

Kilkki, Kalevi; Hämmäinen, Heikki

## Conference Paper

# Value of Time in the Context of Communications Services

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# Value of Time in the Context of Communications Services

Kalevi Kilkki, Heikki Hämmäinen

Aalto University

Espoo, Finland

## Introduction

There is a long tradition of studies using the concept of the value of time (VoT) to assess human behavior in diverse situations. The underlying assumption in most of the studies is that when different activities are available, a rational person selects the activity that provides the highest value or utility for her. However, two major restrictions affect the selection: time and money. Thus, the selection process needs to take into account the average value created over a period of time and the (possible) money spent during the activity. In practice, this selection process is complicated and arduous to model accurately.

There is an obvious need in many fields to predict how people behave, how they appreciate different situations, and how they allocate their time, which has led to extensive scientific literature. For instance, Jacoby et al. (1976), Concas & Kolpakov (2009), Small (2012), and Jara-Díaz & Rosales-Salas (2017) offer valuable overviews on the history and terminology related to the value of time. Although some interesting VoT papers were published already in the 1940s, the first wide-ranging treatment of the value of time was Gary S. Becker's 'A Theory of the Allocation of Time' published in 1965. Becker's paper is still, by far, the most cited VoT paper. Other important, early VoT papers include Beesley (1965), DeSerpa (1971), and Evans (1972).

The viewpoint in the early VoT papers is mostly economic, the tools are mostly mathematical, and the starting point for VoT modeling is the hourly wage rate. Nevertheless, human life consists mainly of non-economic aspects that are hard to incorporate in the standard economic models. By ignoring many human and social aspects, the economic models often lead to highly variable results (e.g., as to the value of time), depending on the specific situation and the methods used in the studies. For instance, even when the starting point is the hourly wage rate, there are considerable variations in the coefficient that gives the value of time travel time savings proportional to wage rate: in Zamparini & Reggiani (2007, Table 1) the coefficient varies from 0.13 to 3.4. Similarly, the estimated values of leisure time ranged from 2.9 to 26.7 US\$/hour in Jara-Díaz et al. (2008). There is even more variation in the results of the value of life studies (see, e.g., Blomquist, 1979, and Viscusi, 1993).

Consequently, after over 50 years of studies, there is no consensus about the average value of time among the citizens of a society. One reason for this situation, as Jara-Díaz & Rosales-Salas (2018) have noted, is that research in time-related topics has shown little interaction across disciplines. Still, it would be natural to assume that each person has an average value of time that is independent of the context or situation, be it traveling, recreation, housework, paid work, studying, leisure time, or life in general.

As to the value of time, a significant part of the studies have been carried out in the context of transportation, often to justify huge investments by the presumed time savings for car drivers and passengers in public transportation systems. This is still a critical research topic; however, as to the

general use of time, versatile and even addictive mobile devices are used continuously, both in motion and in place, alone and together with others. Thus, it is of utmost importance to understand how and why the devices and mobile services are used and what kind of additional value and cost they offer to users. This situation calls for a general framework for assessing the value of time. For instance, the dominant advertising-based business model in the Internet makes it imperative for all key players to understand and measure how users are spending their precious time.

In this paper, we present a VoT framework that is, in principle, applicable in diverse contexts without changing the terminology and definitions of key concepts. In particular, we argue that it is crucial to define a reference level, called zero-benefit level, that gives a straightforward way to measure the value of time of a person independent of the context. In addition, we present a simple (but preliminary) way to measure the value of time based on a stated-preference method. Finally, we discuss the relationship between our framework and other value of time studies.

## Terminology

*Value of time* consists of two elusive parts, value and time. It would be easy to merely note that time is a physical quantity with clear meaning in everyday life. However, in many social contexts, time is a challenging term, partly due to the differences in the perception of time between people and between cultures. Most of the science is based on the (mostly western) monochronic time in which a person does one thing at a time (Hall, 1989, Chapter 3). An essential aspect of monochronic time is that it can be saved, spent, wasted, killed, etc. – or at least, those words are used with time regardless of the apparent difficulties to do anything specific with time. Monochronic time is also the viewpoint of most of the scientific VoT studies. Nevertheless, many cultures are based on the polychronic time that stresses the continuous interaction between people and the multiplicity of activities going on all the time. Besides, everyday life is rather polychronic than monochronic due to complex social interactions that, nowadays in the wake of mobile devices can be managed almost without interruption.

One of the problems of the conventional way of modeling of the value of time is that social aspects and other complexities of human life are mostly ignored (see, e.g., Adam, 2013, Baumann, 2000, and Thompson, 1967). Although the framework proposed in this paper is based on the monochronic mindset, we still try to keep in mind that people naturally have several simultaneous undertakings. For instance, if you travel with your family, you are not just moving from place A to place B, but you are caring for your relationships, and perhaps even learning something valuable by discussing or reading, etc. All these additional activities can essentially increase (or sometimes, decrease) the value of traveling time.

Value is an intricate term that has been widely discussed already from the time of Karl Marx, who made a focal distinction between *exchange value* and *use value*. This is also an important aspect in an extensive discussion of value; see, e.g., Anderson (1995), Aurum & Wohlin (2007), Orsi (2015), Sánchez-Fernández & Iniesta-Bonillo (2007), and Woodall (2003). In the VoT literature (that is, papers in which *value of time* appears in the body text) terms like *use value* or *exchange value* are rarely used. Brown (1970), Czajkowski et al. (2014), Garcia-Llorente et al. (2016), and Lockwood & Tracy (1995) are rare but valuable examples of papers with more extensive value terminology.

The typical economic approach is to study human life as a series of rational decisions that lead to a (more or less) optimal outcome. The main challenge of this approach is that human life is valuable *per se*, also without any money involved and without any rational optimization. Thus, it would be reasonable to use a purely subjective, non-monetary scale similar to introduced in Horowitz (1978). Nevertheless, because a vast majority of VoT studies relies on economic-based utilitarian models (Sánchez-Fernández & Iniesta-Bonillo, 2007), our framework is founded on economic modeling.

As to the value of time, a patently economic assumption is that the labor market always determines the value of time of a person. In the simplest model, a person's value of time is her net wage rate (that is, the wage rate after taxes). For instance, the value of a saving of ten minutes during traveling is 5 €, if the person's hourly wage rate 30 €. This kind of modeling, though intuitive and practical in the context of economic calculations, is very narrow compared to the intricacies of human life as observed by numerous authors, e.g., Hensher (1995), Hess et al. (2005), and Jara-Diaz et al. (2008).

The rigid relationship between the wage rate and the value of time in economic models also creates an ethical problem because it tends to lead to a severely unequal valuation of people. Certainly, the wage rate (or more generally, a person's income and wealth) affects the behavior of the person when money is involved, and thus, is an integral part of an appropriate behavioral model. But this should not lead to conclusions that the fundamental value of a person is directly tied to the wage rate defined by the labor market. Therefore, to call a parameter tied to wage rate *value of time* is problematic. The most common solution to this ethical dilemma is to use as a basic unit a group of people rather than an individual. Even an approach in which differences in wage rate are hidden behind groups may lead to a conclusion that people with a high wage rate or wealth should be preferred, for instance, when designing traffic rules. Therefore, there seems to be a need to use two scales for the value of time: one for economic purposes in which person's value may depend on her wage rate and another one in which all people are treated equally. However, because of the established practice, we do not propose any new term or scale in addition to the value of time expressed on a monetary scale. We need to keep in mind that the true value of a person is not attached to her wage rate or income.

As money is substitutable, a monetary scale is one-dimensional. However, value is not necessarily one-dimensional. For instance, Pihlström & Brush (2008) distinguish monetary, convenience, emotional, social, conditional, and epistemic values. In reality, the market value differs from use value, immediately experienced value differs from cumulative or instrumental value, and value for an individual differs from the value for society. Any VoT framework that claims to be all-encompassing should be able to handle these kinds of dichotomy.

First of all, the market value of a person is not the same as the value of a person for herself. There are different usages for VoT analysis, but it might be reasonable to call VoT used in economic (behavioral) models the *economic value of time* and to distinguish it from the *intrinsic value of time* that also covers various non-economic aspects. The term *economic value of time* (EVoT) is sometimes used in VoT literature though not regularly, see, e.g., Chen et al. (2015) and DeVoe & Pfeffer (2011). In this paper, we use it as a parameter in all models where people try to find a balance between the use of money and the use of time, or between paid work and leisure. Another option would be to use term *cost of time* as proposed by Concas and Kolpakov (2009) whenever time appears as a negative factor.

We also agree with Daly & Hess (2019) in their argument that the *value of travel time saving* is a confusing term that should be avoided in scientific studies.

The *intrinsic value of time* (IVoT) is a rarely used term. As far as we know, there is no regularly used term for the fundamental value of time for the person that includes all essential aspects of life, not only economic or other measurable aspects. There is no reason to assume that EVoT is equal to IVoT on a monetary scale. It is not even clear whether it is reasonable to measure IVoT on a monetary scale, but if measured, then in most cases IVoT is likely larger than EVoT (because there are so many positive things in life that market cannot measure). One of the main objectives of this paper is to build a framework that includes both EVoT and IVoT in a consistent way.

Moreover, IVoT refers to a hugely complex phenomenon. A part of the value of an activity requiring attention and effort for a period of time, is “consumed” during the activity in the sense that that part of the value is not directly available for any later usage—think, for instance, the excitement when watching a new movie or a soccer game in real time. However, another part of the value arises from the possibility to utilize something achieved during the activity. After traveling to a holiday resort, you are (hopefully) able to enjoy your life in the next days. Or, if you have a harsh physical exercise that does not create immediate enjoyment, you may have a better feeling afterward, and you may even develop your physical condition. You may also create epistemic value by studying a subject that might be useful later, either in your professional or personal life. Finally, you may spend a day at work and be paid a wage that you can use later to improve your experiences. All of these activities, traveling, exercising, studying, and working, may create some immediate discomfort compared to an emotionally neutral situation, but often they also create some instant gratification often in the form of social interaction.

Typically, the value of time is considered from the individual’s viewpoint: an individual selects the activity that produces the highest value per time unit for him. However, there are situations in which this is a too narrow or even incorrect perspective. For the employer, the value of an employee’s time is (purely) instrumental and may differ essentially of the value of the same period for the employee himself (Small, 2012). Furthermore, when a parent cares for children at home, the most essential aspect of the activity is social rather than individual.

The traditional VoT approach is used to rely on the economic (or market) value, on a relative (rather than absolute) scale, and considers only the individual decision-making (Sánchez-Fernández & Iniesta-Bonillo 2007). We aim to extend the framework in a way that includes the intrinsic value of time, defines the zero level of VoT, and naturally embraces both immediate and cumulative effects of an activity.

## Framework

A typical weakness of value of time models is that, because the origin of the value scale is not clearly defined, the value of time seems to hover in the air. Many papers refer to opportunity cost, that is, to the value of the best alternative activity without explaining how the value of the alternative activity is determined. If the value of the best alternative is, in turn, defined by the next best alternative, one ends up with an infinite regression. As a typical example, Hensher (1995) assumes that the opportunity cost is measured by (competitive) market price—while admitting that market prices are

often distorted due to numerous externalities. We solve this problem of origin by defining a reference level, called zero-benefit level. On the zero-benefit level, a person completely wastes his time, not only in the sense of missing the opportunity to do something useful, but the person also knows that other people know he is wasting his time. This situation is similar to what Brown (1970) describes as “For a man not to value time at all would be for him not to value at all any of the ways of passing time that was possible to him; his life would not be worth living.” Thus, a life remaining permanently on the zero-benefit level would be worthless.

This kind of situation creates severe discomfort compared to mostly neutral feelings experienced during everyday life. This neutral point (neither pleasant nor unpleasant) provides another reference level similar to what Kahneman (2000) proposes in his behavioral model. Note, however, that in our framework, zero level means wasted time rather than neutral feeling as in Kahneman’s model. Now when a person selects an activity and spends a period (or an episode to use Kahneman’s terminology), the activity (e.g., working or traveling) creates an experience that can be pleasant or unpleasant.

One of the main sources for unpleasantness (or discomfort) during work or travel is the perceived lack of freedom; in a paid work, someone else defines what you shall do and achieve, and during commuting, you must sit (or stand) more or less still in your place. In addition, you may have limited freedom to select with whom you interact. In our framework, all these negative aspects experienced during an episode are summarized under the term *discomfort*.

In addition to momentary experience, the episode may also generate permanent gains in the form of monetary reward (wage), improved social relationships, moving to another place, improved health, etc. We could also use terms *human capital* (e.g., Becker, 1965; Heckman, 1976) and *social capital* (e.g., Ozanne, 2010; Wang & Mayer-Schonberger, 2010) to describe the positive, permanent effects. In our framework, the permanent gains are summarized under the term *utilitarian value*. Respectively, the episode may generate permanent negative effects in the form of monetary fee, fatigue (say, due to long walking, standing in full train, or drinking alcohol), or broken social relationships. These adverse effects are summarized under the concept of *utilitarian cost*. Disutility is also often used as a generic term that covers both momentary and permanent adverse effects, see valuable discussions about various sources of disutility in Blomquist (1979), Concas & Kolpakov (2009), Festjens & Janiszewski (2015), Jin et al. (2015), Kroes et al. (2014), Moses & Williamson (1963), and Wardman (2004). However, we prefer to separate momentary and permanent aspects under different concepts.

In Figure 1, both the utilitarian value and the utilitarian cost are divided evenly over the whole episode. As a result, we get the following simple equation:

$$\text{the net value of time of an episode} = \text{the value of neutral feeling} - \text{the value of discomfort} + \text{the utilitarian value of the episode} - \text{the utilitarian cost of the episode.}$$

Moreover, we assume that people are rational in the sense that they make a decision between different activities based on this kind of net value of time. The often-used term *opportunity cost* is then the difference between the net VoT of the activity under study and the net VoT of the best alternative activity.

In principle, we have three options to define the (average) value of time of a person: 1) the value of time with neutral feelings, 2) the average net value of time of the person over wake-up time, and 3) the average value of momentary experience of the person over wake-up time. In all options, the reference level is the same, the zero-benefit level. Note also the hedonic value used as the counterpart for the utilitarian value (Sánchez-Fernández & Iniesta-Bonillo, 2007) is included in the value of momentary experience, in particularly, during comfortable events.

All options have their strengths and drawbacks. The second option is problematic because, in it, those utilitarian benefits that are not directly consumed would be counted twice, first when the utilitarian value is created and then when the utilitarian value is used. Think, for instance, a skill that is first learned and then utilized (note that, in contrast, money is first earned and then consumed). Thus, the average net value of time is a useful parameter in the behavior models of rational persons, but it is not a good candidate for the average value of time of a person.

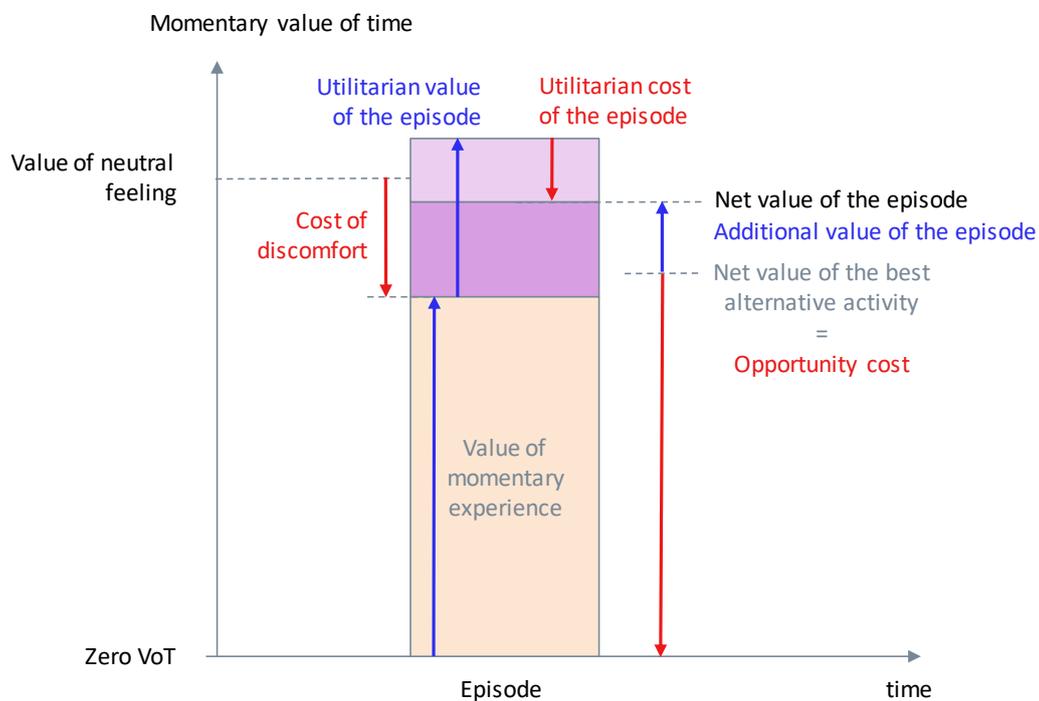


Figure 1. Basic terms of the VoT framework. Note that value is a positive and cost a negative effect on the momentary VoT scale. Both utilitarian value and cost are distributed evenly throughout the episode.

There also is a kind of ethical distinction between the first option (based on neutral feeling) and the third option (based on real feeling). In the third option, the intrinsic value of time of a happy person is higher than the intrinsic value of time of an unhappy person (*ceteris paribus*) while in the first option, they are identical. Because we define the intrinsic value of time as a result of a subjective assessment, it seems reasonable to prefer the third option. It could also be possible to define the value of time and life satisfaction as two different dimensions and keep the value of time largely independent of momentary ups and downs of everyday life. In the current framework, the (intrinsic) value of time of a person is defined as the average value of momentary experience over the zero-benefit level during every life.

We believe that this definition is in line with ordinary people’s idea about the value of their time: the value is something that they would lose if they could not live their everyday life at all. Also, the definition is exact enough to be used in analyzing and modeling human behavior.

## Measuring VoT

So far, we have assumed that all aspects of life can be measured on a monetary scale. We could ask people directly what is their value of time (after explaining the VoT model presented in the previous chapter). Even though that kind of simple question might be useful, we prefer to use a more complicated and more reliable way of estimating VoT. We have used a simple stated preference method (Kroes & Sheldon, 1988). The logic of our approach is as follows. There are two choices, presented in Figure 2, for spending 8 hours: A) to work 8 hours in a hamburger bar with an acceptable wage, and B) to spend  $X$  hours without doing anything meaningful, while spending the rest of the 8 hours on any freely selected activities. The assumption is that the earned money, which is the same in both choices (eight times the acceptable hourly wage rate), will be later used for consuming extra services that can improve the momentary experiences later. The task of the participant is to find an estimate for  $X$  that makes the two options equally attractive, as illustrated in Figure 2.

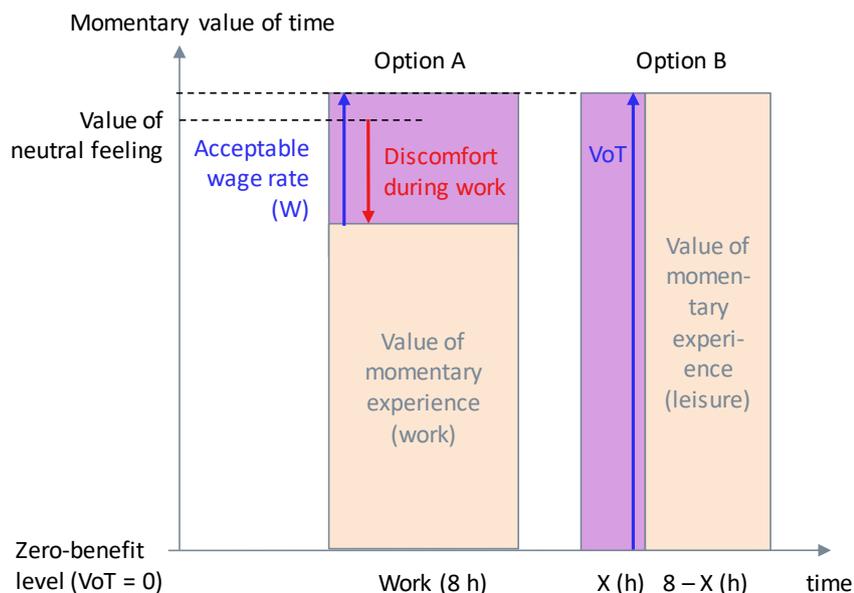


Figure 2. Measuring VoT with stated preference method: parameter  $X$  is selected in a way that Options A and B are equally attractive. Note that in Option B, the presumed payment ( $8W$ ) is divided evenly among the  $X$  hours spent on the zero-benefit level.

We have conducted this study several times at Aalto University from 2010 to 2019. All the participants, 184 in total, were master-level students, mostly from Finland or from Asian countries. The main results of the study are (see also Figures 3 and 4):

1. The median of acceptable wage rate is 12 € per hour. However, due to the step-wise form of the distribution, it is more reasonable to use the median of the fitting function, 11.80 €/h. Note also that the wage rate in real hamburger bars is below €10 per hour.
2. The median of  $X$  among all the participant is 2 hours, whereas the median of the fitting function is 2.26 hours.

Our reasoning when estimating the value of time is based on the assumption that the answers reflect a situation in which the wage rate per hour compensates the discomfort during working (case A in Figure 2) compared to a day spent on ordinary, free activities. Similarly, the net value of time spent on zero-benefit level (X hours) in Option B is zero while the total expected value created during the free time (8 – X hours) should be  $IVoT * (8 - X)$  hours. Thus, options A and B are equally attractive when  $8*W = X*IVoT$ , or  $IVOT = 8W/X$ .



Figure 3. Stated values for parameter X in the order of magnitude (184 respondents).

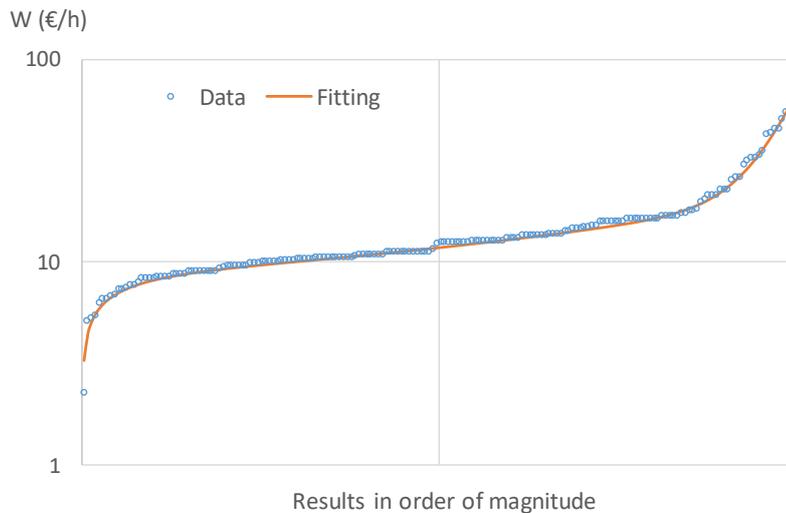


Figure 4. The acceptable hourly wage rate for working in a hamburger bar in the order of magnitude (184 respondents).

Based on the results of the experiment, the median IVoT is 41.69 €/h (when using the fitting function shown in Figures 3 and 4) or 48 €/h when using the median values of the original distributions. These preliminary results indicate that typically the intrinsic value of time for university students in Finland is between 40 and 50 €/h. This VoT is noticeably higher than the wage rate of achievable by a typical student. The value of momentary experience even during working is much higher than the real wage rate.

Similar results were presented by Kumaraguru (2013). One of his questions (p. 70) was “If you could sell an hour in the day, at what price would you sell that hour for? Assume you still have to sleep the same number of hours. Think of that hour you are selling as doing something that has no future benefit that brings you no pleasure apart from financial reward.” Thus, the reference situation in Kumaraguru’s study is essentially the same as the zero-benefit level in our framework. His result is that the median price for the first, second, and third hour are \$30, \$50, and \$80, respectively. This result is consonant with our results, mainly because in our study the acceptable time spend on the zero-benefit level is around 2 hours – €45 in our studies is close enough to \$50 in Kumaraguru’s study.

We may also estimate the value for more extended periods. VoT of 45 €/h would mean 720 €/day (sleeping excluded), 21 600 €/month, and 263 000 €/year. These numbers could be compared to the estimates about the value of life or statistical value of life. In Ashenfelter (2006) value of statistical life is, based on traffic accident statistics, either \$1.6 million or \$6.0 million depending on the analytical method. In Viscusi (1993), the implicit value of life for air travelers varied from \$1 million to \$12.8 million. Our preliminary study indicates that a reasonable value of life might be in the order of 10 million euros. However, we do not claim that the method presented in this paper is an accurate way to estimate the value of life.

## Discussion

Time is valuable, also the time used with smartphones – but do they make our lives more worthwhile? The answer depends on the overall construction of the situation. If we assume a person to be the zero-benefit level, the value of smartphone as the sole way of spending time would be considerable, maybe in the order of 50 €/h. Similarly, if a person is not allowed to use a smartphone (or any other similar device), say, for a week, that would mean a considerable discomfort and mental cost for the person. Another question is how much smartphones have improved our life in reality, if at all? Like any other addiction, smartphones have significant negative externalities, for instance, in the form of traffic accidents, or more generally, due to weakening attention to anything that happens in the physical environment. The problem is that while smartphones and other devices create immediate benefits through delightful experiences, they also create significant cumulative costs that are easy to ignore. This ignorance may lead to a suboptimal behavior in which the frequent checking of the status of various applications running the phones interrupts a critical task requiring constant attention; writing a conference paper is a typical though trifling example, whereas driving could be a fatal example.

A crucial limitation of typical VoT models is that they consider persons as separate units that make individual decisions without any effect on other people; this is far from the truth, for instance, in the case of transportation. This topic requires more studies and even extensions to our simple VoT framework that now includes two basic dichotomies, (positive) value vs. (negative) cost and immediate effect vs. instrumental effect. Particularly in those cases in which the main viewpoint is that of society, it would be necessary to add a third dichotomy: the impact of an activity on the person herself vs. the impact on other people.

It seems likely that the lasting connection with friends through various social applications can improve, or at least intensify our social relationships. However, very close interaction with a group of

similar people may create a bubble that distances us from other people outside the bubble, and may even induce confrontation between different groups of people. This process is hard to describe or measure without system-level analysis. In any case, there is a need to consider the role and meaning of the value of time in complex, interactive systems. For instance, smartphones (and other mobile devices) likely increase the perceived value of time during travels, that is, they are able to diminish the cost of discomfort. That change affects typical traveling behavior in a way that longer travel times will become more acceptable (Lyons & Urry, 2005; Shires & De Jong, 2009; De Almeida Correia et al., 2019). However, even when smartphones and social applications serve the immediate needs and wishes of individual users (in addition to the business of application providers), there is no guarantee that the overall consequences are beneficial for the society. This is an important topic for further research.

There also are some more specific questions that are worthy of analysis. For instance, with given total travel time (and average speed), the average value of momentary experience likely is reduced when there are longer stops on the way (compared to a lower speed when moving but without any stops). Similarly, the most annoying situations with smartphones are when nothing visible happens without any justifiable reason. This effect is exaggerated when the length of the blank period is unknown. In general, waiting creates considerable discomfort, see, e.g., Antonides et al. (2002), Fan et al. (2016), Leclerc et al. (1995), and Seow (2008). An interesting question is whether (the perceived cost of) discomfort due to waiting depends on the context or whether there is a general cost of waiting independent of the context.

Finally, communications services allow us to make observations and create models in a context where both the value of time and the monetary cost have significant effects on human behavior. For instance, mobile services provide an abundant amount of raw data about user preferences related to the usability, price, and usefulness of the services. This kind of data could be highly useful when estimating the value of positive and negative effects of various activities, both momentary and permanent. The results can then be used in diverse contexts.

There is an extensive body of literature on the concept of the value of time in the context of car drivers and public transport passengers, see e.g., Abrantes & Wardman (2011), Börjesson & Eliasson (2014), Jin et al. (2015), Metz (2008), and Small (2012). Many recent papers have also studied the effect of reliability of travel time, see, e.g., Carrion & Levinson (2012), Fosgerau & Karlström (2010), and Brownstone & Small (2005). It could be possible to compare the values obtained in those studies with our results. However, that would be misleading because of some fundamental differences between the models. Thus, we outline here how the typical studies and their results could be interpreted in our framework.

Let us consider a typical research setting in which a person has two choices for traveling to a recreational site. In option A, the journey takes longer ( $t_1$ ), but the road is free of charge. In option B, the route is quicker ( $t_2 < t_1$ ), but the person needs to pay a toll (C). These two options are illustrated in Figure 5. The total values in those options are as follows:

$$V_A = (V_N - D_1)t_1 + U$$

$$V_B = (V_N - D_2)t_2 + U - C + (V_N + B_3)(t_1 - t_2)$$

where  $D_1$  is the average discomfort during traveling in option A,  $D_2$  is the average discomfort during traveling in option B,  $V_N$  is the momentary value of time with neutral feeling,  $U$  is the utilitarian value of reaching the destination site, and  $B_3$  is the value of momentary comfort at the destination compared to neutral feeling. Note also that the utilitarian value per time unit is higher in option B ( $U_2' = U/t_2$ ) than in option A ( $U_1' = U/t_1$ ), because the traveling time is shorter.

Now options A and B are equally valuable when  $V_A = V_B$ . Then  $-D_1t_1 = -D_2t_2 - C + B_3(t_1 - t_2)$ . If we also assume that the two road choices are equally unpleasant or  $D_1 = D_2 = D$ , then we get

$$D + B_3 = C/(t_1 - t_2)$$

This is what often is meant by value of time in a context where (travel) time could be ‘saved’ by paying more: the value of time is the value of discomfort between the two options per time unit ( $Z$  in Figure 5). Thus, when the results of other studies are used in our framework, they usually give information about the values of discomfort or comfort rather than about the value of time as defined in our framework.

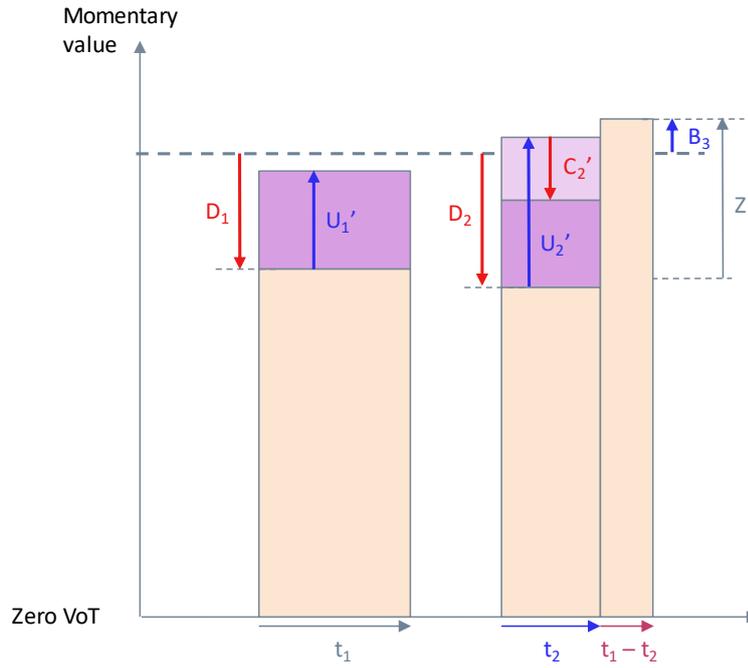


Figure 5. A research setting in which a person can ‘save’ time by paying a toll. The utilitarian value of reaching the destination ( $U$ ) and toll ( $C$ ) are distributed over the travel time ( $t_1$  or  $t_2$ ).

## Conclusion

There is a long and prolific practice of analyzing the value of time, especially in the field of transportation. However, the quality of human experience and the value of human life are complex matters that are hard to condense into one numerical value. As a consequence, the concepts and the models used in the value of time research often narrow in the sense that people are assumed to be rational agents that optimize their economic situation. Alternatively, the models and terminology are built to evaluate a more realistic, but also more specific situation. Obviously, there has been a need for a framework that could be used in any context, and that makes realistic assumptions about human behavior. The objective of our framework is to satisfy that need.

The most critical building block of our framework is the concept of zero-benefit level; when a person is on the zero-benefit level, he wastes his time completely. The value of time is defined as the average perceived value of time compared to the zero-benefit level measured on a monetary scale. According to preliminary studies conducted with students at Aalto University, the value of time of students seems to be as high as €45 per hour, which is substantially higher than the available wage rate for students. In addition to the monetary scale, the framework includes two important dichotomies: value vs. cost and momentary vs. utilitarian. The framework provides a solid basis for analyzing the usage and value of communications services both for the users and for the service providers.

## References

- Abrantes, P. A., & Wardman, M. R. (2011). Meta-analysis of UK values of travel time: An update. *Transportation Research Part A: Policy and Practice*, 45(1), 1-17.
- Adam, B. (2013). *Timewatch: The social analysis of time*. John Wiley & Sons.
- Anderson, E. (1995). *Value in ethics and economics*. Harvard University Press.
- Antonides, G., Verhoef, P. C., & Van Aalst, M. (2002). Consumer perception and evaluation of waiting time: A field experiment. *Journal of Consumer Psychology*, 12(3), 193-202.
- Ashenfelter, O. (2006). Measuring the value of a statistical life: problems and prospects. *The Economic Journal*, 116(510), C10-C23.
- Aurum, A., & Wohlin, C. (2007). A value-based approach in requirements engineering: explaining some of the fundamental concepts. In *International Working Conference on Requirements Engineering*, (pp. 109-115). Springer, Berlin, Heidelberg.
- Bauman, Z. (2000). Time and space reunited. *Time & Society*, 9(2-3), 171-185.
- Becker, G. S. (1965). A theory of the allocation of time. *The Economic Journal*, 75, 493-517.
- Beesley, M. E. (1965). The value of time spent in travelling: some new evidence. *Economica*, 32(126), 174-185.
- Blomquist, G. (1979). Value of life saving: Implications of consumption activity. *Journal of Political Economy*, 87(3), 540-558.
- Börjesson, M. & Eliasson, J. (2014). Experiences from the Swedish Value of Time study. *Transportation Research Part A: Policy and Practice*, 59, 144-158.

- Brown, D. G. (1970). The value of time. *Ethics*, 80(3), 173-184.
- Brownstone, D., & Small, K. A. (2005). Valuing time and reliability: assessing the evidence from road pricing demonstrations. *Transportation Research Part A: Policy and Practice*, 39(4), 279-293.
- Carrion, C., & Levinson, D. (2012). Value of travel time reliability: A review of current evidence. *Transportation research part A: policy and practice*, 46(4), 720-741.
- Concas, S., & Kolpakov, A. (2009). Synthesis of research on value of time and value of reliability. Center for Urban Transportation Research, University of South Florida (No. BD 549-37).
- Chen, C., Xu, H., & Zheng, J. (2015). The relationship between economic value of time and feelings of time pressure. *Social Behavior and Personality*, 43(8), 1395–1408.
- Czajkowski, M., Giergiczy, M., Kronenberg, J., & Tryjanowski, P. (2014). The economic recreational value of a white stork nesting colony: A case of 'stork village' in Poland. *Tourism Management*, 40, 352-360.
- Daly, A., & Hess, S. (2019). VTT or VTTS: A note on terminology for value of travel time work. *Transportation*, 1-6.
- De Almeida Correia, G. H., Loeff, E., van Cranenburgh, S., Snelder, M., & van Arem, B. (2019). On the impact of vehicle automation on the value of travel time while performing work and leisure activities in a car: Theoretical insights and results from a stated preference survey. *Transportation Research Part A: Policy and Practice*, 119, 359-382.
- DeSerpa, A. C. (1971). A theory of the economics of time. *The Economic Journal*, 81(324), 828-846.
- DeVoe, S. E. & Pfeffer, J. (2011). Time is tight: How higher economic value of time increases feelings of time pressure. *Journal of Applied Psychology*, 96(4), 665.
- Evans, A. (1972). On the theory of the valuation and allocation of time. *Scottish J. Polit. Econ.* 19 (1), 1–17.
- Fan, Y., Guthrie, A., & Levinson, D. (2016). Waiting time perceptions at transit stops and stations: Effects of basic amenities, gender, and security. *Transportation Research Part A: Policy and Practice*, 88, 251-264.
- Festjens, A. & Janiszewski, C. (2015). The value of time. *Journal of consumer Research*, 42(2), 178-195.
- Fosgerau, M. & Karlström, A. (2010). The value of reliability. *Transportation Research Part B: Methodological*, 44(1), 38-49.
- García-Llorente, M., Castro, A. J., Quintas-Soriano, C., López, I., Castro, H., Montes, C., & Martín-López, B. (2016). The value of time in biological conservation and supplied ecosystem services: A willingness to give up time exercise. *Journal of Arid Environments*, 124, 13-21.
- Hall, E. T. (1989). *The dance of life: The other dimension of time*. Anchor.

- Heckman, J. J. (1976). Estimates of a human capital production function embedded in a life-cycle model of labor supply, in Household production and consumption, NBER Book Series Studies in Income and Wealth, 225-264.
- Hensher, D. A. (1995). Value of travel time savings in personal and commercial automobile travel. Working Paper ITS-WP-95-4.
- Hess, S., Bierlaire, M., & Polak, J. W. (2005). Estimation of value of travel-time savings using mixed logit models. *Transportation Research Part A: Policy and Practice*, 39(2-3), 221-236.
- Horowitz, A. J. (1978). The subjective value of the time spent in travel. *Transportation Research*, 12(6), 385-393.
- Jacoby, J., Szybillo, G. J., & Berning, C. K. (1976). Time and consumer behavior: An interdisciplinary overview. *Journal of Consumer Research*, 2(4), 320-339.
- Jara-Díaz, S. R., Munizaga, M. A., Greeven, P., Guerra, R., & Axhausen, K. (2008). Estimating the value of leisure from a time allocation model. *Transportation Research Part B: Methodological*, 42(10), 946-957.
- Jara-Díaz, S., & Rosales-Salas, J. (2017). Beyond transport time: A review of time use modeling. *Transportation Research Part A: Policy and Practice*, 97, 209-230.
- Jin, X., Hossan, M. S., & Asgari, H. (2015). Investigating the value of time and value of reliability for managed lanes. Tallahassee, FL: Florida Department of Transportation, 2015.
- Kahneman, D. (2000). Experienced utility and objective happiness: A moment-based approach. In D. Kahneman & A. Tversky (Eds.), *Choices, values, and frames* (pp.673–692). New
- Kroes, E., Kouwenhoven, M., Debrincat, L., & Pauget, N. (2014). Value of crowding on public transport in île-de-France, France. *Transportation Research Record: Journal of the Transportation Research Board*, (2417), 37-45.
- Kroes, E. P., & Sheldon, R. J. (1988). Stated preference methods: An introduction. *Journal of transport economics and policy*, 11-25.
- Kumaraguru, G. R. (2013). How do students value time? MSc Thesis, Stanford University.
- Leclerc, F., Schmitt, B. H., & Dube L. (1995). Waiting time and decision making: Is time like money? *Journal of Consumer Research*, 22, 110-119.
- Lockwood, M., & Tracy, K. (1995). Nonmarket economic valuation of an urban recreation park. *Journal of Leisure Research*, 27(2), 155-167.
- Lyons, G., & Urry, J. (2005). Travel time use in the information age. *Transportation Research Part A: Policy and Practice*, 39(2-3), 257-276.
- Metz, D. (2008). The myth of travel time saving. *Transport reviews*, 28(3), 321-336.
- Moses, L. N., & Williamson Jr, H. F. (1963). Value of time, choice of mode, and the subsidy issue in urban transportation. *Journal of Political Economy*, 71(3), 247-264.
- Orsi, F. (2015). *Value theory*. Bloomsbury Publishing.

- Ozanne, L. K. (2010). Learning to exchange time: Benefits and obstacles to time banking. *International Journal of Community Currency Research*, Vol 14.
- Pihlström, M., & Brush, G. J. (2008). Comparing the perceived value of information and entertainment mobile services. *Psychology & Marketing*, 25(8), 732-755.
- Sánchez-Fernández, R., & Iniesta-Bonillo, M. Á. (2007). The concept of perceived value: a systematic review of the research. *Marketing theory*, 7(4), 427-451.
- Seow, S. C. (2008). *Designing and Engineering Time: The Psychology of Time Perception in Software*. Addison-Wesley Professional.
- Shires, J. D., & De Jong, G. C. (2009). An international meta-analysis of values of travel time savings. *Evaluation and program planning*, 32(4), 315-325.
- Small, K. A. (2012). Valuation of travel time. *Economics of transportation*, 1(1-2), 2-14.
- Thompson, E. P. (1967). Time, work-discipline, and industrial capitalism. *Past & present*, (38), 56-97.
- Viscusi, W. K. (1993). The value of risks to life and health. *Journal of economic literature*, 31(4), 1912-1946.
- Wang, Q. H., & Mayer-Schonberger, V. (2010). The monetary value of virtual goods: An exploratory study in MMORPGs. In System Sciences (HICSS), 2010 43rd Hawaii International Conference on (pp. 1-11).
- Wardman, M. (2004). Public transport values of time. *Transport policy*, 11(4), 363-377.
- Woodall, T. (2003). Conceptualising 'value for the customer': an attributional, structural and dispositional analysis. *Academy of marketing science review*, 12(1), 1-42.
- Zamparini, L., & Reggiani, A. (2007). Meta-analysis and the value of travel time savings: a transatlantic perspective in passenger transport. *Networks and Spatial Economics*, 7(4), 377.