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The Relative Importance of Time and Money for Consumer Behavior and Prosperity

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We develop a consumption model to analyze the relative importance of time and money for consumer behavior and prosperity. The model is characterized by three situations a consumer may face. Equilibrium conditions are different in each of those situations. At equilibrium A only the time constraint is binding. The appropriate situation is called *relative time scarcity*. At equilibrium B, *relative satiation*, the consumer's income constraint is binding at the optimal allocation of time. At equilibrium C, consumers deviate from their optimal allocation of time because of the income constraint. Those consumers face *relative money scarcity*. We analyze behavioral reactions to changes in prices, disposable income and available time in each of those three situations. It turns out that substitution effects only exist in situations of *relative money scarcity* – the only situation dealt with in ordinary (i.e. timeless) consumer theory. The absence of substitution effects in situations of *relative time scarcity* and *relative satiation* leads us to the conclusion, that the impact of changes in relative prices on consumer behavior is much less important than usually assumed. Another interesting result is that increases in disposable income do not necessarily lead to a gain in prosperity. The effects of changes in disposable income and time availability on prosperity depend on the situation a consumer faces.

Keywords: consumer behavior, time use, satiation

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1. Introduction

"Economics is at bottom the study of how humans spend their lifetimes."

Nicholas Georgescu-Roegen (1983, S.LXXXV)

This article follows a research agenda briefly outlined by Richard Zeckhauser (1973) in the Quarterly Journal of Economics. Zeckhauser claims that the only ultimate source of utility is the disposition of time. An individuals prosperity is exclusively described in terms of activity times. Accordingly, Zeckhauser proposed a life time utility function, that contains activity times as arguments. Almost 30 years later, Ian Steedman (2001) published the book *Consumption takes time*. Steedman also proposed a utility function that only contains activity times as arguments.

Zeckhauser's and Steedman's treatment of time contradicts with previous economic writings about time use and consumer behavior. Both complain that Becker (1965) and Linder (1970) treat time as an input.[1] In Becker's and Linder's writings, time is conceived as constraining the consumers ability to realize utility. The question whether time is to be treated as an input or as the ultimate source of utility, like Zeckhauser puts it, depends on the implicit assumption about what people are striving for. In accordance with Zeckhauser and Steedman, Lawrence Abbott (1955) argues that people strive for satisfying experiences rather than products:

> "[w]hat people really desire are not products but satisfying experiences. Experiences are attained through activities. In order that activities may be carried out, physical objects or the services of human beings are usually needed. Here lies the connecting link between man's inner world and the outer world of economic activity. People want products because they want the experience-bringing services which they hope the products will tender. Two levels of wants are thus distinguishable. The more fundamental kind of want–the desire for an experience–will be termed a basic want; its derivative–the desire for a product which actually or supposedly provides the means to that experience–a derived want." (Abbott, 1955, p.39f, quoted in Wadman (2000))

Goods bought and sold in the market are still a necessary part of the analysis of consumer behavior. They enable consumers to create the most favorable allocation of time.

Albert O. Hirschman (1973) raises another important reason for modeling activities. He argues that the notion of activities in Linder's work is insufficient. In accordance with ordinary microeconomics, Linder's analysis is confined to two activities: work and consumption. The dichotomy of unpleasant work and pleasure seeking consumption ignores the plurality of human motivation. Our understanding of human behavior suffers, when motivations like the maintenance of old friendships, striving for respect or prestige

[1] To treat time as an input, i.e. commodification of time, engenders serious cultural implications. This topic has been dealt with by authors like Michael Ende (1973), Erich Fromm (1976) and Goodhew & Loy (2002).

or power, participation in public affairs, the pursuit of achievement or truth or creativity and salvation are ignored or treated as if they were just another branch of pleasure seeking (Hirschman, 1973, p.635). A manifold understanding of activities may contribute substantially to our understanding of behavior.

Zeckhauser's most interesting contribution was the compilation of an activities model (Zeckhauser, 1973). He also discusses some of the most fundamental problems associated with such an approach. The model is very general and does not allow to derive conclusions about behavioral responses to changes in prices, income or other variables. In his seminal contribution, Steedman (2001) provided the first rigor formal analysis of consumer behavior based on an activities model. Besides the usual comparative statics of price and income changes, Steedman scrutinized a large range of further interesting phenomena. One of those are variations in the amounts of goods per unit of activity time.

We also develop an activities model for consumer behavior. The specification of the model is especially oriented towards the analysis of the relative importance of time and money for consumer behavior and prosperity.

Section two describes the model. It focuses on the explication of ideas and assumptions used in the model. Detailed information about all relevant calculations are provided in appendix B. Depending on the scarcity of time and money, section three identifies three situations of relative scarcity. Section four derives changes in goods consumed, depending on changes in price (demand curve), income (Engel curve) and available time (time-availability curve). Section 4 discusses the theoretical results and draws policy conclusion. It especially deals with distributional issues and the effects of increases in income versus available time on prosperity.

2. Consumer Behavior: Concepts and Assumptions

The decision problem in ordinary consumer theory consists in an optimal allocation of a given budget. Consumption is conceived as the challenge to choose the right amounts of goods. The problem vanishes in the land of Cockaigne, where all things are free. Consideration of time unveils an economic problem that reaches beyond ordinary consumer theory. Even if there is unlimited material wealth, consumers would have to decide about their allocation of time. This decision problem is so general, that it even prevails in the hypothetical case of immortal individuals. People would still have to decide how to allocate their time to different activities, within each period. It is exactly this most fundamental and general decision problem Hermann Heinrich Gossen was concerned about in his analysis of human decision making (Georgescu-Roegen, 1985, p.1137). Our illustration of the model starts with the more general economic problem – in the land of Cockaigne – where the budget constraint can be ignored. After that, we move on to analyze the influence of a restricting budget constraint on consumer behavior.

A brief note concerning notation: multiplication of two vectors $x*y$ gives the entrywise product (also known as Hadamard product or Schur product).

Time adaption

Behavior is described in terms of activity times. t_i denotes activity time for activity i. Vector t contains activity times for all activities. The value of any activity is defined in terms of it's *time target*. Time targets are ideal amounts of time, a person wants to spend with any activity.[2] Values are expressed in physical time units, rather than metaphysical units of utility. We therefore call the unit of account *time use value* instead of *utility*.[3] Time targets represent satiation points. With respect to activities and time use, the non satiation assumption of ordinary consumer theory does not make much sense. Spending more time with any activity necessarily requires spending less with others. As time can neither be saved nor overconsumed, the time constraint is an identity. The sum of all activity times must be identical to consumption time T.

$$\sum_{i=1}^{m} t_i \equiv T \tag{1}$$

In situations where realized activity time (t_i) is smaller than the respective time target (a_i), marginal time use value is assumed to be positive. It decreases with an increase in realized activity time (t_i). This assumption is in accordance with Gossen's first law of diminishing marginal returns of activities. The marginal value of time use becomes 0 when the realized activity time equals the time target and satiation occurs. If realized activity time is larger than the time target ($a_i < t_i$; e.g. paid work), marginal time use value is negative and increasing.

$$\begin{array}{lllll} \frac{\partial Tuv_i}{\partial t_i} \geq 0 & \text{and} & \frac{\partial^2 Tuv_i}{\partial t_i^2} \leq 0 & \forall & t_i \leq a_i \\ \frac{\partial Tuv_i}{\partial t_i} < 0 & \text{and} & \frac{\partial^2 Tuv_i}{\partial t_i^2} > 0 & \forall & t_i > a_i \end{array} \tag{2}$$

We term activities with activity time lower than or equal to the respective time target *consumption activities*. The opposite applies to *production activities*.[4] As this paper is on consumer behavior, we only deal with consumption activities.

We assume that consumers try to minimize the relative deviation of activity times (t_i) from the respective time targets (a_i). From this assumption, and in accordance with the previous assumptions about time use values, we derive the following function for marginal time use values ($mTuv$):

$$mTuv_i = \frac{a_i - t_i}{a_i} \tag{3}$$

Increases in overall time use value can only be achieved in case marginal time use values deviate from each other. Due to the time constraint, an increase in activity times of

[2] Steedman's utility function implicitly contains time targets (Steedman, 2001, p.22).

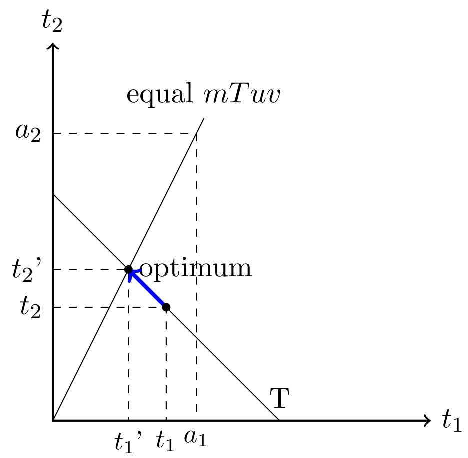
[3] An important feature of time targets is their ability to take differences in values (i.e. preferences) into account. They allow to give up the restrictive assumption of similar preferences and the application of a general utility function. The importance of differences in perception of activities and the resulting ways of living is stressed by Phelps (1973).

[4] This nomenclature is only appropriate when $\sum a_i \geq T$. In case of $\sum a_i < T$ consumers would expand activity times of consumption activities beyond time targets because they are bored.

activities yielding higher than average marginal time use values must be compensated by a reduction in activity times of activities yielding lower than average marginal time use values. Consumers have an incentive to substitute activity time of activities with low marginal time use value for activities with high marginal time use value as long as all activities yield identical marginal time use values.

This kind of behavior can easily be illustrated in activity-space. Suppose there are two possible consumption activities. The first activity deviates only slightly from it's time target ($a_1 = 1; t_1 = 0.8$), the second one much more strongly ($a_2 = 2; t_2 = 0.8$). This implies that the marginal time use value of activity 1 is lower than that of activity 2. The consumer will substitute activity time 1 for activity time 2, until she reaches the point where marginal time use values for both activities are equal (i.e. the optimum t_1'; t_2'). Figure 1 illustrates the behavioral changes. The straight line 'equal $mTuv$' combines all points in the activities space, with the same marginal time use values of all activities. A consumer's optimum lies at the intersection of the time constraint and the equal $mTuv$ line. We call a consumers tendency to reach the optimum, irrespective of the budget constraint, *time adaption*.

Figure 1: Behavior in case of two activities without a restricting budget constraint



Time-cost adaption

We leave the land of Cockaigne now and deal with consumers who are unable to reach their optimal allocation of time due to the budget constraint. The budget constraint in goods-space has it's familiar form.

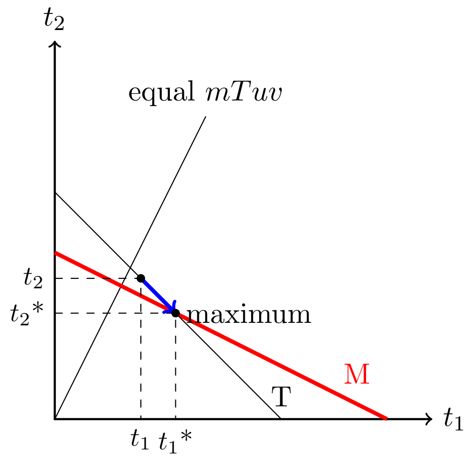
$$\sum_{j=1}^{n} p_j x_j \leq M \tag{4}$$

Amounts of goods x_j times their respective prices p_j have to be equal or less than disposable income M. Activity costs per unit of activity-time are denoted by c_i. The budget constraint in activity-space is:

$$\sum_{i=1}^{m} c_i t_i \leq M \tag{5}$$

The sum of activity times times the respective activity costs must be equal or less than disposable income. The slope of the budget constraint in activity-space depends on relative activity costs per unit of activity time. Suppose that activity costs of activity 2 (c_2) are twice as much as activity costs of activity 1 (c_1). Figure 2 shows an arbitrary initial distribution of activity time ($t_1; t_2$), the consumer can not afford. The consumer has to substitute activity-times to reach a balanced budget. An adaption of activity times to point t_1*,t_2*, at the intersection of the time constraint T with the money constraint M, is necessary. We call this change in activity times *time-cost adaption.* As the consumer moves away from his optimum, overall time use value decreases.

Figure 2: Behavior in case of two activities and a restricting budget constraint



Cognitive requirements for consumer behavior in our model are much lower than in ordinary consumer theory. Consumers do not have to be aware of a complete ordering of the goods-space in terms of indifference curves. In the two activities case, the choice set of a consumer only consists of points at the time constraint. The consumer has not to be aware of the value of all combinations (i.e. points) in activities- or goods-space. Points closer to the intersection of the time constraint line and the equal $mTuv$ line are preferred to points further away. Steedman (2001, p.3) convincingly argues that the consideration of time in consumer theory renders the application of indifference curves in goods-space irrelevant. Because only those combinations of goods are feasible which lie on the time constraint. This is just a very small subset of the whole goods-space.

Quantity and quality adjustment

In the last section we assumed constant activity costs (vector c). Our next step is to dismiss this restrictive assumption. To do so, we have to identify what determines activity costs. The vector of activity costs results from the amounts of goods to perform activities (matrix G) times the prices of the respective input-goods (vector p).

$$c = G * p \tag{6}$$

According to equation 6, potential changes in the amounts of goods or prices cause activity costs to vary. Matrix G results from the technical ability of goods to enable activities. Besides that technical (objective) feature of matrix G, it depends on each consumers way of dealing with goods. Consumers may use goods thrifty or wastefully. Changes in *use intensity* effect the elements of matrix G. A high level of use intensity reduces the required amount of goods (i.e. thrift) and a low level increases it (i.e. wastefulness). We label changes in use intensity *quantity adjustments*.[5]

The elements of matrix G may vary within a given, technically determined, range. Consider for example the activity 'mobile communication'. It requires a net provider and a mobile phone. Some people may change their mobile phone every year – when a new product is launched, others may use it until the end of its durability of e.g. 5 years. As a consequence of differences in use intensity, the required amounts of input-goods and activity costs vary appropriately.

To incorporate quantity adjustments into our model we assume that consumers have a general level of use intensity (i), that applies to all activities – a universal tendency for thrift or wastefulness. Use intensity is defined to be in the range $[-1 \leq i \leq 1]$. To renew a mobile phone after five years would represent the highest use intensity of 1, three years represent a use intensity of 0 and one year would be the lowest use intensity of -1. Matrix G represents a use intensity of 0. We calculate a vector which contains the effects of the level of use intensity on quantities (input-goods) and activity costs (cI). To get those effects we employ a vector of quantity reactions to changes in use intensity (dc), multiply it times the level of use intensity and ad 1.

$$cI = 1 - dc * i, i \in \Re[-1, 1] \tag{7}$$

Consequently, activity costs depend on use intensity.

$$c(i) = cI(i) * (G * p). \tag{8}$$

Besides quantities also prices of goods effect activity costs. Under the assumption of homogenous goods in ordinary consumer theory, products with different prices have to be considered fundamentally different (Lancaster, 1966). We assume that goods which perform a similar task with respect to an activity, can be substituted for each other. Such goods constitute a *group of goods* with variable quality and price. We are used

[5] Also Steedman (2001, p.13ff) analyzes the effects of changes in use intensity. He employs the rather technical term *rates of consumption* instead of use intensity.

to large varieties of products which perform similar tasks. For example, almost all mobile phones allow to perform phone calls, send messages and surf on the internet, i.e. perform a similar task and enable the activity 'mobile communication'. Nevertheless, the differences in prices of mobile phones are substantial.

Variable quality has been an important and heavily debated issue in consumer theory for a long time. Wadman (2000) gives an extensive overview of the literature about variable quality. He makes clear, that any treatment of variable quality hinges on a precise definition of the relations of goods, i.e. a sound definition of groups of goods. Activities seem to provide a solid ground for defining relations of goods based on the task they provide for any activity.

To deal with groups of goods rather than goods themselves implies that the elements of the price vector in equation 6 are not products but groups of goods with variable quality. In his seminal contribution, Houthakker (1952) proposed a model for variable quality, where prices of goods, within each group of goods, are a positive linear function of quality. In accordance with Houthakker we use a linear function to relate quality and price. The cheapest (p_{min}) and most expensive (p_{max}) goods of each group of goods determine the range of prices for each group of goods. Within this range [p_{min}, p_{max}], consumers can adjust quality.[6] We call this process of adjustment, which determines the price vector, *quality adjustments*. Similar to quantity adjustment, we assume that consumers have a general level of quality (q) that applies to all activities. Quality is defined in the range [-1,1]. The price for any group of goods (p_j) is given by:

$$p_j = \frac{p_{j,max} + p_{j,min}}{2} + \frac{p_{j,max} - p_{j,min}}{2} * q, q \in \Re[-1, 1] \tag{9}$$

As goods prices vary with quality, the respective activity costs vary accordingly. Due to quantity and quality adjustments, activity costs become a function of use intensity and product quality. Equation 6 changes to

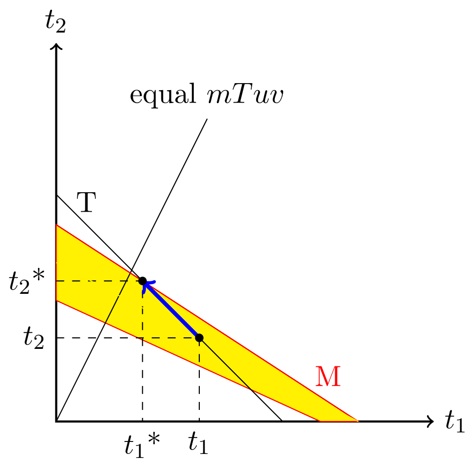
$$c(i, q) = cI(i) * (G * p(q)). \tag{10}$$

In our two-activity case with quality and quantity adjustments, the budget constraint changes from a straight line (constant activity costs) to a plane. The magnitude of the plane is determined by the combined range of potential quality and quantity adjustments. Figure 3 illustrates a case where the range of adjustment of activity 2 is exactly twice as large as the range of adjustment of activity 1. As consumers are interested in activity times, they will adjust quality and use intensity to allow them to approach the optimal allocation of time. Starting with arbitrary activity times t_1 and t_2, the consumer will substitute activity 1 for activity 2 until she reaches t_1* and t_2*. Quality will decrease to its minimum and use intensity increases to its maximum. This drives activity costs to minimum (c_{min}).[7]

[6] A continuous linear function within the range $[p_{min}, p_{max}]$ takes a large amount of different goods as given.

[7] To provide another example of quality and quantity adjustments consider the input-good accommodation. An increase in quality would be a larger and better equipped accommodation. Higher quantity would mean an increase in the number of places of residence.

Figure 3: Quantity and quality adjustment



Activity times, use intensity and quality

Behavior in consumption models usually refers to a single variable, like amounts of goods. We expanded the explanation of behavior to three variables. In our model, consumers have to allocate their available time (1), determine within given boundaries the quality of input-goods (2) and decide, also within given boundaries, how many goods they use for any particular activity (use intensity)(3). Contrary to activity times, quality and use intensity do not effect time use value directly. They influence activity costs and activity expenditure e_i.

$$e_i = t_i * c_i(i, q) \tag{11}$$

Figure 3 illustrates the indirect effect of quality and quantity adjustments on time use value – they enable the most preferred allocation of time subject to the budget constraint.[8] When consumers are indifferent about the way to achieve a reduction (or increase) in activity costs, we can simplify our model. Under the assumption of a common level of quality and use intensity both mechanisms can be reduced to a single variable. Changes in quality and use intensity effect activity costs in opposite directions. Consequently, use intensity i can be substituted for $-q$. The calculation of vector cI becomes

$$cI = dc * q + 1, \tag{12}$$

and equation 11 changes to:

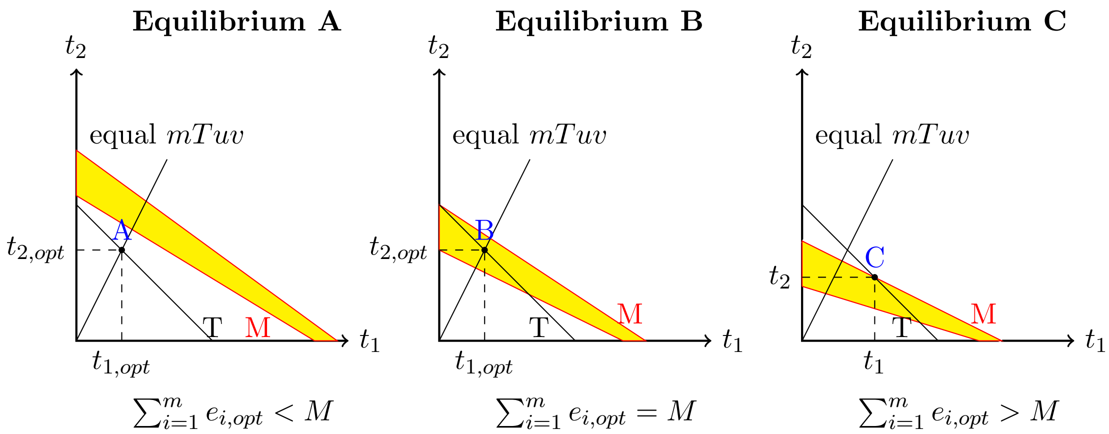
$$e_i = t_i * c_i(q) \tag{13}$$

[8]To deal with aspects like *snob effects* would require to model also the direct effects of the level of quality on time use value.

3. Static results: Situations of relative scarcity

An application of the four *mechanisms of behavior*, described in the last section, originates three different situations consumers may face.[9] Figure 4 illustrates them graphically. Equilibrium conditions are different in each of those situations.

Figure 4: Situations of relative scarcity



At equilibrium A the consumer's income M is higher than his expenditure at the optimal activity times ($\sum_{i=1}^{m} e_{i,opt}$). Quality is at the highest and use intensity at the lowest level (activity costs per unit of time are at their maximum c_{max}). The consumer is forced to save the residual amount of money (forced saving because of a lack of time to spend the money). Consumers who have reached or approach equilibrium A face *relative time scarcity.* An increase in individual prosperity (i.e. time use value) would require an increase in available time (T). Changes in income or prices will not affect the consumer's behavior as long as they are low enough not to move the consumer into equilibrium B.

At equilibrium B the consumer is characterized by a balanced budget at the optimal activity times. Consumers who have reached or approach equilibrium B face the situation of *relative satiation*, because both restrictions are binding at the optimal activity times. Changes in income or prices will be compensated by quality and quantity adjustments. As long as the consumer's optimal activity times lie within the budget plane, the consumer is not forced to substitute activity times.

At equilibrium C the consumer can not afford the optimal activity times ($\sum_{i=1}^{m} e_{i,opt} > M$). Quality is at the lowest and use intensity at the highest level – forcing activity costs to be at their minimum (c_{min}). Consumers who have reached or approach equilibrium C face *relative money scarcity.* Changes in income or prices cause adoptions of activity times and affect the consumer's prosperity. Ordinary consumer theory is restricted to

[9] Already time adaption and time-cost adaption alone would be sufficient to derive them.

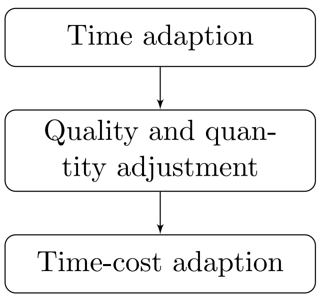
this equilibrium, where the 'non-satiation of goods' assumption holds.

4. Changes in prices, income and available time: behavioral responses and the demand for goods

The four *mechanisms of behavior*, described in section 2, are not equally relevant for all consumers. Their relevance depends on each consumer's *situation of relative scarcity*. Consider a consumer who is before and after any change in his conditions (i.e. prices, income or available time) in a situation of relative time scarcity. Time adaption is sufficient to analyze the consumers behavioral responses. To analyze a consumers behavioral responses, who is before and after any change in his conditions in a situation of relative satiation, requires time adaption as well as quality and quantity adjustment. Suppose a consumer is before and after any change in his conditions in a situation of relative money scarcity. To analyze her behavioral responses requires the mechanism of time adaption and time-cost adaption. Only time adaption turned out to be a universal mechanism of behavior, which applies to any situation of relative scarcity. When the equilibrium a consumer approaches switches, the necessary mechanisms of behavior change appropriately. A general model of consumer behavior has to be able to analyze behavior in any situation of relative scarcity.

To tackle this challenge, behavior in our model can be described as consisting of three stages. Consumers pass through those three stages, which consist of the mechanisms of behavior. The first stage represents any consumers affection to achieve the most preferred allocation of time (i.e. time adaption). The second stage makes sure that the consumer achieves the highest affordable level of quality and quantity (i.e. quality and quantity adjustment). It only effects behavior in cases of relative satiation. If quality and quantity are at their minimum and the consumer is still running a deficit, the third stage prevents a violation of the budget constraint. Time-cost adaption is the consumer's last chance to save money in case the aspired activity times are too expensive. It effects behavior only in case the consumer faces relative money scarcity. Figure 5 illustrates the hierarchical composition of the model.

Figure 5: Structure of the model



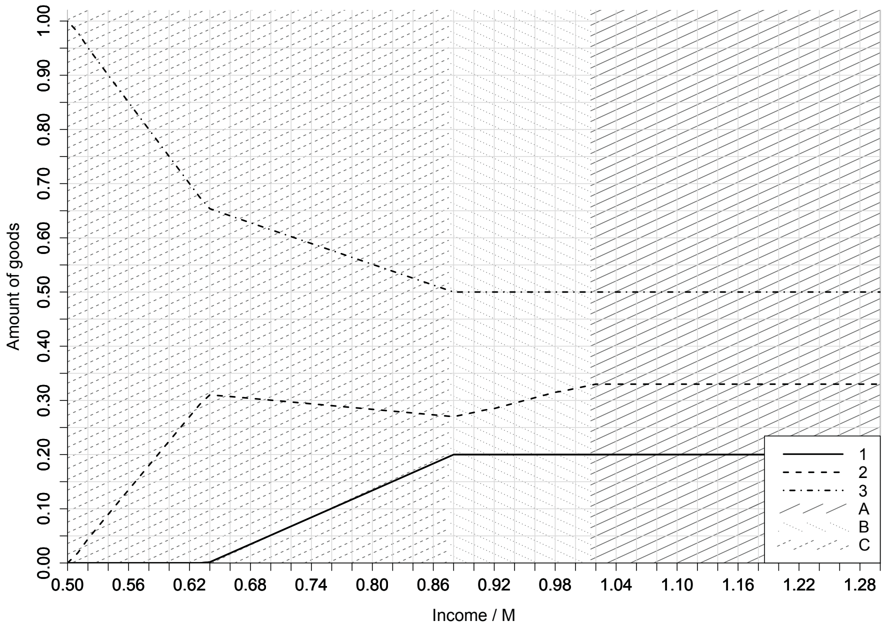
The calculation of model results is explained in more detail in appendix B. Due to the hierarchical composition of the model we employ an algorithmic approach to solve it.

The algorithmic model allows to derive comparative static results. In addition to Engel and demand curves we derive time-availability curves. They depict changes in consumed quantities due to an increase or reduction in available time.

To illustrate results, we have to specify the required parameters. The driving force behind these specifications is to illustrate the most important features of the model in a very tight and comprehensive way. We use a simple set of parameters. The example is restricted to three activities with time targets of $a = (0.2; 0.3; 0.5)$ time units respectively. Consumption time (T) is equal to 1. Activity costs per unit of time are $c = (2; 1; 0.5)$ money units respectively. Quality and quantity of activity 3 can not be adjusted. Activity 2 allows for quantity adjustments (use intensity variations) of 10 percent. And activity 1 allows for quality adjustments of 10 percent ($p_{max} = 2.2$ and $p_{min} = 1.8$ money units).[10] The available money budget is 1 money unit ($M = 1$). Further we assume that the matrix G is an identity matrix, implying that any activity requires only one good. Consequently, changes in activity times can be interpreted as changes in the demand for the respective good.

Figure 6 illustrates the effects of variations in disposable income on demand. For

Figure 6: Engel curves



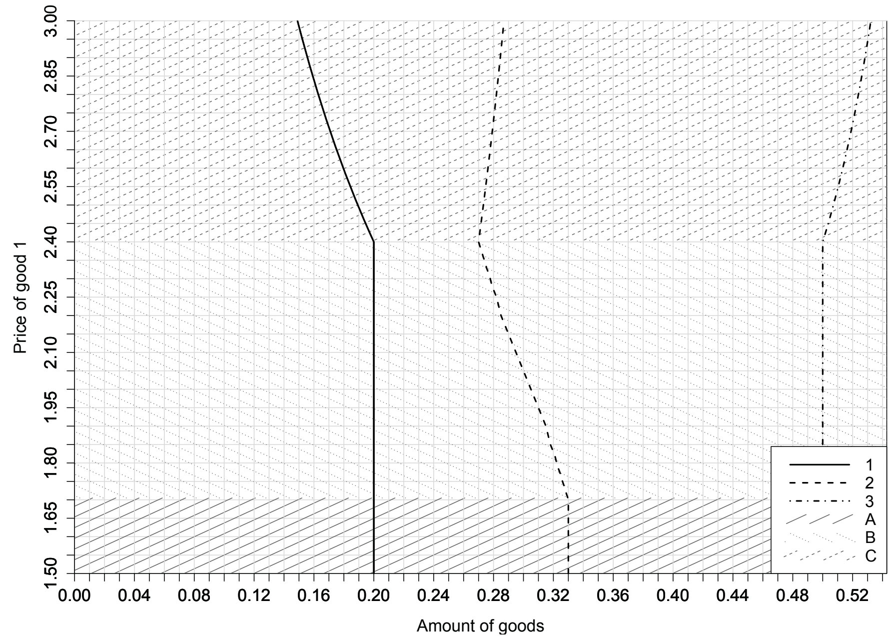
each activity (1,2,3) an Engel curve is derived. In situations of *relative time scarcity* (A) consumers earns more than they spend. Increases or decreases in income do not affect

[10]Usually activities allow for both (large) quality and quantity adjustments. We simply assume this to isolate the resulting effects.

activity times and the amount of goods consumed. Activity times also stay the same in situations of *relative satiation* (B). Changes in available income are compensated by appropriate adjustments of quality, in case of activity 1, and quantity, in case of activity 2. A decrease in income causes use intensity of good 2 to increase and the demand for good 2 to fall. In case of good 1 (quality adjustment), demand stays the same but decreases in income force the consumer to switch to lower-quality (i.e. cheaper) goods. In case the consumer has exhausted all possible quality and quantity adjustments and income is still decreasing, the consumer faces *relative money scarcity* (C). Her only chance to save is to reduce activity time for expensive activities in favor of cheap ones. The consumer reduces activities with costs above average (activity 1) and increases activities with costs below average (activities 2 and 3). The slope of the curves in situations of relative money scarcity depends on the deviation of activity costs from average activity costs. Activity 2 is slightly below average and activity 3 substantially so. At an income level of about 0.64 money units the expensive activity 1 ceases and the new average cost value determines the new substitution relation (slopes of the curves) until disposable income is low enough that only the cheapest activity can be exercised.

Figure 7 illustrates the demand curve for good 1 (input-good for activity 1). We

Figure 7: Demand curve good 1 and demand for good 2 and 3



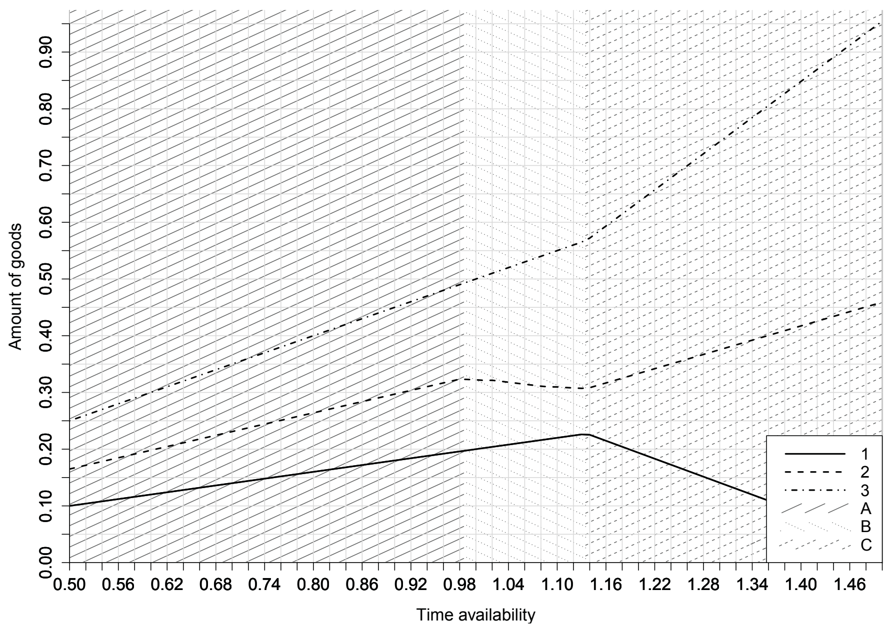
vary the price of good 1 in such a range that the consumer faces all three equilibria. To illustrate the interactions between the three activities we have to plot them together. Demand for activity 1 is vertical in situations of relative time scarcity and relative satiation (A and B). Activity times stay constant at the time targets. Price changes under relative satiation (B) are compensated by quality adjustments of good 1 and quantity adjustments of good 2 (i.e. falling demand).

The situation of relative money scarcity (C) deserves special attention. As activity 1 is an expensive activity, its demand curve is negative. Activity time is reduced. Relatively cheap activities would show increasing demand curves. The slope of a demand curve depends on the relative deviation of activity costs from average costs. Besides an income effect there is also a substitution effect, which results from the relative change in expensiveness (or inexpensiveness) of an activity. When the price of activity 1 goes up, it becomes an even more expensive activity, relative to the other activities, and activity cost per unit of activity time (c_1) increase as well as it's deviation from average activity costs ($\bar{c}$).[11] The substitution effect always works in the same direction. In case of an increasing price it reduces the amount of goods consumed, irrespective of the direction of the income effect.

To sum up, demand curves of relatively cheap activities are positively sloped in situations of relative money scarcity (C) (Giffen goods). in the same situation (C), demand curves of expensive goods are negatively sloped (ordinary goods). In situations or relative time scarcity or relative satiation (A and B) only income effects exist. Activity times stay constant. An activity with quantity adjustments shows a declining demand curve in situations or relative satiation (B). Substitution effects only exist in case of relative money scarcity.

Figure 8 illustrates the demand for goods associated with an increase or decrease

Figure 8: Time availability curves



[11]The relative increase of c_1 to $\bar{c}$ depends on the number of activities (m). Consequently, the substitution effect increases proportionally to the number of alternatives (i.e. activities) ($\Delta\bar{c} = \frac{\Delta p_j}{m}$).

in available time. Time availability might change in case of increased or reduced working hours. Variations in time availability (T) are represented graphically by a shifting time constraint. Due to the fact that the time constraint is always binding, shifts of the time constraint have effects on activity times in all three situations of relative scarcity. We can immediately conclude that with respect to behavioral responses and demand for goods, changes in the time constraint are more general than changes in the budget constraint. So far the available amount of time was one ($T = 1$). We start at an initial amount of time of 0.5 and increase it until 1.5 units of time. In situations of relative time scarcity (A) an increase in the available amount of time increases activity times and amounts of goods consumed, proportionately to the time targets. At a time availability of 0.98, the consumer has to adjust quality and quantity to finance further proportionate increases in activity times. Even though activity times of all three activities increase with the same speed as before, the demand for good 2 decreases slightly. This is due to quantity adjustments (increasing use intensity).[12] Also quality of good 1 decreases. In situations of relative money scarcity (C) further increases in time availability have to be financed by changes in activity times according to activity costs.

We can conclude that in situations of *relative time scarcity*, changes in income or prices do not affect behavior at all. Changes in behavior are triggered exclusively by changes in the available amount of time. In situations of *relative satiation*, changes in prices do not cause substitution effects. Changes in prices have the same effects as changes in income. Only in situations of *relative money scarcity* we find substitution effects. These findings are in consistence with empirical results, showing the importance of changes in income and the minor relevance of substitution effects (e.g. Lavoie, 1994).

5. Discussion

In this paper we followed the idea of Zeckhauser (1973) to describe behavior and prosperity in terms of activity times. This conception of prosperity expands economic theory beyond the narrow focus on goods and services. The reluctance of many economists to consider GDP as an indicator for economic progress and the growing interest in alternative indicators illustrates the need for new approaches. An analysis of prosperity in terms of activity times turned out to be promising.

To deal with activity times also provides a more general understanding of consumer behavior. Our model is characterized by three distinct situations a consumer may face: relative time scarcity, relative satiation and relative money scarcity. Equilibrium conditions in each of those situations are different. Also behavioral responses to changes in prices, income and time availability depend on a consumers situation of relative scarcity. These differences have important implications for economic policy. Measures for an increase in prosperity deviate substantially with respect to the situation of relative scarcity. An increase in disposable income increases prosperity of consumers who face relative money

[12] As activity 3 does not allow for quality or quantity adjustments, increases in activity time 3 have to be financed by quantity adjustments of activity 2 and quality adjustments of activity 1.

scarcity but has no effect on prosperity of consumers who face relative time scarcity. Increases in available time have positive effects for people with relative time scarcity and cause a deterioration in prosperity for people with relative money scarcity. Such consumers have even more time to fill with their already limiting money. To answer for example the question whether increases in labor productivity should lead to increases in income or reduce working hours, it is necessary to know the share of the population in each situation of relative scarcity. In high income economies, where most people face relative time scarcity or relative satiation, a reduction in working hours would be the proper choice. In low income economies, where most people experience relative money scarcity, disposable income should rise. Another solution to the problem would be to design separate policies for each group.[13]

Our model renders policies which affect available time and disposable income to be more effective than changes in relative prices. This is due to the fact that substitution effects only exist in situations of relative money scarcity. The stressing of substitution effects in ordinary microeconomic theory seems to result from the non-satiation assumption. This assumption restricts the analysis to situations of relative money scarcity.

A. List of important variables

Indices
$i = 1...m$ activities
$j = 1...n$ input-goods

Time use
a_i time target for activity i
t_i realized activity time for activity i
Tuv time use value
$mTuv$ marginal time use value

Restrictions
T available consumption time
M available money

Other variables
G goods requirements per unit of activity time (at use intensity 0)
c_i activity costs for activity i per unit of activity time
p_j Price of good j
p_{min} vector of minimal goods prices (depending on goods-quality)
p_{max} vector of maximal goods prices (depending on goods-quality)
i use intensity of input-goods

[13] In his seminal contribution to consumer theory Duesenberry (1949) argued that potential quality adjustments are very large. For him almost all people face the situation of relative satiation and consumer behavior should exclusively be described in terms of quality adjustments.

q quality of input-goods
e_i expenditure for activity i
$e_{i,opt}$ expenditure for activity i at the optimal allocation of time
$\sum_{i=1}^{m} e_i$ total expenditure
cI effect of the level of use intensity on quantities (input-goods) and activity costs
dc vector of quantity reactions (input-goods) to changes in use intensity
v_c vector of deviations of activity costs from average activity costs
dE necessary expenditure reduction (to have a balanced budget)
dE_v effect of changing activity times on expenditure

B. Model

The choice problem:

$$\begin{array}{lrcl} \text{Maximize} & Tuv & = & \sum_{i=1}^{m} t_i - \frac{t_i^2}{2a_i} \\ \text{subject to} & \sum_{i=1}^{m} t_i & \equiv & T \\ & \sum_{i=1}^{m} c_i t_i & \leq & M \\ \text{with} & c & = & cI(q) * G * p(q) \\ & a, t, c & \geq & 0. \end{array}$$

This problem is of an intractable kind. In chapter 2 we argued the necessity to apply a hierarchical approach. The model has to be solved in three steps: time adaption (1) – quality and quantity adjustment (2) – time-cost adaption (3).

Like in the previous chapters, multiplication of two vectors $x * y$ gives the entrywise product.

Time adaption

Time adaption adjusts activity times to maximize time use value. It guides the consumer to his optimal allocation of time, the point at the time constraint where all $mTuv$'s are equal. The vector of optimal activity times (t_{opt}) depends on time targets (vector a) and available time (T).

$$t_{opt} = a * \frac{1}{\sum a} * T \tag{14}$$

Quality and quantity adjustment

Quality and quantity adjustments determine activity costs per unit of activity time (c). We defined quality and use intensity in the range $[-1 \leq q \leq 1]$. Consumers choose the highest affordable q. The determination of q_{max} requires a few calculations.

At the beginning we ignore quantity adjustments. Activity costs depend on the amounts of goods times the respective goods prices (equation 6). At use intensity 0 the vectors for maximum activity costs (c_{p-max}) and minimum activity costs (c_{p-max}) are calculated the following way:

$$c_{p-max} = G * p_{max} \quad (15)$$
$$c_{p-min} = G * p_{min} \quad (16)$$

Substituting the respective elements of the resulting vectors into equation 9 gives activity costs of any activity (c_i) depending on quality (at use intensity 0).

$$c_i = \frac{c_{i,p-max} - c_{i,p-min}}{2} * q + \frac{c_{i,p-max} + c_{i,p-min}}{2} \quad (17)$$

To simplify this equation we define vectors k and d. The respective elements of the vectors for each activity are calculated the following way:

$$k_i = \frac{c_{i,p-max} - c_{i,p-min}}{2} \quad (18)$$
$$d_i = \frac{c_{i,p-max} + c_{i,p-min}}{2} \quad (19)$$
$$(20)$$

The vector for activity costs, depending on quality can now be written as

$$c = k * q + d. \quad (21)$$

To include quantity adjustments we only have to add equation 12 from page 9:

$$cI = dc * q + 1.$$

Activity expenditures after time adaption depend on optimal activity times (vector t_{opt}) and q:

$$e(t_{opt}, q) = t_{opt} * cI(q) * (G * p(q)). \quad (22)$$

Substituting equation 12 and equation 21 into equation 22 gives:

$$e_{opt} = t_{opt} * (dc * q + 1) * (k * q + d). \quad (23)$$

Activity expenditure are a quadratic equation of q.

$$e_{opt} = t_{opt} * dc * k * q^2 + t_{opt} * (dc * d + k) * q + t_{opt} * d \quad (24)$$

To compare total expenditure with disposable income (M) requires to sum up:

$$\sum_{i=1}^{m} e_{i,opt} = \sum_{i=1}^{m} (t_{i,opt} * dc_i * k_i) * q^2 + \sum_{i=1}^{m} (t_{i,opt} * (dc_i * d_i + k_i)) * q + \sum_{i=1}^{m} (t_{i,ipt} * d_i). \quad (25)$$

This equation can be solved for disposable income. In case of an affordable level of q lower -1, the consumer's budget is too low to finance the optimal activity times. An affordable level of quality higher 1 means the consumer can not spend her whole income.

$$q_{max} = \begin{cases} q & q \in [-1, 1] \\ -1 & q < -1 \\ 1 & q > 1 \end{cases} \quad (26)$$

The first case ($q \in [-1, 1]$) corresponds to situations of relative satiation, the second to situations of relative money scarcity and the third to situations of relative time scarcity.

Time-cost adaption

Time-cost adaption affects activity times. It makes sure that the budget constraint is not violated. If necessary, expenditures are brought in line with income by extending the time spent with relatively cheap activities at the expense of expensive activities.

Before applying time-cost adaption, we have to calculate the necessary expenditure reduction (dE). To get dE, total expenditure at minimum activity costs (c_{min}) is subtracted from income (M).

$$dE = M - \sum(t_{opt} * c_{min}) \tag{27}$$

Finding the necessary activity time adaption requires a few calculations. First, we calculate a vector that illustrates the deviation of activity costs per unit of time (c) from average activity costs per unit of time ($\overline{c}$).

$$v_c = c - \overline{c} \tag{28}$$

Vector v_c identifies the relative cost of any activity. It is used to adapt activity times. To get the necessary change in activity times we have to know the effect of changing activity times on expenditure. It is calculated the following way:

$$dE_v = \sum(v_c * c_{min}) \tag{29}$$

The reduction in expenditure due to changes in activity times has to be equal necessary savings (dE).

$$dE = -\beta * dE_v \tag{30}$$

β identifies how strong deviations of activity costs from average activity costs have to be considered to reach the necessary savings. A simple rearrangement of equation 30 illustrates the calculation of β:

$$\beta = -\frac{dE}{dE_v} \tag{31}$$

Adapted activity times (t) are subsequently calculated the following way:

$$t = t_{opt} - v_c * \beta \tag{32}$$

Time-cost adaption can only be applied as long as no activity is reduced to zero activity time. Excluding an activity changes average activity costs $\overline{c}$, the vector v_c and as a consequence the necessary β. To take exclusions (or inclusions) of activities into account we have to extend the mechanism of time-cost adaption.

For any activity, a β can be calculated that reduces the respective activity time to zero ($\beta_{t0,i}$).

$$\beta_{t0,i} = -\tfrac{t_{opt,i}}{v_{c,i}} \tag{33}$$

The smallest positive β identifies the limiting activity: the first one reduced to zero activity time.

$$\beta_{max} \quad = \quad \min\left(\beta_{t0}\right) \quad \forall \quad \beta_{t0} > 0 \tag{34}$$

β or β_{max} are used to change activity times. If β is larger than β_{max}, β_{max} is applied.

$$t = \begin{cases} t_{opt} + v_c * \beta_{max} & \beta > \beta_{max} \\ t_{opt} + v_c * \beta & otherwise \end{cases} \tag{35}$$

In case the change in activity times is limited by β_{max}, the achieved reduction is smaller than required (dE). Further reduction is necessary. This is achieved by reapplying time-cost adaption recursively without the excluded activity, i.e. changed parameters. Equation 36 shows how the remaining necessary reduction (dE_n) is calculated.

$$dE_n \quad = \quad dE + \beta_{max} * dE_v \tag{36}$$

A new vector (v_n), not considering activities with zero activity time, is calculated.

$$\begin{aligned} c_{ni} &= \begin{cases} c_i & t_i > 0 \\ 0 & otherwise \end{cases} \\ v_n &= c_n - \overline{c_n} \end{aligned} \tag{37}$$

This process is repeated until the necessary cost reduction is achieved or only the cheapest activity is left.

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