lack of proper evaluation of consequences leads the decision maker to inadvertently take even more risk.

The conflict theory supports also the second observation, since presence of slack resources implies that the decision maker is not in a high stress conflict situation, and is thus more likely to make a vigilant choice.

An example of simplistic decision making suitable for high stress situations seems to be the Elimination-by-Aspects decision algorithm (Tversky, 1972). This algorithm assumes that the decision maker ranks the aspects of alternatives in the order of importance, and assigns acceptable levels to these aspects. The decision process is a sequential consideration of the aspects, dropping alternatives from further consideration if they do not meet the minimum criteria. This algorithm takes explicitly into account the tendency to simplify decision making by considering only few aspects and eliminating alternatives in the early stage of decision making process.

Kogan and Wallach (1964) studied risk taking, cognition, and personality in an extensive experimental study on students. They hypothesized that personality could be seen as a modifier to how the students chose between risk strategies in different test situations.

The behavior was found to be consistent based on either motivational or cognitive source. Kogan and Wallach summarize:

> "The consistency of behavior which originates from motivational sources leads to overgeneralized behavior; it ignores patent differences in task properties ... When consistency takes its origin from cognitive sources, it tends to respect discriminable task differences and confine itself to those procedures that are similar in one or more aspects of their intrinsic structure, rather than similar in their extrinsic motivational consequences." (p.190).

The evaluation of risk strategies was likewise different for the two groups with different origin of behavioral consistency. In the light of poor performance in a test a person from cognitive-source group was ready to change her risk strategy. In similar situation a person from the motivation-source group insisted that the strategy she chose was good and claimed that she was happy with the test results. Members of both of the groups reduced cognitive dissonance, first group by undoing the commitment to choices, second by emphasizing the desirability of the choices by failing to appreciate the consequences.

Compared to the stress model, it is interesting to note that defensive avoidance and hypervigilance are characterized by the word "emotional" referring to behavior that bases its consistency on motivation, while the description of a vigilant decision maker resembles the decision making process when the source of consistency is cognitive. There seems to be a connection between the level of stress a particular decision involves and the type of behavior a person applies to that situation. Reflecting this finding Larrick (1993) proposes that behavior is a combination of psychophysical factors and situational factors. He posits: "psychophysical processes lie at the core of decision making, but are surrounded by a layer of motivational processes. In the absence of threat, the motivational processes are not significant; but as the potential for threat is increased, the motivational processes play a larger and larger role." p. 488.

HYPOTHESIS 1: Stress increases emotionality of the decision process. I expect a stressed commuter to behave according to the defensive avoidance, which would be manifested as inertia to changes in present commuting habits.

## 4.3 Motivational theories

Motivational theories explain behavior through the decision maker's emotional states. Regret theory (Loomes and Sugden, 1982) states that an individual considers both how the attaining of different outcomes of alternatives would make him feel (a choiceless utility) and how the "losing" of good outcomes of the not-chosen alternatives would make him regret not choosing that alternative (the modified utility). Regret theory takes into account not only the utility from the chosen alternative, but also the utilities of the rejected alternatives. This mechanism leads to non-transitivity of choices and is not compatible with either the expected utility or prospect theory.

Bell (1982, 1983, 1985) states that the strongest ingredient for inducing regret is explicit feedback. In the absence of feedback the decision maker can ignore his regrettable choice, but when he knows that the feedback is explicit and maybe even public, the anticipation of regret is largest. Thus the expectation of feedback makes the person to regret most losing the good outcomes when the decision involves gains, leading to a preference for more risky alternatives. When the decision involves potential losses, an expectation of feedback makes the person to anticipate regretting the potential worst outcomes, and to choose a risk averse alternative. In commuting situation, expecting explicit negative feedback like a loss of an hour's worth of pay should induce a stronger change in behavior than less direct feedback, like potential loss of reputation or loss of possible future promotions, while commuters who do not anticipate any negative consequences should be least risk averse towards late arrival. If wage-earners are more likely to lose pay due to lateness than salaried personnel, regret theory suggests that they should be more averse toward late arrivals than salaried personnel.

HYPOTHESIS 2: Anticipation of negative consequences from lateness at work makes the commuter more risk averse with respect to late arrival, ceteris paribus. The more undeniable the consequences, the more risk averse the decisions.

Atkinson (1957) proposed a theory that explains risk taking in terms of two basic motivations: the need to achieve and the need to avoid failure. Since Atkinson considers skilled tasks and not gambles, he assumes that the attractiveness of an action is based on the likelihood of success or failure, not how much the decision maker would value the outcome when attaing it would be certain. Atkinson assumes that both the satisfaction from success and the pain from failure are decreasing functions of the probability of the anticipated outcome. The expected utility of an action is assumed to be the standard expected utility, i.e. the value (in terms of satisfaction or pain) of the outcome multiplied by the probability of the outcome.

If the good outcome is sure to follow from the action, the action offers no challenge and not very much satisfaction from achievement. This makes the action only mildly interesting. On the other hand, if the action has very slight chances of producing the intended outcome, the satisfaction from the good outcome would be very high, but the low probability of it happening will make the overall utility of the action rather low. Thus the Atkinson theory predicts that in risky situations involving gains, the maximum utility will be reached by selecting actions that have about 0.5 probability of succeeding. An example assuming linear “satisfaction function” is presented in Figure 5, with the black dot indicating best action.

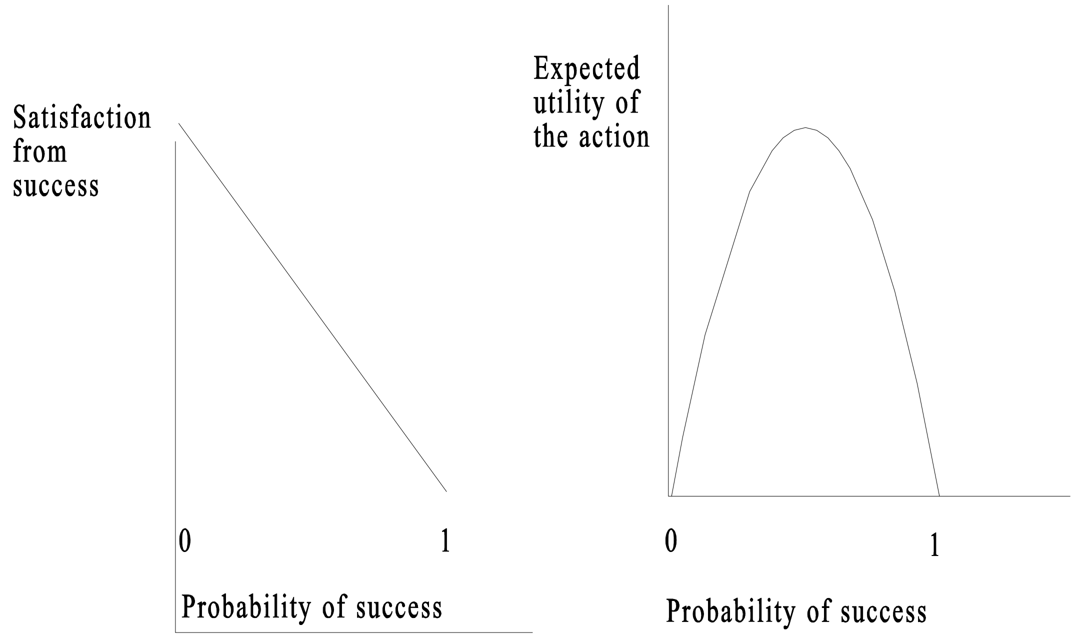


Figure 5. Atkinson's theory of behavior for successes.

If the action is directed towards avoiding pain, the same concave utility function follows. But now the goal is to minimize the pain, leading to two local minima at each end of the probability range. In the first minimum a person would choose actions that have very low probabilities of getting the anticipated bad outcomes, playing it safe from the start. The second minimum would describe behavior that expects a negative outcome with a slight chance of receiving a good one. In this case the person would not lose face when the bad outcome is expected, and still has a slight probability of a good outcome, like in a lottery. The Atkinson model for negative outcomes is presented in Figure 6, with black dots indicating the most beneficial actions.

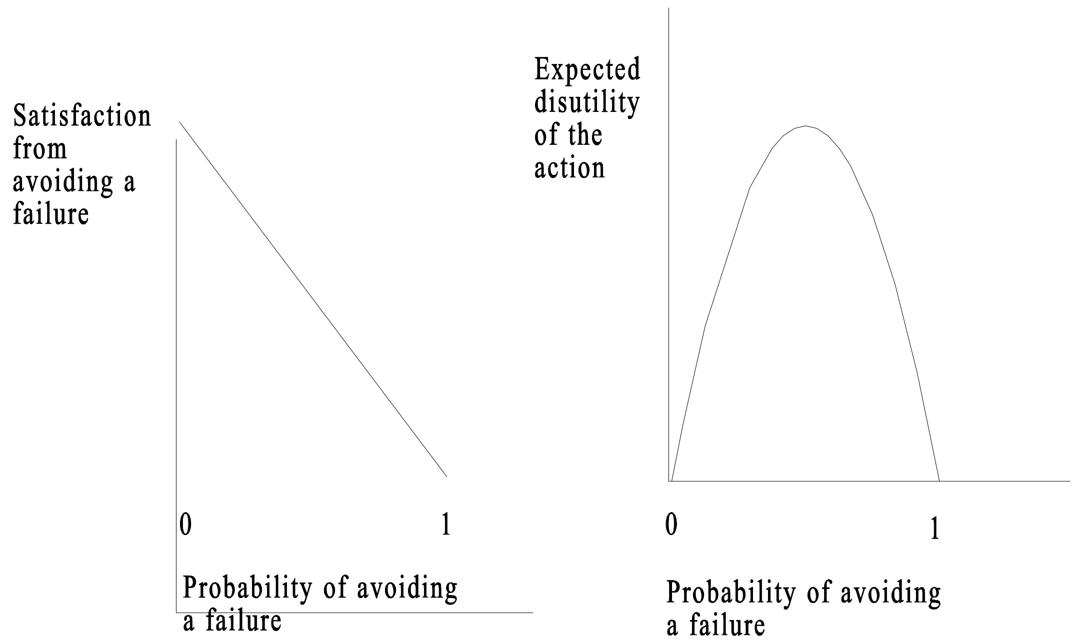


Figure 6. Atkinson's theory of behavior for negative risks.

The assumptions about the 'satisfaction function' at each end of the probability range are critical to the theory. If the satisfaction is selected so that the expected values of actions A and B are equal, the utilities of A and B are equal. For example, if p(A)=.25 offers 200 units of satisfaction and p(B)=.5 offers 100 units of satisfaction, both offer actions A and B 50 units of utility.

Lopes (1990) proposed that people are motivated by two basic concerns when deciding on a risky proposition: safety and potential (SP) of the outcomes and aspiration (A) to a certain level. According to Lopes people utilize a dual criteria to assess an alternative. The security-potential is assessed through a decumulative weighting process, often emphasizing the extreme outcomes, while the aspiration to the reference level is assessed through probability-based averaging. The direct empirical testing of the theory is problematic due to its high degree of flexibility.

All the reference point theories have common elements. Like the prospect theory and Atkinson's theory, SP/A theory predicts asymmetrical behaviors with regards to gains and losses. The theories differ from each other in two respects: Kahneman and Tversky do not give the explanation for this behavior through affective processes like Atkinson, or focus of attention like Lopes, and Atkinson's theory is developed for skilled tasks, whereas SP/A and prospect theory speak of strictly probabilistic outcomes where the decision maker cannot change the odds by skillful participation.

However, these theories could cover the same type of behavior. People seem to have an "illusion of control" in situations that are pure chance (Langer 1975; Gilovich, Vallone, and Tversky 1985; Wagenaar 1988). And paradoxically, this illusion of control seems to be an essential element of robust decision making.

## 4.4 Locus of control

The previously considered theories emphasize the decision maker's particular situations to explain her behavior. The concept of locus of control emphasizes that the decision maker's belief in the determinacy of such factors influences her behavior.

Locus of control addresses a person's belief that what happens to her is either due to personal factors or caused by factors external to her. Rotter (1966) proposed a unidimensional Internal-External scale of locus of control based on a social learning theory.[5] Later studies (e.g. Mirles (1970)) have found two or more dimensions of control beliefs, where the external forces are either powerful other beings or pure luck. Also the control beliefs have been connected to beliefs that the external forces are not only external, but also malevolent. Even though the construct seems to have some definitional problems, locus of control has been successfully used in explaining behavior under stress.

[5] Social learning theory focuses on the speed that an individual learns to control his behavior to have an intended effect on other’s behavior.

The internal Locus of control serves a buffering role in stressful situations. According to the review by Schaubroeck and Ganster (1991) it has been associated with a higher resistance to illness caused by stress, systolic blood pressure reactivity, diastolic blood pressure reactivity, heart rate reactivity, and among the most important psychological predictors of cardiovascular reactivity. Internal locus of control is also a central part of "hardiness", a behavioral pattern characterized by optimism, commitment, willingness to take challenges, and responsibility of outcomes, a pattern existentialists call authentic behavior[6]. Correspondingly, a less internal locus of control is positively related to anxiety.

Psychological strain affects locus of control. Lefcourt et al (1981) studied the impact of locus of control on the relationship between life events and psychological strain. They used the Rotter scale and found a significant interaction between the scale and the negative life events, indicating that the locus of control does act as a moderating variable between experienced stress and negative life events: as the individual encounters negative experiences, her belief in her ability to control the events shifts from internal towards external, which in turn makes accepting the occurrence of those events easier (Tom Cox and Eamonn Ferguson, 1991). Thus one may expect to find external locus of control among social groups that have had high stress and relatively more negative life events. On the other hand, Antonovsky (1991) disagrees with this interpretation: he contents that it is not the

[6] For discussion about hardiness, see Kobasa and Maddi (1977).

negative life events as such, but the amount of incomprehensible life events that causes the loss of control (p. 82).

4.4.1 Locus of control in work environment

Spector (1989) conducted a meta-analysis of 88 studies of perceived control of employees in work environments. His summary of the findings indicates that internal locus of control also moderates experienced stress at workplace:

> "Employees who perceive comparatively high levels of control at work are more satisfied, committed, involved, and motivated. They perform better and hold greater expectancies. They experience fewer physical and emotional symptoms, less role ambiguity and conflict, are absent less, have fewer intentions of quitting, and are less likely to quit."

Different occupational groups can be expected to have a different degree of self-determination. McGraw (1978) has shown that self-determination leads to better performance on complex heuristic tasks, but control in the form of extrinsic rewards can facilitate performance at certain algorithmic tasks.

The literature offers some evidence of self-selection to occupations which offer optimal locus of control. Although people with external locus of control have been found to be less happy with their work life, Hurrel and Murphy (1991) cite Marino and White (1985) who found that highly internal health care personnel experienced more distress than externals in a highly controlled environment. They also cite Szaba and Colwill (1988), who found that undergraduates in training for managerial jobs believed that other powerful people and luck had less influence on their lives than trainees for clerical jobs, and Kopalka and Lachenmayer (1988), who found that people in supervising jobs had higher internal locus of control scores than those in non-supervisory jobs.

Hurrel and Murphy conclude that those who have an internal locus of control appear to have higher expectancies about the relationship between effort and job performance, and between performance and rewards.

Applying this result to the regret theory I assume that because Internals believe that performance is recognized and appropriately rewarded, they incorporate more of the regret and rejoice of their action in their decision making than Externals. Thus Internals should be more daring towards gains and more cautious towards losses than Externals. Since Internals are described as optimists, this seems to be the case.

One way to describe the attitude difference is through Atkinson’s theory. It seems that when Internals look at risks which involve both potential gains and losses, they see the risk more as an opportunity to gain satisfaction from success, while Externals see the threat of failure and thus are looking for ways to minimize the potential pain. Internals see the world offering reasonably good chances for gainful actions, and are motivated to see the fruits of their efforts to materialize. While they are interested in insuring themselves against the negative future outcomes, they are likely see the failures as failed trials, avoidable in the future. Externals do not expect to change the situation for their betterment. If they do succeed in these efforts, Externals see the reason for the change as good luck or the outcome of powerful other's influence on their behalf.

Another way of approaching the differences is through reference points. Internals are more anchored to their idea of how things **should be**, an "internal reference point". They have inertia to accept a shift towards a less preferred reference point, and will actively seek to maintain their reference point by changing their behavior according to changing situations. Externals are more anchored to how things **are**, an "external reference point". They are have a harder time to see their possibilities to change the environment, but less inertia to accept the change once it has happened. The descriptions are summarized in Table 1. Under the "Anticipated outcome" I list for positive outcomes a nice return on investment. A person who invests obviously expects to earn money by doing so. Since Internals are optimists, they tend to be more likely to believe that their investment will prove to be advantageous. Externals are pessimists, they do not expect the world to go their way, and are more likely to expect to lose money on any activities that require risk taking. Correspondingly, under "Unanticipated outcome" I have listed for positive outcomes winning in a lottery. The person does not anticipate winning, but responds even to an unreasonably small chance. An example of a negative, unanticipated outcome is a failed trial in a project, where the failure is a reason to change procedure in order to avoid the same type of failure in the future. An internal person has a sense of control over what he is doing, and does not take a failed trial as evidence of futility of effort.

Table 1. Hypothesized expectations of people with Internal and External locus of control

| Unanticipated outcome<br>“Luck” | Anticipated outcome<br>“Expected reality” | | |
|---|---|---|---|
| Winning a lottery | Return on investment | Example | Positive outcomes |
| External expectations | Internal expectations | Expectations | |
| A failed trial, avoidable in the future | Unavoidable misery of life | Example | Negative outcomes |
| Internal expectations | External expectations | Expectations | |

I categorize the risks people take into two classes: planned risk and reaction risk. When a person chooses to take a certain risk before she is in the risky situation, the risk is a planned risk, like an investment. The risk taker chooses according to her established reference point, ex ante.

Reaction risk taking occurs when a situation changes in an unexpected manner. The decision maker finds that there is no possibility to avoid the risk but only to react to it, ex post. The new decision is made relative to either the new external reference point or the original internal reference point.

If the decision is made based on the new external reference point, commitments to earlier decisions are conflicted. If the decision is made based on the internal reference point, commitments to earlier decisions are kept, but the decision maker may have to accept other risks. Both strategies reduce cognitive dissonance.

I expect that Internals tend to make their decisions more often based on the internal reference point, and Externals on the external reference point.

HYPOTHESIS 3: Internals are more optimistic than Externals. When Internals consider commuting risks ex ante, they are less risk averse than Externals. When Internals are facing risks ex post, they are more risk averse with respect to the intended arrival time than Externals.

The ex ante risk aversion should show up in the stated preference choices: the reliability of travel time is expected to be relatively more important than mean travel time for Externals than for Internals. But since the Internals are more goal oriented than Externals, Internals should be more averse to schedule delay early and schedule delay late. The Internals's optimism to beat the traffic should show up in the question which describes a worsened traffic condition where delays happen more often but there is still a good possibility to arrive on time: I expect Internals to have a smaller tendency to increase slack time between arrival and work start, or to change their commuting habits in any other way. The ex post risk aversion should show in the question which describes an unexpected 30 minutes traffic jam. I expect commuters with internal locus of control to be more willing to pay to restore the original expected arrival time than commuters with external locus of control.

We can now combine the situationalist findings of risk behavior as summarized by March and Shapira and the findings about situation specific theories and effects of stress and locus of control into the commuting context:

1. We react to threatening situations either by taking increasingly onerous steps in order to avoid the danger, or by behaving extremely rigidly. In the context of commuting this could mean that a tight time constraint or an unexpected delay on road would induce some people to select an otherwise unpleasant alternative which had a reasonable chance to meet the time constraint, while others would not even consider changing plans and would fatalistically wait out what happens. I assume that the first group would have more people with internal locus of control, while the latter would have more people with an external locus of control.

2. Slack resources increase risk taking. In transportation this means that if the traveler does not have to arrive at a certain time, he is more willing to take the less reliable transportation mode. Slack resources can be seen as stress reducing factors, which in turn allow the decision maker to accept more risky alternatives without reaching the threshold of intolerable stress.

3. We tend to be risk taking below an aspiration point but risk averse above it. In transportation modeling this would mean a utility function that is a nonlinear function of expected arrival time. The prospect theory predicts that we should find concave disutility functions for both early and late arrivals, but the late side should be steeper. Lopes's theory would lead us to expect that the extreme deviations get more weight on both early and late side (as they are both negatively valued) than the smaller deviations from intended arrival time, leading to a convex disutility function

on both sides of the target arrival time. The division of people by locus of control indicates that the prospect theory utility function of Internals is steeper and less concave for gains, and flatter and less convex for losses than the utility function for Externals.

4. We tend to be more risk taking with resources we assimilate to somebody else than with resources we consider our own. In transportation this transforms into the question whether the work related travel is really employer's time or employee's time. I expect this to vary between occupations.

5. If we are successful risk takers, we tend to believe the success is due to our better skills and not luck. This finding has a analogy in commuter beliefs about their ability to avoid delays in traffic. The commuters with internal locus of control are more optimistic and risk preferring than people with external locus of control before the delay occurs, but after the incident has occurred they are more likely to accept an otherwise less attractive alternative that which has a reasonable chance to meet the original time constraint.

4.4.2 Socio-economical indicators of locus of control and stress

According to Schaubroek and Ganster (1991) earlier studies have found that professionals experience more internal locus of control than blue-collar workers and college students (Ryckman and Malikiosi (1974), and in some studies females experienced more internal locus of control than males (Nowicki and Segal, 1974; Zika and Chamberlain, 1987). Age was found to be unrelated to locus of control (Ryckman and Malikiosi, 1975).

Jenkins (1991) reviews studies of occurrences of mental illness as an indicator of stress. She cites that low social class or economic strain is associated with the occurrence of mental illness for both sexes in most of the studies. Also, marital status has an effect: in most of the studies married people are considerably less prone to mental illnesses than single, widowed, or separated counterparts. The differences are more marked for men, but exist also for women. Single parenthood increases the likelihood of depression for both sexes.

About the occupational effects on stress Jenkins mentions that higher stress have been found among health technicians, waiters and waitresses, practical nurses, inspectors, and musicians (Colligan, Smith, and Hurrell (1977)). These occupations are also characterized by high turnover rates, which can be seen as an indicator of a high stress occupation. When Schuckit and Gunderson (1973) found that the men in high stress occupations were older, more likely divorced or single, had lower education, and a lower social class of origin.

Jenkins cites mixed findings of gender effects on stress: when Vingerhoet and Van Heck (1990) explored gender differences in coping, they found that males preferred problem-focused coping strategies, planned and rational actions, positive thinking, personal growth and humor, day-dreaming and fantasies. Women preferred emotion-focused coping solutions, self-blame, expression of emotions, seeking of social support and wishful thinking/emotionality. But when Martocchio and O'Leary (1989) analyzed 15 studies about sex differences in occupational stress, their results indicated that there are no sex differences in psychological and physiological stress in occupational settings. There was also no support found for the earlier supported idea that men and women experience stress differently (i.e. psychologically versus physiologically). Perhaps these conflicting findings are explained by self-selection into occupations. After the self-selection, men and women could be quite similar in their response to stress in a given occupation.

## 5. RISK TAKING PERSONALITY ?

In its simplest, and rebuffed, form the personality trait theory states that the personality of the decision maker determines her preferences and is a good predictor of her choices.

Personality measures, or scales, can be derived from objectively measured behavior. These measures can be composites of repeated measurements of several items or measurements of behavior in different situations. Self-reported ratings are also used: the person describes herself, or a person is presented a list of opinion and attitude statements and she expresses her agreeing or disagreeing with each statement. There exists an abundance of different personality scales for illuminating different facets of personality[7].

Personality theory has been criticized and largely side sideswept by the cognitive and situationalist approaches since the 60's. The cognitive approach seeks to unfold the mechanisms of our decision making, while situationalist theory emphasizes the significance of the particularities of the choice situation.

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[7] See for instance Robinson et al. 1969, Robinson and Shaver 1973.

Mishel[8] presents three major sorts of critique against personality trait theory: 1) low correlations between objective (i.e. non-self-report) measures of the same trait, 2) doubt of the validity of self-report measures, clinical assessment procedures, and their eventual utility, and 3) positive accumulating evidence for situational explanations. Mishel argued for a social learning theory, emphasizing highly situationally specific behavior. The commonly held belief of stable general personalities was a paradox to him, waiting to be scientifically explained. An often cited factor against trait approach is Mishel's finding that self-report measures of a trait characteristically produce correlations no greater than .30 with non-self-report measures of the same trait[9].

Lately personality trait theory has started to gain new support. Epstein (1979) argued that traits cannot be measured by single items of behavior because traits refer to stable, broad dispositions. As dispositions, traits permit actuarial prediction, that is, reasonably accurate prediction of behavior averaged over a sample of situations and occasions, but not the prediction of single behavioral acts.

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8 Epstein and O'Brien (1985) and Mishel (1968).

9 Epstein and O'Brien, p.515.

According to Epstein, measuring a trait requires establishing both temporal reliability, or stability, and generality. The former can be accomplished by averaging behavior over sufficient occasions and the latter by averaging behavior over appropriate situations. Reviewing the previous studies Epstein and O'Brien (1985) found evidence of consistent behavior in multiple, but not single items of behavior. They concluded that the main reason for earlier found low correlates was the use of unreliable measures of non-aggregated behavior. Also, the earlier empirical results were misinterpreted, they explained, because of the erroneous belief that if behavior is highly situation specific, it cannot also be general. In the earlier studies the variation of behavior that could not be explained by the poor measures of traits was erroneously interpreted to be situation specific. This led to a research design where the poorer the trait measure used and therefore less of the variation in behavior explained, the more of the variation was interpreted as evidence for situationalist approach.

Another explanation for poor correlation between self-report personality measures and behavior is that the respondent is inconsistent in her statements. Eisner (1987, p.71) theorizes that each attitude is generated context specific. A person generalizes her attitudes to other contexts only when a new judgement is needed. This leads to a situation where a person is likely to hold inconsistent attitudes at any particular time. Only through interaction with other people, clarifying and defending her attitudes she adjusts them to be consistent. Thus having consistent attitude about any topic would require that the attitude is repeatedly challenged.

Schoemaker (1993) surveyed research from economic, decision making, behavioral, and biological studies about intrinsic risk attitude (IRA). IRA measures try to capture basic traits or dispositions toward risk taking independent of situation or endowments. In other words, Schoemaker was searching for evidence of risk averse or risk preferring personality.

Schoemaker discusses five factors which affect the credibility of IRA measures: 1) how problems are structured (framing), 2) how people form beliefs about probability of particular events, 3) the difference between a person's value functions and expected utility functions, 4) internal inconsistency of temporal discount rates, and 5) multiple strategies for processing information.

When two persons differ in any of these five categories, their observed risk behavior can be different even when their risk attitudes are identical. Schoemaker concluded, that "Subjects' responses, it appears, reflect primarily influences of framing, information processing strategies, and value functions, as opposed to intrinsic risk attitudes." However, contrasting this to the latest developments in personality trait theory Schoemaker notes that personality approaches have been in disfavor, but now the pendulum appears to be swinging back. All of the findings seem to agree that risk taking is not a personality trait that would describe a person in all situations. Rather, if there are stable personality differences in risk preferences, these differences are also situation specific.

5.1 Possible approach: occupational personality types

It is clear that the problem of empirically explaining the commuting time reliability preferences is in the abundance of interdependent explanatory variables, leading to an identification problem in estimation. Another problem with many psychological variables is their reliable measurement and data availability. One remedy to such problems is to see if the observations form a small number of easily observable clusters, identified by proxy variables, that maintain most of the information of the original variables. Holland (1973, 1985) has presented a theory that relies on the clustering of several background variables, which he claims identify the personality of an individual.

Holland hypothesized that a person's personality and occupation are empirically connected. He assumes:

1. Most persons can be categorized as one of six main personality types.

2. There are six corresponding environments.

3. People search for environments that will let them exercise their skills and abilities, express their attitudes and values, and take on agreeable problems and roles.

4. Behavior is determined by an interaction between personality and environment.

According to Holland each personality type is a product of a characteristic interaction among a variety of cultural and personal forces. Out of this experience a person learns to prefer some activities. The activities become interests and lead to a special competencies, which create a particular personal disposition that in turn leads the person to think, perceive, and act in special ways.

Each type has a characteristic repertoire of attitudes and skills for coping with environmental problems and tasks. Different types select and process information in different ways, but all types seek fulfillment by exercising characteristic activities, skills, and talents and by striving to achieve special goals. The theory is interactive in that it assumes that many career and social behaviors are the outcome of people and environments acting on one another: on the one hand people gravitate towards their optimal vocation and on the other the work environment molds them towards the typical in the vocation.

The categories got started from Holland's vocational counseling work. He proposed the classification of occupations into six categories in 1957, mainly aiming to ease the career choice of his clients and to help the work of other councelors. Since then Holland has been refining the theory and the empirical sub-classifications, but the main idea of the theory has remained same: Holland claims that the choice of a vocation is an expression of personality. He explains that the six main personality types are analogous to types proposed earlier by Adler, Fromm, Jung, Sheldon, Spranger, and later by Gordon, and Welsh, but unlike those other classifications, his classification has its origin in the vocational literature and in the empirical definitions.

Holland (1958,1977) developed a Vocational Preference Inventory, a personality inventory based entirely on occupational titles. He states that these inventories are in fact personality inventories, assessing prior learning, genes, psychological and sociological influences, or the behavioral repertoires that such influences create. Thus people in a vocational group will have similar personalities, and they will respond to many situations and problems in a similar way.

Holland's theory of personality types fits well into our study about unreliable commuting time. First, as the theory is about occupational personalities, we can assume it to cover the 'commuting personalities'. Secondly, as the theory has been empirically tested[10] to actually separate different personality types, we do not have to test the theory, but only the specific application to commuting. Thirdly, since the personality types in this theory are defined on an aggregate level i.e. they speak about temporally stable behavioral traits that are repeated in a variety of situations like Epstein emphasized, the critique of personality trait theories from situationalists like Mishel loses its validity. Thus there is a good reason to expect this approach to have some explanatory power.

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[10] See a theme issue in Journal of Vocational Behavior 1992, No.2. Eg. Hyland and Muchinsky (1991) write: "Over the past two decades, approximately 700 studies have been directed toward various aspects of Holland's (1973,1985) theory. Those studies in which the structural validity of the theory has been addressed have been concerned with the correctness of the hexagon for modeling the structure of interests ... Findings supportive of the proposed

5.1.1 Summary of the main six personality types

Holland (1985) gives brief descriptions of the six main personality types. **The realistic** type prefers activities that entail the explicit, ordered, or systematic manipulation of objects, tools, machines, and animals and has an aversion to educational and therapeutic activities. These tendencies lead to the acquisition of manual, mechanical, agricultural, electrical, and technical competencies and to a deficit in social and educational competencies. The realistic person values concrete things or tangible personal characteristics - money, power, and status.

Realistic person is apt to be:

| | | |
|---|---|---|
| Asocial | Materialistic | Self-effacing |
| Conforming | Natural | Inflexible |
| Frank | Normal | Thrifty |
| Genuine | Persistent | Uninsightful |
| Hard-headed | Practical | Uninvolved |

**The investigative** type prefers observational, symbolic, systematic, and creative investigation of physical, biological, and cultural phenomena in order to understand and control such phenomena, and has an aversion to persuasive, social,

structure were reported in a large percentage of these studies." (p.75).

and repetitive activities. These tendencies lead to the acquisition of scientific and mathematical competencies and to a deficit in persuasive competencies. The investigative type values science.

Investigative type is apt to be:

| | | |
|---|---|---|
| Analytical | Independent | Rational |
| Cautious | Intellectual | Reserved |
| Critical | Introspective | Retiring |
| Complex | Pessimistic | Unassuming |
| Curious | Precise | Unpopular |

**The artistic** type prefers ambiguous, free, unsystematized activities that entail the manipulation of physical, verbal, or human materials to create art forms or products, and has an aversion to explicit, systematic, and ordered activities. These tendencies lead to the acquisition of competencies in language, art, music, drama, and writing, and to a deficit in clerical or business competencies. Artistic type values esthetic qualities.

Artistic type is apt to be:

| | | |
|---|---|---|
| Complicated | Imaginative | Intuitive |
| Disorderly | Impractical | Nonconforming |
| Emotional | Impulsive | Original |
| Expressive | Independent | Sensitive |
| Idelistic | Introspective | Open |

**The social** type prefers manipulation of others to inform, train, develop, cure, or enlighten, and has an aversion to explicit, ordered, systematic activities involving materials, tools, and machines. These tendencies lead to the acquisition of interpersonal and educational competencies and to a deficit in manual and technical competencies. The social type values social end ethical activities and problems. The social type is apt to be:

| | | |
|---|---|---|
| Ascendant | Helpful | Responsible |
| Cooperative | Idealistic | Sociable |
| Patient | Empathic | Tactful |
| Friendly | Kind | Understanding |
| Generous | Persuasive | Warm |

**The enterprising** type prefers the manipulation of others to attain organizational goals or economic gain, and has an aversion to observational, symbolic, and systematic activities. These tendencies lead to the acquisition of leadership, interpersonal, and persuasive competencies, and to a deficit in scientific competencies. The enterprising type values political and economic achievement.

The enterprising type is apt to be:

| | | |
|---|---|---|
| Acquisitive | Energetic | Flirtatious |
| Adventurous | Exhibitionistic | Optimistic |
| Agreeable | Exitement- | Self-confident |
| Ambitious | seeking | Sociable |
| Domineering | Extroverted | Talkative |

**The conventional** type prefers explicit, ordered, systematic manipulation of data, such as keeping records, filing materials, reproducing materials, organizing written and numerical data according to a predescribed plan, operating business machines and data processing machines to attain organizational or economic goals, and has an aversion to ambiguous, free, exploratory, or unsystematized activities. These tendencies lead to the acquisition of clerical, computational, and business system competencies and to a deficit in artistic competencies. Conventional type values business and economic achievement.

Conventional type is apt to be:

| | | |
|---|---|---|
| Careful | Inflexible | Persistent |
| Conforming | Inhibited | Practical |
| Conscientious | Methodical | Prudish |
| Defensive | Obedient | Thrifty |
| Efficient | Orderly | Unimaginative |

5.2 Resource exhange theory

Holland's occupational classification has a counterpart in Foa's Resource exhange theory (1973, 1993). Foa's theory states that human interaction can be seen as exhanges of different resources. Incidentally, the resource classes of Foa's theory describe the Holland occupational groups. Now the occupational groups can be given another interpretation: the occupational groups are characterized by the main resource exchanged. I have not come across any mention of this coincidence of the two theories in the published literature.

Foa classifies resources into six categories and posits that the categories of resources follow distinct rules of exhange. The six resources are love, services, goods, money, information, and status. Foa characterizes the resources as follows:

> 'Love' is defined as an expression of affectionate regard, warmth, or comfort; 'status' is an expression of evaluative judgement which conveys high or low prestige, regard, or esteem; 'information' includes advice, opinions, instruction, or enlightenment, but excludes those behaviors which could be classed as love or status; 'money' is any coin, currency, or token which has some standard unit of exhange value; 'goods' are tangible products, objects, or materials; and 'services' involve activities on the body or belongings of a person which often constitute labor for another.

Foa places the resources in a two-dimensional space -- particularistic-universal and concrete-symbolic as presented in Figure 7. Foa mentions that the resource classes are presented as points in a 2-dimensional space for illustrative reasons, while their truer presentation would be a range or a distribution.

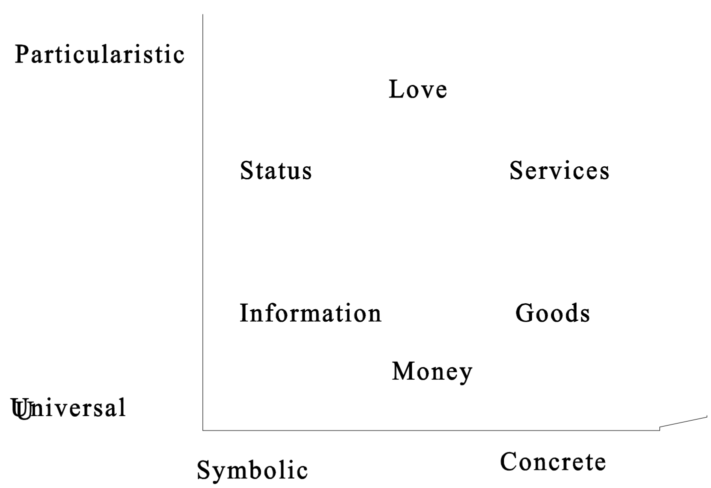


Figure 7. Foa's resource circle.

As an example of the different rules for successful resource exchange Foa elaborates the distinctions of rules of exchange in the particularistic-universal dimension:

1) The relationship between giving the resource to the other and giving it to self is positive for love but decreases and becomes negative as one moves from love to money. In consequence, an exchange in money can be a zero-sum game, while an exchange of love can not.

2) Giving love doesn't exclude the concurrent presence of some hostility, but giving and taking away money are unlikely to occur in the same act.

3) Money doesn't require an interpersonal relationship in order to be transmitted, while love can hardly be separated from the interpersonal situation.

4) Giving and receiving love cannot be done in a hurry; it requires time. Money, to the contrary, can change hands very rapidly.

5) Love is a relatively long-term investment, with rewards being reaped only after several encounters. An exchange of money with another resource can be completed in a single encounter.

6) The optimum group size for exchanging love is relatively small, while large groups meet for stock or commodities exchange.

The classification is more insightful if Foa's circle of resources is rearranged into a 3 x 2 matrix. In Table 2 the resources are presented in a 3 x 2 matrix with the corresponding Holland occupational groups.

Foa's discussion about the differences between 'Love' and 'Money' is a discussion about the differences between the three rows and the two columns of resources. I will elaborate further on the differences. I call the three tiers of resources Value creation, Realizing existing values, and Material means for realizing the values, respectively from top to bottom. L'Abate (1993) has named the skills associated with them as Presence, Performance, and Production, while he calls the functions Being, Doing, and Having, respectively.

Table 2. Foa's resources and Holland's occupations.

| Exchanged resources and corresponding occupations | | Use of resources | L'Abate's terms |
|---|---|---|---|
| Symbolic-universal | Concrete-particularistic | | |
| Resource: Status<br><br>Occup. : Artistic | Resource: Love<br><br>Occup. : Social | Creating values | Presence<br>Being |
| Resource: Information<br><br>Occup. : Investigative | Resource: Service<br><br>Occup. : Enterprising | Realizing existing values | Performance<br>Doing |
| Resource: Money<br><br>Occup. : Realistic | Resource: Goods<br><br>Occup. : Conventional | Material means for realization of values | Production<br>Having |

The top tier has resources Status and Love. These resources are concerned with the experience of timeless present. It is reasonable to assume that time use with these resources is experienced less metered than with other resources: instant occurrences seemingly lasting a long time, or long time activities seemingly lasting just a blink.

At the bottom tier are resources Money and Goods. It is equally reasonable to assume that time used for producing these resources supports a metered, objectified time concept. Time used for producing these resources becomes as fragmented as the production is removed from experiencing the present.

The experience of time when performing with Information and Services, is generally a mixture of the extremes, and depends on the degree of internalized or externalized values the performer attaches to her performance.

HYPOTHESIS 4: Of the three tiers of occupations, employees in Realistic and Conventional occupations have most external experience of time at work. They are most likely to treat the commuting time like Externals. Employees in Artistic and Social occupations are most likely to treat the commuting time like Internals.

Ex ante, I expect employees in Realistic and Conventional occupations to be most risk averse: there is most tendency to change behavior when the traffic conditions worsen but there is still a good possibility to arrive on time. The more internal attitude would be to not reserve more slack time between arrival time and work start. However, when unexpected delay has happened on the road, I expect employees in Realistic and Conventional occupations to be less likely to try to maintain their previous commuting timetable, and less likely to be willing to pay to circumvent the delay. Employees in Artistic and Social occupations should have least inertia to try other avenues to secure a timely arrival at work.

The trade-offs of travel time and arriving early and late are most likely understood by people working in Realistic and Conventional occupations, while the trade-offs may stay somewhat 'academic' for people working with higher tier resources. The question of acceptability of arriving 15 minutes late should be clearest for people working in Realistic and Conventional occupations.

On the other hand, these three levels of resources pose different supervisory problems to the employer. Most clear-cut way to supervise production is to measure output. When measuring the outputs is hard, supervisors tend to measure inputs, including time spent at work.

In absense of team work requirements, the outputs of Realistic and Conventional occupations are most external and thus easiest to measure, while the outputs of Social and Artistic occupations are most internal and hardest to measure. That would make the employer to set strictest arrival time requirements for the Artistic and Social occupations and most lenient for the Realistic and Conventional occupations.

However, team work intensity changes things. As discussed earlier, team work can be measured by the interdependency, interchangeability, and criticality of the activities in the occupation. The work is most team work intensive when it is high in interdependency and criticality, and low in interchangeability.

Realistic and Conventional occupations can be assumed to be high in all three criteria. This makes the work highly team work intensive by interdependency and criticality. Also, even though the output is most external in these occupations, the quality assessment of the work may not be assigned to the individual as much as to the team. Thus both the employer and other team members have an incentive to make sure that the employees work as a team and thus it becomes important that they arrive promptly.

Artistic and Social occupations can be assumed to be low in all three team work criteria, making these occupations team work intense only as far as interchangeability of the worker is concerned. The supervisor has a harder time to asses the quality of output, since the output is most internalized in these occupations. On the other hand, the supervisor has an easier time assessing which of the employees was instrumental in producing the output. The main reason for supervising time input in these occupations is to make sure that the work is done at all. The main reason for the supervisor to demand the employee to arrive punctually are customers expecting to meet with a particular employee.

I assume that Investigative and Enterprising occupations are in the middle of all three team work intensity scales, making their productivity easiest to assess. This makes the employer least likely to monitor these employees's arrival time.

The third element affecting employer's supervision needs is the typical locus of control of the employees in the occupation. Specifically, if the locus of control in the occupation is external, the employer has more incentives to introduce penalties due to late arrival, in order to induce the employees to behave as if they had more internal locus of control. Furthermore, the employer has an incentive to provide more direct feedback to Externals, for instance a cut in pay, rather than rely on more subtle or indirect feedback like loss of reputation or future promotions.

Measuring output separately is easiest in Realistic and Conventional occupations, but both team work requirements and external locus of control require most supervision to these occupations. The employer's rules are expected to be strictest in Realistic and Conventional occupations.

The difference between the supervisory strictness of the other two tiers is not as clear. Measuring output is hardest in Artistic and Social occupations, and the team work intensity is middle range, but the internal locus of control requires minimum supervision.

Measuring output is in the middle range in Investigative and Enterprising occupations, the team work intensity is lowest, and the locus of control is in the middle range. Two out of three criteria indicate that employees in Artistic and Social occupations would be more strictly supervised than employees in Investigative and Enterprising occupations.

HYPOTHESIS 5: Employers use more immediate and concrete lateness penalties for employees with external locus of control than for employees with internal locus of control.

HYPOTHESIS 6: Of the three tiers of occupations, the employers supervise arrival time punctuality most strictly in Realistic and Conventional occupations and least strictly in Investigative and Enterprising occupations because of the typical locus of control, ease to measure outputs, and team work intensity of these occupations.

Commuters in Realistic and Conventional occupations should report most negative consequencies from late arrivals. Also, I expect that their disutility functions are steepest after the intended arrival time. The opposite should be true for commuters in Enterprising and Investigative occupations: they should report least negative consequences from late arrival and their disutility functions should be flattest after the intended arrival time.

Now, let's look at the columns of resources. On the left side the value of the resources depends on their relative scarcity between participants, whereas on the right their value depends on their absolute amounts in the individuals history, time, and individual tastes. For instance, the value of the left side resources inflates due to their symbolic-universal nature: if everybody has an equally pompous title, nobody has higher status than the next person; if we all share a piece of information, it has lost its exchange value; increasing the money supply inevitably leads to inflation. Further, these resources have a unidimensional, continuous nature, which allows a quick, person- and situation-free value formation: more is always better. Each risk has its own separable value, defined by the probability distribution of the outcomes. Each risk decision can be made separately: acquiring one does not exclude the possibility of simultaneously acquiring another.

On the concrete-particularistic side, the value of the resources depends more on the subjective tastes of the persons involved in the exchange: a teenager might like to spend time with a friend whom her parents cannot stand, she might appreciate a haircut that would be inconvenient for somebody else, or she might like a specific piece of clothing that nobody else is willing to wear. It is hard to get a single value for an exhange of these resources, as any experimental economist must have found out.

The value of concrete-particular side resources also depends more on the timing of the exchange, and more on their absolute amounts in the person's history than relative market scarcity: at certain intervals getting a haircut is a 'good' even when everybody else has one, but here the diminishing marginal value is also clearly observable: usually one at a time is enough. These resources also come in naturally discrete packages: half a haircut is often worth less than no haircut at all. The choice of one action, say a haircut, automatically excludes simultaneously attaining any other haircut.

In the pursuit of the symbolic-universal side resources one is ultimately in conflict with others pursuing the same resources due to the relative value formation. Coordination is more likely in the pursuit of the concrete-particular resources, since coordination is limited only by physical need and envy, not the intrinsic nature of the resources. Some type of coordination is also a required mode of interaction in order to carry out the exchange: there has to be a basic understanding between the hairdresser and the client about the goal in order for a successfull exhange to happen. Similarly, a goods manufacturer has to please the tastebuds of the retailer and the ultimate customer in order to stay in business. In a sense, anyone in pursuit of the concrete-particular resources has to find people who have or understand his or hers goals, whereas in the symbolic-universal side the resources are so tastefree that exchange is possible also under conflicting goals. Thus the mode of working is more conducive to coordination in the concrete-particular side, while the exhanges are more atomistic in the symbolic-universal side.

Risk of activities is approached differently with different resources. The left column of resources -- symbolic-universal -- spans the range of resources capable of immediate, separable exchanges, while the one on the right -- concrete-particularistic -- spans the resources whose successful exchange requires conscious coordination and longer term commitments.

In the pursuit of the symbolic-universal resources the investment can quite easily be divided between the resources: it is relatively easy to draft portfolios and hedge risks by 'betting on both sides'. Also due to the large optimal exhange group size, the probabilities of different outcomes are rather objective and steady: the individual cannot change them much with effort or skill. Since the symbolic-universal resources allow for an immediate exchange, the most beneficial strategy is to increase the volume of exchanges up to the limit set by information management capacity. This leads to a situation where the emphasis is placed on expanding the volume of exchanges at the cost of developing individual-specific exchange methods.

Due to their discrete nature, the concrete-particular resources often require undivided investment: it may be hard to 'hedge' by getting half a haircut from a novice and half from a master. The exchanges in these resources have externalities: if the novice spoils her half of the cut, the master's impeccable half cannot compensate to save the haircut to look even 'average'. Also, unlike with the universal-symbolic resources, the probability of a good outcome often depends on the personal involvement of both the client and the hairdresser and their cooperation skills. The emphasis on developing the individual specific exchange methods leads to a better return to effort than trying to increase the amount of exchanges. A good strategy with the concrete-particular resources is not spreading the risk by "placing the eggs in different baskets", but rather keeping them in one basket and tending the basket carefully, a la Mark Twain.

The information processing for these resources should also be apt to happen differently: the resources in symbolic-universal column require less commitment, are less connected, and have fewer value dimensions. They are best managed with information processing which considers the utility from potential outcomes and their probabilities, not the regrets of choosing the wrong alternative if the unfavorable state of world occurs. This type of information processing excludes 'sunk cost' as a factor in decision making.

The concrete-particular side resources require more commitment, are more connected, and have more value dimensions. Because they require more commitment, their evaluation requires taking possible regret into account. Thus they are best managed with information processing that incorporates anticipated emotions and consequently the 'sunk cost' of previous plans and actions. In the external-internal axis, symbolic-universal resources are better dealt with external attitude, and concrete-particularistic resources with internal attitude.

To repeat, the resources in the symbolic-universal column can be exchanged without history or dependance on individual tastes. Their value is determined by relative amounts between the potentially exchanging parties, creating an inherent conflict between two parties in pursuit of the same resource. Risk in the pursuit of these resources can be managed by hedging, but not by changing the probabilities by skill or effort. The exhanger cannot go for the most beneficial portfolio if he commits to a particular resourse, a particular alotment of a resource, or any particular provider of the resource. The efficiency is most likely derived from increasing the volume of exchanges. These exchanges require and are malleable to reasoning, which considers actions based only on the possible outcomes of each action and their probabilities, an external attitude.

To the contrary, the resources in the particularistic-concrete column derive their value from their absolute amounts, history, and individual tastes. The attainment of these resources requires a common goal between exchanging parties, making coordination a conducive mode of conduct. Consequently, the probability of success depends largely on the skill and effort of the exchanging parties. This makes the risk management more of an effort to tending the chosen projects into a successful finish than dividing resources between conflicting trials. The resources have multidimensional values, which depend more on the amounts of other resources the person has, his history with these resources, and his history of exhanges of the resources with other people. Decisions concerning these resources requires considering earlier commitments and acknowledging regrets when things do not go the planned way. They require emotional evaluation of the alternatives, an internal attitude.

If people drift towards the occupations where their specific skills and talents are rewarded and enforced, people are likely to approach commuting risks the same way they approach other risks concerning time use in their occupation. People in particularistic-concrete occupations: Social, Enterprising, and Conventional, are more likely to react to changing commuting situations more internally than people in symbolic-universal occupations: Artistic, Investigative, and Realistic.

HYPOTHESIS 7: The occupations in the particularistic-concrete column: Social, Enterprising, and Conventional, support more internal locus of control than the occupations in the symbolic-universal column: Artistic, Investigative, and Realistic.

Ex ante, employees in Social, Enterprising, and Conventional occupations are expected to be less risk averse than employees in Artistic, Investigative, and Realistic occupations: there is less tendency to change behavior when the traffic conditions worsen but there is still a good possibility to arrive on time. The more external attitude would be to reserve more slack time between arrival time and work start. However, when unexpected delay has happened on the road, employees in Social, Enterprising, and Conventional occupations are more likely to try to maintain their previous commuting timetable, and are thus more likely to be willing to pay to circumvent the delay than employees in Artistic, Investigative, and Realistic occupations. In stated preference questions, the respondents in Social, Enterprising, and Conventional occupations should be less averse to general planning uncertainty than respondents in Artistic, Investigative, and Realistic occupations. Also, the respondents in Social, Enterprising, and Conventional occupations are expected to be more concerned about scheduling. Thus their trade-offs of scheduling variables versus mean travel time should he higher than the corresponding ratios for respondents in Artistic, Investigative, and Realistic occupations.

# 6. EARLIER EMPIRICAL FINDINGS

## 6.1 Commuter perceptions of travel time reliability

To be able to discuss reliability of travel time one has to first define what we mean with reliability and how our definition matches the commuters's perception of reliability.

Proussaloglou and Koppelman (1989) study how accurately perceptions corresponded with different ‘hard’ measurements of performance of commuter trains. They find that the perception ratings of on-time performance are weakly related to the percent trains more than six minutes late. A stronger relationship exists between perception ratings of the train being on-time and the severity of delays expressed by the average delay per delayed train. Thus, they conclude that severity of delays is a more appropriate determinant of riders's perceptions of rail reliability than percent of late trains.

Also there is no clear relationship between perception of '’getting to destination quickly’ and average operating speed. However, a line that has long average delays gets unexpectedly low rating, and a line that has relatively low average speed but excellent on-time performance gets the highest rating for ‘getting to destination quickly’. Thus the perceptions of reliability and average speed may be intertwined.

When the authors use the perception attributes to estimate a mode choice model, the perception of getting to destination quickly is the most important factor. Another interesting observation is that monetary cost was the least important factor.

Senna (1994) refers to Benwell and Black (1984) to make a distinction between reliability and punctuality. Reliability is defined in terms of the amount of lateness and the probability of its occurring. Punctuality is defined as the probability of not arriving late. Respondents were offered three profiles of lateness associated with representative 10 train journeys:

| | Mean lateness in minutes | Standard deviation |
|---|---|---|
| A: {0,0,5,6,8,7,6,4,5,9} | 5 | 2.86 |
| B: {0,0,0,0,0,0,25,5,10,10} | 5 | 7.75 |
| C: {0,0,0,0,0,0,0,0,20,30} | 5 | 10.25 |

Majority of the respondents , 56%, chose option C, 38% chose option A, and only 6% chose option B. Senna restates that respondents prefer low probability of lateness (punctuality), and given unpunctuality, the respondents prefer the alternative with the smallest amount of lateness. He refers to the authors mentioning that the result may be due to the visual presentation, and connects this result to the hypothesized risk-proneness of commuters.

This kind of result is very plausible even when it is not due to framing. The respondents may simply have a taste for the skewness of the distribution. We cannot say anything about risk-proneness when the higher order moments are not controlled for. Had the authors kept both the skewness and the mean constant, respondents would have probably preferred a smaller second moment.

The reaction to uncertain morning commuting time can be divided into two levels: first the preference over uncertain travel time when the departure time from home is unchangeable. This preference order maps the relative valuations of early, on time, and late arrival times when one cannot change the probability distributions. The second level of the preference order frees the choice of departure time and thus allows trading-off the probability distributions against time spent at home. The studies just mentioned refer to preferences in the first level: a train rider has little influence over the departure times of trains. However, a carpooler only has to coordinate her departure with a few other individuals, and a solo driver can decide on the departure time on her own.

Lopes's SP/A theory predicts that the commuters concern about uncertainty at the first level of preference is mostly about the security-potential part. We would expect people to use decumulative weighting and focus on the extreme outcomes more than their objective probabilities would warrant. When the departure time is not fixed and there is an opportunity to adjust the total time devoted to work related activities, we would expect the aspiration part to be more prominent and the outcomes to be evaluated according to probability based averaging, i.e. less risk averse in the case of commuting. Black & Towris (1993) conducted an experiment asking people to choose between travel options that had a varying spread of travel times, mean travel times, and monetary cost. They estimated linear utility functions consisting of the mean travel time, standard deviation of the travel time, and monetary cost of the trip. Their model for car drivers commuting is presented in Table 3.

Table 3. Estimation results of Black and Towris (1993)

| | Coefficients (t-statistic) |
|---|---|
| Mean travel time | -0.0635<br>( 8.90) |
| Standard deviation of travel time | -0.0352<br>( 3.17) |
| Monetary cost | -0.0082<br>( 6.34) |
| Value of time (pence/minute)<br>95% confidence interval | 7.72<br>1.57 |
| Reliability ratio (std/mean travel time)<br>95% confidence interval | 0.55<br>0.30 |
| F-ratio:<br>Sample size | 26.9<br>835 observations, from a total of 354 car drivers |

Since they did not limit the departure time, the respondents were presented a situation where they could adjust their probability of arriving late by departing earlier. Compared to situations where the commuter does not have that choice (for instance when carpooling), the commuter is expected to emphasize mean travel time more than the unreliability of the travel time.

They found that the coefficient for standard deviation of travel time remained stable when the standard deviation changed, which indicated that a coefficient of variation of travel time (standard deviation divided by the mean) could be used directly in the utility formulation. Both of these formulations have plausible descriptions: in the first utility formula, the commuter is assumed to formulate her reliability perceptions and preferences based on the absolute amount of variation of travel time. In the second formulation, the commuter is supposed to have a constant preference over the ratio of standard deviation of travel time to mean travel time. Their generalized cost (GC) estimate for car driving commuters is (in 1993 English pounds):

GC = -0.0082* Monetary cost + 7.72* Mean travel time ( 1 + 0.55 * coefficient of variation).

## 6.2 General preferences about arriving early and late

Commuters can avoid the risk of being late by leaving so early that they are likely to arrive earlier than needed. The time between required arrival time and intended arrival time has many names: it is called a safety margin, schedule delay early, slack time, and preferred arrival time (PAT). If the only risk in commuting can be construed to be that of arriving late, people with a greater schedule delay early can be described as risk averse.

Abkowitz (1981) found that people do not consider this risk at all: his results can be interpreted to show that people consider the expected arrival time only, not the uncertainty. Abkowitz used somewhat arbitrary assumptions to specify the functional form, which may have influenced the results.

Small (1982) found an aversion to arriving both early and late. He computed several marginal values of arriving early or late in terms of travel time units. He characterized the results: "On average, urban commuters will shift their schedules by 1 to 2 minutes toward the early side, or by 1/3 to 1 minutes toward the late side, in order to save a minute of travel time."

Pells (1987) measured the value of early and late arrival time to work in two experiments. The early arrival time experiment does not offer any consideration for unreliable travel time. It is a measure of the value of time at home versus the value of time at work prior to the work start time. The estimated value of early arrival was 1.5 pence/minute, corresponding to $ 1.46 / hour.

The other experiment required the respondent to consider a choice between an option in which she was guaranteed to arrive at work on-time and another which, although cheaper, incorporated some risk of late arrival. Pells incorporated the risk of arriving late in different amounts of minutes and also by the frequency of lateness (once a month or once in two weeks). The value for late arrivals was 6.7 pence/minute, corresponding to $ 6.50 /hour.

Mahmassani & Tong (1989) found that schedule delay is of much greater concern than travel time. Schedule delay associated with lateness was more negatively valued than schedule delay associated with earliness. Their result, however, was derived from an experiment where no lateness or flextime was allowed to the commuters.

Mahmassani, Caplice and Walton (1990) reported more closely the distribution of the slack time. The mean was 14 minutes before the work started and the standard deviation was 13.9 minutes. 16 % of commuters reported that they did not try to arrive earlier than official work start time. Caplice and Mahmassani (1992) analyzed their data further to produce a model to explain the distribution of slack time. Since lateness tolerance in the work place had the most effect on slack time, further findings are discussed in a later occasion.

### 6.3 The effects of gender, age, and marital status on arrival time preferences

Abkowitz (1981) analyzed data that contains calculations for each individual for uncertain auto in-vehicle travel time for twelve alternative time periods during peak period. He found that gender had a small and insignificant effect on the choice, but older workers are more inclined to depart so as to arrive earlier than the official work start time. His findings are contrasted by Prashker (1979), who found the gender of the respondent to be a significant classification variable with respect to the attitudes towards different kinds of travel related reliability measures. However, he qualified that this difference can be attributed to difference in education, or alternatively to employment status, which were not controlled in his study.

Pells (1987) found that gender has an effect on time values. Value of early slack time was significantly greater for women than men. Pells found a highest value for slack time for married women, but also the value for single women remained significantly higher from men's value. Small (1982) results indicated that early arrival was especially disadvantageous for singles.

## 6.4 The effects of travel mode on arrival time preferences

It is not clear whether the choice of travel mode causes different behaviour with respect to schedule delays or whether the preference over schedule delay affects mode choice. In any case, there seems to be a difference in behavior.

Prashker (1979) found that car users are more irritated with the unreliable time spent looking for parking than transit users were for unreliable waiting time. Abkowitz (1981) found that car travelers are more likely to plan on arriving at work exactly on time, while bus travelers are only not likely to depart so as to arrive extremely early on work. Small (1982) found that regular car poolers were more likely to arrive early at work and they find the travel time less onerous than solo drivers. Pells (1987) confirmed that car drivers had a lower value of monthly lateness compared to fortnightly lateness, but bus riders had equal value for both.

Black and Towriss (1992) survey indicated that company car drivers had highest value of time measured as the ratio of coefficients for mean travel time and monetary cost of the trip ($\beta_T/\beta_C$), while the bus passengers the lowest value of time.

However, the company car drivers had the smallest coefficient of reliability ratio[11], followed by bus passengers, train passengers and private car passengers, respectively.

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[11] Coefficient of reliability ratio is the ratio of coefficient of standard deviation of travel time to coefficient of mean travel time.

6.5 Time-of-day decision

I present the time-of-day decision results separately from results presenting behavior concerning schedule delay. When incorporating schedule delay in her commute, a commuter reserves more time for commuting and is prepared to spend some of the time waiting, but plans to start work at the customary time. When the commuter changes the time-of-day of her commute, not only her does departure time change, but also her arrival time and work start time change. As her work start time changes the timing of work activities changes, possibly affecting productivity of other employees. When she adjusts to the unreliable commuting by incorporating schedule delay, the timing of work activities stays the same. Of course it is impossible to give a clear cut threshold value after which the change of departure time is big enough to be called time-of-day choice. Rosenbloom (1988, 1989) and Giuliano (1993) give evidence that women, particularly if they have small children, find it harder to change the time-of-day of commuting, because such changes would create conflicts with their responsibilities towards family members.

Bates et. al (1990) distributed departure times into half hour slots during morning and afternoon peaks, and asked people to trade-off the length of commuting time with more or less convenient time-of-day slots. They found that people on the outskirts of the peak have a higher resistance to move further away from the peak in order to have a smoother commute than people in the middle of the peak. Bates et al. called this a 'centripetal' behavioral pattern. They also warned that it is dangerous to rely on the average elasticities of trade-offs, when the elasticity depends on the person's current departure time.

Polak et. al. (1993) develops a model where the traveler assigns value to an activity based on the time of day of the activity. The individual maximizes a utility function which is a sum of utilities of activity at home before tour, activity at home after tour, activity at destination, travel, and utility from generalized goods. The authors found that commuters tend to be more constrained in the start time of the tour, but that they were more willing to extend than to shorten their tour. They also found non-linearities in response to shifts in the timing of the tour later. Not surprisingly, scheduling is more important for commuters than for shoppers or leisure travelers. But both commuters and shoppers and leisure travelers suffer a strong negative impact if they are not able to spend at least a minimum amount of time they require at the destination. However, these results could be sample specific: the authors chose to the sample only persons who made only one return trip per day. Thus when the sample largely consists of people who prefer to make only one trip per day, it is not surprising that they were more willing to extend their trip than to cut it short and make another later.

HYPOTHESIS 8: Earlier empirical findings indicate that age, gender, and presence of small children modify commuting preferences. Older age has been connected to willingness to arrive early at work. Especially women who live with small children often have to coordinate commuting timetables with family responsibilities. This is expected to increase risk averse behavior in both ex ante choices and ex post reactions to changing situations for women with small children.

## 6.6 The effects of occupation, income, and commuting distance on arrival time preferences

The effects of occupation and income are interrelated. Williams (1978) estimated three versions of logit and probit models for commuting mode choice. He found that while relative prices of bus and car alternatives or individual income played no significant role in the mode choice, white collar workers were more likely to select a car alternative than blue collar workers when commuting. In the "Pre-BART" Household Survey in San Francisco in 1965 the respondents were asked "How many minutes late can you arrive at work without it mattering very much?" The highest frequencies of answers indicating zero were from semi-skilled and unskilled workers (84% and 80%, respectively). The lowest zero-answers were in managerial (35%) and retail (41%) categories. The intermediate categories were professional, clerical, skilled, and service sector, in increasingly tightening schedule order (McFadden et al, 1977). Cubukgil and Miller (1982) results indicated that there are clear differences in housing and employment locational patterns and sensitivity to auto travel time, which cannot be explained only by income. They also concluded that the simple white collar-blue collar classification is inadequate, because extreme variation in behavior exists within these broad categories.

Abkowitz (1981) concluded that individuals employed in a professional, technical, management, or administration capacity typically avoid departure such that arrival at work will be early. He also found low income workers to have a definite interest in arriving at or slightly before the official work start time.

Small (1982) found that white collar workers were less averse to late arrival, both the slope and the constant term of disutility were lower than for the blue collar workers. Small also mentions somewhat ambiguous results suggesting that scheduling considerations may be more important relative to travel time for high-wage workers.

Pells (1987) found that individuals living further away, people in senior positions, and at the top end of income were more likely to accept arriving early. Because women were disproportionally represented in clerical occupations, Pells segmented the data further by occupation, but the value of slack time was found to vary independently of it.

When we bear in mind the result of Cubukgil and Miller that occupational segregation is correlated with spatial segregation, it could be that the distance variable in Pells study picks up some variation due to occupation.

Contrasting these findings, Mahmassani, Caplice and Walton (1990) reported that travel time has no significant effect on the preference to arrive early or late at the work place.

In his experiment about the willingness to risk arriving late at work Pells found that people at lower organizational positions were clearly averse to late arrivals. Also people in the lower income class had twice as high a value for arriving late fortnightly than commuters in the higher income class. This result did not carry to monthly lateness, where the values for income classes were practically equal. Geographical distance was significant for the monthly category only, indicating that lateness once a month could be excused by long commuting distance, but the travel distance was not an acceptable reason for fortnightly lateness. Black and Towriss (1992) found that reliability ratio[12] was highest in the lowest income class while the two other income classes had similar values. However the value of reliability[13] was higher in higher income classes.

HYPOTHESIS 9: Commuting distance, and income have been found to be positively correlated. The six occupational groups are expected to have characteristic commuting distances irrespective of the effects of income.

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[12] Reliability ratio is the ratio of coefficients for standard deviation of travel time and mean travel time.

[13] Value of reliability is the ratio of coefficients for coefficient of variation for travel time and travel cost.

## 6.7 The effects of work place tolerance for lateness

Abkowitz (1981) found that the availability of a flexible work schedule is important for people planning to arrive exactly on time, and extremely important for those planning a late work arrival. Also Small's (1982) estimations confirmed that late arrival is less onerous for workers who report some flexibility. It was extra onerous at instances where lateness exceeded the stated flexibility limit.

Mahmassani, Caplice and Walton (1990) report that more than half of the respondents stated that there was no tolerance of lateness at their workplace, while one third stated that they had unlimited tolerance. The remaining 7.6% reported a time ranging from 5 to 60 min. Commuters working in the CBD, female commuters and those with scheduled shift work were more likely to have no lateness tolerance at the workplace.

Caplice and Mahmassani (1992) find that lateness tolerance in the work place has the most striking effect on reserved slack time, basically dividing the respondents into two segments: those with lateness tolerance and those without. Lateness tolerance in the workplace reduces the reserved slack time before the official work start time. This supports the previous findings of a flatter disutility function for lateness tolerant work places.

Caplice and Mahmassani find that if the workplace does not tolerate lateness, being a man, a renter, and having a work start time between 7:45 and 8:15 reduces reserved slack time before official work start time. On the other hand, if the respondent's workplace tolerates lateness, being male and a renter increases the reserved slack time.

Since the competing independent variables are highly correlated, the authors could have come up with a very different set of statistically significant individual and workplace characteristics. That the lateness tolerance is such a good predictor of reserved slack time may be because it is a rather subjective measure. A commuter who tends to arrive just-on time or late to work may report a more lax expectation than a more careful colleague working in the same establishment. Also, lateness is commonly better tolerated in the higher levels of organizational status. Thus it is expected that the job status loses significance in the estimation when the lateness tolerance is introduced as an explanatory variable. Renter status was used as a proxy for low income. These results could indicate that low income males are either less responsive to employer sanctions and expectations than other people, or that they are less likely to report employer expectations according to their current commuting habits.

Mahmassani, Caplice and Walton (1990) find that commuters working in an environment with a high tolerance for late arrivals had lower propensity to change their departure time from home as a response to congested traffic conditions. Total travel time and listening to radio traffic reports increase the propensity to change departure time. However, it can be argued that people who are willing to consider changing routes and departure times are the ones seeking for the traffic information, so one should be careful in interpreting the direction of causation with this variable.

Black and Towriss (1992) survey indicates that the value of mean travel time increases with the importance of punctual arrival. However, the value of reliability ratio showed a weak *decreasing* trend, i.e. the more important a punctual arrival was, the less the commuters were willing to pay to lower the ratio of standard deviation of travel time to mean travel time. One interpretation for this finding could be that commuters do not consider each commute as a separate risky situation. Instead, they might be interested in decreasing the risk of high proportion of late arrivals, but do not mind the risk of being late sometimes as long as they on the average spend less time commuting and usually arrive on time. This interpretation is supported by the Black and Towriss finding that frequent travelers placed more importance on mean travel time and less on reliability than first time travelers.

## 6.8 Non-linearity of the utility function and its stability

Prashker (1979) estimated a utility function of travel time variation. It was found to be convex at least along the lower values of variation. This suggests that up to a point people are less irritated with each additional amount of variation. Prashker hypothesized, however, that beyond some critical value the function might be concave. The earlier mentioned results of Proussaloglou and Koppelman (1989) also seem to support the idea that disutility of being late is non-linearly increasing.

Pells (1987) results indicated that the frequency of being late matters: when the value of late time was segmented by lateness frequency, the marginal value for monthly lateness was 6.5 and for fortnightly lateness 7.9 pence/minute (corresponding to $ 6.31/hour and $ 7.67/hour, respectively). The growing marginal disutility from more frequent lateness is modified by Black and Towriss (1992). They report that frequent travelers placed more importance on mean travel time and less on reliability than first time travelers. They also find the value of travel time to be a non-linear function of the mean travel time: there was no clear trend, except at 20 minutes it was clearly lower and at 90 minutes clearly higher than in between.

Aside frequency, Pells found that the value of schedule delay early was a slightly concave function, but concluded that a linear approximation would be acceptable. Also Small (1982) found that a linear model was better than non-linear in the case of too early arrival. However, schedule delay late was increasingly onerous, indicated by a significant quadratic term.

In a laboratory experiment Mahmassani & Tong (1989) tested for parameter stability of the disutility function over time. Their warned that "it would not be appropriate to assume that [commuters] consistently apply the same utility function to a changing set of attribute values to predict the day-to-day evolution of time-dependent flows in congested traffic systems."(p.21). "In particular, a static utility function, estimated using observations of user behavior in a system that is effectively in equilibrium, is not likely to provide an appropriate basis for predicting the responses to changes in the system."(p.21). Besides indicating truly changing preferences this result could indicate that the utility formulation they used was mis-specified.

## 7. HYPOTHESES FOR THIS STUDY

The following hypotheses are tested in this dissertation:

HYPOTHESIS 1: Stress increases emotionality of the decision process. I expect a stressed commuter to behave according to the defensive avoidance, which would be manifested as inertia to changes in present commuting habits.

HYPOTHESIS 2: Anticipation of negative consequences from lateness at work makes the commuter more risk averse with respect to late arrival, ceteris paribus. The more undeniable the consequences, the more risk averse the decisions.

In commuting situation, expecting explicit negative feedback like a loss of an hour's worth of pay should induce a stronger change in behavior than less direct feedback, like potential loss of reputation or loss of possible future promotions, while commuters who do not anticipate any negative consequences should be least risk averse towards late arrival. If wage-earners are more likely to lose pay due to lateness than salaried personnel, regret theory suggests that they should be more averse toward late arrivals than salaried personnel.

HYPOTHESIS 3: Internals are more optimistic than Externals. When Internals consider commuting risks ex ante, they are less risk averse than Externals. When Internals are facing risks ex post, they are more risk averse with respect to the intended arrival time than Externals.

The ex ante risk aversion should show up in the stated preference choices: the reliability of travel time is expected to be relatively more important than mean travel time for Externals than for Internals. But since the Internals are more goal oriented than Externals, Internals should be more averse to schedule delay early and schedule delay late. The Internals' optimism to beat the traffic should show up in the question which describes a worsened traffic condition where delays happen more often but there is still a good possibility to arrive on time: I expect Internals to have a smaller tendency to increase slack time between arrival and work start, or to change their commuting habits in any other way. The ex post risk aversion should show in the question which describes an unexpected 30 minutes traffic jam. I expect commuters with internal locus of control to be more willing to pay to restore the original expected arrival time than commuters with external locus of control.

I use one measure of locus of control that is based on the respondents chosen description of her work, in question 9. I also associate locus of control to occupational groups.

HYPOTHESIS 4: Of the three tiers of occupations, employees in Realistic and Conventional occupations have most external experience of time at work. They are most likely to treat the commuting time like Externals. Employees in Artistic and Social occupations are most likely to treat the commuting time like Internals.

Ex ante, I expect employees in Realistic and Conventional occupations to be most risk averse: there is most tendency to change behavior when the traffic conditions worsen but there is still a good possibility to arrive on time. The more internal attitude would be to not reserve more slack time between arrival time and work start. However, when unexpected delay has happened on the road, I expect employees in Realistic and Conventional occupations to be less likely to try to maintain their previous commuting timetable, and less likely to be willing to pay to circumvent the delay. Employees in Artistic and Social occupations should have least inertia to try other avenues to secure a timely arrival at work.

The trade-offs of travel time and arriving early and late are most likely understood by people working in Realistic and Conventional occupations, while the trade-offs may stay somewhat 'academic' for people working with higher tier resources. The question of acceptability of arriving 15 minutes late should be clearest for people working in Realistic and Conventional occupations..

HYPOTHESIS 5: Employers use more immediate and concrete lateness penalties for employees with external locus of control than for employees with internal locus of control.

HYPOTHESIS 6: Of the three tiers of occupations, the employers supervise work time most strictly in Realistic and Conventional occupations and least strictly in Investigative and Enterprising occupations because of the typical locus of control, ease to measure outputs, and team work intensity of these occupations.

Commuters in Realistic and Conventional occupations should report most negative consequences from late arrivals. Also, I expect that their disutility functions are steepest after the intended arrival time. The opposite should be true for commuters in Enterprising and Investigative occupations: they should report least negative consequences from late arrival and their disutility functions should be flattest after the intended arrival time.

HYPOTHESIS 7: The occupations in the particularistic-concrete column: Social, Enterprising, and Conventional, support more internal locus of control than the occupations in the symbolic-universal column: Artistic, Investigative, and Realistic.

Ex ante, employees in Social, Enterprising, and Conventional occupations are expected to be less risk averse than employees in Artistic, Investigative, and Realistic occupations: there is less tendency to change behavior when the traffic conditions worsen but there is still a good possibility to arrive on time. However, when unexpected delay has happened on the road, employees in Social, Enterprising, and Conventional occupations are more likely to try to maintain their previous commuting timetable, and are thus more likely to be willing to pay to circumvent the delay than employees in Artistic, Investigative, and Realistic occupations, respectively. Also, the respondents in Social, Enterprising, and Conventional occupations are expected to be more concerned about scheduling. Thus their trade-offs of scheduling variables versus mean travel time should he higher than the corresponding ratios for respondents in Artistic, Investigative, and Realistic occupations, respectively.

HYPOTHESIS 8: Earlier empirical findings indicate that age, gender, and presence of small children modify commuting preferences. Older age has been connected to willingness to arrive early at work. Especially women who live with small children often have to coordinate commuting timetables with family responsibilities. This is expected to increase risk averse behavior in both ex ante choices and ex post reactions to changing situations, most markedly by women with small children.

HYPOTHESIS 9: Commuting distance, and income have been found to be positively correlated. The six occupational groups are expected to have characteristic commuting distances and carpooling tendencies irrespective of the effects of income.

8. OPERATIONALIZATION OF THE MODEL USING STATED PREFERENCE DATA

I use a standard binomial logit model to analyze data from the Stated Preference questions. The model calculates a probability that the decision maker will choose a particular alternative from the set of alternatives, given the observed data. A good description of logit models is in Greene (1990), and Maddala (1983).

A standard logit model has been criticized for its “independence of irrelevant alternatives” property, or IIA. This property indicates that the ratio of choice probabilities of two alternatives, say *h* and *k*, depends on those two alternatives only and not on any irrelevant third alternative, *m*. IIA becomes a problem when the two choice alternatives *h* and *k* give similar unobserved utilities, which makes the corresponding random utilities $e_h$ and $e_k$ correlated. This leads to a situation where the ratios of choice probabilities between *h* and *k* are distorted with respect to a third irrelevant alternative *m*.

Fortunately, IIA is not a problem in hypothetical choice situations where the alternatives are not mode specific and the only characteristics of the alternatives are the ones explicitly presented. Thus the logit models used in this study are not suffering from IIA. However, many choice models using Stated Preference data suffer from large error terms[14], indicating perhaps that the explicit elimination of the irrelevant alternatives leads the decision maker to make personal assessments that

[14] For instance Senna (1994) mentions this tendency.

the experiment designer did not intend to include in the model. This creates a trade-off between the attributes that are explicitly accounted for in the model, and the attributes the respondent assigns to the alternatives without explicit prompting from the experiment designer.

## 8.1 Modeling transportation choices with attitude or personality variables

The transportation mode choice modelers almost always use structural variables like travel time and cost, variables describing person's household size, age, and gender etc., that can be seen as describing the decision maker's life situation. But some modelers have also used attitudes and perceptions as explanatory variables. The rationale for this is that our decisions are based on what we understand and feel about a situation, not what it objectively is.

For descriptive models this practice offers possibilities for new insights. But for forecasting models it poses some problems:

1) It is often hard and expensive to get data on attitudes about e.g.. level-of-service variables for different travel modes, while it is relatively easy to collect the 'hard data' of headways and seat availability.

2) For planning purposes, it is more relevant to know how people react to the 'hard data' decision variables directly, thus avoiding the decreased reliability of data from estimating the attitudes and then using those estimates to forecast choices.

3) In many applied studies the personality types are defined study-specific. These results are hard to generalize.

Holland's occupational personality theory circumvents these problems, because it uses a 'hard' variable - occupation - to describe the subjects personality. Occupational data of the residents or employees of a specific area are often attainable without surveys conducted on the individuals making commuting decisions.

The Institute of Transportation Studies at Irvine has recently conducted a comprehensive nine wave panel study on commuting[15]. This study provides information on the respondents' commuting habits, socio-economic background, vehicle information and employer supplied incentives to discourage solo driving to work.

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[15] A detailed description of the data is contained in Brownstone, Golob, Uhlaner, Sarmiento, and Choi (1994). See also Kim (1993) and Sarmiento (1995), who use

the same data.

Since the questionnaires of the present study were individually designed for each respondent, I considered it best to use the participants of the panel study. That way I had the needed information for the questionnaire design already available and was able to avoid multiple contacts with each respondent. The ready information also reduced the number of required background questions and enabled concentrating on the main topic areas: occupational and work information, requirements and incentives concerning time use, and questions concerning individual preferences concerning uncertain commuting time. An example of the questionnaire is annexed in the end.

The questionnaire is divided into three parts. The first part concentrates on the respondent's occupation, the industry she is working in and the terms of earned income she has. The second measures the daily work and individual timetable constraints on the timing of commute. The third concentrates on the current commuting experience and the commuter's willingness to change her behavior when the commuting environment changes.

The third category is speculative: it contains statements about consequences from violating the work rules, for instance expectations to lose pay or professional reputation if one arrives late. The last category contains traditional contingency questions: given a hypothetical situation, what would the respondent do. There are three hypothetical questions asking if the respondent would consider paying a toll if different traffic conditions occur.

Responses to contingency questions are known to yield biased answers. Bradley and Kroes (1990) cite Bonsall (1985) on four specific types of biases:

affirmation bias, rationalization bias, policy response bias, and unconstrained response bias.

Affirmation bias happens when the respondent wishes to please the interviewer. Anonymity provided by mail-in survey might alleviate this bias. Rationalization bias should not be a problem, because I'm not asking for reasons for choices. Policy response bias is probably present. Toll roads were a highly politicized topic when this survey was conducted. The pilot survey indicated that people who oppose toll roads are likely to state that they are not willing to pay anything at all, under any circumstances. This bias can be tackled by analyzing the response in two parts: decision to pay or not, and a conditional decision about the amount of payment.

Unconstrained response bias would mean that respondent does not fully incorporate the consequences of her decision to her other activities. In a question asking how much a respondent would pay to circumvent a major traffic jam (30 minutes or more in immobile traffic), it means that the respondent discounts the importance of at least half an hour delay or the payment alternatives in the question (up till $ 5.00).

Since a delay of this magnitude is rare, the bias would most likely discount more the time loss than the money loss. In addition to these biases respondents have a tendency to give flippant answers if they are not familiar with the hypothetical situation. Respondents also have a resistance to accept negative situations, and the answers to such questions are more ambiguous than in positive situations. Based on these considerations I expect the *pay/don't pay* decision to have some political bias and the money values to be downward biased.

The questionnaire ends with a question about the respondent's willingness to acquire traffic information for the commute to work, which can be used as an indicator of how much the uncertainty of travel time affects the willingness to spend some extra time for sure to reduce the uncertainty.

## 8.2 The Stated Preference questions

The third part contains also a set of nine stated preference choices (question 29). Each choice is between two alternative commutes to work. For both alternatives the travel time is uncertain, but it is going to be one of the five possible times listed for that alternative. Alternatives are also described by departure times, so that the respondent can see how much late or early she can arrive at work with each alternative. The travel mode is not specified.

The choice of the question format is a compromise between two objectives. One of the objectives was to describe a travel time distribution that would be realistic to the respondent. Another objective was to keep the question simple enough so that it would be understood.

The most realistic travel time distribution is a continuous, positively skewed and not closed distribution. Describing this distribution to a respondent meaningfully was considered infeasible. Black and Towriss (1993) studied different question formats and concluded that a five point discrete travel time distribution was the best format for the British study. Based on their experience the travel time distribution in the current study was also described as a five point discrete distribution, where each point had an equal chance to be realized. The points were determined by choosing a lognormal distribution with a given mean and fixed skewness and picking 1st, 3rd, 5th, 7th, and 9th decile points. These points were rounded to a nearest integer.

To represent a travel time distribution as a discrete distribution is clearly a simplification of reality. The most severe aspect of the simplification is that it presents the distribution as a closed set of points so that the true nature of uncertainty - the unboundedness of outcomes - cannot be presented. The maximum delay can thus be calculated with certainty. Another aspect is that one cannot really represent the skewness of the underlying distribution by only five points. When the respondent is choosing between given alternatives, the researcher can only treat the choice as between those alternatives, not the ones they were derived from. To counter for the hidden skewness effects all presented alternatives are derived from distributions with the same skewness and also the final discrete distributions have approximately same skewness. This saves the results from the bias resulting from misspecification of the utility model by leaving higher than second moments out. The cost for this is that the effects of higher moments of travel time distribution cannot be studied with this data set.

Although the representation of the travel time distribution is simplified, it may still be too cumbersome to some respondents. The respondent has to process the information before she can express her preference.

I considered presenting the travel time uncertainty as a graph of travel time distribution, as a range of travel times, as five differences between the possible travel times and the departure time, and as only the mean and the maximum travel time. Besides representing the distribution as a graph, all the other methods reduce information by assuming a certain preference formation. E.g.. if the respondent is only interested in the range of possible travel times but not in the distribution, representing the alternative as travel time range makes the choice easier and the collected information more reliable. But at this point it is not an established fact that people use one dominant heuristic when they process the information to form their preferences[16]. By leaving the calculations to the respondent it is possible to test different information processing heuristics against each other.

Since the stated preference (SP) questions are hypothetical questions, they incorporate the same biases as any questions dealing with hypothetical situations. Respondents to hypothetical questions have been reported to demonstrate several kind of biases in their answers. Inconsistency in attitudes discussed by Eisner (1987) is a general problem: if the situations presented to the respondent are not realistic or familiar, the respondent will not really know what she would choose in real life. Thus she is likely to give a flippant answer. Even when the respondent is clear about her attitudes and holds a consistent stand, she might have other reasons to adjust her responses.

[16] For instance Hall (1982) found in his public transportation experiment that some subjects used bus route maps, but no timetable information at all in their decision making.

In addition to the four biases mentioned earlier, respondents may also be misguided to answer in a misleading way due to cognitive biases, which Piattelli-Palmarini (1994) calls 'mental tunnels'. The tunnels relevant for the kind of questions I use are due to: 1) framing of choices, 2) segregating decisions, 3) misplaced causality 4) the certainty effect, and 5) disjuction effect.

Framing refers to the way the choice situation is worded. By representing the exactly same situation with different words e.g.. 40% probability of arriving late instead of 60% probability arriving on time might induce the respondent to answer differently. Segregating decisions is the same effect as previously mentioned unconstrained response bias: the respondent considers this particular choice only, not the full implications to her other activities. Misplaced causality refers to problems like understanding that with a smaller sample size the probability fraction of observations beyond a certain threshold is larger than with a big sample, even when the samples are drawn from the same distribution. Usually people think about the underlying distribution and do not think about the sample size. This fallacy actually works for my SP questions: the respondent is told to answer based on her normal commute to work, with the intention that she would consider it a draw from a very large sample.

The certainty effect refers to situations where there is a large psychological difference between a small probability of an unwanted outcome and zero probability of such an outcome. In the questions I have avoided certainty of travel time: even the most reliable alternatives have some variation in the travel time. On the other hand, some of the alternatives offer a possibility to leave home so early that it is 'certain' that the commuter will not arrive late. None of the alternatives offers certainty of arriving late.

Disjuction effect refers to situations where something has already happened, but the respondent doesn't know the outcome when she has to make another choice. This situation does not come up in the SP questions, because the commute to work is considered in its entirety (e.g.. these are not situations where something happens during the commute to change the original travel time distribution).

In light of these concerns the SP questions were designed to be realistic and relevant to the respondents. From the latest panel wave data I knew how long the respondents usually spend on their commute to work. Using this information I divided the respondents into five commuting time groups: less than 20 min 20-29 min, 30-39 min, 40-55 min, and 55 minutes or longer. The alternatives presented to each respondent were designed to not deviate too far from the current mean travel time.

I also used another modification to reduce the effect of flippant answers. The computer program that generated the pairwise alternatives had to sort them by their ordinal number. This would have generated a situation where the later alternative (B) would have a tendency to have a smaller mean travel time and a larger standard deviation of travel time than the first alternative (A). In order to avoid this, the program automatically switches every other pair of alternatives. This technique combats the bias from a flippant respondent who always chooses the first alternative without further considering them.

In order to avoid affirmation bias the questions were designed in a way where there was no clear 'politically correct' or 'incorrect' answer. This was the main reason for eliminating alternatives where the respondent would have arrived late for sure. Also the preceding questions avoided setting up the respondent to answer in a specific manner such as always preferring the smaller spread of travel times. The design also presents the alternatives as generic (i.e. the transportation mode is not specified) and therefore the affirmation bias that one "should" support a particular mode is eliminated.

Rationalization bias is not a problem in these questions. If the questions did succeed to be described in attributes so meaningful that the respondent can describe her own commuting behavior in terms of these attributes, her rationalization is exactly what we want to learn from her answers.

Policy response bias was a serious drawback in the pilot study design where a road toll was an additional attribute for the alternatives. Toll roads are a current political topic in southern California and for many respondents the questions generated extreme choice behavior: even with very low tolls the choice was always for the lower toll alternative. For this reason the toll attribute was dropped from the design. The other attributes (mean and standard deviation of travel time and departure time) do not have such strong political connotations. Also the fact that the alternatives are generic eliminates a political bias the might feel towards different transportation modes.

Unconstrained response bias would happen if the person would not take into account the consequences in the other aspects of her resources when she is choosing between the alternatives.  In this case, the consequences are brought into the choice and it is hard to avoid them.  For example, if the respondent chooses the alternative where she can leave home later it will be also clear that she will either choose an alternative where she has a greater unreliability of travel time or a longer mean travel time.

Each respondent received a unique questionnaire.  There are no two identical ones.  Each of the five travel time groups had the question of current commuting time distribution modified for that specific group.  Further, the sets of SP questions are randomly assigned for each individual.

## 8.3  The SP question design

According to Hensher (1993) the experimental design can be divided into several tasks:

1)  Identification of the set of attributes.

2)  Selecting the measurement unit for each attribute.

3)  Specification of the number and magnitudes of attribute levels.

4)  Statistical design.

5)  Translating the designed experiment into a set of questions and show cards for data collection.

The tasks for the present study were as follows:

1) Identification of the set of attributes: In this study the set of attributes included in the SP design is consisted of mean travel time, reliability of travel time, and departure time.

2) Selecting the measurement unit for each attribute: The mean travel time is measured in minutes. The reliability of travel time is measured in standard deviation of travel time, but presented to the respondent as five equally likely travel times, drawn from a log-normal distribution at .1, .3, .5, .7, and .9 deciles. The departure time from home is presented in minutes of the time the respondent reserves for the commute. It is made clear to the respondent that this time does not have to end at the official work start time, as many workers prefer to have some preparation time prior to the work start time while some do not mind arriving late.

3) Specification of the number and magnitudes of attribute levels: The experiment is customized around the usual commuting times that the respondents indicated in the last panel study wave. The identified groups are < 20 min, 20-29 min, 30-39min, 40-55 min, and 55+ minutes of average travel time. I discuss the 20-29 minutes group here in more detail.

For any kind of comparison the number of attribute levels has to be at least two. If one wants to study possible non-linearities or increase the range and reliability of estimation, three attribute levels are necessary. Three magnitude levels are used in this study.

Example of the magnitudes for 20-29 min group:

- Mean travel time: 20, 25, 30 minutes

- Standard deviation: 1, 4, 6 minutes

  (corresponding to ranges of 4, 11, and 16 minutes)

- Departure time: mean travel time, mean travel time + standard deviation, mean travel time + 2 * standard deviation

The mean travel time was constructed in the other average travel time groups in the same manner. The standard deviations were larger for longer average travel time groups. To test the hypothesis that people have a threshold value for coefficient of variation as their measure of 'acceptable' uncertainty in travel time, the ratios of mean travel times and standard deviations in each group were kept approximately equal. The departure times were constructed according the above mentioned formula in each group. The experiment design is presented in Table 4.

Table 4. The set of all choice alternatives in stated preference questions

| Group | Mean travel time | Standard deviation of travel time | Departure time | Possible travel times 1st | 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|---|---|---|---|
| 1 | 15 | 3 | 15 | 12 | 13 | 14 | 16 | 20 |
| 1 | 10 | 5 | 10 | 5 | 7 | 9 | 12 | 18 |
| 1 | 15 | 1 | 16 | 14 | 14 | 15 | 15 | 17 |
| 1 | 10 | 3 | 16 | 7 | 8 | 9 | 11 | 15 |
| 1 | 7 | 5 | 12 | 2 | 4 | 6 | 9 | 15 |
| 1 | 10 | 1 | 12 | 9 | 9 | 10 | 10 | 12 |
| 1 | 7 | 3 | 13 | 4 | 5 | 6 | 8 | 12 |
| 2 | 30 | 4 | 30 | 26 | 27 | 29 | 32 | 38 |
| 2 | 25 | 6 | 25 | 19 | 21 | 24 | 27 | 34 |
| 2 | 30 | 1 | 31 | 29 | 29 | 30 | 30 | 32 |
| 2 | 25 | 4 | 29 | 21 | 22 | 24 | 26 | 31 |
| 2 | 20 | 6 | 26 | 14 | 16 | 19 | 22 | 29 |
| 2 | 25 | 1 | 27 | 24 | 24 | 25 | 25 | 27 |
| 2 | 20 | 4 | 28 | 16 | 17 | 19 | 21 | 26 |
| 3 | 40 | 5 | 40 | 35 | 37 | 39 | 42 | 48 |
| 3 | 35 | 8 | 35 | 27 | 30 | 33 | 38 | 47 |
| 3 | 40 | 1 | 41 | 39 | 39 | 40 | 40 | 42 |
| 3 | 35 | 5 | 40 | 30 | 32 | 34 | 37 | 44 |
| 3 | 30 | 8 | 38 | 22 | 25 | 28 | 33 | 42 |
| 3 | 35 | 1 | 37 | 34 | 34 | 35 | 35 | 37 |
| 3 | 30 | 5 | 40 | 25 | 27 | 29 | 32 | 39 |
| 4 | 55 | 5 | 55 | 50 | 52 | 54 | 57 | 63 |
| 4 | 45 | 9 | 45 | 36 | 39 | 43 | 48 | 59 |
| 4 | 55 | 1 | 56 | 54 | 54 | 55 | 55 | 57 |
| 4 | 45 | 5 | 60 | 40 | 42 | 44 | 47 | 54 |
| 4 | 40 | 9 | 49 | 31 | 34 | 38 | 43 | 54 |
| 4 | 45 | 1 | 47 | 44 | 44 | 45 | 45 | 47 |
| 4 | 40 | 5 | 50 | 35 | 37 | 39 | 42 | 48 |
| 5 | 70 | 6 | 70 | 64 | 66 | 69 | 72 | 79 |
| 5 | 60 | 11 | 60 | 48 | 53 | 58 | 64 | 77 |
| 5 | 70 | 1 | 71 | 69 | 69 | 70 | 70 | 72 |
| 5 | 60 | 6 | 66 | 54 | 56 | 59 | 62 | 69 |
| 5 | 55 | 11 | 66 | 43 | 48 | 53 | 59 | 72 |
| 5 | 60 | 1 | 62 | 59 | 59 | 60 | 60 | 62 |
| 5 | 55 | 6 | 77 | 49 | 51 | 54 | 57 | 64 |

4) Statistical design: Statistical design is where the attribute levels are combined into an experiment. A combination of attribute levels describes the alternative, referred to as a profile or a treatment.

The attribute mix can be defined for a particular mode, or it can be abstract. Because of the number of attributes and attribute levels already included in the experiment, it was decided that the attributes are presented as abstract. The mode choice will be taken into consideration when the choice models are estimated: since we know from the earlier study if the respondent is a car pooler, separate sets of model parameters can estimated conditional on the respondent being a car pooler or a dummy variable indicating car pooler status can be used in for the combined data set.

The alternatives are generated with the aid of statistical design theory. In a statistical experiment each attribute has levels, and it is the set of combinations of attribute levels that define a design. A full factorial design contains descriptions of all possible attribute combinations, enabling one to independently estimate the statistical effects of each attribute combinations. In practice the full number of combinations is impracticable to evaluate, and so a fractional factorial design can be constructed. The price of deviating from the full factorial design is that information on certain interactions is lost. There are published standard experimental design tables, which one can follow to design a fractional factorial.

Orthogonality, the property of zero correlation between attributes, enables the analyst to undertake tests of the statistical contribution of main effects and interactions, and is promoted as a major appeal of stated preference (SP) data compared to revealed preference (RP) data. Hensher (1993) expresses a concern about this view: the RP modelers have had to live with correlation and have developed tests to detect multicollinearity and a recent study[17] has shown that fears of collinear attributes are often exaggerated.

Orthogonal design has one unpleasant technical characteristic: in order to preserve orthogonality, the analyst has to include clearly dominated alternatives in the design. When confronted by such alternatives the respondent will not give any information to the researcher and is also likely to lose interest in the survey.

Hensher and Barnard (1990) have made a distinction between design data orthogonality and estimation data orthogonality. This is important when the choice is modeled using logit or probit models, which use as input the difference of the attributes. Hensher and Barnard demonstrate that if one designs an orthogonal design of the differences of all possible combinations of attribute levels, the presence of dominant alternatives will be worse. So there is a trade-off between information-efficiency and orthogonality in the statistical design.

There is an alternative method to orthogonal statistical design: selecting the largest subset of non-dominated alternatives to form the basis of choice sets. This set of alternatives cannot be obtained from the factorial designs, and it is not orthogonal. Using only these alternatives in the choice sets guarantees that each choice presented to the respondent is a real choice, which makes the approach

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[17] Mason and Perreault (1991).

information-efficient. Also, because the number of alternatives is limited, the choice set design can be kept smaller.

Because the design considered here has three variables in three levels and there is some concern of the sample size, I decided to use the non-dominated alternatives approach. There are 7 non-dominated alternatives in the full set. Because of concerns of response fatigue and quality of answers, each respondent is presented with nine pairwise choices. These pairwise comparisons are generated by random drawing (with replacement) from the previously mentioned set of 7 non-dominated alternatives.

5) Translating the designed experiment into a set of questions for data collection: In the questionnaire the choice is presented by giving five equally likely travel times. The questionnaire does not mention that they are from a log-normal distribution, nor does it specifically mention the mean nor standard deviation of that distribution. The first alternative in Table 4 would be described to the respondent as:

- five equally likely travel times: 12 13 14 16 20
- departure from home: 15 minutes before you prefer to arrive at work place

I wrote a computer program to identify the travel time group the respondent belongs to, randomly draw (with return) 9 pairs of alternatives from the correct set of 7 alternatives, check that the same pair is not drawn twice, switch the elements of every other pair, and write the alternatives for that individual.

8.4 Implementation of the survey

The survey was a mail-in survey. The participants were recruited from the participants of an earlier nine wave panel study by the Institute of Transportation Studies. The survey was conducted in July-September 1994. Of the 677 questionnaires that were sent out 543 were returned, giving a response rate of 80.2%. The response rate was high because of two reasons: 1) The participants were highly motivated group and interested in the transportation issues, and 2) They were given $ 3.00 with the questionnaire as a gift with the hope that they would be more likely to participate. Earlier experiences have indicated that giving the incentive before the participant responds actually induces her to answer more than a promise to give the gift after she has returned the questionnaire. The pilot study indicated that $ 5.00 was actually too high an incentive, because participants started to treat the money as pay, not as a gift.

The panel study was employer based: about half of the respondents work at the Irvine Spectrum employment center, the rest elsewhere in Southern California. The earlier waves were fortified by refreshment samples from outside Irvine Spectrum. Because of the questionnaire design for the present study, no refreshment sample was available for this sample.

There are some known biases at the sample. Due to employer based sampling it oversamples people working for larger employers. Also, since this is a panel study, self-selection of the participants has taken place. The self selection has led to a car pooler over-representation. This is actually a blessing since the effect of mode choice on risk behavior is of interest in the study. The self selection seems to have brought on also an age distribution towards older commuters and the organizational status towards higher rank positions. The bias in organizational status could also be due to the fact that a large portion of the respondents works in Irvine Spectrum employment center, and the companies operating in this center may not represent the average Californian companies. Brownstone and Golob (1992) estimated the effects of earlier waves of the data and concluded that the biases in the sample did not affect the results significantly.

I coded the occupations based on two questions: "What is your title in your work organization?" and "What is your occupation?". I compared the answer to the Dictionary of Holland occupations, which has also the codes of U.S. Department of Labor Occupational Codes Dictionary. If the occupation was not listed in the Dictionary of Holland occupations, I searched for a fitting description of the occupation from the U.S. Department of Labor Occupational Codes Dictionary, and translated the code into a Holland code. Despite the rather straightforward principle, the coding process has a random element: if the occupation title is not directly found from the Holland Dictionary of Occupational Titles, the search for the most fitting title imports some randomness to the results. However, since my analysis uses only the six major occupational categories and the classification errors are most likely to happen between subcategories, randomness is limited. It is possible to reduce the randomness by coding the occupations twice and comparing discrepancies, but that was not done here. Another element bringing randomness to occupational coding is that the U.S. Occupational classification changes over time (Clogg, Rubin, Schenker, Schultz, and Weidman 1991). To counteract that change, I used the edition of U.S. Department of Labor occupational codes what the Holland Dictionary is referring to.

# 9. DATA DESCRIPTION

## 9.1 Basic background variables

There were slightly more female respondents in the younger cohorts and more male respondents in the older cohorts, leading to 53% males and 47% females in the total sample (Table 5). The median personal income was in the bracket $ 45,000 to $ 49,999 (Table 6). For households the median income fell in the bracket $ 75,000 to $ 84,999 (Table 7).

Brownstone and Golob (1992) compared the first wave of this sample to a population of full-time workers in the South Coast Air Basin by using the March 1987 Current Population Survey of the U.S. Census Bureau. Tables 1 and 2 contain corresponding percentage distributions from that study. According to that survey this sample over represents women. However, women are more likely to be part time workers, so the bias is not as large as it may appear. More serious omission is the under representation of younger individuals, especially younger men. Also, this sample under represents people who earn $ 35,000 or less per year.

The overwhelming form of employment was an employee with benefits (Table 8). The sample thus under represents people in less secure work positions. One fourth of the sample are in jobs where the pay is based on an hourly wage (Table 9). The respondents were distributed over different industries, but the largest concentration was in manufacturing of durable goods, 22% of all participants (Table 10).

Table 5. Age and gender distributions

| Age in years | Male | Female | Total | Percent |
|---|---|---|---|---|
| 20-29 | 15 | 17 | 32 | 6.1% |
| 30-39 | 75 | 81 | 156 | 29.8% |
| 40-49 | 94 | 91 | 185 | 35.3% |
| 50-59 | 59 | 46 | 105 | 20.0% |
| 60-69 | 32 | 9 | 41 | 7.8% |
| 70-79 | 3 | 1 | 4 | .8% |
| 90-100 | 1 | 0 | 1 | .2% |
| Total | 279 | 245 | 524 | |
| Total % | 53.2% | 46.8% | | 100.0% |
| Brownstone and Golob (1992) | 60.7% | 39.3% | | 100.0% |

Table 6. Personal income distribution

| Income per year | Frequency | Percent | Combined Income Brackets | Brownstone and Golob (1992) |
|---|---|---|---|---|
| Less than $ 10,000 | 6 | 1.1% | | |
| $ 10,000 to $ 14,999 | 7 | 1.3% | 2.4% | 7.39% |
| $ 15,000 to $ 19,999 | 9 | 1.7% | | |
| $ 20,000 to $ 24,999 | 19 | 3.5% | 5.2% | 8.99% |
| $ 25,000 to $ 29,999 | 35 | 6.4% | | |
| $ 30,000 to $ 34,999 | 45 | 8.3% | 14.7% | 17.75% |
| $ 35,000 to $ 39,999 | 60 | 11.0% | | |
| $ 40,000 to $ 44,999 | 50 | 9.2% | 20.2% | 16.66% |
| $ 45,000 to $ 49,999 | 52 | 9.6% | | |
| $ 50,000 to $ 54,999 | 56 | 10.3% | 19.9% | 14.25% |
| $ 55,000 to $ 59,999 | 36 | 6.6% | | |
| $ 60,000 to $ 64,999 | 37 | 6.8% | 13.4% | 9.44% |
| $ 65,000 to $ 69,999 | 26 | 4.8% | | |
| $ 70,000 to $ 74,999 | 14 | 2.6% | 7.4% | 5.74% |
| $ 75,000 to $ 84,999 | 17 | 3.1% | | |
| $ 85,000 to $ 94,999 | 19 | 3.5% | 6.6% | 5.32% |
| $ 95,000 to $ 119,999 | 19 | 3.5% | | |
| $ 120,000 or more | 12 | 2.2% | 5.7% | 10.17% |
| Missing | 24 | 4.4% | | |
| Total | 543 | 100.0% | | |

Table 7. Household income distribution

| Household's annual gross income | Frequency | Percent |
|---|---|---|
| Less than $ 15,000 | 6 | 1.1% |
| $ 15,000 to $ 24,999 | 8 | 1.5% |
| $ 25,000 to $ 34,999 | 25 | 4.6% |
| $ 35,000 to $ 44,999 | 50 | 9.2% |
| $ 45,000 to $ 54,999 | 67 | 12.3% |
| $ 55,000 to $ 64,999 | 46 | 8.5% |
| $ 65,000 to $ 74,999 | 59 | 10.9% |
| $ 75,000 to $ 84,999 | 66 | 12.2% |
| $ 85,000 to $ 94,999 | 58 | 10.7% |
| $ 95,000 to $ 119,999 | 62 | 11.4% |
| $ 120,000 to $ 149,999 | 46 | 8.5% |
| $ 150,000 or more | 30 | 5.5% |
| Missing | 20 | 3.7% |
| Total | 543 | 100.0% |

Table 8. Form of payment distribution

| Form of payment | Frequency | Percent |
|---|---|---|
| An employee with benefits | 487 | 89.7% |
| An employee without benefits | 19 | 3.5% |
| An independent contractor within a comp. | 7 | 1.3% |
| Self-employed / An entrepreneur | 22 | 4.1% |
| Other | 7 | 1.3% |
| Missing | 1 | .2% |
| Total | 543 | 100.0% |

Table 9. Distribution of basis of earned income

| Basis for earned income | Frequency | Percent |
|---|---|---|
| A fixed monthly salary | 387 | 71.3% |
| An hourly wage | 131 | 24.1% |
| Commission | 11 | 2.0% |
| Missing | 14 | 2.6% |
| Total | 543 | 100.0% |

Table 10. Industrial distribution

| Industry | Frequency | Percent |
|---|---|---|
| Mining | 1 | .2% |
| Construction | 18 | 3.3% |
| Manufacturing, nondurable goods | 52 | 9.6% |
| Manufacturing, durable goods | 120 | 22.1% |
| Transportation | 19 | 3.5% |
| Public utilities, Post, Telecommunications | 16 | 2.9% |
| Wholesale trade | 18 | 3.3% |
| Retail trade | 12 | 2.2% |
| Finance, Insurance, Real Estate | 53 | 9.8% |
| Business and Repair services | 7 | 1.3% |
| Personal Services | 5 | .9% |
| Entertainment and Recreation | 9 | 1.7% |
| Health services | 86 | 15.8% |
| Educational services | 28 | 5.2% |
| Other professional services | 79 | 14.5% |
| Public administration | 8 | 1.5% |
| Missing | 12 | 2.2% |
| Total | 543 | 100.0% |

9.2 Work related time constraints

One of the key hypothesized variables influencing commuting behavior is the type of occupation the respondent has. Table 11 summarizes general descriptive findings about the six occupational groups defined by Holland classification.

Realistic and Conventional occupations concentrate in large, single work sites. People in these occupations tend to be wage-earners and not independent contractors or entrepreneurs and are less mobile between employers and work sites than people in the other occupational groups. Realistic occupations are male dominated while Conventional occupations are strongly female dominated.

Most mobile between employers and work sites are the Social and Artistic occupational groups. Although many in these groups are wage-earners, these groups show the highest share or entrepreneurs or independent contractors. Both Social and Artistic occupations are female dominated.

People in Enterprising and Investigative occupations tend to work in smaller work sites. Like people in Artistic and Social occupations, people in Enterprising and Investigative occupations often have multiple work sites and change jobs. But unlike in Artistic and Social occupations, changing jobs does not mean that they would also change employers. People in Enterprising and Investigative occupations are least likely to be wage-earners. They tend to be male and have high earned income. On the other end, people in Conventional and Realistic occupations tend to have smaller than average income .

An attempt to build a subjective measure for locus of control was to use the work descriptions the respondents chose to describe their own work. An internal locus of control was assigned to people who described their work as “Influencing people in their opinions, attitudes, or judgements about ideas or things” or “Direction, control, and planning of an entire activity or the activities of others.” An external locus of control was assigned to people who described their own work as “Precise attainment of limits, tolerances, or standards” or “Repetitive operations carried out according to set procedures or sequences.” If the respondent chose both internal and external descriptions, she was assigned to neither group. With these definitions, 222 individuals were identified with an internal locus of control, 120 individuals with an external locus of control, and 201 individuals in neither group. This measure of a locus of control is much more subjective than defining the locus of control by measuring the work time rules, which are discussed in the next paragraph. However, the subjective measures distinguish between the occupational groups clearly: Realistic and Conventional groups have high proportions of external locus of control, and small proportions of internal locus of control occupations (Table 11), indicating that theses two occupations support more external locus of control than the other four. Artistic and Social occupations together have lower proportions of external LOC, and higher proportions of internal LOC scores than Investigative and Enterprising occupations. This finding supports hypothesis 4, which stated that Social and Artistic occupations would have most internal LOC and Realistic and Conventional occupations most external LOC. When the occupations are compared columnwise, Artistic, Investigative, and Realistic occupations have higher proportions of external LOC scores and lower proportions of internal LOC scores than Social, Enterprising, and Conventional occupations. This finding supports hypothesis 7, which stated that the particularistic-concrete occupations would support more internal LOC than the symbolic-universal occupations.

On the next page:

Table 11. General descriptions associated with Holland occupational categories. Note: Each row in this table consists of a 2 x 6 cross-tabulation of a particular variable and the occupational groups. A $chi^2$ test indicates whether there are statistically significant differences between the occupations with respect to the particular variable. The p-value indicates the size of the test. If p-value $< 0.05$, the test indicates that the hypothesis that there is no difference between the occupations can be rejected with 5% risk.

| Correlated variable | Artistic | Social | Investigative | Enterprising | Realistic | Conventional | p-value of $chi^2$ test |
|---|---|---|---|---|---|---|---|
| <u>Employees in the work site</u>: | | | | | | | |
| · Less than 25 employees | 6% | 15% | 12% | 17% | 9% | 9% | 0.319 |
| · 100 or more employees | 71% | 63% | 72% | 63% | 80% | 74% | 0.056 |
| Multiple work sites | 29% | 30% | 23% | 32% | 16% | 14% | 0.022 |
| Job change during previous 6 months | 12% | 6% | 12% | 13% | 6% | 7% | 0.302 |
| At least one employer change 1- 4 year ago | 12% | 14% | 9% | 9% | 7% | 2% | 0.265 |
| At least one work site location change 1 - 4 years ago | 18% | 16% | 12% | 11% | 8% | 2% | 0.101 |
| Wage-earner | 29% | 27% | 19% | 13% | 42% | 41% | 0.000 |
| Independent contractor or entrepreneur | 12% | 10% | 6% | 6% | 1% | 0% | 0.048 |
| Male | 41% | 37% | 67% | 56% | 63% | 14% | 0.000 |
| Average age, years | 43 | 43 | 44 | 44 | 45 | 45 | -- |
| Average personal income, $ 1000 (approximated) | 41 | 53 | 56 | 60 | 42 | 35 | -- |
| Performing under stress | 9% | 15% | 18% | 18% | 9% | 5% | 0.047 |
| External locus of control | 17% | 11% | 23% | 11% | 42% | 43% | 0.000 |
| Internal locus of control | 58% | 47% | 39% | 54% | 23% | 21% | 0.000 |

## 9.3 Employer’s expectations

Occupational groups place different time requirements on employees (Table 12). Employees in the Realistic and Conventional occupations tend to have the most strict arrival requirements: they report more often than employees in other groups that it is important to arrive on time every day. On the other extreme, people in Investigative occupations tend to have work requirements where it is practically never important to arrive at the work premises at a particular time, while people in Enterprising occupations tend to report that it is important to arrive on time only on some days.

Employers have different rules for the earlier than usual arrival times. Employers of people in Realistic and Conventional occupations tend not to want their employees to start work earlier than the normal hours, while employers of people in Investigative and Enterprising occupations have a smallest tendency to object. The same rules apply also to extending the normal work hours at the end of normal working hours: employers object least in Investigative and Enterprising occupations, and most in Realistic and Conventional occupations. Working outside office or taking work home seems to be equally accepted in both Artistic and Social occupations, and Investigative and Enterprising occupations, but not so much in Realistic and Conventional occupations. These findings support hypothesis 6, which expected the employer to supervise work time most strictly in Realistic and Conventional occupations, and least strictly in Investigative and Enterprising occupations.

People in Artistic occupations have most irregular work hours: more than the other groups they tend to be part time workers and work in rotating shifts (Table 13). They also have least say on choosing the work schedule, but counteract this by working at home more often than people in the other occupations. People in Investigative and Enterprising occupations have the most say in choosing their work schedule. Most changes to day-to-day schedules happen in Social occupations, least in Conventional and Realistic occupations.

People in every occupational group are most likely to start work between 7.30 and 8.30 am, but people in Social occupations have a high likelihood to start later than that while people in Realistic occupations have a high likelihood to start earlier than that. People in Conventional occupations have the most peaked work start time distribution.

Table 12. Time constraints associated with Holland occupational categories, part 1.

| Correlated variable | Artistic | Social | Investigative | Enterprising | Realistic | Conventional | p-value of $chi^2$ test |
|---|---|---|---|---|---|---|---|
| <u>Important to arrive on time:</u> | | | | | | | |
| · Every day | 41% | 44% | 26% | 31% | 56% | 64% | (Columns sum to 100%) |
| · 2-4 times a week | 18% | 19% | 15% | 18% | 10% | 9% | |
| · 2-4 times a month | 18% | 11% | 12% | 16% | 8% | 3% | |
| · Once a month or less often | 24% | 26% | 47% | 35% | 24% | 25% | 0.000 |
| Can arrive and start earlier | 76% | 80% | 83% | 87% | 65% | 69% | 0.000 |
| Can stay after hours | 82% | 91% | 88% | 94% | 73% | 75% | 0.000 |
| Can work outside office | 71% | 51% | 59% | 62% | 35% | 31% | 0.000 |
| Sometimes works at home | 29% | 16% | 16% | 13% | 7% | 3% | 0.023 |
| <u>Lateness causes:</u> | | | | | | | |
| · Loss of pay | 12% | 14% | 7% | 4% | 18% | 22% | 0.000 |
| · Loss of reputation | 18% | 44% | 52% | 49% | 59% | 52% | 0.048 |
| · Rushing and stress | 24% | 35% | 22% | 25% | 24% | 21% | 0.374 |
| · Some negative consequences | 47% | 73% | 64% | 63% | 80% | 69% | 0.089 |
| <u>Can arrive 15 minutes late:</u> | | | | | | | |
| · No | 35% | 49% | 24% | 28% | 49% | 41% | 0.000 |
| · Yes | 59% | 35% | 64% | 56% | 44% | 52% | 0.002 |
| · No specific arrival time | 6% | 16% | 12% | 15% | 9% | 5% | 0.099 |

Table 13. Time constraints associated with Holland occupational categories, part 2.

| Correlated variable | Artistic | Social | Investigative | Enterprising | Realistic | Conventional | p-value of $chi^2$ test |
|---|---|---|---|---|---|---|---|
| Part time worker | 18% | 6% | 5% | 2% | 7% | 2% | 0.018 |
| Working in a rotating shift | 12% | 9% | 0% | 3% | 5% | 2% | 0.012 |
| Able to choose a work schedule | 24% | 37% | 42% | 41% | 30% | 29% | 0.231 |
| Day-to-day changes in a work schedule | 35% | 43% | 27% | 37% | 25% | 16% | 0.004 |
| Work starts: | | | | | | | |
| 6.30 a.m. or earlier | 0% | 5% | 12% | 11% | 27% | 5% | 0.000 |
| 6.30 a.m. - 7.30 a.m. | 12% | 12% | 22% | 20% | 24% | 22% | 0.499 |
| 7.30 a.m. - 8.30 a.m. | 47% | 35% | 42% | 41% | 28% | 55% | 0.033 |
| 8.30 a.m. or later | 24% | 33% | 17% | 19% | 15% | 14% | 0.029 |

Note: The working time percentages do not sum up to 100% because some commuters do not have a regular work start time.

When asked if it is acceptable to arrive 15 minutes late, people in Conventional, Realistic, and Social occupations tend to say no. However, it seems that for people in Social occupations this way questioning is least relevant: more people in this occupational group than the other two answered that the question is not applicable because they do not have a specific starting time. By the same criteria, this question is most meaningful to people in Conventional and Realistic occupations, who could most easily answer either yes or no. This finding supports hypothesis 4, which stated that time is most external the occupations producing the material means for value realization (Realistic, Conventional), and least external in occupations concerned with value creation (Social, Artistic). In the other occupation concerned with value creation, Artistic, more than half of the respondents answered that it is acceptable to arrive 15 minutes late.

Least concerned about arriving 15 minutes late are respondents in Investigative and Enterprising occupations. Both groups have less than 30 % respondents who indicate that it is not acceptable to arrive 15 minutes late. Respondents in these occupations also often answered that this question is not relevant because they do not have a specific arrival time.

## 9.4 Possible consequences from lateness

When asked if there would be negative consequences from arriving late, 10.5% of the respondents answered that they would be paid less, 49.4% felt that their reputation would suffer, 24.5% would have stress from rushing things, and 13.8% stated that there would be some other kind of negative consequence, while 31.1% stated that there would not be negative consequences.[18]

People most likely to lose earnings due to lateness are in Realistic and Conventional occupations, while people least likely to lose earnings due to lateness are in Investigative and Enterprising occupations (Table 12). Also wage-earners are more likely to expect to lose earnings due to lateness than salaried employees or respondents receiving commission pay (Table 14). Respondents in lower income brackets are more likely to lose earnings due to late arrival at work (Table 13). Women report an insignificantly higher likelihood of losing earnings due to lateness (table not reproduced). Lateness tends to cause loss of reputation, especially in Realistic and somewhat in Social occupational groups, but not for Artistic (Table 12). About half of the respondents who earn more than $25,000 expect to lose their reputation if they arrive late at work. However, this effect is not linearly increasing

[18] The percentages do not add up to 100 because respondents were asked to indicate all possible consequences.

after the threshold (Table 15). Wage-earners are more likely to feel the loss of reputation from lateness than the salaried employees (Table 17).

People in Realistic occupations have the highest likelihood to encounter some negative consequences due to lateness, while those working in Artistic occupations report avoiding all negative consequences more often than people working in other occupations (Table 12). When the respondents are classified to those who expect monetary or other penalties, those who expect only non-monetary penalties, and those who do not expect any penalties, the expectation of monetary losses is most common in Realistic and Conventional occupations and least common in Investigative and Enterprising occupations. Also, respondents in Investigative and Enterprising occupations are most likely to expect no penalties due to late arrival at work, while respondents in Realistic and Conventional occupations report least such expectations. These results support hypothesis 6, which stated that employers supervise the arrival time most in Realistic and Conventional occupations and least in Investigative and Enterprising occupations.

When the subjective locus of control scores were cross tabulated by expected penalties due to late arrival, the respondents identified as working in an internal locus of control work had statistically lower probability to expect monetary penalties, and higher probability to expect other or no penalties due to lateness than respondents that were not identified as working in an internal locus of control work. Respectively, respondents identified as working in an external locus of control work had statistically higher probability to expect monetary penalties and lower probability to expect other than monetary penalties due to late arrival at work, than respondents that were not identified as working in an external locus of control work (no tables reproduced). These results are supporting hypothesis 5, which stated that employers use more immediate and concrete lateness penalties for employees with external locus of control than for employees with internal locus of control.

While respondents in lower income bracket report that late arrival at work causes losing pay relatively often and losing reputation relatively seldom, the opposite is true in high income brackets. Thus about an equal percentage of respondents in every income bracket expect some negative consequences (Table 15). Wage-earners expect to face the negative consequences more often than salaried workers (Table 17). The findings about wage-earners support an assumption made in hypothesis 2, which identified wage-earners as a group less likely to avoid negative feedback from late arrivals.

Although women have a slightly higher likelihood to be wage-earners, the negative consequences from lateness are as likely for men and women (table not shown). Lateness also causes rushing and stress indiscriminately in all occupational groups (Table 12).

Table 14. Associations of selected variables with personal income, part 1.

| | $ 25, 000 or less | $25,000 - $45,000 | $45,000 - $65,000 | $65,000 - $95,000 | $95,000 or more | p-value of $chi^2$ test |
|---|---|---|---|---|---|---|
| Male | 41% | 35% | 57% | 77% | 87% | 0.000 |
| <u>Late 15 minutes due to traffic:</u> | | | | | | |
| · At least twice a month | 15% | 20% | 26% | 35% | 23% | 0.086 |
| · Less than 5 times a year | 73% | 61% | 61% | 49% | 67% | 0.112 |
| <u>If traffic is bad twice as often:</u> | | | | | | |
| · Would reserve more time for commuting | 61% | 56% | 51% | 34% | 29% | 0.001 |
| · Would not change commuting habits | 34% | 36% | 45% | 56% | 58% | 0.008 |
| Willing to pay to escape a traffic delay | 68% | 86% | 82% | 92% | 97% | 0.003 |
| Average amount one is willing to pay | $1.07 | $1.17 | $1.36 | $1.84 | $1.87 | -- |

Table 15. Associations of selected variables with personal income, part 2.

| | $ 25, 000 or less | $25,000 - $45,000 | $45,000 - $65,000 | $65,000 - $95,000 | $95,000 or more | p-value of $chi^2$ test |
|---|---|---|---|---|---|---|
| Reserves slack time between arrival at work and work start | 59% | 49% | 42% | 35% | 38% | 0.069 |
| <u>Lateness causes:</u> | | | | | | |
| · Some negative consequences | 68% | 74% | 62% | 61% | 81% | 0.150 |
| · Loss of pay | 27% | 17% | 5% | 4% | 0% | 0.000 |
| · Loss of reputation | 37% | 54% | 49% | 51% | 58% | 0.276 |
| Carpools | 17% | 26% | 22% | 22% | 10% | 0.284 |
| Occupational stress | 10% | 14% | 14% | 16% | 26% | 0.396 |

Table 16. Associations of selected variables with the form of earned income, part1.

| | Hourly wage | Monthly salary | Commission or partly commission | p-value of $chi^2$ test |
|---|---|---|---|---|
| Male | 44% | 54% | 64% | 0.125 |
| Late 15 minutes at least twice a month due to traffic conditions | 19% | 26% | 27% | 0.312 |
| Late 15 minutes less than 5 times a year due to traffic conditions | 64% | 59% | 55% | 0.535 |
| If traffic is bad twice as often: | | | | |
| · Would reserve more time for commuting | 56% | 48% | 45% | 0.237 |
| · Would not change commuting habits | 38% | 45% | 55% | 0.266 |
| Willing to pay to escape a traffic delay | 78% | 86% | 91% | 0.118 |
| Average amount one is willing to pay | $0.96 | $1.47 | $1.36 | -- |

Table 17. Associations of selected variables with the form of earned income, part 2.

| | Hourly wage | Monthly salary | Commission or partly commission | p-value of $chi^2$ test |
|---|---|---|---|---|
| Reserves slack time between arrival and work start | 54% | 40% | 27% | 0.101 |
| Lateness causes: | | | | |
| · Some negative consequences | 83% | 63% | 45% | 0.000 |
| · Loss of pay | 34% | 3% | 0% | 0.000 |
| · Loss of reputation | 56% | 48% | 18% | 0.029 |
| Carpools | 18% | 25% | 9% | 0.111 |
| Occupational stress | 11% | 16% | 0% | 0.169 |

9.5 Traffic induced lateness: who is affected and how do they respond?

When asked how often bad traffic conditions delay the commute by 15 minutes or more, people in Enterprising occupations tend to attribute frequent lateness (twice or more during a month) to bad traffic, while people in Conventional occupations seem oblivious to this problem (Table 18).

One way to avoid arriving late is to plan to arrive earlier than the work starts. This happens most in occupations which least allow lateness. A cross tabulation of the habit of reserving slack time by occupational groups shows that people in Enterprising and Investigative occupations are less likely to reserve some slack time before starting to work than people in other occupations (Table 18).

Wage-earners are more likely to reserve slack time than salaried or commission based workers (Table 17), but the difference is not statistically significant when the respondents on commission pay are included as a separate category. When the dependent variable is wage-earner/not wage earner, the wage-earner's tendency to reserve slack time is statistically significant. This finding supports hypothesis 2, which identified wage-earners as a potential group who would face more immediate and concrete penalties due to lateness, and would thus be more averse towards late arrival. Income decreases the propensity to reserve slack time (Table 15). Also income decreases the propensity to change commuting habits if the traffic conditions worsen (Table 14).

On the other hand, length of commute offers explanatory power for lateness frequency: the longer the commute, the more often the respondents arrive 15 minutes or more late (Table 19). Interestingly, length of the commute does not affect the reserved slack time to avoid lateness (Table 19). Maybe more frequent late arrivals are offset by as frequent early arrivals, so that the work time 'washes' in the long run. The location patterns of different occupational groups vis-à-vis work places explain some of the different effects of bad traffic: occupational groups tend to have different mean lengths of commute (Table 18 ). The occupational groups explain commuting length in a regression where the effects of income, wage-earner status, and education are controlled (Table 20). But when gender is added to the explanatory variables, occupations lose their explanatory power (Table 21). This finding supports hypothesis 9, which stated that occupations have an effect on length of commute, independent of the effect of income. The large explanatory power of gender shows that it is not income, but gender either through biological differenses or through sosialization and occupationsl choice, that has the larger influence on the length of commute.

Respondents in Realistic occupations tend to carpool most and respondents in Artistic and Social occupations tend to carpool less (Table 18). With the exception of Artistic occupations, the tendency to carpool follows the hypothesized order of external locus of control of the occupational groups, i.e respondents in Investigative and Realistic occupations are more likely to carpool than respondents in Enterprising and Conventional occupations, respectively. And respondents in Conventional occupation are more likely to carpool than respondents in Enterprising occupations, who in turn are more likely to carpool than respondents in Social occupations. And respondents in Realistic occupations are more likely to carpool than respondents in

Investigative occupations. The differences in carpooling between occupations are fully ranked by the occupational constants in the regression explaining commuting distance, when the respondent's carpooling is not included as an explanatory variable (tables not reported). Even though carpooling is correlated with commuting distance, it is not correlated with the decision to reserve slack time or with the frequency of lateness due to bad traffic (no tables reproduced).

Table 18. The commuting experience of different occupational groups.

| Variable | Artistic | Social | Investi-gative | Enter-prising | Realis-tic | Conven-tional | p - value of $Chi^2$ test |
|---|---|---|---|---|---|---|---|
| Late 15 minutes due to traffic:<br>· At least twice a month<br>· Less than 5 times a year | <br>18%<br>59% | <br>20%<br>63% | <br>25%<br>57% | <br>29%<br>58% | <br>24%<br>54% | <br>10%<br>81% | <br>0.076<br>0.025 |
| Average length of commute, miles | 12.3 | 14.8 | 18.8 | 18.1 | 21.5 | 16.3 | -- |
| Reserves slack time between arrival and work start | 47% | 49% | 38% | 35% | 55% | 50% | 0.019 |
| If traffic is bad twice as often:<br>· Would reserve more time for commuting<br>· Would not change commuting habits | <br>76%<br>18% | <br>49%<br>44% | <br>51%<br>43% | <br>45%<br>46% | <br>47%<br>48% | <br>60%<br>40% | <br>0.101<br>0.272 |
| Willing to pay to escape a traffic delay | 94% | 92% | 82% | 88% | 73% | 80% | 0.008 |
| Average amount one is willing to pay | $1.56 | $1.58 | $1.36 | $1.04 | $1.12 | $1.40 | -- |
| Carpools | 0% | 14% | 27% | 21% | 34% | 24% | 0.005 |

Table 19. Associations of selected variables to commuting distance.

| Variable | 5 miles or shorter | 5.1 miles - 10 miles | 10.1 miles - 15 miles | 15.1 miles - 30 miles | 30 miles or longer | p-value of $chi^2$ test |
|---|---|---|---|---|---|---|
| Male | 45% | 50% | 44% | 57% | 64% | 0.033 |
| Late 15 minutes due to traffic:<br>· At least twice a month<br>· 5 times or less a year | <br>5%<br>84% | <br>11%<br>71% | <br>23%<br>65% | <br>38%<br>42% | <br>39%<br>40% | <br>0.000<br>0.000 |
| Reserves slack time between arrival and work start | 42% | 53% | 40% | 41% | 46% | 0.303 |
| Carpools | 17% | 17% | 14% | 27% | 40% | 0.000 |

Table 20. Regression of the commuting distance on occupational group, income, wage-earner status, 4 year college degree, and gender.

| Distance, miles | Coef. | t-statistic |
|---|---|---|
| Occupational dummy variables: | | |
| Artistic | 11.71403 | 2.929 |
| Social | 13.92107 | 5.615 |
| Investigative | 17.03796 | 6.981 |
| Enterprising | 15.60213 | 7.040 |
| Realistic | 19.67732 | 8.268 |
| Conventional | 16.15636 | 6.587 |
| Personal income, $1000 | .045631 | 1.503 |
| Wage-earner | -1.039127 | -0.613 |
| 4 year college degree | -3.697344 | -2.461 |
| Male | 3.248917 | 2.196 |

Notes: Number of obs = 497
F( 10, 487) = 75.15
Prob > F = 0.0000
Adj R-squared = 0.5987
Root MSE = 14.647

A test for the joint hypothesis that the occupational constants are equal: F( 5, 485) = 0.72, Prob > F = 0.6094, which does not reject the hypothesis that occupational constants are equal.

Table 21. Regression of commuting distance on occupational group, income, wage-earner status, and a 4 year college degree.

| Distance, miles | Coef. | t-statistic |
|---|---|---|
| Occupational dummy variables: | | |
| Artistic | 12.07529 | 3.010 |
| Social | 13.81038 | 5.550 |
| Investigative | 17.94126 | 7.429 |
| Enterprising | 16.04778 | 7.243 |
| Realistic | 20.71067 | 8.843 |
| Conventional | 15.70492 | 6.401 |
| Personal income, $1000 | 0.06611 | 2.279 |
| Wage-earner | -0.71898 | -0.424 |

| | | |
|---|---|---|
| 4 year college degree | -3.50781 | -2.329 |

Notes: Number of obs = 497
F( 9, 488) = 82.32
Prob > F = 0.0000
Adj R-squared = 0.6029
Root MSE = 14.704

A test for the joint hypothesis that the occupational constants are equal:
F( 5, 488) = 2.32, Prob > F = 0.0420, which does reject the hypothesis that occupational constants are equal.

9.6 Reactions to worsening traffic conditions: time or money

When the respondents were confronted with the hypothetical situation where the bad traffic conditions would happen twice as often as now, about half of the respondents indicated that they would reserve more time for commuting, while 44% indicated that they would not change their commuting habits. Very few of the respondents would change their jobs, residence, or travel mode, but about 10% of the respondents would be willing to pay a road toll to guarantee timely arrival (Table 22)[19].

Table 22. The reaction to a hypothetical situation where bad traffic conditions occur twice as often as now.

[19] The percentages in this and other hypothetical questions do not add up to 100 because respondents were asked to indicate all of their responses.

| Reaction | Percent |
| --- | --- |
| Starts to carpool if now drives alone | 5.0% |
| Starts to drive alone if now carpools | 0.7% |
| Changes work and commuting hours | 14.9% |
| Changes residence | 3.5% |
| Changes work place | 2.8% |
| Is willing to pay a road toll to guarantee timely arrival | 10.5% |
| Reserves more time for commuting | 49.5% |
| Does not change commuting habits | 43.7% |
| Other | 8.3% |

Occupational group , carpooling (Table 18), or the subjective locus of control are not correlated with the decision to keep present commuting habits in the face of worsening traffic conditions (tables not reproduced).

Since most respondents indicate that they would either keep their present commuting habits or reserve more time for commuting, I investigated that choice a little further. The anticipated penalty from lateness affects this choice. I classified the respondents to those who expect monetary or other penalties, those who expect only non-monetary penalties, and those who do not expect any penalties. The group expecting monetary penalties is most likely to reserve more time for commuting, and the group expecting no penalties is least likely to change their current commuting habits (table not reproduced). This supports hypothesis 2, which stated that expectation of more concrete and undeniable negative consequences makes the commuter more risk averse.

In the lower income classes people would reserve more time for commuting, while in the upper income classes they would not change their present commuting habits (Table 14). This indicates that the value ratio of free time to work time is higher for people in higher income brackets.

I tested the effect of the locus of control of the occupation based on the chosen descriptions of occupations. There were no statistically significant effects for either internal or external locus of control.

The hypothetical situation was pushed further by posing permanently bad traffic. The alternative 'reserve more time for commuting' was rephrased into 'reduce or drop activities', while 'not change your commuting habits' was not offered as an alternative. The rephrasing was done because the respondents would be constantly at least 15 minutes late if they would not change their behavior.

The change apparently confused respondents, since some respondents wrote in that they would not change their commuting habits (Table 23). This indicates that the answers to the hypothetical questions are probably biased towards status quo, and somewhat politically motivated.

Table 23. The reaction to hypothetical situation where bad traffic conditions occur every day.

| Reaction | Percent |
|---|---|
| Starts to carpool if now drives alone | 12.5% |
| Starts to drive alone if now carpools | 2.4% |
| Changes work and commuting hours | 37.4% |
| Changes residence | 8.1% |
| Changes work place | 5.5% |
| Is willing to pay a road toll to guarantee timely arrival | 22.1% |
| Reduces or drops some of free time activities | 21.2% |
| Does not change commuting habits | 2.7% |
| Other | 24.3% |

Overall, the response indicates that the other alternatives would be chosen more often than in the previous scenario, but few would consider changing residence or work place. More respondents would consider carpooling and commuting at different hours, and about 22% would be willing to pay a road toll to decrease the commuting time. The locus of control measures based on chosen work descriptions produced just tentative results: those who were assigned an internal locus of control were more likely to change work and commuting hours (p=0.012) and would be more willing to pay a toll (p=0.021) than those who were not assigned internal locus of control. Respondents with external locus of control indicated that they would start to drive alone if they now carpool (p=0.034).

In the hypothetical situation where the respondent was stuck in an immobile traffic for at least 30 minutes and was offered a bypass for a fee, 85% of the respondents indicated that they would pay a fee. Willingness to pay was dependent on income: people in higher income classes are more willing to pay a fee, and the fee that they are willing to pay is higher (Table 14). Willingness to pay a fee was also dependent on the basis of earned income: salaried employees are more willing to pay a fee than wage-earners. There are so few people on commission that it is hard to draw any conclusions concerning them (Table 16). Most people in all occupations would pay something, but people in Social and Artistic occupations are most likely to pay (Table 18). This finding supports hypothesis 3, which stated that respondents with internal locus of control would be more likely to be willing to pay to regain the prospect of arriving at work at the intended time. I get the same result using the locus of control scores derived from the respondent's subjective descriptions of her work. People who are assigned an internal locus of control are statistically more likely to pay than the rest of the sample. Respectively, people who are assigned an external locus of control are less likely to pay than the rest of the sample (tables not reproduced).

The willingness to pay a toll is not dependent on commuting distance , form of benefits, or carpooling (tables not reproduced).

## 9.7 Occupational stress and commuting behavior

The respondent is identified as having occupational stress if she picked from nine alternative descriptions of work "Performing under stress" as a primary or secondary description of her own work. This description was selected by 77 persons out of 543.

When reported occupational stress was contrasted with commuting stress, there was no association: occupational stress was not related to commuting during on or off peak of the rush hour, or the commuting distance. People with occupational stress reported experiencing the same frequency of major traffic delays on their way to work than others and reserved about the same amount of slack time than the rest of the sample. Carpoolers were only insignificantly more stressed at their work than solo drivers. (Tables are not reproduced).

Kind of work was a better predictor of making the worker stressed. People in Conventional, Realistic, and Artistic occupations are the least stressed, while people in Investigative and Enterprising occupations are most stressed (Table 11). When contrasted with income, the higher income earners describe their work more often as "working under stress" (Table 15), as do salaried workers compared to wage-earners (Table 20), but the two associations are statistically insignificant. People who have to arrive punctually "practically never" are more stressed than others, while people who need to arrive punctually 2-4 times a week are least stressed (Table 24). However, the data shows a linear association suggesting that the people who have to arrive punctually most often are less likely to feel stressed at work. Table 24 presents a logit model of identified determinants of stressing work. Unfortunately I am not able to explain stress by locus of control measures based on selected work descriptions. All three variables: stressful work, and the two measures of control are all based on anwers to question 9. The choice of one indicator , e.g. "performing under stress" is automatically negatively correlated with the other two.

Table 24. "Performing under stress" explained by background variables

| Dependent: "Performing under stress" | Coefficient | t-statistic |
|---|---|---|
| Personal income | .0056718 | 1.077 |
| 4 year college degree | -.5639351 | -1.990 |
| Monetary penalty due to lateness | -.7229869 | -1.297 |
| Loss of reputation due to lateness | .3388659 | 1.266 |
| Has to arrive to work "practically never" at a specified time | .5170835 | 1.851 |
| Not able to choose work schedule | .4966462 | 1.687 |
| Works in Investigative occupation | 1.079815 | 2.597 |
| Works in Enterprising occupation | .9803632 | 2.614 |
| Works in Social occupation | .9216804 | 2.041 |
| Constant | -3.597435 | -5.143 |
| Number of obs | 513 | |
| Log Likelihood (constant) | -215.19497 | |
| Log Likelihood (θ) | -202.7874 | |
| Likelihood-ratio test: Prob > chi2(9) | 0.0032 | |

When presented with bad traffic conditions twice as often as now, and possible ways to accommodate daily commuting to the changed conditions, people with stressing work are less willing to make behavioral changes. Stress seems to increase inertia in commuting: the people who describe their occupation as stressful are statistically significantly less likely to reserve more time for commuting and more likely to keep their present commuting habits in the face of worsening traffic.

They are less inclined to come up with any other strategy to accommodate the daily commute to worsening traffic conditions. (Table 25).

The inclination toward inertia came up with other topics, such as a smaller likelihood to change travel mode, work and commuting hours, or place of residence or work. These inclinations were not statistically significant in the sample, but they all had the same direction: stress increased inertia with respect to time use.

When the hypothetical traffic conditions were worsened to permanently bad traffic, people with stressing work were statistically less likely to change work place or residence than other people. People with stressing work were also more likely to write that they would not change their commuting habits even when the alternative was not offered.

Since the reported stress is positively associated with income and Investigative, Enterprising, and Social occupations, a possible explanation comes through the locus of control: people who are stressed at work have mostly internal locus of control. This conclusion is supported by the negative association to anticipated loss of pay due to lateness, but positive association to anticipated loss of reputation due to lateness.

This finding conflicts with the earlier findings of occupational stress: most of the earlier studies indicate that an occupation supporting external locus of control is the more stressing one. This data support the hypothesis of stressful external locus of control only by the positive association between an inability to choose ones own work schedule. For Internals, a bad traffic condition can seem unacceptably low, and therefore not as a reason to change expectations of the regular speed of traffic or a reason to change own commuting behavior. However, the data support hypothesis 1 which stated that stressed people are in a state of defensive avoidance, avoiding new information and averse to changing behavior under stress. Another interpretation of this result is that the delay due to bad traffic is actually a welcomed and socially acceptable break from the stressful work.

The survey method is limited when the purpose is to elicit behavior during a specific state of mind. Therefore these results should be interpreted as tentative only.

Table 25. The association of selected variables with experiencing stress at work.

| Variable | Describes work as "performing under stress" | Does not describe work as "performing under stress" | p-value of Chi2 test |
|---|---|---|---|
| Needs to arrive on time at work: | | | |
| · Every day | 14% | 86% | Rows sum to 100% |
| · 2-4 times a week | 9% | 92% | |
| · 1-4 times a month | 13% | 87% | |
| · Practically never | 19% | 81% | |
| If traffic is bad twice as often: | | | |
| · Would keep present commuting habits | 57% | 41% | 0.010 |
| · Would reserve more time for commuting | 44% | 50% | 0.308 |
| · Would start to carpool | 3% | 5% | 0.301 |
| · Would start to drive solo | 0% | 1% | 0.415 |
| · Would change work and commuting hours | 9% | 16% | 0.121 |
| · Would change residence | 1% | 4% | 0.257 |
| · Would change workplace | 0% | 3% | 0.110 |
| · Would be willing to pay a toll to guarantee timely arrival | | | |
| · Would do something else | 13% | 10% | 0.442 |

| | | | |
|---|---|---|---|
| | 0% | 10% | 0.004 |
| <u>When traffic is permanently bad:</u> | | | |
| · Would keep present commuting habits | | | |
| · Would reduce or drop some of free time activities | 8% | 2% | 0.004 |
| · Would start to carpool | 21% | 21% | 0.926 |
| · Would start to drive solo | 13% | 12% | 0.809 |
| · Would change work and commuting hours | 4% | 2% | 0.352 |
| · Would change residence | 34% | 38% | 0.479 |
| · Would change workplace | 3% | 9% | 0.056 |
| · Would be willing to pay a toll to guarantee timely arrival | 0% | 6% | 0.022 |
| · Would do something else | 21% | 22% | 0.763 |
| | 22% | 25% | 0.622 |

9.8 Summary of the findings from data description

Since the data description is rather lengthy, I summarize the findings with respect to the hypotheses.

Hypothesis 1: A stressed commuter tends to resist changing her current commuting habits in the face of worsening traffic. This supports the hypothesis that stress increases defensive avoidance and in the case of commuting inertia to incorporate the new information into commuting behavior.

Hypothesis 2: Anticipation of loss of pay due to late arrival at work is positively correlated with a tendency to reserve slack time. In hypothetical situation of worsening traffic, anticipation of a monetary penalty is positively correlated with increased time reserved for commuting, while anticipating no penalty is least correlated with increased time reserved for commuting. Wage-earners are more likely to expect to lose pay due to late arrival, and are also more likely to reserve extra time to insure timely arrival at work. These findings support the regret theory hypothesis that the more undeniable the anticipated penalty from lateness, the more the regret of encountering the penalty is taken into consideration.

Hypothesis 3: The locus of control scores are based on the chosen work descriptions of the respondent, the persons assessed as working in an internal locus of control work. The hypothesis stated that ex ante the internals should be less risk averse and should have more inertia to change their commuting habits when there is still a good chance to arrive on time. The findings did not support the ex ante part of the hypothesis: there was no statistical difference between respondents with internal locus of control and the rest of the respondents, and likewise no difference between the respondents with external locus of control and the rest of the sample.

When the hypothetical bad traffic conditions were permanent, Internals were more likely to change their commuting and working hours and they were more likely to pay to circumvent the bad traffic. In the third hypothetical situation, where the respondent is already in the unexpected traffic jam, internals are more willing to pay to circumvent the traffic jam than persons who are not indicated as having a job that supports internal locus of control. Correspondingly, persons who were assigned as having a job that supports an external locus of control are less likely to pay to circumvent an unexpected traffic jam than persons that are not having an external locus of control job. Also, respondents in Social and Artistic occupations are more likely to pay to circumvent the traffic jam than respondents in other occupational groups. These findings support the part of hypothesis 3 which stated that Internals are more risk averse ex post than Externals.

Hypothesis 4: Respondents in Realistic and Conventional occupations score highest in external locus of control measure that is based on their chosen work descriptions, and lowest in internal locus of control measure. The next on the scale is Investigative occupations, while the remaining three score approximately equally most internal.

Respondents in Realistic and Conventional occupations have a high propensity to answer either yes or no to a question that asks if it is acceptable to arrive 15 minutes late. This finding supports hypothesis 4 which states that employees in Realistic and Conventional occupations experience work time most externally. Respondents in Artistic and Social occupations are not clearly different from respondents in Investigative and Enterprising occupations in this matter.

Hypothesis 5: The respondents who were assigned internal locus of control based on their chosen work descriptions had a lower propensity to expect monetary penalties due to late arrival at work than respondents that were not assigned as having internal locus of control. Correspondingly, respondents who were assigned external locus of control based on their chosen work descriptions had a higher propensity to expect monetary penalties due to late arrival at work than respondents that were not assigned as having external locus of control. This supports hypothesis 5 which states that employers use more immediate and concrete penalties for employees with external locus of control than for employees with internal locus of control.

Hypothesis 6: If work time supervision is measured by explicit rules about desirability of employees to arrive and start working earlier than official work hours or to stay after work hours, work time is most supervised in Realistic and Conventional occupations and least supervised in Investigative and Enterprising occupations.

Respondents in Realistic and Conventional occupations expect monetary penalties due to lateness most often, while respondents in Investigative and Enterprising occupations expect monetary penalties least often. On the other hand, respondents in Realistic and Conventional occupations expect no penalties due to lateness least often, while respondents in Investigative and Enterprising occupations expect no penalties most often. These findings support hypothesis 6, which stated that employers supervise work time most strictly in Realistic and Conventional occupations, and least strictly in Investigative and Enterprising occupations.

Hypothesis 7: Respondents in Artistic, Investigative, and Realistic occupations have a higher percentage of respondents assigned an external locus of control based on their chosen work descriptions than respondents in Social, Enterprising, and Conventional occupations, respectively. Respondents in Artistic, Investigative, and Realistic occupations have a lower percentage of respondents assigned an internal locus of control based on their chosen work descriptions than respondents in Social, Enterprising, and Conventional occupations, respectively.

Respondents in Artistic, Investigative, and Realistic occupations a lower percentage of respondents reporting that they can arrive and start working earlier than the official work start time or that they can stay at work after hours than respondents in Social, Enterprising, and Conventional occupations, respectively.

These findings support hypothesis 7, which stated that particularistic-concrete occupations support more internal locus of control than the symbolic-universal occupations.

Hypothesis 9: Occupational groups were found to explain the length of commute when the effects of income, wage-earner status, and education are controlled for. This finding supports hypothesis 9, which stated that the occupational groups would have characteristic commuting distances irrespective of the effects of income. However, when gender was included as an explanatory variable, it overrode the occupational effects indicating that sex segregation into occupations may explain a lot of the occupational differences.

# 10. HOW ARE THE VARIOUS VARIABLES INTERCONNECTED ?

The cross-tabulations of data are illustrative, but do not reveal causal relationships between the variables. Next I will take another approach and analyze the data stepwise: first how the frequency of need for punctual arrival is connected with the background variables, second how the need for punctuality with other variables explain the tendency to reserve slack time, and third, how they both and other background variables influence the willingness to pay a fee to escape traffic jams. In the end I analyze the amount the person states she is willing to pay. At each step of this analysis the variables get more subjective, and thus the numerical values get less reliable. This is unavoidable in a situation where "revealed preference" data is not feasible. However, while the numerical values are rather unreliable, the classification into influencing variables and non-influencing variables is more reliable.

## 10.1 How often do commuters need to arrive punctually?

Respondents to the transportation survey were asked "How often is it important that you arrive at work at a precise pre-determined time?" The distribution of answers was:

| | |
|---|---|
| Practically never | 29.6% |
| Once a month or less frequently | 3.4% |
| Two to four times a month | 11.9% |
| Two to four times a week | 15.3% |
| Every day | 39.9% |

The answers are further grouped by combining the intermediate values into one group. This leads to a distribution:

| | |
|---|---|
| Practically never | 29.6% |
| Some days | 30.5% |
| Every day | 39.9% |

I search for explanations of these differences based on occupational characteristics and personal characteristics of the commuter. I am looking for relatively objective explanatory variables to explain the need for punctuality. Later I will use the predicted values for different punctuality need categories to estimate the decision to reserve slack time and willingness to pay. If the link from the more objectively measured variables to more vaguely measured variable to decision making can be established, the objectively measured variables can be used directly with understanding as to why they should have the hypothesized effect.

In my preliminary analysis of the data many background variables were correlated with the need for punctuality, but it was also clear that the background variables are correlated with each other. To control for 'double counting', I estimated a multinomial logit model[20] for the three punctuality need categories (Practically never, Some days, and Every day).

Those who "Practically never" need to be punctual form the base category of the model and their coefficients are normalized to zero. The coefficients on the "Some days" and the "Every day" categories are therefore relative measures to the base category.

[20] I considered estimating an ordered logit model instead of multinomial logit, but the dependent classes, even though ordered by the frequency of punctuality needs, are not monotonically influenced by the explaining variables. Therefore I proceeded to not assume any ordering between the punctuality categories.

From Table 26 we can see that a person who needs to arrive punctually every day can neither start working before the official work start time nor later. The person can not choose her own schedule. People in this category are typically female who work in Realistic, Conventional, and Social occupations. People in Investigative occupation have least strict punctuality requirements. A significant portion of those needing to be punctual every day have to arrive at work by 6.30 am.[21]

People, who face high punctuality needs, have on the average lower incomes. However, the other variables in the model are more significant and income is rendered statistically insignificant.[22]

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[21] Other variables, not included in the table, that seem to measure the same strictness on time use as the included variables are: losing pay if arriving late, not being able to stay after official hours, and not being able to take work home. These variables were highly correlated with the included variables and were not included in the model.

[22] Of the occupational categories the highest educational level is in Investigative and Social occupations. Education measured by a dummy variable indicating a four year college degree was not significant alone or for only women or men. Specially

Conventional and to a lesser degree Social and Artistic occupations are female dominated, while the clearest male dominance is in the Investigative. Also, earlier studies have found that the length of commute and commuting time are positively related to income. This finding holds true also in this sample. To see if commuting time had an additional effect on punctuality requirements, it was entered in the earlier version of the model. However, commuting time had no additional effect and was left out of the reported model.

Those who need to be punctual on some days differ from the other two groups by their later work start time, smaller work site size, and the occupational composition. They also tend not to work in Investigative occupations.

To investigate hypothesis 8, whether the presence of children has an effect on the perceived need of punctual arrival, I added variables indicating gender and presence of younger and older children interacted with gender. To control for the effect of age on the household composition, I also added age and age squared as explanatory variables. All these variables were clearly insignificant for the need to be punctual on some days. For those who need to be punctual every day age seems to have a non-linear effect. Women with older children tend to report a higher need for punctual arrival, but all the coefficients concerning age and presence of children are statistically insignificant.

Exploring the gender roles further, I found out that women working in Realistic, Conventional and Social occupations tend to report a higher need for punctuality than do men in these occupations. However, having less control over time use is not directly reflected in pay: in this sample women earn less than men in Investigative, Social, Enterprising, and Conventional occupations, but not in Realistic or Artistic occupations (tables not reproduced).

Also college education is unevenly distributed among the occupations and gender. The highest proportion of 4 year college degrees for men are in Artistic and Social occupations, the lowest in Realistic and Conventional occupations. However, the differences are only moderate, leading to a borderline significant Chi-square statistic. Women are least college educated in Conventional occupations, followed by Realistic and Enterprising occupations. However, significantly higher proportion of women in Investigative occupations have college education, making the overall distribution highly significant (tables not reproduced).

People in Investigative occupations report most often that they need to be punctual practically never. One can conclude that women trade off more of the advantage of education for higher command over their time use, whereas men can translate the full advantage of education into a higher pay.

On the next page:

Table 26. Need for punctuality, a multinomial logit model

Notes for table 26: The base category = Needs to be punctual "Practically never"
Number of obs = 503
$L(0) = -547.9751$
$L(\theta) = -397.1604$
Likelihood-ratio test: chi2(13) = 301.63, Prob > $chi^2$ = 0.0000

| | Need to be punctual on some days | | Need to be punctual on every day | |
|---|---|---|---|---|
| Explanatory variables | Coef. | t-value | Coef. | t-value |
| Possibility to arrive to work earlier than official start time | - | - | -3.196 | -7.672 |
| Not acceptable to arrive 15 minutes late | - | - | 1.509 | 5.254 |
| Can choose own work schedule | - | - | -.669 | -2.263 |
| Less than 25 employees at work site | .499 | 1.704 | - | - |
| Multiple work sites | - | - | -.778 | -2.046 |
| Work starts at or before 6.30 am | - | - | 1.013 | 2.351 |
| Work starts at or after 8.30 am | 0.866 | 3.351 | - | - |
| Working in an Investigative occupation | -.484 | -1.733 | -.779 | -2.046 |
| Woman working in a Social occupation | - | - | 1.113 | 2.316 |
| Woman working in a Conventional occupation | - | - | 1.475 | 3.082 |
| Woman working in a Realistic occupation | - | - | 1.032 | 1.710 |
| Woman, children 15 years or younger | .356 | 0.790 | -.163 | -0.313 |
| Man, children 15 years or younger | -.369 | -0.976 | -.040 | -0.078 |
| Woman , children 16-21 years old | -.314 | -0.621 | .728 | 1.302 |
| Man, children 16-21 years old | .151 | 0.370 | -.108 | -0.193 |
| Age (years) | -.049 | -0.561 | -.127 | -1.394 |
| Age squared | .000323 | 0.336 | .00151 | 1.534 |
| Male | -.091 | -0.294 | -.273 | -0.679 |
| Constant | 1.473 | 1.946 | 4.372 | 2.064 |

10.2 Reserving slack time to ensure punctuality

A commuter can leave home earlier to insure punctual arrival, a practice I call here reserving slack time[23]. I had expected that the same variables that explain high need for punctuality would also explain reserving slack time before work start. To count for the effect these variables have through the need for punctuality, I entered the predicted values for need for punctuality "every day" and "some days". Of these, only the predicted need "every day" was significant. The sign is positive, as would be expected: those who need punctuality are more likely to reserve slack time to insure it. However, the possibility of arriving earlier and benefiting form the early arrival is important: even though the lack of possibility to start working earlier is associated with need for punctuality, flexible start time towards early start increases the attraction of slack time. The only added variable that increased the likelihood for slack time was, as one would expect, an expected monetary penalty from lateness.[24] This finding supports hypothesis 2, since the expected loss of

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[23] The time between required arrival time and intended arrival time has many names: it has been called safety margin, schedule delay early, and slack time.

[24] The variables that do not explain slack time were: gender interacted with education, female interacted with presence of 0-5 years old children, female interacted with 6-15 years old children, presence of 0-5 years old children, presence of 6-15 years old children, respondent's age, education, personal income, wage vs. salary income, being an entrepreneur or an independent contractor, occupational groups, work start time, perceived damage to reputation due to lateness, being able to continue working after the official hours, being able to take work outside office during or after work hours, being able to work sometimes at home instead of in the office, working part time, working in rotating shift, being able to choose the work schedule, working under changing schedule vs. fixed, number of employees in the worksite, multiple work sites, and commuting distance and time.

reputation due to lateness does not have a significant effect. To test the ‘family responsibilities’ explanation for women with young children, I interacted dummy variables indicating a presence of a pre-school and school-age (0-15 years), and older children (16-21 years) with gender of the respondent. Of these, only the older children had a statistically significant effect, decreasing the probability to reserve slack time. This finding is against the family responsibility hypothesis, which indicates that the presence of young children would influence women’s time use. The older children can often drive themselves, and their effect here is more on men’s time use, not women’s. This effect could be a confounded effect of the decreased tendency to make side trips when the children are older. In general, men tend to not reserve slack time, and the tendency is not dependent on their age. Women’s tendency to reserve slack time is dependent on their age, irrespective of the presence of children. Income has a statistically insignificant effect on the decision to reserve slack time.

Table 27. Choice to reserve slack time before work starts, a binary logit model

| Dependent variable: slack | Coef. | t-value |
|---|---|---|
| Predicted "every day" importance of prompt arrival | 2.224 | 2.507 |
| Predicted "some days" importance of prompt arrival | -.514 | -0.396 |
| Possibility to arrive to work earlier than official start time | .960 | 2.399 |
| Monetary penalty for lateness | .782 | 2.206 |
| Man, youngest children in the household are 0-15 years old | -.366 | -1.037 |
| Woman, youngest children in the household are 0- 15 years old | .377 | 0.969 |
| Man, youngest children in the household are 16-21 years old | -1.113 | -2.739 |
| Woman,youngest children in the household are 16-21 years old | -1.075 | -2.327 |
| Age of a woman | -.338 | -2.550 |
| Age of a woman squared | .00359 | 2.346 |
| Age of a man | .0276 | 0.358 |
| Age of a man squared | -.000386 | -0.491 |
| Personal income, in thousand dollars | .00266 | 0.592 |
| Man | -7.446 | -2.289 |
| Constant | 5.477 | 1.843 |

Notes: Base category: no slack, Number of obs = 485,
L(0) = - 332.0730, L(θ) = - 296.9579,
Likelihood-ratio test: $chi^2(14) = 70.23$, Prob > $chi^2$ = 0.0000

10.3 Willingness to pay to escape unexpected schedule delay

Willingness to pay a fee to avoid an unexpected 30 minute delay during the commute to work[25] is analyzed in two stages: first the decision to pay anything at all, and secondly the highest amount to be paid once the decision to pay has been made. The reason for this two stage estimation is partly to control for political bias in answers: most respondents who wish to exert political influence against toll roads answer that they would pay nothing. The other reason for this estimation procedure is the belief that many people use this kind of lexicographic decision algorithm. The first decision is presented in Table 28.

The predicted importances of “every day” and “some days” punctual arrivals affect significantly the willingness to pay. However, the negative sign indicates that those who “practically never” need to arrive punctually are the ones most willing to

[25] The question : Suppose during your regular morning commute you found yourself in a traffic jam where you expected to stand in immobile traffic for 30 minutes or more. If you could bypass the traffic jam and continue uninterrupted by paying a fee, would you be willing to pay a fee of a) \$0.50 b) \$1.00 c) \$2.00 d) \$3.00 e) \$5.00. The respondent could answer yes or no to each alternative.

pay. Also the predicted slack time affects willingness to pay. The sign is negative: those who are going to reserve slack time are not likely to pay. Also working in Realistic or Conventional occupations decreases the willingness to pay. Because the effect of these occupations is already included through the need for "every day" promptness, the result indicates that these two occupations have additional factors besides the need for promptness that further decrease the willingness to pay. Locus of control provides an explanation that fits this seemingly paradoxical behavior: respondents in Realistic and Conventional, the two most external occupations, are most likely to adapt to the new situation and form their new reference point accordingly. They are most likely to see it as beyond their duty or interest to pay their own money for something that happens during the time they have already devoted to the job. Those who face the strictest external time control are the ones least likely to internalize the goal of arriving punctually.

Investigative occupations do not support an external locus of control with respect to work time constraints. On the contrary, people in Investigative occupations report more often than anybody else that they need to arrive promptly "practically never". Since the effect of working in Investigative occupation is negative on predicted need for "every day" promptness, the negative effect in the willingness-to pay model indicates that Investigative occupation has something else than a need for prompt arrival that promotes smaller willingness to pay. Two potential explanations for this result exist: the locus of control determined by the subjective descriptions and political bias in answers. According to the hypotheses 4 and 7, Investigative occupations support a more external locus of control than

Artistic, Social, or Enterprising occupations. Also, the respondents in Investigative occupations have higher persentage of external locus of control scores and lower persentage of internal locus of control scores based on the work descriptions the respondents chose, than the other three occupations (Table 12). These respondents may feel detached from their work in a way that doesn't show up in work time usage. The other reason, political bias, is plausible because people in

Table 28. Willingness to pay a fee to avoid a 30 minute delay in traffic, a binary logit model

| Dependent variable: Willing to pay a fee | Coef. | t-value |
|---|---|---|
| Predicted "every day" importance of prompt arrival | -2.269 | -1.708 |
| Predicted "some days" importance of prompt arrival | -2.161 | -0.960 |
| Predicted probability to reserve slack time | -2.479 | -1.015 |
| Loss of pay for lateness | 1.224 | 2.057 |
| Personal income, in thousand dollars | .0184 | 2.096 |
| Working in Conventional occupation | -.985 | -2.010 |
| Working in Realistic occupation | -.592 | -1.482 |
| Working in Investigative occupation | -1.042 | -2.470 |
| Woman, youngest child in the household is 0 - 15 years old | 1.635 | 1.367 |
| Man, youngest child in the household is 0 - 15 years old | .577 | 1.109 |
| Woman, youngest child in the household is 16-21 years old | -.106 | -0.083 |
| Man, youngest child in the household is 16-21 years old | -1.860 | -2.550 |
| Age of a woman | .175 | 0.699 |
| Age of a woman squared | -.00200 | -0.729 |
| Age of a man | -.0185 | -0.189 |
| Age of a man squared | .000232 | 0.229 |
| Man | 2.780 | 0.493 |
| Constant | 1.200 | 0.189 |

Notes: Number of obs = 479, L(0) = -199.2404 , L(θ) = -162.4421
Likelihood-ratio test: $chi^2(6) = 73.60$, Prob > $chi^2$ = 0.0000

Investigative occupations are probably more familiar with uses and abuses of survey data than people in other occupations.

As the theory predicts, personal income increases one's willingness to pay, as did the expected loss of pay from late arrival. Also, living with young children increases the willingness to pay, but more so for women. This result supports the hypothesis 2 based on Regret theory and the explanation that family responsibilities increase the importance of timing of activities for women (hypothesis 8), but the effect seems to be true also for men living with young children. However, this is only a tentative result, as the coefficients are not statistically significant. Again the older children in the household have an opposite effect on behavior: their presence decreases men’s willingness to pay. In general, though, men are more willing to pay.

Age does not have any influence on the willingness to pay. Other insignificant variables not included in the reported model are college education, commuting time, and a host of variables measuring time use flexibility at the work place. Since stress is hypothesized to affect decision making, the indicator of stressful occupation was added as an independent variable to the model. The coefficient, however, was only insignificantly positive, and was left out at this stage of the model to see if it would gain explanatory power at the second stage of the willingness-to-pay decision.

In the second stage, which analyses the amount of fee for only those that are willing to pay something, the predicted need for punctuality and slack time lose their significance. The second stage is presented in Table 29. At this stage of decision process, working in Investigative occupation and high personal income tend to increase the fee, but both coefficients lack statistical significance. A degree from a four year college changes especially the amount a woman is willing to pay, but the data suggests that college degree may also increase the fee for a man. These effects can be explained through an assumed internal locus of control: educated respondents treat the time at work more as their “own” time[26]. Thus they are willing to pay more of their own money to get to work at the intended time. On the other hand, being a wage-earner is an indication of stricter external control on the respondent’s time use, and therefore doesn’t motivate the respondent to pay a lot.

The presence of children in the household does not affect the amount men or women are willing to pay, neither does the age or gender of the respondent. This result is not consistent with the “family responsibility” explanation. Stressful work does not influence the fee one is willing to pay.

Because willingness-to-pay questions are subject to well known biases[27], numerical values of the fee derived from this model should not be taken too religiously. As hypothetized earlier, the money amount are likely to be biased

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[26] College education is significantly positively associated with the internal locus of control measure based on chosen work descriptions, and significantly negatively associated with the external locus of control measure based on chosen work descriptions.

[27] See e.g. Kemp and Maxwell (1992) for a demonstration of how biases affect contingent valuation questions.

downwards. There is more reason to believe the relative importance of explaining variables this model indicates.

Table 29. The highest fee one is willing to pay in order to avoid a 30 minute delay during a commute to work, given that the person is willing to pay something, an OLS regression.

| Dependent variable: The highest amount one is willing to pay to avoid a 30 minute delay during a commute to work | Coef. | t-value |
|---|---|---|
| Predicted "every day" need for prompt arrival | .188 | 0.299 |
| Predicted "some days" need for prompt arrival | .473 | 0.515 |
| Predicted probability to reserve slack time | -.858 | -0.696 |
| Personal income, in thousand dollars | .00421 | 1.404 |
| Loss of pay due to lateness | .760 | 2.475 |
| Wage-earner | -.348 | -1.850 |
| Working in an Investigative occupation | .286 | 1.458 |
| 4 year college degree, if the respondent is a man | .313 | 1.513 |
| 4 year college degree, if the respondent is a woman | .571 | 2.944 |
| Woman , youngest child in the household is younger than 16 years | -.218 | -0.875 |
| Man , youngest child in the household is younger than 16 years | -.0374 | -0.152 |
| Woman, youngest child in the household is 16 - 21 years old | -0.842 | -0.241 |
| Man, youngest child in the household is 16 - 21 years old | .168 | 0.457 |
| Age of a woman | -.0749 | -0.611 |
| Age of a woman squared | .000735 | 0.541 |
| Age of a man | -.0185 | -0.371 |
| Age of a man squared | .0000962 | 0.192 |
| Man | -1.109 | -0.391 |
| Constant | 2.976 | 0.967 |

Notes: Number of obs = 404
F( 18, 385) = 2.95
Prob > F = 0.0000
R-square = 0.1212
Adj R-square = 0.0801
Root MSE = 1.2576

At this stage, the predicted probability to reserve slack time does not have an impact on the amount the respondent is willing to pay. The story that these models are telling: the negative impact of reserved slack time on the decision to pay, and the negative correlation between the amount of reserved slack time and the amount the respondent is willing to pay (-.17), does not comply with the common description of a risk averse or risk preferring person. Instead of being overall averse to the risk of late arrival, those who are willing to plan ahead and reserve slack time are not willing to pay a fee if they get stuck in a major traffic jam and would be late without paying, and those not willing to spend time to insure punctuality are willing to pay in case of unexpected delays.

This behavior may be explained in terms of locus of control. The individuals that perceive an external control for their arrival and take precautions by reserving slack time, have a clearer and more constrained image of the limits of their influence and duty. Landing in an unexpected traffic delay is clearly beyond their realm and "not their fault", and they are not willing to pay their own money to get out of it. Individuals with internal locus of control, on the other hand, are more likely to internalize the unwelcome occurrence and are willing to pay to change it.

What I have demonstrated here is that commuters have a value for punctuality which depends on their perception of control or ownership of their time. I have gone beyond the description of 'tastes' of different socio-economic groups, and provided an explanation to a seemingly contradictory behavioral pattern. This interpretation differs from the standard "value of time" , or here "value of punctuality" interpretation, where the commuter is supposed to have unknown, but unambiguous, values for different aspects of time, commonly assumed as functions of earning power.

## 10.4 Summary of findings from revealed preference and hypothetical questions data

The need for punctual arrival can be explained by occupational requirements. The attraction of occupations can be explained by personality. One aspect of personality -- locus of control -- can be used to explain the seemingly puzzling finding that those who state the highest need for punctuality are least willing to pay to circumvent traffic delays: the high need for punctuality is not the commuter's need, but the employer's. When the employee has done his duty to reserve enough time for the commute, it is not in his interest to pay for delays that he sees beyond his responsibility. This pattern persists when income, the regular economic explanation, is controlled for.

Conventional and Realistic occupations have the strictest time requirements and are therefore concluded to indicate highest portions of employees with external locus of control.

Even though there are clear differences in commuting behavior between men and women, 'family responsibilities' could explain only some of the differing commuting behavior, while the ‘locus-of-control’ provided another explanation.

# 11. THE DEMAND MODELS BASED ON STATED PREFERENCE QUESTIONS

Up to this point I have explored revealed preference questions and hypothetical what - if questions. The survey contained also a set of stated preference questions. Each question describes two uncertain commuting alternatives of which the respondent chooses one. The questions do not allow the respondent to resort to inertia, but at the same time are designed to describe plausible alternatives for the respondent. The SP questions had about 11% lower response rate than the other questions. This may be due to the respondents's reluctance to abandon status quo in cases where neither one of the alternatives described the current commuting pattern or due to the complexity of the question format.

## 11.1 The form of the model

If we assume that people are risk averse at both sides of the intended arrival time, we would expect the disutility functions to be convex on both sides. On the other hand, if we assume that people are risk preferring on the early side, the disutility function would be concave on the early side and linear or convex on the late side. Further, if we want to assume that people are risk preferring through an acceptable range around the intended arrival time, but risk averse outside it, we would have to assume flexible functional forms on both sides of the intended arrival time.

In this stated preference study the maximum difference of expected late arrival times between alternatives A and B was 4.2 minutes. This is a very small range, due to the design emphasizing only politically acceptable alternatives. The maximum difference between expected early arrival times was considerably larger, 20.8 minutes. Thus the design gives more range to fit the different functional shapes on the schedule delay early (SDE) and the expected (mean) travel time components.

I consider the form of the utility function first without the modifying socio-economic variables, and add the modifiers after the basic form of the model is determined. Since the specific utility function form is not clear a priori, SDE and mean travel time are fitted with linear, quadratic and cubic functions and their combinations. The cubic terms are not significant, but the quadratic terms are, indicating a risk averse attitude toward arriving earlier than intended, but risk preferring attitude toward mean travel time. The estimation results of linear models are in Table 30 and the models including quadratic terms are in Table 31.

The restriction of timing of commute affects the choice in the SP questions. An earlier study (Black and Towris, 1993) compared timing-unrestricted alternatives. That allowed the use of a reliability measure as an indicator of both the scheduling preferences and the general scope of unpredictability of travel time. In this study the timing of the trip is restricted. The data has a natural reference point -- preferred arrival time -- and the early and late arrival times and probabilities can be explicitly included in the utility formula. When these effects are already counted for, the general unreliability measure refers to the disutility deriving from respondent's inability to plan activities.

To clarify presentation of the models, the estimated coefficients of mean travel time, squared shedule delay early, and schedule delay late are multiplied by 10. This change of scale does not change the results in any other way but by shifting the decimal point one digit to the right. For the squared mean travel time the coefficient is multiplied by 100 , which shifted the decimal point two digits to the right. The planning utility is expressed as coefficient of variation, i.e. standard deviation of the travel time distribution divided by its mean. This measure is not multiplied for presentation purposes.

The statistical significance of these models is somewhat exaggerated by the fact that there are nine observations from each respondent. This violates the assumption of independent error terms, because the nine observations have more in common than is counted for by the independent variables in the models. If the error terms of a given respondent would be perfectly correlated, the adjustment for the bias would be to divide the t-statistic by a square root of the number of repeated measures ($\sqrt{9}$ in this data set) as suggested by Louviere and Woodworth (1983). However, since the error terms are probably not perfectly correlated, the true t-statistic lies somewhere between the reported and adjusted values.

Looking at the first model (M1) we can see that the expected number of minutes of lateness and the probability of arriving late are both significant. However, due to the short range of shedule delay late variable, the coefficients of schedule delay late and lateness probability have to be correlated with each other and with the coefficient for planning uncertainty (coefficient of variation). To keep the basic model robust, Model M2 drops the lateness probability variable and M3 drops the schedule delay late variable. When compared to M1, M3 maintains the coefficients of other variables better at their earlier level than M2, and has a slightly better likelihood value. M3 would be the best linear model.

In models M4-M7 the quadratic terms are entered for mean travel time and schedule delay early. The quadratic term is not entered for expected schedule delay late because its range is only four minutes. M4 and M5 are the models with quadratic terms. Both the quadratic terms are significant, but the linear component of the schedule delay early becomes insignificant. The fit of both models increases with respect to the corresponding linear models. Another benefit from adding the quadratic terms in the model is that planning uncertainty is generally more significant in the models containing the quadratic terms.

M6 and M7 are models where the insignificant linear component of schedule delay early is dropped. Dropping the linear component from the expected early arrival does not affect the fit of the model, which indicates that the more parsimonious model is better. Based on these considerations I selected M6 as the functional form for further examination.

Table 30. Linear models based on SP data.

| | M1 | | M2 | | M3 | |
|---|---|---|---|---|---|---|
| | Coef. | t-stat | Coef. | t-stat | Coef. | t-stat |
| Mean travel time | -1.049 | -10.128 | -1.283 | -15.421 | -.920 | -10.059 |
| Schedule delay early | -.932 | -10.611 | - .967 | -11.007 | -.864 | -10.342 |
| Schedule delay late | -1.311 | -2.716 | -2.819 | -10.634 | | |
| Lateness probability | -1.347 | -3.704 | | | -2.178 | -10.910 |
| Planning uncertainty | -.344 | -1.391 | -.664 | -2.893 | -.326 | -1.316 |
| L(θ) | | -2755.6247 | | -2762.5221 | | -2759.3340 |

Note: In all models the L(0) = -3004.0999 and sample size = 4334.
To convert the coefficients to correspond effects for one minute, shift the decimal point one digit to the left for mean travel time, schedule delay early, and schedule delay late.

Table 31. Basic models with both linear and quadratic terms.

| | M4 | | M5 | | M6 | | M7 | |
|---|---|---|---|---|---|---|---|---|
| | Coef. | t-stat | Coef. | t-stat | Coef. | t-stat | Coef. | t-stat |
| Mean travel time | -2.052 | -9.182 | -1.765 | -6.668 | -2.11524 | -10.608 | -1.848 | -7.409 |
| Mean travel time$^2$ | .098 | 4.716 | .088 | 3.856 | .10276 | 5.108 | .093 | 4.201 |
| Schedule delay early | .167 | 0.621 | .247 | 0.925 | | | | |
| Schedule delay early$^2$ | -.043 | -3.654 | -.043 | -3.726 | -.03594 | -9.027 | -.033 | -8.676 |
| Schedule delay late | -1.671 | -5.440 | | | -1.70985 | -5.688 | | |
| Lateness probability | | | -1.199 | -4.638 | | | -1.243 | -4.885 |
| Planning uncertainty | -2.095 | -6.704 | -1.907 | -5.125 | -2.06662 | -6.686 | -1.856 | -5.041 |
| L(θ) | | -2732.5063 | | -2736.6874 | | -2732.6991 | | -2737.1161 |

Note: In all models the L(0) = -3004.0999 and sample size= 4334.
To convert the coefficients for minutes, shift the decimal point one digit to the left for mean travel time, schedule delay early, schedule delay early$^2$ and schedule delay late. For the coefficient of mean travel time$^2$ shift the decimal point two digits to the left.

This model differs from the earlier models in a couple of ways. Traditionally people have assumed that the travel time is increasingly onerous, that each additional minute to the travel time is more onerous than the previous one. However, when travel is assumed to take place in a context of timetable constraints and the model allows estimating the value of expected travel time separately from schedule considerations, an additional minute of travel time becomes *de*creasingly onerous. According to model M6 an additional minute of expected travel time at 70 minutes causes about one third as much disutility than when the expected travel time is only 7 minutes.

Another peculiarity of this model is the quadratic form of expected schedule delay early. Here the quadratic form indicates that each additional minute of schedule delay early is increasingly onerous. In (Small 1982) the expected schedule delay late had a significant quadratic term, but the expected schedule delay early did not. I suspect that had the range for expected schedule delay late been wider in this data, both sides would have had a quadratic form. The marginal utilities and marginal rates of substitution of this basic model are illustrated later with the variants of the model.

## 11.2 Demand models incorporating socio-economic variables

### 11.2.1 Models incorporating age, gender, presence of children, commuting distance, and income

Based on the earlier results I expect that gender, age, presence of young and driving age children, commuting distance, income, wage-earner status, education, occupational group, locus of control, and stress affect commuting preferences. I will study each of these factors separately and later combine the salient variables.

I specified demand models modified by a gender dummy, age, and gender specific age. All three modifications were statistically insignificant by likelihood ratio test compared to the basic model M 6. Also individual variables were clearly insignificant. The only borderline significant effect (t-test p=0.077) was that older age increased women's disutility from too early arrival. This finding confirms the results from the earlier models that the "family responsibilities" explanation of preferences concerning unreliable travel time is not supported.

None of the modifiers distorted the overall models: the relative magnitudes and significance of variables remained relatively stable when the modifiers were introduced. This indicates that the basic model is rather robust. On the other hand, while the overall fit of the M 6 model with modifiers was often better than without modifiers, many individual effects were statistically insignificant. I will elaborate on the effects that were found.

Model M 8 present the basic model modified by presence of children. Presence of children has distinct effects on the values of different elements of uncertain travel time. In general, preschool and school age children have similar effects, but the presence of older children has opposing effects. Since many families have both preschool and school children, those categories were combined in the presented model.

Presence of preschool and school children increases acceptability of schedule delay early. That is the only statistically significant effect of younger children.

Presence of driving age children affects the attitude towards expected total travel time: the linear component is steeper and the disutility is more concave. The planning disutility is notable for these commuters, maybe indicating more need to coordinate activities with others' timetables. Commuters who have driving age children at home also have a smaller coefficient of schedule delay late indicating that arriving late is more acceptable to them than to the rest of the respondents.

Model M 9 presents the effect of commuting distance on commuting preferences. People with a longer commute are less averse to prospects of longer expected travel time or arriving at work earlier than intended, but otherwise the commuting distance doesn't affect commuting preferences.

Table 32. Models M 8 and M9: The effect of presence of children and the commuting
distance on the commuting preferences.

| | M 8: Children in the household: 0-15 years: Preschool and School age; 16-21 years: Driving age | | M 9: Commuting Distance (in miles) | |
|---|---|---|---|---|
| | Coef. | t-stat. | Coef. | t-stat. |
| Mean travel time | -1.613 | -6.616 | -1.853 | -5.829 |
| Mean travel time$^2$ | .0569 | 2.283 | .0596 | 1.660 |
| Schedule delay early$^2$ | -.0428 | -8.196 | -.0645 | -6.942 |
| Schedule delay late | -2.728 | -7.193 | -2.597 | -4.990 |
| Planning uncertainty | -.919 | -2.422 | -1.589 | -3.633 |
| <u>Modifier effects:</u> | | | | |
| Mean travel time | PS: 1.555 | 1.613 | -.012651 | 2.484 |
| | D: -2.741 | -2.997 | | |
| Mean travel time$^2$ | PS: -.0642 | -0.706 | .001663 | 1.201 |
| | D: .180 | 2.082 | | |
| Schedule delay early$^2$ | PS: .0437 | 2.477 | .000735 | 3.483 |
| | D: -.0179 | -1.045 | | |
| Schedule delay late | PS: .483 | 0.361 | .027310 | 1.579 |
| | D: 2.488 | 1.955 | | |
| Planning uncertainty | PS: 1.835 | 1.058 | -.006322 | -0.244 |
| | D: -4.913 | -2.937 | | |
| L(0) | -3004.0999 | | -2947.2618 | |
| L(M6) | -2732.6991 | | -2686.8597 | |
| L(θ) | -2711.5113 | | -2680.0379 | |
| LR-test between L(M6) and L(θ) | chi2(10) p=0.0000 | | Chi2(5) p=0.0180 | |
| Sample size | 4334 | | 4252 | |

Income effects were studied by using two models: one assuming that each unit of additional income has a constant effect on the variables of unreliable travel time, modeled by multiplying income by the variables (M 10). The other model assumes that high income respondents have a different preference structure than low income respondents, but it does not assume that each incremental income dollar has the same effect. The second assumption is modeled by using a dummy variable indicating a high income respondent (M 11).

Income modifiers of the first model increase the value of likelihood function only marginally, and the model is not statistically improved from model M 6. The exceptions are increased disutility from the linear element of expected mean travel time and additional disutility from planning uncertainty.

The second income model used two income categories: less than $ 50,000 a year (base group) and $50,000 or more per year (high income group). The fit of this model is better, indicating that the implicit assumption of constant marginal effect of income on commuting preferences is incorrect.

High income is associated with stronger disutility from mean travel time, but more concave disutility function. There is no statistical difference between the income groups about preferences of schedule delay early, but high income is associated with almost no disutility from schedule delay late. High income is also associated with more sensitivity to planning uncertainty.

Table 33. Models M 10 and M11: The effect of income to the commuting preferences.

| | M 10: Income<br>In $ 1000's | | | M 11: Income<br>Higher income (H)<br>$ 50,000 or more | |
|---|---|---|---|---|---|
| | Coef. | t-stat | | Coef. | t-stat |
| Mean travel time | -1.236 | -2.575 | | -1.420959 | -5.418 |
| Mean travel time$^2$ | .0468 | 0.939 | | .062542 | 2.291 |
| Schedule delay early$^2$ | -.0360 | -3.347 | | -.031142 | -5.571 |
| Schedule delay late | -2.458 | -3.348 | | -2.252772 | -2.302 |
| Planning uncertainty | -.689 | -0.966 | | -1.086153 | -2.706 |
| <u>Modifier effects:</u> | | | | | |
| Mean travel time | -.0179 | -2.083 | H: | -1.858278 | -4.423 |
| Mean travel time$^2$ | .00119 | 1.362 | H: | .1189713 | 2.875 |
| Schedule delay early$^2$ | -.00001 | -0.059 | H: | -.0107825 | -1.319 |
| Schedule delay late | .0158 | 1.268 | H: | 1.421406 | 2.302 |
| Planning uncertainty | -.0268 | -2.109 | H: | -2.491571 | -3.774 |
| L(0) | -2893.8895 | | | -2893.8895 | |
| L(M6) | -2634.8843 | | | -2634.8843 | |
| L(θ) | -2631.2018 | | | -2619.1357 | |
| LR-test between L(M6) and L(θ) | chi2(5) p=0.1949 | | | Chi2(5) p=0.0000 | |
| Sample size | 4175 | | | 4175 | |

11.2.1.1 Implications of income to commuting preferences

The implications of a non-linear model are not transparent. To help to analyze the basic model and an important modifier -- income -- I calculate the marginal effects of mean travel time and schedule delay early. Table 34 presents the incremental utilities from an additional minute of expected mean travel time at different travel time values. The marginal utilities are computed for the basic model M 6 and model M 11, which uses the high income dummy for respondents who earn $ 50,000 or more per year.

The marginal utilities are computed as follows. The utility function is of the form

$$U = a \cdot 0.1 \cdot T + b \cdot 0.01 \cdot T2 + c \cdot 0.1 \cdot SDE2 + d \cdot 0.1 \cdot SDL + e \cdot PU,$$

where
$T$ = expected travel time (in minutes)
$T^2$ = square of expected travel time (in minutes)
$SDE^2$ = square of expected schedule delay early (in minutes)
SDL = expected schedule delay late (in minutes)
PU = planning uncertainty, ratio of standard deviation and expected travel time, and

a,b,c,d, and e = estimated coefficients.

The marginal effect of increased travel time is: $a \cdot 0.1 + 2 \cdot b \cdot 0.01 \cdot T$, where T denotes the current expected travel time[28]. For example in model M6, when

[28] The multipliers 0.1 and 0.01 are added so that the time can again be expressed in minutes As mentioned earlier, the only reason for multiplying the data in the estimation phase was to reduce the amount of zeros when displaying the estimation results.

travel time equals 10 minutes, the marginal increase of utility due to one extra minute of expected travel time is: $-2.11524 \cdot 0.1 + 2 \cdot 0.10276 \cdot 0.01 \cdot 10 = -0.190972$. The marginal increases in the table are calculated as arc elasticities, at one minute distance. Using the derivative gives approximately the same result.

The effect of planning utility was not included in the calculation of the marginal utility of travel time. Doing so is implicitly assuming that the standard deviation of the travel time is zero. Table 35 gives values of marginal utilities of expected mean travel time, when the standard deviation is zero, 3, and 6[29].

The marginal effect of increased expected schedule delay early is: $c \cdot 0.1 \cdot 2 \cdot SDE$, where SDE denotes the current expected schedule delay early. For example in model M 6, when expected schedule delay early is 5 minutes, an additional minute of schedule delay early brings utility: $-0.03594 \cdot 0.1 \cdot 2 \cdot 5 = -0.03594$. The marginal effect of one incremental minute of schedule delay late in model M 6 is: $0.1 \cdot (-1.70985) = -0.170985$ .

A higher marginal utility of an alternative A compared to alternative B indicates that the decicion maker is more likely to choose A. For example, if both A and B are initially equally preferred, then $U_A = U_B = 0.5$, and the decision maker is

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[29] About 20% of the questions the difference of standard deviation of alternatives was zero, while about half of the remaining questions had a difference of standard deviation less than 3. Less than 10% of the questions had standard deviation differences larger than 6.

as likely to choose A as he is to choose B. If the utility of A increases by 0.2, the

$$\frac{e^{U_A+.2}}{e^{U_A+.2}+e^{U_B}}=\frac{e^{.2}}{e^{.2}+1}=\frac{1.22}{1.22+1}=.55.$$

probability of the decision maker to choose A increases to

And consequently his probability to choose B diminishes to .45.

Table 36 presents the incremental utilities from an additional minute of expected schedule delay early for the same three groups. Finally table 37 presents marginal rates of substitution between expected schedule delay early and expected mean travel time. The numbers can be interpreted to answer a question: how many additional minutes of expected mean travel time would the person incur in order to save one minute of expected schedule delay early?

The rate of substitution varies between 0.036 and 2.125 for the whole sample, but the range is slightly larger for both subgroups. Generally there is not much difference between the rates of higher and lower income groups. At a typical trade-off point, where the expected mean travel time is 30 minutes and schedule delay early 10 minutes, the average respondent would take half a minute longer mean travel time to decrease one minute of schedule delay early. At the same situation a commuter from the higher income group would increase his expected commute 0.38 minutes, and a commuter from lower income group would increase his commute 0.59 minutes to decrease one minute of expected schedule delay early.

Table 34. Utility from an additional minute of expected mean travel time: Models M 6 and M 11

| | Utility from an additional minute of expected mean travel time | | |
|---|---|---|---|
| | M 6 | M 11 | |
| Mean travel time | Whole sample | Higher income | Lower income |
| 10 | -0.1910 | -0.2916 | -0.1296 |
| 20 | -0.1704 | -0.2553 | -0.1171 |
| 25 | -0.1601 | -0.2372 | -0.1109 |
| 30 | -0.1499 | -0.2191 | -0.1046 |
| 35 | -0.1396 | -0.2009 | -0.0984 |
| 40 | -0.1293 | -0.1828 | -0.0921 |
| 50 | -0.1088 | -0.1465 | -0.0796 |
| 60 | -0.0882 | -0.1102 | -0.0671 |
| 70 | -0.0677 | -0.0739 | -0.0546 |

Table 35. Marginal utility of travel time conditional on different standard deviations of expected travel time: Model M 6

| | Marginal disutility of travel time | | |
|---|---|---|---|
| Expected mean travel time | Std = 0 | Std = 3 | Std = 6 |
| 10 | -0.190972 | -0.1289734 | -0.0669748 |
| 30 | -0.149868 | -0.1429793 | -0.1360905 |
| 50 | -0.108764 | -0.1062840 | -0.1038041 |
| 70 | -0.067660 | -0.0663947 | -0.0651294 |

Table 36. Marginal utility from an additional minute of expected schedule delay early

| | Marginal utility from an additional minute of expected schedule delay early | | |
|---|---|---|---|
| Expected schedule delay early | Whole sample Model M 6 | Higher income Model M 11 | Lower income Model M 11 |
| 1 | -0.007188 | -0.00838 | -0.00622 |
| 5 | -0.035940 | -0.04190 | -0.03110 |
| 10 | -0.071880 | -0.08380 | -0.06220 |
| 15 | -0.107820 | -0.12570 | -0.09330 |
| 20 | -0.143760 | -0.16760 | -0.12440 |

Table 37. Marginal rate of substitution between expected schedule delay early and expected mean travel time for the whole sample, and the higher and lower income groups.

| Whole sample, Model M 6 | | | | |
|---|---|---|---|---|
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected mean travel time | 0.188 | 0.376 | 0.565 | 0.753 |
| 10 | 0.240 | 0.480 | 0.719 | 0.959 |
| 30 | 0.330 | 0.661 | 0.991 | 1.322 |
| 50 | 0.531 | 1.062 | 1.594 | 2.125 |
| 70 | | | | |

| Higher Income: $50,000 or more per year, Model M 11 | | | | |
|---|---|---|---|---|
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected mean travel time | 0.143 | 0.287 | 0.431 | 0.575 |
| 10 | 0.191 | 0.383 | 0.574 | 0.765 |
| 30 | 0.286 | 0.572 | 0.858 | 1.144 |
| 50 | 0.567 | 1.133 | 1.700 | 2.267 |
| 70 | | | | |

| Lower income: less than $ 50,000 per year, Model M 11 | | | | |
|---|---|---|---|---|
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected mean travel time | 0.240 | 0.480 | 0.720 | 0.960 |
| 10 | 0.297 | 0.595 | 0.892 | 1.190 |
| 30 | 0.391 | 0.781 | 1.172 | 1.563 |
| 50 | 0.570 | 1.139 | 1.709 | 2.278 |
| 70 | | | | |

Valuation of expected schedule delay late differs more between the groups. For the whole sample the utility from an incremental minute of expected schedule delay late is -1.709, while the number for higher income group is -0.831 and for lower income group -2.253. Table 38 presents the marginal rates of substitution between an additional minute of expected schedule delay late and an additional minute of expected mean travel time. The numbers can be interpreted to answer a question: how many additional minutes of expected mean travel time would the person incur in order to save one minute of expected schedule delay late?

Table 38. Marginal rate of substitution between expected schedule delay late and expected mean travel time: Models M6 and M 11

| | Marginal rate of substitution between expected schedule delay late and expected mean travel time | | |
|---|---|---|---|
| Mean travel time | Whole sample Model M 6 | Higher income group, Model M 11 | Lower income group, Model M 11 |
| 7 | .8674 | .3051 | 1.7020 |
| 10 | .8951 | .3143 | 1.7512 |
| 15 | .9642 | .3314 | 1.8379 |
| 20 | 1.0203 | .3512 | 1.9355 |
| 25 | 1.0838 | .3742 | 2.0424 |
| 30 | 1.1555 | .4014 | 2.1642 |
| 35 | 1.2386 | .4339 | 2.2992 |
| 40 | 1.3351 | .4731 | 2.4552 |
| 45 | 1.4485 | .5215 | 2.6403 |
| 50 | 1.5822 | .5821 | 2.8381 |
| 55 | 1.7455 | .6603 | 3.0765 |
| 60 | 1.9472 | .7654 | 3.3640 |
| 65 | 2.2024 | .9119 | 3.7052 |
| 70 | 2.5320 | 1.1324 | 4.1314 |

For the whole sample, the rate varies between .867 and 2.53. An average commuter would accept about 1.15 minutes of additional expected travel time to offset one minute of expected schedule delay late. This rate is rather small, but expected, when we bear in mind that the range of expected schedule delay late is from 0 to 4 minutes.

Income group clearly differentiates behavior with respect to desirability of late arrivals. The respondents in higher income group are not worried about arriving late: they generally would increase less than a minute of expected travel time to reduce one minute of expected schedule delay late. The respondents in the lower income group are willing to increase their expected travel time by 1.7 to 4.1 minutes to reduce one minute of expected schedule delay late. An average commuter in lower income group would accept about 2 minutes of additional expected travel time to reduce one minute of expected schedule delay late.

### 11.2.2 Models incorporating wage-earner status, education, and occupation

Wage-earner status (Table 39, M 12) affects value of early arrival: wage-earners mind less than the other respondents arriving earlier than intended. In all other respects the wage-earners have similar travel time values as salaried, commission pay, and self employed people. Hypothesis 2 assumed that wage-earner status would make people more averse to late arrival. It may be that because the data allows only few minutes of schedule delay late, the aversion to arriving late is shifted to more acceptable early arrival.

Table 39. Models M 12 and M 13: The effect of wage-earner status and a four year college degree on the commuting preferences

| | M 12: Wage-earner | | M 13: Four year college degree | |
|---|---|---|---|---|
| | Coef. | t-stat. | Coef. | t-stat. |
| Mean travel time | -2.107 | -9.029 | -2.025 | -6.583 |
| Mean travel time$^2$ | .0871 | 3.704 | .101 | 3.341 |
| Schedule delay early$^2$ | -.0423 | -8.633 | -.0207 | -3.635 |
| Schedule delay late | -1.715 | -4.893 | -.867 | -1.811 |
| Planning uncertainty | -1.932 | -5.356 | -2.259 | -4.672 |
| Modifier effects: | | | | |
| Mean travel time | .155 | 0.337 | -.190 | -0.468 |
| Mean travel time$^2$ | .0443 | 0.976 | -.000342 | -0.008 |
| Schedule delay early$^2$ | .0265 | 3.017 | -.0318 | -3.893 |
| Schedule delay late | .0890 | 0.127 | -1.372 | -2.215 |
| Planning uncertainty | -.401 | -0.562 | .339 | 0.537 |
| L(0) | | -2959.7385 | | -2991.6232 |
| L(M 6) | | -2701.1431 | | -2720.8680 |
| L(θ) | | -2692.7266 | | -2710.2426 |
| LR-test between L(M 6) and L(θ) | Chi2(5) | p=0.0048 | Chi2(5) | p=0.0007 |
| Sample size | | 4270 | | 4316 |

College educated people (M 13) assign increased value on ‘wasted’ time: both the schedule delay early and schedule delay late coefficients are negative and significant. College education does not affect how mean travel time or planning uncertainty are valued.

Occupations were hypothesized to be proxies of personality types and also indicators of particular set of work rules. Based on this hypothesis the commuting preferences were assumed to differ between the occupational groups. Model M 14 estimates the basic model for all six groups separately. It is equivalent to estimating model M 6 on six separate subsamples, but estimating them jointly allows a comparison to model M 6. The model is statistically better than M 6, indicating that the occupational groups do differ in their preferences.

Artistic occupations is the smallest group and that may be why none of the variables is statistically significant. Social occupations has the highest statistically significant coefficient for schedule delay late, confirming the earlier finding that Social occupations had a high proportion of respondents that answered that it is "not acceptable" to arrive 15 minutes late to work.

Investigative and Enterprising occupations are quite similar otherwise, except that people in Investigative occupations derive more disutility from planning uncertainty and Enterprising from schedule delay late.

Realistic occupations derive less disutility from longer mean commuting time than the other commuting groups. This finding supports the status quo: respondents in Realistic occupations also have the longest average commute. Respondents in Realistic occupations also do not derive disutility from schedule delay early. This may lead to less efficient time use, because their employers typically do not want them at the work premises before the work start time.

Table 40. Model M 14: Commuting preferences of the six occupational groups.

| | Artistic Coef. | Artistic t-stat. | Social Coef. | Social t-stat. |
|---|---|---|---|---|
| Mean travel time | 1.695 | 1.093 | -2.203 | -4.653 |
| Mean travel time$^2$ | -.392 | -1.741 | .124 | 2.301 |
| Schedule delay early$^2$ | -.0509 | -0.912 | -.0585 | -4.556 |
| Schedule delay late | -3.664 | -1.809 | -2.340 | -2.835 |
| Planning uncertainty | -.929 | -0.503 | -.906 | -1.149 |
| | **Investigative Coef.** | **Investigative t-stat.** | **Enterprising Coef.** | **Enterprising t-stat.** |
| Mean travel time | -2.104 | -4.653 | -2.370 | -6.919 |
| Mean travel time$^2$ | .0875 | 1.985 | .102 | 2.971 |
| Schedule delay early$^2$ | -.0343 | -3.858 | -.0530 | -7.517 |
| Schedule delay late | -1.493 | -2.252 | -2.046 | -3.939 |
| Planning uncertainty | -2.980 | -4.262 | -1.566 | -2.842 |
| | **Realistic Coef.** | **Realistic t-stat.** | **Conventional Coef.** | **Conventional t-stat.** |
| Mean travel time | -1.758 | -3.380 | -2.466 | -4.288 |
| Mean travel time$^2$ | .108 | 2.128 | .143 | 2.341 |
| Schedule delay early$^2$ | -.00638 | -0.753 | -.0123 | -0.864 |
| Schedule delay late | -1.791 | -2.452 | .240 | 0.255 |
| Planning uncertainty | -2.283 | -3.253 | -2.835 | -3.253 |
| L(0) | | -2985.3849 | | |
| L(M6) | | -2716.8522 | | |
| L(θ) | | -2684.3407 | | |
| LR-test between L(M6) and L(θ) | Chi2(25) | p=0.0000 | | |
| Sample size | | 4307 | | |

Respondets in Conventional occupations group derive most disutility from long commutes, and they have the most concave utility function with respect to expected commuting time. Like Realistic group, also Conventional group does not display any statistically significant disutility from schedule delay early. But unlike Social, Investigative, Enterprising, or Realistic, it does not derive disutility from schedule delay late, either.

Interestingly, the occupational groups that displayed the least willingness to pay to circumvent unexpacted traffic delays -- Investigative, Realistic, and Conventional -- are the groups that derive most disutility from planning uncertainty.

Hypothesis 3 stated that Externals would be more risk averse than Internals, while Internals would be more goal oriented. With the hypothesized locus of control order for the occupations (hypotheses 4 and 7), this turns into hypotheses about the relative magnitude of ratios of incremental increases of the uncertain travel time elements. I calculate the marginal rates of substitution, i.e. the ratios of partial derivatives of the utility function for expected mean travel time, expected schedule delay early, expected schedule delay late, and planning uncertainty.

The ratio of planning uncertainty to travel time was hypothesized to be larger for Externals than for Internals, while the ratio of scheduling variables to mean travel time was hypothesized to be smaller for Externals.

These ratios can not be calculated as plain ratios of coefficients because the expected mean travel time and expected schedule delay early are non-linear. Also the planning uncertainty contains the expected mean travel time. However, since assuming that the standard deviation equals zero did not change the marginal utilities of travel time considerably, I will treat planning uncertainty as an independent variable in the analysis. To account for the eralier change in units of the independent variables, I multiply the coefficients of mean travel time, squarred schedule delay early, and schedule delay late by 0.1, and the coefficient for the quadratic term of mean travel time by 0.01. Planning uncertainty was not modified, so it does not need rescaling. Since the partial derivatives include variable values, I decided to evaluate the ratios at the average value of the variables. The largest group of mean travel times was between 20 and 30 minutes, so the mean travel time is evaluated at 25 minutes. Likewise, the expected squared schedule delay early was centered around 40, so SDE is evaluated at 6.3 minutes. The ratios of incremental increases of planning uncertainty, schedule delay early, and schedule delay late evaluated at the mean of variable values are presented in Table 41. The inequalities predicted by hypothesis 3 are presented in Table 42 with the findings.

Table 41. The ratios of marginal utilities of planning uncertainty, schedule delay early, and schedule delay late to marginal utilities of mean travel time for the six occupational groups: Model M 14 evaluated at travel time = 25 minutes, schedule delay early = 6.3 min.

| | Planning uncertainty/ Mean travel time | Schedule delay early/ Mean travel time | Schedule delay late/ Mean travel time |
|---|---|---|---|
| Artistic | 35.06 | 1.210 | 13.83 |
| Social | 5.72 | 0.233 | 1.48 |
| Investigative | 17.88 | 0.130 | 0.90 |
| Enterprising | 8.42 | 0.180 | 1.10 |
| Realistic | 18.74 | 0.033 | 1.47 |
| Conventional | 16.19 | 0.044 | -0.14 |

Table 42. The hypothesized and estimated ratios of marginal utilities of planning uncertainty, schedule delay early, and schedule delay late to marginal utilities of travel time for occupational groups, evaluated at travel time = 25 minutes, schedule delay early = 6.3 minutes

| Hypotheses 4 & 7 | Planning uncertainty/ Mean travel time | Hypotheses 4 & 7 | Schedule delay early/ Mean travel time | Schedule delay late/ Mean travel time |
|---|---|---|---|---|
| <u>Within rows:</u> | | <u>Within rows:</u> | | |
| Social < Artistic | no | Social > Artistic | no | no |
| Enterprising < Investigative | yes | Enterprising > Investigative | yes | yes |
| Conventional < Realistic | yes | Conventional > Realistic | yes | no |
| <u>Within columns:</u> | | <u>Within columns:</u> | | |
| Social < Enterprising | yes | Social > Enterprising | yes | yes |
| Enterprising < Conventional | yes | Enterprising > Conventional | yes | yes |
| Social < Conventional | yes | Social > Conventional | yes | yes |
| Artistic < Investigative | no | Artistic > Investigative | yes | yes |
| Investigative < Realistic | yes | Investigative > Realistic | yes | no |
| Artistic < Realistic | no | Artistic > Realistic | yes | yes |

To test the statistical significance of the ratio comparisons I devised a nonlinear test. I followed Greene (1990, pp. 228-230) about non-linear testing procedure that takes a Taylor approximation of the statistic and computes a variance for the approximation. I devised a test statistic that is a difference of the ratios for each pair of occupations. I then calculated an asymptotic variance of the test statistic by multiplying the appropriate partial derivatives and multiplying the product by the corresponding element of a covariance matrix of the coefficients, and summing all the terms. According to Greene, one can test the significance by dividing the estimated value of the test statistic by a square root of the computed asymptotic variance, and using Normal rather than t-distribution.

Unfortunately the approximation does not test ratios well. There are two things that weaken the test: The estimated utility function is linear in parameters, but not in variables. So the partial derivatives involve both estimated parameters and variables, which have to be evaluated at a given point. I evaluate the test at the mean value of the given variables. The second problem is that since the occupation dummies totally separate the observations, there is zero covariance between occupations, and the covariance matrix of coefficients has blocks of zeroes, leading to a "unstable" estimate of the variance. In some pairs the estimate of the asymptotic variance is so biased that it is negative, making it impossible to compute the statistic at all, leading to statistical indeterminacy of the hypotheses. It is still noteworthy that for most of the occupation group pairs the relative magnitudes support hypotheses 4 and 7.

Another way to to evaluate the ratios is to bootstrap the distributions of the estimated coefficients, conditional on the variable values. To do this I used the point estimate and covariance matrix of the estimated coefficients and created a normal distribution for each coefficient. I then drew one observation from the joint distribution, computed for each occupation and estimated coefficient a spread of coefficient values conditional on the variable values, and saved the means of the imputed conditional coefficients. I repeated this procedure 2000 times, which gave me 2000 observations of all the conditional coefficient values. The means of those conditional coefficient values are in table 43. Unfortunately the standard errors of the imputed marginal utilities are large, so very little can be said about the statistical properties of the ratios of marginal utilities. I have marked with one star the ratios that are different from zero at 5% level, and with two stars the ratios that are different at 1% level. One way of of ensuring a clearer test result would be to jointly test the partial ordering. At this time, however, such test is not available.

Table 43. The ratios of incremental increases in planning uncertainty, schedule delay early, and schedule delay late to incremental increases in mean travel time for the six occupational groups, imputed conditional on the variable values.

| | Planning uncertainty/ Mean travel time | Schedule delay early/ Mean travel time | Schedule delay late/ Mean travel time |
|---|---|---|---|
| Artistic | 18.3 | -.2 | 3.5 |
| Social | 4.4* | 1.3 | 1.2* |
| Investigative | 17.8** | 2.2 | 1.1** |
| Enterprising | 6.9** | 3.9 | 1.0** |
| Realistic | 13.8* | 8.2 | 1.2* |
| Conventional | -6.2** | -7.6 | -1.3 |

Although each of the occupational groups have its characteristic values, I attempted to reduce the model to fewer variables. I separated the Artistic group, because they do not seem to have any consistent values as a group. I also separated the Realistic and Conventional groups from the remaining groups, which in the reduced model form the base group. Model M 15 presents the estimation assuming that Investigative, Enterprising, and Social groups can be collapsed together.

The fit of this reduced model is clearly better than the M 6 basic model. Comparing models M 14 and M 15 with a likelihood ratio test shows that there is still enough statistical difference between Social, Investigative, and Enterprising groups to keep them separate. I further analyzed the model by separating the Social group, leaving only Investigative and Enterprising groups to form the base group together. Even this was not supported by the likelihood ratio test: the Chi2(5) test was significant at p=0.0361 level (model not shown).

Table 44. Model M 15: The effect of Artistic, Realistic, and Conventional occupational groups on the commuting preferences.

| | Occupation: Artistic (A) Coef. | t-stat. | Realistic (R) Conventional (C) Coef. | t-stat. |
|---|---|---|---|---|
| Mean travel time | -2.242 | -9.306 | | |
| Mean travel time$^2$ | .0998 | 4.159 | | |
| Schedule delay early$^2$ | -.0480 | -9.568 | | |
| Schedule delay late | -1.903 | -5.226 | | |
| Planning uncertainty | -1.892 | -5.037 | | |
| <u>Modifier effects:</u> | | | | |
| Mean travel time | A: 3.937 | 2.507 | R: .483 | 0.843 |
| | | | C: -.224 | -0.359 |
| Mean travel time$^2$ | A: -.492 | -2.172 | R: .00852 | 0.152 |
| | | | C: .0432 | 0.658 |
| Schedule delay early$^2$ | A: -.00290 | -0.052 | R: .042 | 4.230 |
| | | | C: .0357 | 2.358 |
| Schedule delay late | A:-1.761 | -0.856 | R: .112 | 0.137 |
| | | | C: 2.143 | 2.122 |
| Planning uncertainty | A: .963 | 0.511 | R: -.347 | -0.394 |
| | | | C: -.943 | -0.994 |
| L(0) | -2985.3849 | | | |
| L(M 6) | -2716.8522 | | | |
| L(M 14) | -2684.3407 | | | |
| L(θ) | -2694.6360 | | | |
| LR-test between L(M 6) and L(θ) | Chi2(15) p=0.0001 | | | |
| LR-test between L(θ) and L(M 14) | Chi2(10) p=0.0241 | | | |
| Sample size | 4307 | | | |

### 11.2.3 Models incorporating locus of control based on chosen work descriptions and stress

Model M 17 in table 45 indicates that the measure for external locus of control has an effect on how the expected travel time was valued: it modifies both the slope and concavity of the function. Also the coefficient for planning uncertainty is very small. The internal locus of control did not affect commuting preferences. Only a borderline t-statistic suggests that a prospect of arriving too early might be more onerous for people who are assigned as working in an occupations supporting internal locus of control.

Stressful occupation (M 18) did not add much to the explanatory value. Even though the general fit of the model increases, none of the modified variables is statistically significant. The signs of coefficients suggest that respondents with stressing work do not mind to arrive earlier or later than intended as long as they can accurately predict the arrival time. However, since the coefficients are statistically insignificant, this assumption cannot be assertained.

Table 45. Models M 17 and M 18: The effect of locus of control measures based on work descriptions respondents chose and occupational stress on commuting preferences.

| | M 17: Locus of Control<br>Internal (I)<br>External (E) | | M 18:<br>Occupational stress | |
|---|---|---|---|---|
| | Coef. | t-stat | Coef. | t-stat |
| Mean travel time | -2.663 | -8.006 | -2.216 | -10.267 |
| Mean travel time$^2$ | .144 | 4.328 | .114 | 5.294 |
| Schedule delay early$^2$ | -.0317 | -4.731 | -.0384 | -8.783 |
| Schedule delay late | -1.516 | -3.001 | -1.908 | -5.836 |
| Planning uncertainty | -2.619 | -5.217 | -1.920 | -5.792 |
| <u>Modifyer effects:</u> | | | | |
| Mean travel time | I: .00872 | 0.018 | 0.054 | 0.903 |
| | E: 2.033 | 4.032 | | |
| Mean travel time$^2$ | I: .00355 | 0.075 | -0.0687 | -1.205 |
| | E: -.155 | -3.091 | | |
| Schedule delay early$^2$ | I: -.0121 | -1.271 | 0.0141 | 1.301 |
| | E: .00250 | 0.252 | | |
| Schedule delay late | I: -.536 | -0.771 | 1.254 | 1.481 |
| | E: .222 | 0.278 | | |
| Planning uncertainty | I: .0430 | 0.060 | -1.034 | -1.115 |
| | E: 2.080 | 2.571 | | |
| L(0) | | -3004.0999 | | -3004.0999 |
| L(M6) | | -2732.6991 | | -2732.6991 |
| L(θ) | | -2710.9249 | | -2725.5037 |
| LR-test between L(M6) and L(θ) | Chi2(10) | p=0.0000 | Chi2(5) | p=0.0133 |
| Sample size | | 4334 | | 4334 |

## 11.3 Demand models incorporating combined socio-economic models

After reviewing the different socio-economic factors separately I now combine them in one model. I first group the variables that logically seem to measure similar effects, and then add each group of variables to the model.

The modifiers are added in three groups, in declining order of direct impact. The first combination model incorporates the effects of income, occupational groups and the wage-earner and college education status. All these variables are dealing directly with status or power in the work place. The second group consists of variables indicating commuting distance and presence of young and driving age children. These variables measure the effects of family and lifestyle. The third stage adds the effects of external locus of control and stress. The variables of the last group are normally not available for transportation modelers and therefore entered separately so that their significance to the overall model can be assessed. A correlation table of all the modifier variables is presented in Table 44.

I started the estimation of combined effects by including all the statistically significant occupational effects from model M 14, and previously estimated significant variables of income, wage-earner status, and a four year college degree (model not shown).

Table 46. Correlations of modifier variables of the Stated Preference models.

| | Artistic | Social | Investigative | Enterprising | Realistic | Conventional | Income ($ 1000's) |
|---|---|---|---|---|---|---|---|
| Income ($ 1000's) | -0.0858 | -0.0181 | 0.1177 | 0.2557 | -0.1736 | -0.2658 | 1.0000 |
| Over $ 50,000 income | -0.1003 | -0.0042 | 0.1007 | 0.2030 | -0.1217 | -0.2328 | 0.8136 |
| 4 year college degree | 0.0009 | 0.0662 | 0.1570 | 0.0122 | -0.0983 | -0.1826 | 0.3524 |
| Wage-earner | 0.0295 | 0.0228 | -0.0693 | -0.1884 | 0.1556 | 0.1492 | -0.4014 |
| Commuting distance, miles | -0.0670 | -0.0917 | 0.0337 | 0.0058 | 0.1067 | -0.0309 | 0.1015 |
| 0-15 years old children | 0.1277 | 0.0209 | -0.0145 | -0.0027 | -0.0266 | -0.0432 | 0.0698 |
| 16-21 years old children | 0.0912 | 0.0122 | -0.0130 | 0.0072 | 0.0044 | -0.0656 | 0.1165 |
| Internal locus of control | 0.0537 | 0.0559 | -0.0407 | 0.2065 | -0.1870 | -0.1391 | 0.3350 |
| External locus of control | -0.0165 | -0.1163 | 0.0235 | -0.1929 | 0.2187 | 0.1530 | -0.2604 |
| Stressful work | -0.0457 | -0.0003 | 0.0579 | 0.0768 | -0.0598 | -0.0943 | 0.0548 |

| | Over $ 50,000 income | 4 year college degree | Wage-earner | Commuting distance | 0-15 years old children | 16-21 years old children | Internal locus of control | External locus of control |
|---|---|---|---|---|---|---|---|---|
| 4 year college degree | 0.3077 | 1.0000 | | | | | | |
| Wage-earner | -0.3248 | -0.3191 | 1.0000 | | | | | |
| Commuting distance | 0.1282 | -0.0798 | -0.0269 | 1.0000 | | | | |
| 0-15 years old children | 0.0235 | -0.0678 | -0.0207 | 0.0399 | 1.0000 | | | |
| 16-21 years old children | 0.0642 | -0.0613 | -0.0345 | 0.0505 | 0.8420 | 1.0000 | | |
| Internal locus of control | 0.2405 | 0.3116 | -0.2505 | -0.0144 | 0.0276 | 0.0202 | 1.0000 | |
| External locus of control | -0.2349 | -0.2016 | 0.2488 | 0.0207 | -0.0399 | -0.0359 | -0.4567 | 1.0000 |
| Stressful work | 0.0393 | -0.0548 | -0.0560 | 0.0432 | -0.0171 | -0.0438 | -0.1069 | -0.1066 |

Note: Sample size 4437 reflects the multiple observations per respondent.

Most of the occupational modifiers lost their significance, except for the additional disutility of expected schedule delay early for Social, Enterprising, and Investigative occupations. These effects are expected, since these occupations support a more internal locus of control than Realistic or Conventional occupations. The remaining Artistic occupational group is very small and has shown in the earlier analysis to be rather inconsistent. Social occupation affects the expected mean travel time as well. Since there is no clear theoretical reason for this effect, it is dropped from the model specification as potentially spurious.

The effects of high income remain consistent from model M 11, but the effects of wage-earner status and college education lose their explanatory power.

I tested a reduced model with only those variables modified by occupational dummies that were significant and all variables modified by work variables that were significant from the first group against the model containing variables modified by all occupational variables and work variables. The likelihood ratio test had a p-value of 0.019, indicating that the more parsimonious model is less fitting at 2% risk level. However, the insignificance of many explanatory variables modified by occupational dummies in the larger model makes the more parsimonious model preferred.

Next I added the variables modified by family and lifestyle variables: commuting distance and presence of young and driving age children. Most of the previously introduced variables maintained their original levels. This indicates that the new variables explain other variation than the variables entered before this stage.

Variables modified by presence of children have the same signs and statistically significant effects as in model M 8: younger children decrease the discomfort of an expected early arrival at work, while presence of driving age children increases the disutility from longer expected mean travel time and planning uncertainty, but decrease the disutility from expected schedule delay late. Commuting distance is insignificant. Model CM 2 presents the combined effects of significant work and lifestyle variables. A likelihood ratio test indicates that including the household composition variables substantially improves the model over the previous model not containing those variables, model CM 0. Likelihood ratio test between model CM 2 and a model including these variables and the eliminated wage-earner status, college degree, commuting distance, and Social occupation effect on mean travel time (CM 1) indicates that including these variables increases the fit of the model at risk level 4.51%. Most of this effect comes from the unexplained effect of Social occupation on expected mean travel time, so I prefer the parsimonious model CM 2.

When a transportation demand model has to be built on variables that are reasonably easily available, model CM 2 is the best to use.

On the next page:

Table 47. Model CM 2. The combined effects of occupations, income, and presence of children on the commuting preferences.

| | Occupations: Social (S) Investigative (I) Enterprising (E)<br>Children: 0-15 years old (Y) 16-21 years old (D) | | High income (H) H=1 when personal Income ≥ $ 50,000 | |
|---|---|---|---|---|
| | Coef. | t-stat. | Coef. | t-stat. |
| Mean travel time | -.914 | -3.053 | | |
| Mean travel time$^2$ | .01296 | 0.672 | | |
| Schedule delay early$^2$ | -.0264 | -4.078 | | |
| Schedule delay late | -3.187 | -6.828 | | |
| Planning uncertainty | .203 | 0.446 | | |
| <u>Modifier effects:</u> | | | | |
| Mean travel time | D: -1.383 | -3.112 | H: -1.835 | -4.360 |
| Mean travel time$^2$ | D: .1104 | 2.618 | H: .1302 | 3.320 |
| Schedule delay early$^2$ | S: -.0345 | -3.387 | | |
| | I: -.0193 | -2.216 | | |
| | E: -.0211 | -2.969 | | |
| | Y: .0202 | 2.636 | | |
| Schedule delay late | D: 2.763 | 4.401 | H: 1.476 | 2.554 |
| Planning uncertainty | D: -3.654 | -5.189 | H: -2.498 | -3.819 |
| L(0) | -2793.3831 | | | |
| L(CM 0) | -2530.0718 | | | |
| L(CM 1) | -2512.2549 | | | |
| L(θ) | -2517.9243 | | | |
| LR-test between | | | | |
| L(CM 0) and L(θ) | Chi2(7) p=0.0000 | | | |
| L(CM 1) and L(θ) | Chi2(5) p=0.0451 | | | |
| Sample size | 4030 | | | |

The third group of variables -- measure of external locus of control based on the chosen work descriptions by the respondent and stressful work -- are not as easily available to transportation modelers. I add their effect to the previous model to see if they improve the model significantly. A model containing the additional variables, model MC 3, is presented in Table 48.

As could be expected, the new variables change the values of base group variables, but they also overlap the influence of the other two groups of variables. The coefficients of high income and presence of children inch a little towards zero, and lose a little of their statistical significance, but overall remain statistically significant. The occupational group variables maintain their significance concerning the expected early arrival.

Of the new variables, external locus of control variables maintained their sign, approximate magnitude, and statistical significance from model M 17. The stress variables maintain their sign, and gain both in magnitude and statistical significance from model M 18: stressing work makes it less onerous to expect to arrive early or late to work, but planning uncertainty about arrival time is more onerous for stressed respondents than for the others. The likelihood ratio test indicates that including the psychological variables improves the model.

On this and the next page:

Table 48. Model CM 3: The combined effects of occupations, income, presence of children, external locus of control at work, and stressful work on the commuting preferences.

| | |
|---|---|

| | Statistics for Model CM 3 |
|---|---|
| L(0) | -2875.1745 |
| L(CM 2) | -2580.0306 |
| L(θ) | -2558.9122 |
| LR-test between L(CM 2) and L(θ) | chi2(6) p=0.0000 |
| Sample size | 4148 |

| | Occupations: Social (S), Investigative (I), Enterprising (E); Children: 0-15 years old (Y), 16-21 years old (D); External locus of control (L) | | High income (H); Stressful work(SW) | |
|---|---|---|---|---|
| | Coef. | t-stat. | Coef. | t-stat. |
| Mean travel time | -1.656 | -4.933 | | |
| Mean travel time$^2$ | .0735 | 2.157 | | |
| Schedule delay early$^2$ | -.0282 | -4.258 | | |
| Schedule delay late | -3.531 | -7.398 | | |
| Planning uncertainty | -.302 | -0.612 | | |
| <u>Modifier effects:</u> | | | | |
| Mean travel time | D: -1.376 | -3.105 | H: -1.505 | -3.503 |
| | L: 2.007 | 5.164 | | |
| Mean travel time$^2$ | D: .108 | 2.565 | H: .1075 | 2.702 |
| | L: -.161 | -4.146 | | |
| Schedule delay early$^2$ | S: -.0412 | -3.859 | | |
| | I: -.0227 | -2.524 | | |
| | E: -.0236 | -3.248 | | |
| | Y: .0182 | 2.376 | SW: .0280 | 3.199 |
| Schedule delay late | D: 2.874 | 4.596 | H: 1.404 | 2.439 |
| | | | SW: 1.919 | 2.790 |
| Planning uncertainty | D: -3.532 | -5.101 | H: -1.961 | -2.970 |
| | L: 1.802 | 3.035 | SW: -1.809 | -3.093 |

Since model CM 2 is the recommended one, I will analyze its implications in greater detail. The utility of an additional minute of expected mean travel time is calculated in Table 49. The table shows the estimated effects of lower and higher income groups, and the effect of presence of driving age children in the household. Table 50 presents the disutility from an additional minute of schedule delay early modified by Investigative occupation and a presence of a young child. Tables 51-54 present the marginal rates of substitution between expected schedule delay early and expected mean travel time for a commuters who have varying incomes, occupations, and household compositions. Table 55 presents the marginal rates of substitution between expected schedule delay late and expected mean travel time.

The marginal rates of substitution between expected schedule delay early and expected mean travel time can again be interpreted to answer a question: how many additional minutes of expected mean travel time would the person incur in order to save one minute of expected schedule delay early? The people least willing to lengthen their expected commute have higher income or young children in the household. A typical high income commuter with young children is willing to increase the expected travel time only 1/30 minutes to decrease one minute of expected schedule delay early, when the expected commute is 30 minutes and the expected schedule delay early is 10 minutes. On the other end, having no children and Investigative occupation (and even more Enterprising or Social occupations), increase the willingness to accept a longer expected commute to reduce the expected schedule delay early. A commuter who works in an Investigative occupation, earns less than $ 50,000 per year, and does not have children in the household would accept .54 minutes longer expected commute if the expected schedule delay early diminished one minute, when the expected commute is 30 minutes long and the expected schedule delay early is 10 minutes. The model indicates that the ratio increases with longer expected commute and larger expected schedule delay early. The estimated ratios at the combined upper boundary of the variable ranges are larger than 1, indicating that those commuters would be willing to spend more than a minute to avoid arriving a minute too early. Since most of the commutes in the sample are 20-30 minutes long, the computed ratios are more reliable at the shorter distances.

The estimated marginal substitution rates for expected schedule delay late are based on a short range of data. As it was clear from the schedule delay early estimations, commuters do not value each minute equally. On the early side a couple of minutes before the intended arrival time causes very little disutility, but as the difference grows larger, each minute causes more disutility than the previous one. Correspondingly, the results on the schedule delay late side should be interpreted to refer to the first four minutes the commuter arrives late. Had the range of schedule delay late been larger, the average disutility from each minute might have been greater.

The rate of substitution varies significantly between higher and lower income groups and the presence of driving age children diminishes the harm from expected delay late. Let's compare the values at an ordinary commute, when the expected commute is 30 minutes. Commuters in the lower income group without driving age children are willing to add almost 4 minutes to their expected commute to reduce one minute of expected schedule delay late, while those from the same income group but with driving age children are willing to increase the commute by 1/4 minutes. Commuters from the higher income group who do not have driving age children are willing to increase their commute around one minute to reduce one minute of expected schedule delay late. And finally, the effects of high income and driving age children are so strong in the model that their combined effect turns the ratio negative for the commuters who have both high income and driving age children at home. The short range of expected schedule delay late variable is probably the main reason for this error. The result should be interpreted that the last group would rather arrive late a few minutes than increase their expected mean travel time.

Table 49. The incremental disutility of an additional minute of expected mean travel time

| | Incremental disutility from one additional minute of expected mean travel time: Model CM2 | | | |
|---|---|---|---|---|
| Expected mean travel time | No driving age children | Higher income No driving age children | Lower income and driving age children | Higher income and driving age children |
| 7 | -0.0896 | -0.2549 | -0.2125 | -0.3777 |
| 10 | -0.0888 | -0.2463 | -0.2051 | -0.3625 |
| 15 | -0.0875 | -0.2320 | -0.1927 | -0.3371 |
| 20 | -0.0863 | -0.2176 | -0.1804 | -0.3118 |
| 25 | -0.0850 | -0.2033 | -0.1681 | -0.2864 |
| 30 | -0.0837 | -0.1890 | -0.1557 | -0.2611 |
| 35 | -0.0824 | -0.1747 | -0.1434 | -0.2357 |
| 40 | -0.0811 | -0.1604 | -0.1311 | -0.2104 |
| 45 | -0.0798 | -0.1460 | -0.1187 | -0.1850 |
| 50 | -0.0785 | -0.1317 | -0.1064 | -0.1596 |
| 55 | -0.0772 | -0.1174 | -0.0941 | -0.1343 |

| | | | | |
|---|---|---|---|---|
| 60 | -0.0759 | -0.1031 | -0.0817 | -0.1089 |
| 65 | -0.0746 | -0.0888 | -0.0694 | -0.0836 |
| 70 | -0.0733 | -0.0745 | -0.0571 | -0.0582 |

Table 50. The incremental disutility of an additional minute of expected schedule delay early

| | Incremental disutility from one additional minute of expected schedule delay early. Model CM2 | | | |
|---|---|---|---|---|
| Expected schedule delay early | No young child present | Investigative occupation, and no young child present | Young child present | Investigative occupation, and young child present |
| 1 | -0.0026 | -0.0046 | -0.0006 | -0.0026 |
| 2 | -0.0053 | -0.0091 | -0.0012 | -0.0051 |
| 3 | -0.0079 | -0.0137 | -0.0019 | -0.0077 |
| 4 | -0.0106 | -0.0183 | -0.0025 | -0.0102 |
| 5 | -0.0132 | -0.0229 | -0.0031 | -0.0128 |
| 6 | -0.0158 | -0.0274 | -0.0037 | -0.0153 |
| 7 | -0.0185 | -0.0320 | -0.0043 | -0.0179 |
| 8 | -0.0211 | -0.0366 | -0.0050 | -0.0204 |
| 9 | -0.0238 | -0.0412 | -0.0056 | -0.0230 |
| 10 | -0.0264 | -0.0457 | -0.0062 | -0.0255 |
| 11 | -0.0291 | -0.0503 | -0.0068 | -0.0281 |
| 12 | -0.0317 | -0.0549 | -0.0074 | -0.0306 |
| 13 | -0.0343 | -0.0595 | -0.0081 | -0.0332 |
| 14 | -0.0370 | -0.0640 | -0.0087 | -0.0357 |
| 15 | -0.0396 | -0.0686 | -0.0093 | -0.0383 |
| 16 | -0.0423 | -0.0732 | -0.0099 | -0.0409 |
| 17 | -0.0449 | -0.0778 | -0.0105 | -0.0434 |
| 18 | -0.0475 | -0.0823 | -0.0112 | -0.0460 |
| 19 | -0.0502 | -0.0869 | -0.0118 | -0.0485 |
| 20 | -0.0528 | -0.0915 | -0.0124 | -0.0511 |

Table 51. Marginal rate of substitution between expected schedule delay early and expected mean travel time for a commuter who earns less than $50,000 and whose occupation is not in Social, Investigative or Enterprising group.

| Lower income, no children present | | | | |
|---|---|---|---|---|
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected mean travel time 10 | 0.1486 | 0.2973 | 0.4459 | 0.5945 |
| 30 | 0.1578 | 0.3157 | 0.4735 | 0.6314 |
| 50 | 0.1683 | 0.3365 | 0.5048 | 0.6731 |
| 70 | 0.1802 | 0.3604 | 0.5405 | 0.7207 |

| Lower income, young children present | | | | |
|---|---|---|---|---|
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected mean travel time 10 | 0.0349 | 0.0698 | 0.1047 | 0.1397 |
| 30 | 0.0371 | 0.0742 | 0.1112 | 0.1483 |
| 50 | 0.0395 | 0.0791 | 0.1186 | 0.1581 |
| 70 | 0.0423 | 0.0847 | 0.1270 | 0.1693 |

| Lower income, driving age children present | | | | |
|---|---|---|---|---|
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected mean travel time 10 | 0.0644 | 0.1288 | 0.1932 | 0.2576 |
| 30 | 0.0848 | 0.1696 | 0.2544 | 0.3392 |
| 50 | 0.1241 | 0.2482 | 0.3724 | 0.4965 |
| 70 | 0.2314 | 0.4629 | 0.6943 | 0.9258 |

Table 52. Marginal rate of substitution between expected schedule delay early and expected mean travel time for a commuter who earns $50,000 or more and whose occupation is not in Social, Investigative or Enterprising group.

| Higher income, no children present | | | | |
|---|---|---|---|---|
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected mean travel time | 0.0536 | 0.1072 | 0.1609 | 0.2145 |
| 10 | 0.0699 | 0.1397 | 0.2096 | 0.2795 |
| 30 | 0.1002 | 0.2005 | 0.3007 | 0.4010 |
| 50 | 0.1774 | 0.3547 | 0.5321 | 0.7095 |
| 70 | | | | |
| **Higher income, young children present** | | | | |
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected mean travel time | 0.0126 | 0.0252 | 0.0378 | 0.0504 |
| 10 | 0.0164 | 0.0328 | 0.0492 | 0.0656 |
| 30 | 0.0235 | 0.0471 | 0.0706 | 0.0942 |
| 50 | 0.0417 | 0.0833 | 0.1250 | 0.1667 |
| 70 | | | | |
| **Higher income, driving age children present** | | | | |
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected mean travel time | 0.0644 | 0.1288 | 0.1932 | 0.2576 |
| 10 | 0.0848 | 0.1696 | 0.2544 | 0.3392 |
| 30 | 0.1241 | 0.2482 | 0.3724 | 0.4965 |
| 50 | 0.2314 | 0.4629 | 0.6943 | 0.9258 |
| 70 | | | | |

Table 53. Marginal rate of substitution between expected schedule delay early and expected mean travel time for a commuter who earns less than $50,000 and whose occupation is in Investigative group.

| Lower income, no children present, Investigative occupation | | | | |
|---|---|---|---|---|
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected | | | | |
| mean travel | | | | |
| time | 0.2574 | 0.5148 | 0.7722 | 1.0296 |
| 10 | 0.2734 | 0.5467 | 0.8201 | 1.0934 |
| 30 | 0.2914 | 0.5828 | 0.8743 | 1.1657 |
| 50 | 0.3120 | 0.6241 | 0.9361 | 1.2481 |
| 70 | | | | |

| Lower income, young children present, Investigative occupation | | | | |
|---|---|---|---|---|
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected | | | | |
| mean travel | | | | |
| time | 0.1437 | 0.2874 | 0.4311 | 0.5748 |
| 10 | 0.1526 | 0.3052 | 0.4578 | 0.6104 |
| 30 | 0.1627 | 0.3254 | 0.4880 | 0.6507 |
| 50 | 0.1742 | 0.3484 | 0.5226 | 0.6967 |
| 70 | | | | |

| Lower income, driving age children present, Investigative occupation | | | | |
|---|---|---|---|---|
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected | | | | |
| mean travel | | | | |
| time | 0.1115 | 0.2230 | 0.3346 | 0.4461 |
| 10 | 0.1469 | 0.2937 | 0.4406 | 0.5874 |
| 30 | 0.2150 | 0.4299 | 0.6449 | 0.8598 |
| 50 | 0.4008 | 0.8017 | 1.2025 | 1.6033 |
| 70 | | | | |

Table 54. Marginal rate of substitution between expected schedule delay early and expected mean travel time for a commuter who earns $50,000 or more and whose occupation is in Investigative group.

| Higher income, no children present, Investigative occupation | | | | |
|---|---|---|---|---|
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected mean travel time | 0.0929 | 0.1857 | 0.2786 | 0.3714 |
| 10 | 0.1210 | 0.2420 | 0.3630 | 0.4840 |
| 30 | 0.1736 | 0.3472 | 0.5208 | 0.6944 |
| 50 | 0.3072 | 0.6143 | 0.9215 | 1.2287 |
| 70 | | | | |
| **Higher income, young children present, Investigative occupation** | | | | |
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected mean travel time | 0.0518 | 0.1037 | 0.1555 | 0.2073 |
| 10 | 0.0675 | 0.1351 | 0.2026 | 0.2702 |
| 30 | 0.0969 | 0.1938 | 0.2907 | 0.3876 |
| 50 | 0.1715 | 0.3429 | 0.5144 | 0.6859 |
| 70 | | | | |
| **Higher income, driving age children present, Investigative occupation** | | | | |
| | Expected schedule delay early 5 | 10 | 15 | 20 |
| Expected mean travel time | 0.0631 | 0.1262 | 0.1893 | 0.2523 |
| 10 | 0.0876 | 0.1752 | 0.2628 | 0.3504 |
| 30 | 0.1433 | 0.2865 | 0.4298 | 0.5730 |
| 50 | 0.3928 | 0.7857 | 1.1785 | 1.5713 |
| 70 | | | | |

Table 55. Marginal rate of substitution between an additional minute of expected schedule delay late and expected mean travel time.

| | Marginal rate of substitution between expected schedule delay late and expected mean travel time | | | |
|---|---|---|---|---|
| Mean travel time | Lower income, no driving age children | Lower income, and driving age children | Higher income, no driving age children | Higher income, and driving age children |
| 7 | 3.5566 | 0.1994 | 0.6714 | -0.2786 |
| 10 | 3.5877 | 0.2066 | 0.6949 | -0.2903 |
| 15 | 3.6408 | 0.2199 | 0.7378 | -0.3122 |
| 20 | 3.6955 | 0.2349 | 0.7863 | -0.3376 |
| 25 | 3.7519 | 0.2521 | 0.8417 | -0.3674 |
| 30 | 3.8101 | 0.2721 | 0.9054 | -0.4031 |
| 35 | 3.8700 | 0.2955 | 0.9796 | -0.4465 |
| 40 | 3.9319 | 0.3233 | 1.0671 | -0.5003 |
| 45 | 3.9958 | 0.3569 | 1.1717 | -0.5689 |
| 50 | 4.0618 | 0.3983 | 1.2991 | -0.6592 |
| 55 | 4.1300 | 0.4505 | 1.4575 | -0.7837 |
| 60 | 4.2006 | 0.5185 | 1.6600 | -0.9662 |
| 65 | 4.2736 | 0.6107 | 1.9278 | -1.2593 |
| 70 | 4.3491 | 0.7427 | 2.2985 | -1.8078 |

## 12. CONCLUSIONS

This thesis explores the effects of the type of occupations and other socio-economic variables on preferences concerning unreliable commuting time. Although people have known that such effects exist, most earlier studies have taken this effect as a manifestation of taste differences, and confined themselves to including a dummy variable to represent the different groups.

I study the essence of occupations and I combine theories from different social sciences to build an understanding as to how a concrete and easily collectable variable -- a person's occupation -- can be expected to indicate how that person is going to behave in different commuting situations. The occupations attract and support certain types of people, who thrive in their chosen occupation if they espouse the typical risk strategies beneficial in that occupation. This effect, and the typical incentives applied in an occupation, both work towards differentiating the commuter behavior in different occupational groups.

A psychological construct -- locus of control -- draws a boundary between what an individual believes is influenced by her own actions and what is caused by factors external to her. A person with an internal locus of control is optimistic about her possibilities to influence the outcomes of risky situations, while a person with external locus of control tends to see the cause of events as random or influenced by some powerful others.

Commuters with an external locus of control take less planned risks, reserving more slack time between planned arrival and official work start time. If something unanticipated throws them off the habitual path, they are less likely to go out of their way to maintain the planned arrival time. The commuters with more internal locus of control are more willing to take planned risks and are more committed to see that the risk pays off. The occupational classification developed by Holland can be used to establish a partial order from most external to most internal occupational groups. Using an occupation as an indicator of work rules eliminates the subjective bias from asking commuters to explain the company policy concerning acceptability of late arrivals. I showed the hypothesized difference in behavior with the what-if questions. The Stated Preference data supported the assertion that commuters in different occupational groups have different commuting prefernces, but the estimation was too noisy to support the hypothetized partial ordering of ratios of marginal utilities.

A typical commuter, whose commute is 30 minutes, and whose expected schedule delay early is 10 minutes, is willing to add about 0.5 minutes of expected travel time to decrease a minute of expected schedule delay early, and 1.15 minutes to reduce a minute of expected schedule delay late.

When the effect of occupation, income, and children is taken into account, there is a range of trade-offs. A typical high income commuter who has young children is practically not willing to increase his commute at all to decrease the expected schedule delay early, while a commuter from lower income group and working in an Investigative, Social, or Enterprising occupation is willing to increase his commute 0.6 minutes to decrease one minute of expected schedule delay early.

The ratios for first four minutes of expected schedule delay late and mean travel time vary between 3.8 minutes that a commuter with no children and lower income is willing to trade-off to a virtual zero minutes that a high income commuter with driving age children is willing to sacrifice to avoid one additional minute of expected schedule delay late.

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# APPENDIX A: THE QUESTIONNAIRE