Happiness –
Cracking the Equilibrium State of People's Well-Being

Martin Schmalz
Universität Stuttgart
BWI
Lehrstuhl für Planung
70174 Stuttgart
Germany

Now at:
Princeton University
Economics Department
Princeton
USA
mschmalz@princeton.edu

Theodor Ackbarow
Universität Stuttgart
BWI
Lehrstuhl für Planung
70174 Stuttgart
Germany
ackbarow@mit.edu

Florian Kapmeier*
Universität Stuttgart
Betriebswirtschaftliches Institut
Lehrstuhl für Planung
70174 Stuttgart
Germany

Now with:
PA Consulting Group
Eschersheimer Landstr. 223
60320 Frankfurt am Main
Germany
florian.kapmeier@paconsulting.com

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* Corresponding author

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Abstract

Understanding the mechanisms producing happiness is crucial not only for individuals and psychological research but also for management science and political economy. It is widely accepted in positive psychology that good and bad events affect happiness. Yet, individuals quickly adapt back to hedonic neutrality. This is known as the hedonic treadmill (Brickman and Campbell, 1971), the Dynamic Equilibrium Theory, or the set point theory (Headey, 2006). In this paper, we develop a System Dynamics model to analyze mechanisms creating happiness. It allows a better understanding of the formerly vaguely proposed connections between 'external' life events and individual well-being by qualitatively estimating a person's happiness over time. We model a hedonic treadmill by assuming that people's expectations and aspiration levels adapt to the actual stock levels of happiness drivers, such as income, health, and social networks. With different scenario runs we support propositions by the Dynamic Equilibrium Theory. In addition, we show that applying a holistic view and doing quantitative analysis enables us to enhance the current Dynamic Equilibrium Theory. We are able to explain lasting changes of the individual equilibrium level of happiness.

Keywords

Psychology, Happiness, Dynamic Equilibrium Theory, Hedonic Treadmill, Czikszentmihályi Flow

1. Introduction

More than 200 years ago, BENTHAM (1789) stated that "the best society is one where the citizens are happiest". In order to increase people's happiness, policy-designers debate unemployment rates or health insurance while implicitly assuming that financial prosperity increases people's happiness. Western societies have well managed to increase their financial wealth over the last 50 years. Yet, during the same period, their people have not necessarily become happier: studies have shown that economic performance indicators such as the GDP do not correlate with average happiness in developed societies (Layard, 2005). It thus can be deduced that policy-designers in politics are modifying system parameters without understanding their effect on people's well-being.

To overcome this knowledge gap scientists from various fields such as economics (Layard. 2005; Frey and Stutzer, 2002), psychology (Argyle, 2001; Kahneman et al., 1999; Csikszentmihályi, 1990), neurology, and sociology increasingly focus their research on happiness. Happiness is also relevant in firms. HR managers and company leaders attempt to increase their employees' quality of life in order to boost motivation and to reduce sick leave. Due to the wide span of interest in happiness, scholars oftentimes only focus on certain building blocks in happiness. This is why they often neglect a feedback-loop point of view. The analysis of happiness dynamics requires simulation of the behavior of interrelating variables from a feedback perspective. We suggest the holistic approach of building a System Dynamics model.

The System Dynamics model presented below entails insight from current psychological research and political economy on happiness. It is based on the Dynamic Equilibrium Theory (Brickman and Campbell, 1971) and promotes the general understanding of the interplay between happiness and external events. From the model runs we understand better how happiness develops, what the happiness drivers are, how they affect happiness, and how happiness affects its drivers.

The paper is structured as follows. We first present the state-of-the-art in happiness research in Chapter 1. We then introduce the underlying theoretical framework, describing the behavior of happiness depending on external effects. We postulate our research propositions in Chapter 2. In the subsequent Chapter 3, we present a System Dynamics model on happiness. We discuss the model boundary and present the feedback loop structure and the model's subsystems. In Chapter 3 we analyze the model's behavior. We revise our research propositions in Chapter 4. We revise our research propositions in Chapter 5. We discuss our results and make links to empirical evidence in psychological research in Chapter 6. After summarizing the paper in Chapter 7, we give an outlook on future research in Chapter 8.

1.1 State-of-the-Art in Happiness Research

Research on positive psychology dealing with happiness has emerged in the early 1970's (Brickman and Campbell, 1971), was further developed by CSIKSZENTMIHÁLYI (1990), and became a popular research topic thereafter (Argyle, 2001; Diener and Lucas, 2000; Kahneman, Diener and Schwarz, 1999, for example). Lately, scholars in the field of economics (e.g.,

Frey and Stutzer, 2002) and political economy (Layard, 2005) became increasingly interested in this topic (see Sirgy et al., 2006, for a detailed overview on current research).

Happiness research focuses on a variety of aspects, including the definition of happiness and related terms, the possible aspects influencing happiness, the dynamics of these effects, and the measurement of happiness, among other things. We briefly lay out these facets in the following.

Definition of Happiness

According to EASTERLIN (2006), the term happiness has manifold meanings and is oftentimes used interchangeably with subjective well-being, life satisfaction, quality of life, and well-being. Up to present, "there has certainly not been any consensus as to what happiness is" (Frey and Stutzer, 2002). Some people define their individual happiness by the kind of feelings they have in certain moments. Other people consider certain life events as their sources of happiness (Dette, 2005). KAHNEMAN (1999) considers the term happiness to be found "at the highest level of [temporal] integration", compared with terms such as subjective well-being or emotional arousal. For the purpose of this paper and following ABDEL-KALEK (2006) we use these terms interchangeably. Moreover, although people may have different perceptions of what happiness means to them, we assume the underlying general structure of happiness to be similar to the average of all people.

Measuring Happiness

Another major research topic is measuring happiness. Happiness can be assessed objectively by measuring brain activity. Yet, individuals evaluate 'happiness drivers' like health, status, social networks is highly subjectively. Objectively large networks of friends, for example, may be evaluated rather modest, and vice versa. Studies have shown that biased reporting of one's health situation is common (Kahnemann, 1999). Also, the authors expect that few people will ever state that they are completely happy with their financial situation.

The subjective and qualitative characteristics of happiness make it difficult to capture happiness in quantitative terms for designing a System Dynamics model. FORRESTER (1961) states though, that "[t]o omit such variables is equivalent to saying they have zero effect – probably the only value that is known to be wrong!" Happiness scholars (Abdel-Kalek, 2006; Kahneman and Krueger, 2006) also attempt to find ways of measuring happiness. In their studies,

the authors denote happiness on a single item scale from 0 to 10. We follow FORRESTER'S suggestion and ABDEL-KALEK'S approach of measuring happiness for conducting our analysis.

Different Aspects Influencing Happiness

LAYARD (2005) argues that happiness is mainly affected by seven groups of happiness drivers, called the big seven. They include family relationships, financial situation, work, community and friends, health, personal freedom, and personal values. Each one of them in turn represents an aggregation of other factors. Family relationships, for example, consist of relation to husband or wife, relation to mother or father, etc.

For designing a simple simulation model we subsume the seven factors under two kinds of happiness drivers. We distinguish between 'things money can buy' and 'things money can't buy'. The first group includes the financial situation of the individual, including economic status and wealth. The second group covers family relationships, work, community and friends, health, personal freedom, and personal values. The difference between the two 'happiness drivers' is that expectations in the drivers adapt faster for 'things money can buy' than for 'things money can't buy' (Layard, 2005). This is because people tend to recognize financial rewards faster than non-monetary incentives. We also assume the general structure of the subsystems governing the two 'happiness drivers' to be identical.

Happiness Drivers and Their Effect on Happiness Dynamics

People seem to struggle all their live to achieve goals and experience external events of which they expect themselves to become happier, such as to win the lottery or to find the partner of their dreams. Expectations seem to play an important role for happiness. According to HEADEY AND WEARING (1991) "all people in all walks of life adjust their expectations and aspirations so that these have a close fit with their current situation". They state that "cognitive judgments of life satisfaction depend heavily on the fit between expectations and aspirations and one's current level of achievement".

Further, people are not able to make absolute but only relative judgments of physical or psychological quantities (Kahneman, 1999). If the reference base of a relative happiness value is subject to change due to an external shock, the relative value shows a behavior similar to the one of a differentiator in control engineering problems. In the latter the only the difference

(change) is of importance (Gray and Meyer, 1982). In other words, the absolute level of a 'happiness driver' is unmeaning to changes in happiness and thus happiness itself. This goes along with a perfect hedonic treadmill described above: only changes affect happiness (Brickman and Campbell, 1971). As changes are, per definition, temporary events, the influence of external events on happiness is only temporary.

Changes of the two 'happiness drivers' 'things money can buy' and 'things money can't buy' constitute for changes of the 'psychic income flow' (Headey and Wearing, 1991). As long as the 'psychic income flow' is constant at any given level, a change in 'happiness' does not occur. In case of *deviations from the normal level*, i.e. when life events occur, *happiness changes*. Flows higher than normal make people happier, lower-than-normal flows make them unhappier.

Another factor influencing happiness is the Csikszentmihályi Flow (see Layard 2005; Kahneman 1999). CSIKSZENTMIHÁLYI (1990) observed that people are happiest in situations in which they are totally immersed. The Csikszentmihályi Flow is a psychological phenomenon that can be compared with euphoria. It can be regarded as an experience in which people are so absorbed in what they are doing that they "lose [them]selves in time" (Layard, 2005). They may be playing tennis, singing in a choir, painting a picture, watching football, writing a book or making love. All people have such experiences where they lose their sense of time.

Effect of Happiness on Happiness Drivers

FREY AND STUTZER (2002) hypothesize a positive relationship between happiness and happiness drivers in *both* directions, considering adaptations of expectations of the 'happiness drivers'. In particular, we excerpt from FREY AND STUTZER (2002) that there is feedback from 'happiness' on the two 'happiness drivers'. It is observed that happy people are more successful in their jobs, for example. Happy people tend to have more (and possibly happier) friends, compared with heavy-hearted fellows. As can be seen in Figure 3, 'happiness' affects 'things money can't buy'. LAYARD (2005) and MARMOT (2006b) state that happiness improves health. Similarly, causal relationships in both directions hold for social networks and family relationships. Happier people, for example, tend to find a job more easily, while job satisfaction is a major source of well-being. Happier people thus tend to find partners more easily, and couples are happier than singles (Layard 2005). Similarly, 'things money can't buy' affect 'happiness' again influencing 'things money can't buy'. The two 'happiness drivers'

affect ‘happiness’ via the subsystem ‘psychic income’. The latter is also influenced by the Csikszentmihályi Flow. FREY AND STUTZER’s statements allow us closing the feedback loops between the building blocks.

1.2 Dynamic Equilibrium Theory Explaining Happiness Dynamics

Happiness dynamics can be explained with the Dynamic Equilibrium Theory, developed in the early 1970s. It has been recently revised. We lay out the theories’ characteristics in the following.

Classic Dynamic Equilibrium Theory

Happiness dynamics can be interpreted as a hedonic treadmill. BRICKMAN AND CAMPBELL (1971) state that a process occurs which is similar to sensory adaptation when people experience emotional reactions to life events. People briefly react to good and bad events, but in a short time they return back to hedonic neutrality. The authors call this phenomenon an automatic habituation process.

One characteristic of automatic habituation processes is their adaptiveness. They allow a constant stimulus, represented by a ‘psychic income flow’, to fade into the background. Thus, mental resources remain available to deal with novel stimuli, which most likely require immediate attention. For example, take the feeling of your shirt on your skin. You are not likely to feel it all over the day although the stimulus persists to be there. New stimuli continuously capture one’s attention. One possible consequence is that one strives to obtain stimuli affecting happiness without realizing that in the long run such efforts are futile and happiness is mostly determined not by external, but internal factors, i.e. a person’s personality.

BRICKMAN ET AL. (1978) offered empirical evidence for the adaptation theory, when he showed that lottery winners were not happier than non-winners over a longer period of time. They also found out that people with paraplegia were not substantially less happy than people who can walk (Brickman et al., 1978). However, little is known about how the adaptation mechanism works.

Revised Dynamic Equilibrium Theory

DIENER ET AL. (2006) empirically identified the dynamics of life satisfaction in response to external events, here exemplarily depicted with sudden unemployment or a marriage (see Figure 1). The figure shows the development of life satisfaction over time on a scale from 0-10. Initial life satisfaction is slightly more than 7. At time zero, an external event occurs and the individual loses her job. In the case of unemployment (marriage) life satisfaction drops (increases) to less than 6.5 (more than 7.5) and then smoothly recovers (falls back). The final level of life satisfaction is only slightly smaller (higher) than the initial one. This might be, for example, due to a certain fear of future possible unemployment. It may also be due to secondary effects of the unemployment situation, such as a dropping account balance. Research does not understand yet "to which events we do adapt to and to which we do not adapt to" (Kahneman, 2003).

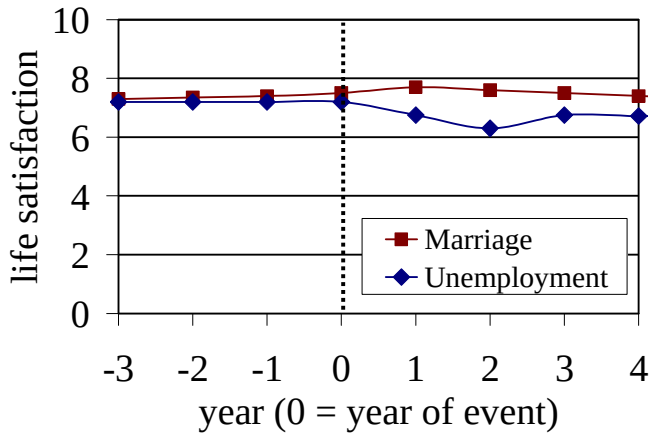

Figure 1: Impact of unemployment on life satisfaction (Diener et al., 2006).

Contradicting the classic Dynamic Equilibrium Theory, DIENER ET AL. (2006) showed that an individual's equilibrium happiness level may increase or decrease over time. This is referred to as the Revised Dynamic Equilibrium Theory. In the long run, emotional stability (less fluctuations of sentiments) as well as higher average happiness levels (increase in 'normal happiness') can be achieved by working on one's personality (Dalai Lama and Cutler, 1998). LAYARD (2005) names Buddhist monks as an example for people who have 'trained' themselves to be extraordinarily happy.

In the following section, we lay out our research propositions.

2. Research Propositions on Happiness

Even though happiness scholars have widely conducted research on happiness, a dynamic approach describing the level of happiness as a function of external events has not emerged. HEADEY AND WEARING (1991) formulated suggestions towards a framework of stocks and flows. We apply their approach and use supporting literature on hedonic psychology to model the dynamics of happiness. We regard the system behavior as a result of feedback from changes in 'happiness' on 'happiness drivers', as proposed by FREY AND STUTZER (2002). On the basis of the context explained above, we postulate the following research propositions that we explain afterwards.

Proposition 1:
Happiness adapts to its initial level after a life event according to the Classic Dynamic Equilibrium Theory.

HEADEY AND WEARING'S (1991) approach explains why happiness is fairly stable in the long run, although people constantly experience 'psychic income flows'. We formalize this notion and thereby show that external events generally have no lasting effect on happiness. Only deviations from the normal levels have an effect on happiness, which is temporary. We illustrate that many life events that people consider to be contributive to happiness in the long run are timely limited. This is an unexpected insight. Humans seem to be unaware of the transience of such feelings.

Proposition 2:
The Classic Dynamic Equilibrium Theory is capable of showing dynamics of lasting happiness changes, as it is postulated by the Revised Dynamic Equilibrium Theory.

Latest empirical research insight reveals that people's happiness levels may change over time (Diener et al., 2006). We argue that the structure of the interrelated variables determining happiness according to the Classic Dynamic Equilibrium Theory also reveals this longer-term effect. We show that the existing purebred equilibrium theory is capable of producing also long-lasting changes of the average level of happiness.

Proposition 3:

An individual can increase her happiness short-time by experiencing Czikszentmihályi Flows.

Experiencing Czikszentmihályi Flows increases 'happiness' for a short-time by going through intensive experiences like playing tennis, painting, having sex.

3. Modeling Happiness

In this paper, we design a simulation model capable of reproducing both the Classic *and* the Revised Dynamic Equilibrium Theory.[1] The model captures full adaptation of happiness to life events and the interdependence between the happiness level and the happiness drivers. In this paper we intend to promote the general understanding of the interplay between the individual's internal happiness factors, i.e. emotions and personality, and external events. We transfer findings from psychological research in a formalized quantitative System Dynamics model. We discuss the model boundary and introduce the reference modes in Chapter 3.1. In Chapter 3.2 we explain the feedback structure of the model. In the subsequent chapter we lay out the structure of the three subsystems. Finally, in Chapter 3.4, we validate the model structure and the model behavior.

3.1 Model Boundary and Reference Modes

In accordance with the model objective, all variables that an individual cannot influence lie outside the model boundary. This includes effects from political and macroeconomic influences, and genetic predisposition, for example. We consider parameters determined by individual personality to be constant over the time horizon of the analysis. Also, active behavior of individuals lies outside the model scope. People's life events are modeled by using external parameters. Table 1 summarizes endogenous, exogenous, and excluded variables in a model boundary chart[2].

[1] Similarly, Sastry (1997), tested Tushman's and Romanelli's theory on punctuated change.
[2] See Sterman (2000), pp. 97-98 for information regarding the model boundary chart.

Endogenous
Happiness
Things money can buy
Things money can't buy
Expected Things money can buy
Expected Things money can't buy
Aspiration Level of Status
Flow of Psychic Income

Exogenous
Csikszentmihalyi Flow
Normal Happiness Adjustment Time
Strength of Monetary event
Impact of Happiness on Things Money Can Buy
Coefficient of Overoptimism of Things Money Can Buy
Adjustment Time for Expectation Level of Things Money Can Buy
Impact of Happiness on Things Money Can't Buy
Coefficient of Overoptimism of Things Money Can't Buy

Excluded
Political Influence
Social Environment besides "Social Networks and Family Relations"
Macro-Economic Influence
Neuronal aspects
Active behavior
Reactions of others

Table 1: Model Boundary Chart

Reference modes capture the expected behavior of the most important variables (Sterman, 2000). We assume that the behavior of the two 'happiness drivers' and happiness itself is similar (see Figure 2). In the long run we expect happiness to be fairly close to its initial level because of an effect of habituation to both positive and negative situations. It may remedy the short-term effect of such events on a longer time scale.

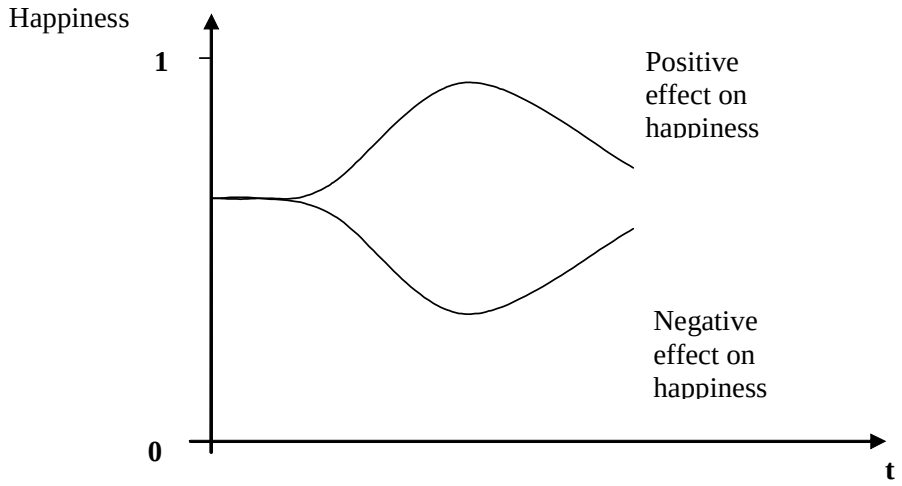

Figure 2: Reference modes for happiness

Overall, due to the high aggregation of variables, we do not seek to find exact quantitative compliance with empirical data. Instead, we seek to get a better qualitative understanding of the dynamics of happiness.

3.2 Feedback Structure of Happiness

The simulation model allows a holistic analysis of the interrelations between ‘happiness’ and the (changes of) ‘happiness drivers’. It also enables us to explain effects between both ‘happiness drivers’ subsumed under ‘things money can buy’ and ‘things money can’t buy’ (see Figure 3). There are two highly symmetric feedback loops between ‘happiness drivers’ and ‘happiness’.

As introduced in Chapter 1, MARMOT (2001 and 2006a) postulates that socio-economic status (‘things money can buy’) affects health (‘things money can’t buy’). However, in most developed countries, at least those with a strong social security system, more money cannot buy more health. People usually have enough money or insurance coverage to undergo surgery or other necessary treatments. Thus, if there is an effect of the socio-economic status (‘things money can buy’) on health (‘things money can’t buy’), it is an indirect with happiness dealing as a mediator. The feedback loops are intertwined (see Figure 3). This is why ‘things money can buy’ may indirectly influence ‘things money can’t buy’.

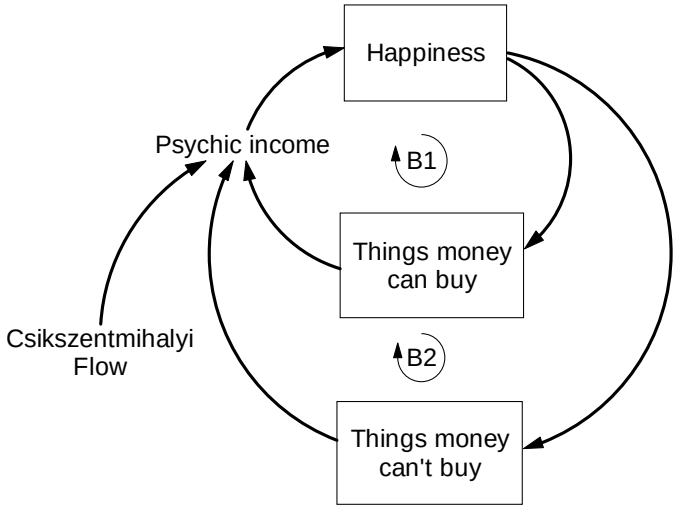

Figure 3: Basic structure of the happiness model

3.3 Subsystems of Happiness

In the following, we describe the ‘happiness’ subsystem and the two structurally identical ‘happiness drivers’, ‘things money can buy’ and ‘things money can’t buy’.

KAHNEMAN (1999) argues that humans are not able to exactly integrate feelings such as instant utility. In the contrary, PARDUCCI (1995) sees happiness as “a theoretical summation

over separate momentary pleasures and pains". According to the author, happiness can be interpreted as a stock. This definition goes along with HEADEY AND WEARING's (1991) point of view. They state that happiness only changes when the person's actual psychic inflow deviates from the normal psychic income flow. Combining PARDUCCI's (1995) AND HEADEY AND WEARING's (1991) perspective, we model happiness as a stock, determined by the 'change in happiness', which is affected by the 'psychic income flow' (see Figure 4).

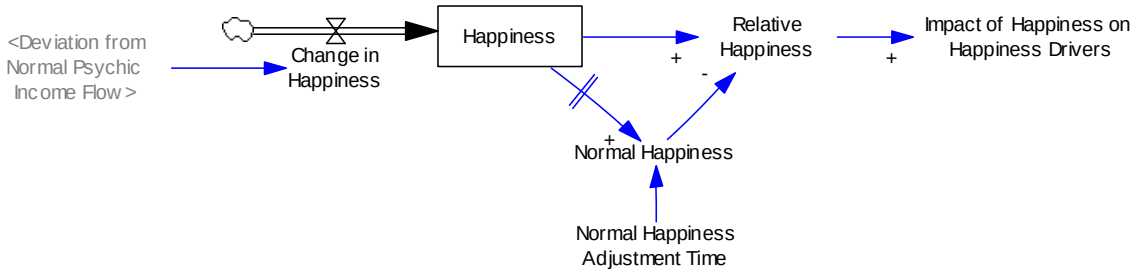

Figure 4: Subsystem 'Happiness'

The flow 'change in happiness' is calculated as follows:

Change in Happiness =

Current Psychic Income Flow

-Normal Psychic Income Flow (1)

The 'psychic income flow' (see Figure 5) can be seen as an aggregated effect of all activities and events that affect happiness. We excerpt from the literature (Headey and Wearing, 1991) that the 'psychic income flow' is influenced by the ratio of a person's actual achievements, compared with her expectation or aspiration level. These relations are considered in our model by the following equations (2) to (7).

The 'psychic income flow' is a sum of 'Csikszentmihályi Flow' experiences and effects of changes in happiness drivers on happiness (see Figure 5).

Current Psychic Income Flow =

Coefficient of Effect to Flow

*Total Effect on Net Psychic Income Flow

+ Csikszentmihályi Flow (2)

The total effect of changes in the happiness drivers is the sum of two components – effects on happiness from things money can buy and from things money can't buy.

Total Effect on Net Psychic Income Flow =

Change in Happiness from Things Money Can Buy

+ Change in Happiness from Things Money Can't Buy (3)

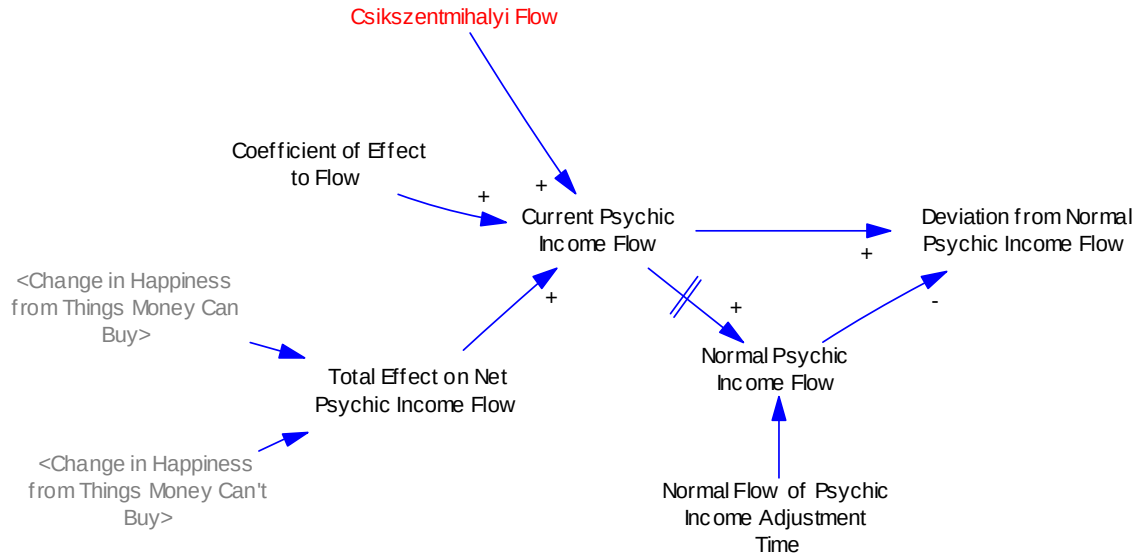

Figure 5: Subsystem 'Psychic Income Flow'

As can be seen in Equation 3, we assume that the effects to be additive (Sterman 2000). The total effect of the two structurally identical subsystems is thus not zero if there is no effect from one of the two happiness drivers.

The following dimensionless analytical nonlinear functions (4) and (6) transform the changes of happiness drivers into psychic income flows. Their output is a measure for the change in 'happiness' (see Figure 6). One distinct point of the functions is (0,-1): high expectations combined with little achievement lead to strong negative psychic income flows. The other distinct point is (1,0). It states that the psychic income flow does not change if achievements coincide with expectations. This goes along with what is stated above: only achievements that outrange expectations have a positive effect on happiness. A negative effect only occurs in situations of unexpectedly low achievements. In situations of relative high achievements compared to expectations, an output of 1 leads to high psychic income flows.

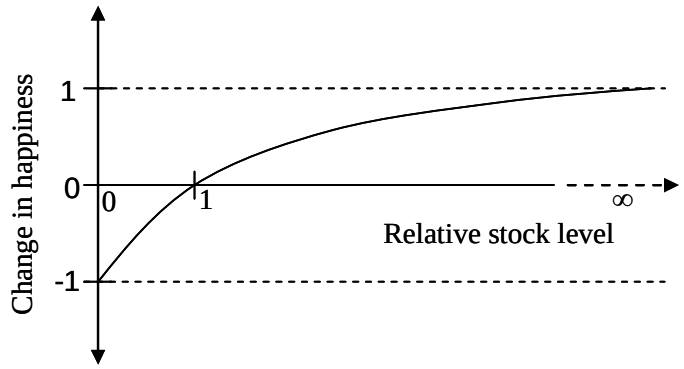

Figure 6: Non-linear function characterizing the link between relative happiness driver stock levels and effects on happiness (source: authors' representation)

We express the analytical function with the above laid out characteristics, as illustrated in Figure 6. It would be both less elegant and less precise to model these characteristics with a table function because latter is not necessarily continuous but contains artificial vertices for which the function is non-differentiable. The equations that grant the above described characteristics are presented in the following.

Change in Happiness from Things Money Can Buy=

(1/0.693147)*LN(Relative Stock Level of Things Money Can Buy+1)-1 (4)

where

Relative Stock Level of Things Money Can Buy=

Things Money Can Buy/Expectation Level of Things Money Can Buy (5)

Change in Happiness from Things Money Can't Buy=

(1/0.693147)*LN(Relative Stock Level of Things Money Can't Buy+1)-1 (6)

and

Relative Stock Level of Things Money Can't Buy=

Things Money Can't Buy/Expectation Level of Things Money Can't Buy (7)

Adjustment times play an important role for the behavior of the system. Consider a step in 'current psychic income flow'. The larger the adjustment time, the longer deviates the 'current psychic income flow' from its normal level. It therefore affects 'happiness' for a longer period of time. The statement concerning adaptation times also holds for the two 'happiness drivers'.

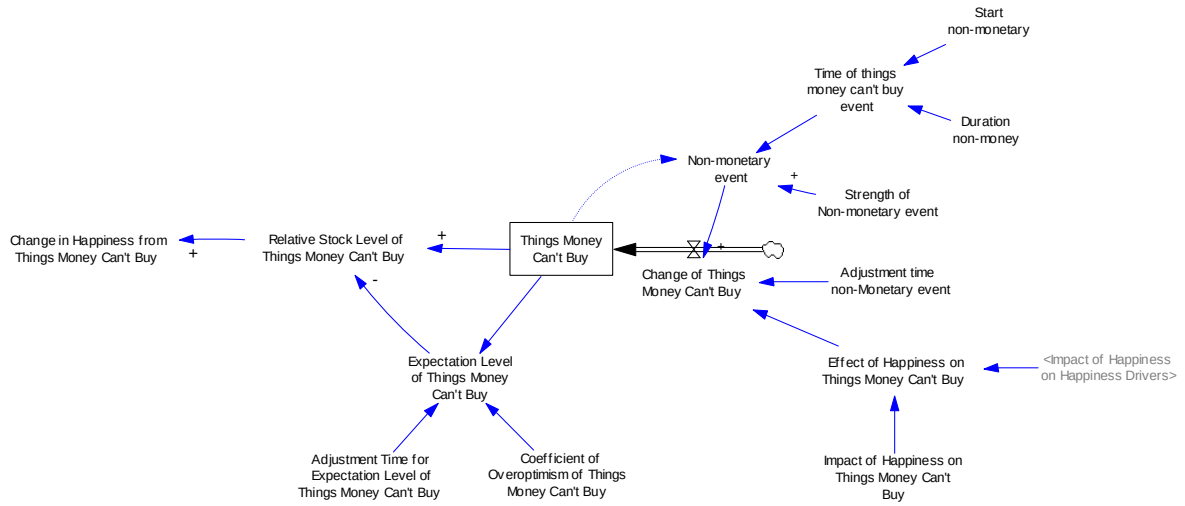

Figure 7: Subsystem 'Happiness Driver', exemplified with 'Things Money Can't Buy'.

According to KAHNEMAN (1999), it is commonly accepted that expectations are usually somewhat higher than the levels actually achieved. In a static perspective, this kind of over-optimism does not have any effect: when there are no life events, optimism does not affect happiness. We assume, however, that a *change* in happiness will induce a *change* in expectation levels. Then, over-optimism is a driving force for the adaptation of expectations up to and above the actual stock levels.

Adaptation of expectations can be interpreted as the reaction of the system to changes in the stocks. Changes are modeled with a pulse function affecting the inflow to the happiness stock, called the 'change of things money can't buy' (see Figure 7). In particular, the aspiration level of the happiness drivers adapts rather quickly to the current state of the respective stock levels. Thus, only *changes* in the stock levels – not the levels themselves - affect happiness. The effect depends on the adaptation time of the aspiration level to the current level:

Expectation Level of Things Money Can't Buy =
SMOOTH3(Things Money Can't Buy,
Adjustment Time for Expectation Level of Things Money Can't Buy)
*Coefficient of Overoptimism of Things Money Can't Buy (8)

To ensure dimensional consistency, happiness drivers are measured in stock points and 'Happiness' in happiness points. Dimensional consistency is an important aspect of model validation. Further tests on model validation are laid out in the following.

3.4 Model Validation

This section contains structure validation and behavior validation of the model (Sterman, 2000). As a first step in model structure validation, we check dimensional consistency. The functions connecting the subsystems link relative and thus dimensionless variables. The stocks in the subsystems are ‘happiness’, ‘things money can buy’, and ‘things money can’t buy’. Their inflows and outflows are measured in the unit of the stock, divided per time. The integration to the stock level and differentiation to the outflow matches with the units.

The feedback structure relies on the findings from literature on happiness. As we base our research on established findings in the theory of happiness, validation of our assumptions was done a priori.

For validating model behavior, we conduct extreme condition tests. The model is to be applied to refer to a large fraction of Western countries’ populations. People who state to have extreme values of happiness cannot be assessed by the existing structure due to the nonlinear nature of the 0-10 happiness scale (Kahneman, 1999). According to studies, individuals’ happiness values lie between 2.5 and 8.5 happiness points. We thus initialize ‘happiness’ in the middle of this range, at 5 happiness points. When initializing stocks and the input functions at reasonable levels, the model behaves in a robust way. Adaptation times and other parameters can be varied in a relatively wide range without altering the qualitative model behavior.

To keep the model simple, we do not include mechanisms to keep ‘happiness’ technically within the non-linear scale from 0 to 10. Consequently, parameter settings have to be chosen with care. To illustrate, imagine a very happy individual. She judges her happiness with 9 out of 10 possible points on the happiness scale. Assume she wins the lottery and becomes so happy that she rates her well-being with 10 out of 10 points. At this point there is no more possibility for her to improve her rating, even if she experiences more favorable events. Hence, the happiness scale is nonlinear at the upper and lower end. If an individual is already very happy, favorable events should thus be rated smaller. Likewise, adverse events should be rated smaller if an individual is not that happy. It is subject to future research to include an appropriate feature in the model that considers this context automatically.

Concluding, model structure and behavior can be interpreted as valid. In the following chapter, we examine model behavior.

4. Model Behavior Analysis

We separate behavior analysis in two parts. We fist study the base run in Chapter 4.1 followed by 9 scenario runs in the subsequent chapters. Table 2 provides an overview over the scenarios conducted. Plus signs (+) stand for positive happiness events, negative signs (-) for negative ones. The events refer to monetary events influencing 'things money can buy, to non-monetary events influencing 'things money can't buy', or to both. For the runs, we assume that all events take place in week 10. From a simulation standpoint, the events are initiated by a pulse function. Thus, multiple plus signs indicate several pulses, like in Scenario 6. In Scenario 7, we analyze two emotional Csikszentmihály Flow experiences. In Scenario 8, we present parameter variations, which lead to emotional instabilities. When introducing the scenarios, we first state the (real world) situation, then specify the model parameter set and finally analyze the model run.

Chapter	3.1	3.2		3.3	3.4	3.5	3.6	3.7	3.8	3.9
Scenario	base run	1a	1b	2	3	4	5	6	7	8
Stock: Money Can Buy		+	+			+	+	+++		Emotional
Stock: Money Can't Buy				+	-	+	-		Flow	Instabilities

Table 2: Summary of the different scenarios discussed

The following parameter settings are used in the scenario runs unless indicated otherwise. For 'normal flow of psychic income adjustment time', 'normal happiness adjustment time' and 'adjustment time for expectation level of things money can't buy', we assume a delay time of 10 days. As described above, the 'adjustment time for expectation level of things money can buy' is half that long.

The 'coefficient of effect to flow' describes the impact of changes in happiness drivers on the psychic income flow. This coefficient is set to one (dimensionless) as 100% of the psychic income flow is governed by the 'total effect of the sum of changes money can/can't buy'. The coefficient may be altered for analyzing different cases of the 'happiness drivers' stocks, like health, socio-economic status, and social networks and family relationships, etc.

We suppose different values for the impact of ‘happiness’ on the ‘happiness drivers’. For the variable ‘impact of happiness on things money can buy’, we choose 0.1 (dimensionless). We hereby assume that a 20% increase in ‘happiness’ causes a 2% increase on success at work. We estimate the impact of ‘happiness’ on ‘things money can’t buy’ to be higher with a value of 0.3 (dimensionless). This implies that, e.g., a 30% increase in happiness would lead to a 9% increase in ‘things money can’t buy’, such as friends and health.

The ‘coefficients of over-optimism’ is a measure indicating how optimistic an individual is about the levels of her future ‘happiness drivers’. We choose a value of 1.3 (dimensionless) for the coefficient of over-optimism.[3] A pessimist will have a ‘coefficient of over-optimism’ between 0 and 1, as this person sees its future prospects worse than they will actually be.

4.1 Base Run

In case of no external events, neither ‘happiness driver’ changes. Hence, the psychic income flow remains constant – not necessarily zero. Thus, there is no deviation from normal psychic income. The system is in dynamic equilibrium (see Figure 8). ‘Happiness’ stays at its initial level which is here assumed to be 5 happiness points.

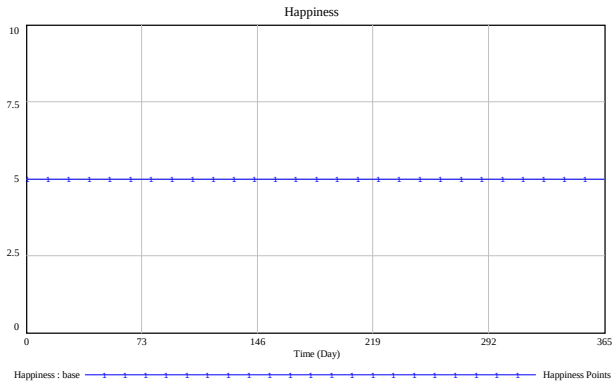

Figure 8: Base run (source: all model runs are authors’ representation)

[3] The value of 1.3 means that a change in the ‘happiness driver’ of 1 corresponds to a change in the expectations of 1.3.

4.2 Scenario 1 – Wage Increase

In the first scenario we assume two individuals who profit from a wage increase. This means that they experience a monetary event. We further assume that they evaluate the event differently, according to their personality. For the first individual, the wage increase has a positive impact on 'things money can buy' of 10%. This can be due to a relative small wage increase *compared to each individual's wealth*. The relative monetary surplus is comparably little. The second individual rates the wage increase much stronger because, for example, the wage increase is higher or she has lower initial wealth. The 'strength of monetary event' has a value of 1 (dimensionless). The positive impact is 100%.

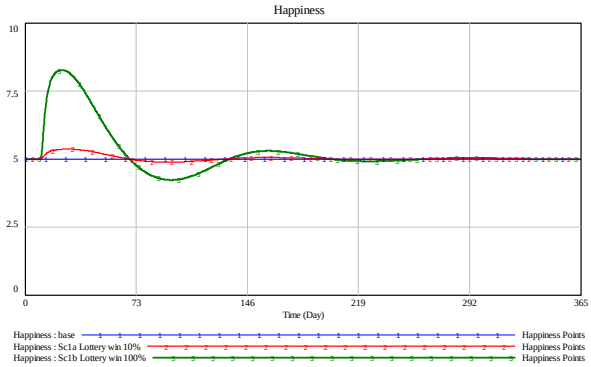

Figure 9: Scenarios 1a and 1b: Wage increase with small and high impact on 'happiness driver'

As can be seen in Figure 9, the behavior for both scenario runs is qualitatively similar (line 2: small impact, line 3: high impact). The runs only deviate in terms of amplitude while the timing of the two is alike. 'Happiness' increases after week 10 to peak on about 2 weeks later. It then declines to its initial level on roughly day 70. It undershoots, recovers, and oscillates smoothly around the initial 'happiness' of 5 happiness points. The change in 'happiness' induces modest changes in the inflow and outflow variables of the two 'happiness drivers'. Although the stock levels oscillate slightly after the event, there is no sustainable net growth or fall in the stock that is not directly affected from the boost in pay. A boost in pay does increase the stock level 'things money can buy' sustainably. It only has transient effects on the subjective valuation of 'things money can't buy', such as social networks (line 2 in Figure 9).

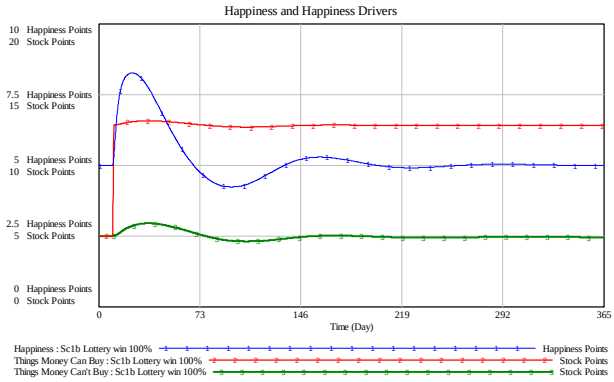

Figure 10: Scenario 1b: ‘Happiness’ and ‘Happiness drivers’, showing the run with high impact on happiness drivers

The wage increase induces a step in ‘things money can buy’. Aspirations of ‘things money can buy’ adapt relatively fast to the new level of the stock variable. The ‘relative stock level of things money can buy’ experiences a steep incline from one to a value greater than one at first (not shown) but levels off at its initial value shortly after. This leads to a pulse-like function of the ‘psychic income flow’ and adjusts the ‘normal flow of psychic income’ to a higher level. As soon as the ‘psychic income flow’ is again below the ‘normal level of psychic income’, ‘deviation from normal flow of psychic income’ changes from positive to negative values, generating the ‘happiness’ behavior explained above.

4.3 Scenario 2 – Found a Spouse

In the second scenario, we assume that an individual meets her future spouse on a night out - love-at-first-sight induces a positive non-monetary event. It is assumed that the individual’s subjective ‘strength of the non-monetary event’ is equal to 0.7 (dimensionless).

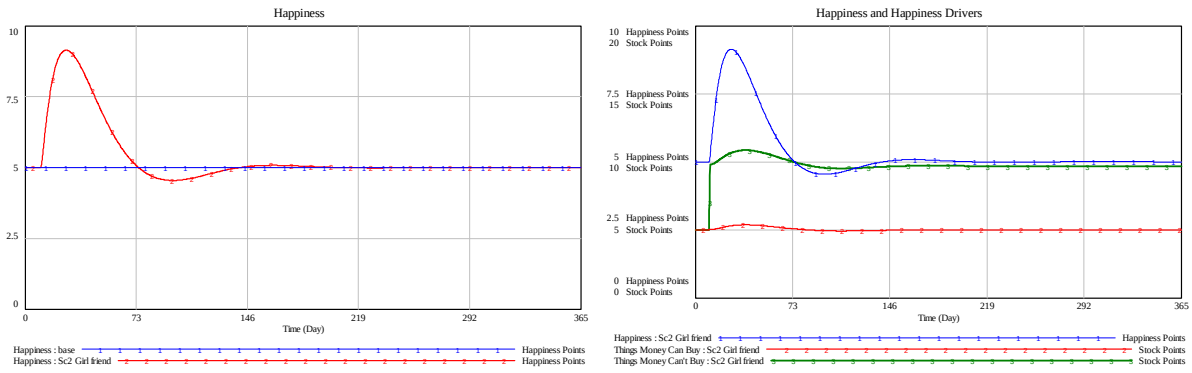

Figure 11: Scenario 2: Finding a spouse – ‘Happiness’ and ‘Happiness drivers’

The dynamics of ‘happiness’ in this scenario (see left-hand side of Figure 11) are very similar to those shown in Scenario 1 (see Figure 9). ‘Happiness’ increases immediately after the two individuals meet and fall in love. It decreases to its initial value after about two months and then falls even below. This might be due realizing that the relationship does not meet the individual’s (over-optimistic) expectations. After about half a year, expectations are adjusted. This is why happiness oscillates around its initial value.

From looking at the ‘happiness drivers’ (see right-hand side of Figure 11) we learn that the stock ‘things money can’t buy’ (line 3) increases sharply and then oscillates around a value double its initial value. Yet, below the expected value ‘things money can buy’ (line 2) is influenced only a little: because of the increase in ‘things money can’t buy’, the individual might be highly motivated at work after the event. As above, this boost in motivation is only transient.

4.4 Scenario 3 – Car Accident

Whereas individuals experience positive events in the scenarios above, the situation reverses in the following. Here, an individual has a major car accident and suffers from injuries like an irreversible loss of health by becoming paraplegic, for example. Besides the algebraic sign of the change, there is no difference between winning in lottery and experiencing a major loss of health in the particular context of this model.

‘Things money can’t buy’ (line 3 in Figure 12) represents the ‘happiness driver’ stock ‘health’. It levels off about one happiness point below its initial level. During an initial phase of unhappiness, the individual realizes she will never be able to walk again. ‘Happiness’ then levels off at its initial value as the individual accepts the new situation and discovers aspects of life that might have been hidden to her prior to the accident. Changes in the subjective evaluation of status and social networks are temporary. The ‘happiness driver’ ‘things money can’t buy’ stays at a lower level – the individual’s health is irreversibly reduced. Effects on ‘things money can buy’ are present, but small due to the small impact of Happiness on this Happiness driver (line 2). ‘Happiness’ behaves similar to its major influencing happiness driver, ‘things money can’t buy’. It immediately drops to reach a trough about a month after the accident, moving into a depression-like mood. It then increases again. ‘Happiness’ even overshoots slightly as a consequence of enthusiasm and then oscillates around its initial value.

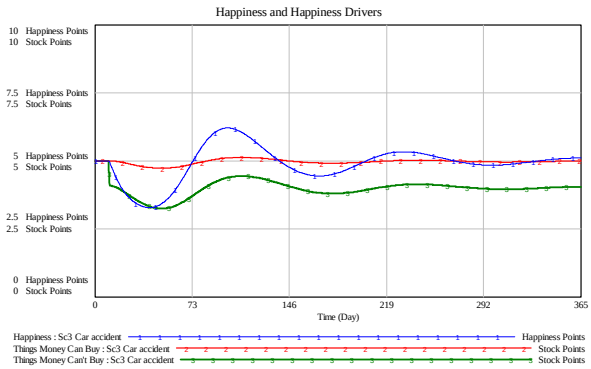

Figure 12: Scenario 3: Car accident

4.5 Scenario 4 – Combinations: Wage Increase and Found a Spouse

In Scenario 4, we model two succeeding positive events, one monetary event on day 10 and a non-monetary event on day 30. In this case we need to consider the nonlinearity of the happiness scale, as mentioned above. The individual in question is already happy and she is not able to report higher values than 10 happiness points. We therefore choose a lower value for the second external event to consider the already high ‘happiness’ at that time.

Parameter sets for this scenario include 0.1 for the ‘strength of monetary event’ at day 10 and 0.7 as the ‘strength of non-monetary event’ at day 30.

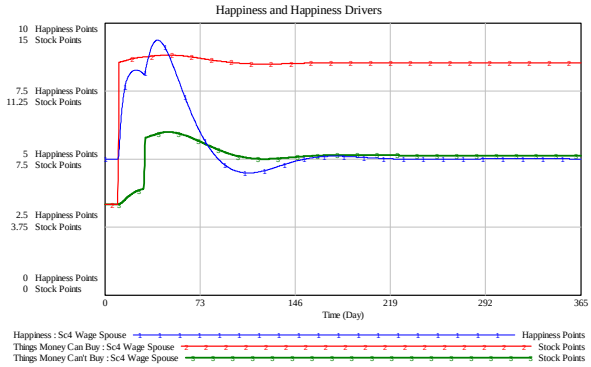

Figure 13: Scenario 4: Wage increase and spouse

As can be seen in Figure 13, ‘things money can buy’ (line 2) increases on day 10 due to the wage increase. The ‘happiness driver’ stays on the higher level, slightly oscillating. ‘Happiness’ (line 1) increases accordingly and peaks at 8.3 happiness points roughly two weeks after and then smoothly starts to decline. The indirectly affected ‘happiness driver’ ‘things money

can’t buy’ also increases slightly. As the individual experiences love-at-first-sight on day 30, ‘things money can’t buy’ (line 3) increases, which makes ‘happiness’ to increase even further to peak at 9.4 happiness points about 10 days after. Over time, both ‘happiness drivers’ stay at a different level than the initial value, whereas ‘happiness’ declines, undershoots, and then oscillates around the initial value and then abates.

4.6 Scenario 5 – Combinations: Got a Wage Rise but Left by Spouse

Things are different in case an individual experiences a wage increase but then is left by her spouse (see Figure 14). As in the previous run, ‘happiness’ (line 1) reacts to the positive monetary event on day 10 and then suffers from the negative event that the individual is left by her spouse 20 days later. After a period of oscillation, ‘happiness’ drops back to the initial value. The ‘happiness drivers’ stay at their new level, away from the initial value (line 2 and 3).

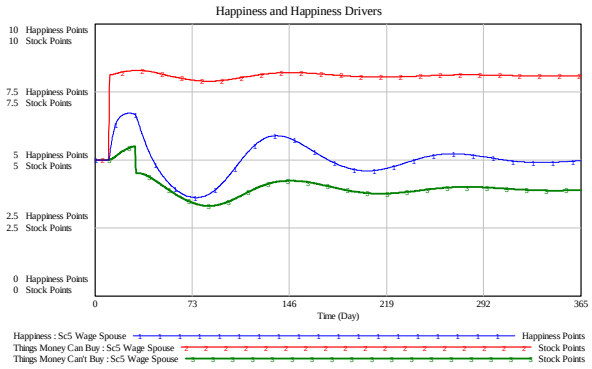

Figure 14: Scenario 5: Wage increase and left by spouse

4.7 Scenario 6 – Being Wealthy

In Scenario 6 we demonstrate why people’s happiness adapts to some things but not to others. It picks up the idea of the purebred Dynamic Equilibrium Theory. We assume a wealthy individual who profits from interests on her capital after gaining this capital on day 10, by winning the lottery, for example. Yet, here we assume that the won money is put on an interest-bearing bank account or yields other forms of interest. Increased interest returns are generated by an assumed underlying reinforcing loop on invested capital. We model this simplified by applying a pulse train function instead of a single pulse. Assuming continuous returns,

each monetary event has a strength of 8%/360 of the 'happiness driver'. Parameter values for the pulse train are start (10 days), duration (1 day) , repeat (1 day), end (730 days).

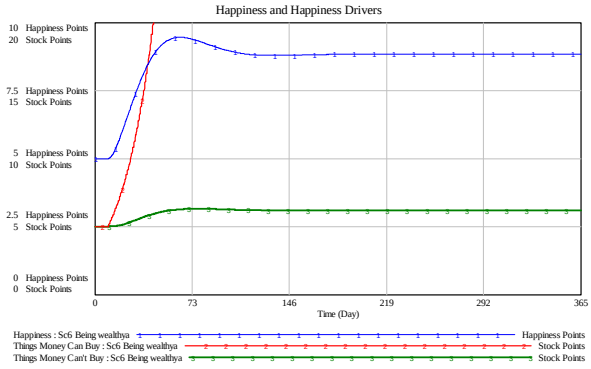

Figure 15: Scenario 6: Being wealthy

As can be seen in Figure 15, the 'happiness driver' 'things money can buy' (line 2) increases exponentially – it incorporates the individual's account balance. 'Happiness' increases and reaches a peak at 8.8 happiness points. The 'happiness driver' 'things money can't buy' (line 3) increases slightly and stays on a higher level than before, but does not increase exponentially like 'things money can buy'. 'Happiness' levels off higher than the initial value. This provides an explanation why wealthy people are observed to be happier, compared to not-so-wealthy individuals within the same society (Easterlin 2006)[4].

4.8 Scenario 7 – Let's Have Fun: Czikszentmihályi Flow Experiences

As laid out above, flow experiences are induced by an activity such as sex, sports or other things. Such flow experiences are considered being among the greatest contributors to happiness (Kahneman, 1999; Layard, 2005). For the following scenario run, we assume a tri-athlete who participates at a 9+ hour sport event – also in order to feel good. Technically, the 'strength of the Czikszentmihályi flow' is set to 4 happiness points per day and the pulse starts at 'Csikszentmihályi start'= 10 days.

From Figure 16 (left and right hand graph) we learn that 'happiness' increases on the day of the sport event (line 1). This effect ripples through the system and has the 'happiness drivers' increase as well. Yet, the happiness effect from this intensive experience wears off. After

[4] It stays untouched that richer *societies* are not happier than not-so-rich societies once they have passed a certain threshold of about $10,000 GDP per capita per year (Layard 2005).

finishing the triathlon, the participant continues to be excited about her fantastic performance. Yet, as she does not participate at any further similar sports event (left hand graph), 'happiness' diminishes. 'Happiness' oscillates, and finally the individual is as happy as it used to be before the triathlon.

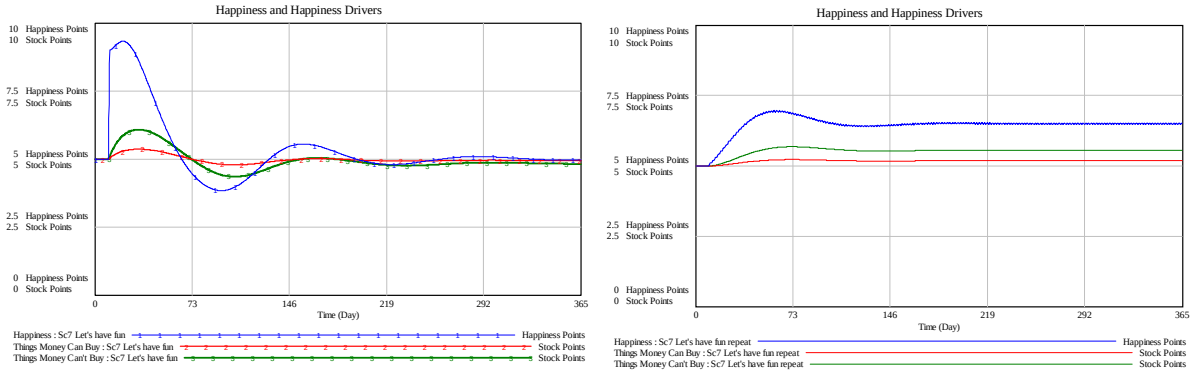

Figure 16: Scenario 7: Let's have fun – Single and Repeated Czikszentmihályi Flow Experiences

The situation is different with the sportsman in the right hand graph of Figure 16. She repeatedly experiences multiple Czikszentmihályi flows as she exercises every other day. From the graph we learn that the average 'happiness' level increases sustainably. We see from the graph that exercising regularly increases the individual's health (line 3), which in turn increases 'happiness' initially. Also, the effect of repeated Czikszentmihályi flow experiences does not wear off over time.

4.9 Scenario 8 – Emotional Instabilities

In the last scenario, we conduct a parameter analysis, surveying the effect of different magnitudes of over-optimism on the maximal magnitude of oscillations of 'happiness'. Figure 17 illustrates that the individual is more emotionally stable when optimism is high and v.v. Extremely pessimistic individuals tend to experience very strong oscillations and extremely optimistic persons experience only small deflections from their initial level of happiness.

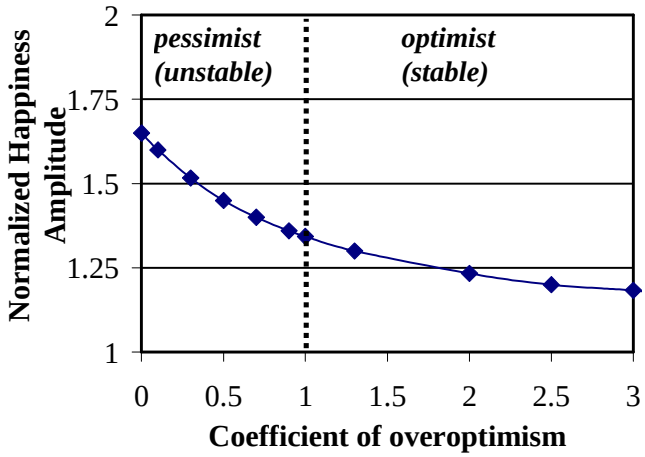

Figure 17: The effect of the 'coefficient of overoptimism' on 'normalized happiness amplitude' (source: authors' representation)

It is assumed that two individuals experience positive monetary events like lottery wins ('strength of monetary event' = 0.5) on day 10. One individual is more optimistic ('coefficient of effect to flow' = 1.5 happiness points/day), the second has a tendency towards pessimism ('coefficient of effect to flow' = 0.5 happiness points/day).

As can be seen in Figure 18, the pessimist's happiness level oscillates around the initial value much longer and with a higher amplitude (line 2) than the optimist's (line 3). This insight still needs to be supported by empirical studies.

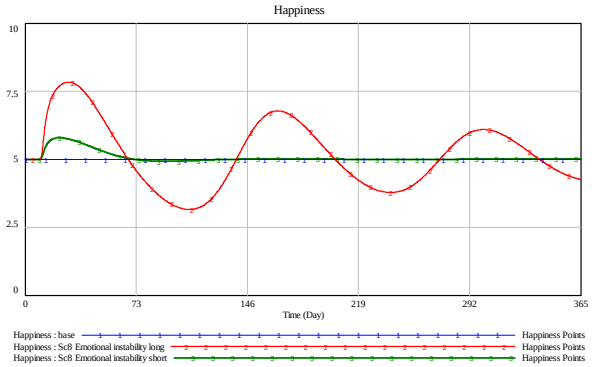

Figure 18: Scenario 8: Happiness curves of an optimist and a pessimist

5. Research Proposition on Happiness - Revisited

In the following, we discuss the implications of the scenario runs conducted above. When individuals seek to increase their individual happiness levels, our scenario runs implicate that it is generally not enough to wait for a positive external life event in order to become happier. Happiness might increase in cases of external life events, but eventually returns to the initial

level after a positive event. In other words, individuals seem to overestimate the length of positive effects of external events on happiness. An example would be an individual who is convinced that she is going to be happy and without sorrow when wining the lottery.[5]

The dynamics shown in Scenarios 1, 2, 3, 4, and 6 are in concordance with empirical results laid out above, supporting the Dynamic Equilibrium Theory. As shown in Scenario 2 (Found a Spouse), for example, finding a spouse has a lasting effect on the 'happiness stock' 'things money can't buy", representing stocks such as health, social networks and family relationships (line 3 in Figure 11), but only a short-time effect on 'happiness'. Moreover, there is a slight effect on the 'happiness driver' 'things money can buy': it oscillates slightly and then levels off at the original value. In Scenario 4 (Wage Increase and Found a Spouse), 'happiness' falls back to its initial level even after the individual has experienced two subsequent positive effects.

We also observe that 'happiness' increases back to its initial level in cases when an individual suffers from negative experiences, as in Scenario 3 (Car Accident). The individual suffers from a lasting effect on the 'happiness stock' 'things money can't buy", here in particular health (line 2 in Figure 12), but only with a short-time effect on 'happiness'. Moreover, there is a slight effect on the 'happiness driver' 'things money can buy': the latter oscillates slightly and then levels off at its original value. From the above observations we infer support for Proposition 1. Moreover, we are able to be more specific.

Proposition 1.1:
Happiness adapts to its initial level after a positive life event according to the Classic Dynamic Equilibrium Theory.

Proposition 1.2:
Happiness adapts to its initial level after a negative life event according to the Classic Dynamic Equilibrium Theory.

Scenario 6 (Being Wealthy) reveals a different behavior as 'happiness' finds a new equilibrium level higher than originally after the individual becomes very wealthy: the 'happiness

[5] Having learned that external events are not a feasible way to improve one's equilibrium level of happiness except for the case of exponentially increasing happiness drivers, the solution must necessarily be within oneself, i.e. in internal factors such as self-esteem, faith, or compassion.

driver' 'things money can buy' grows exponentially. This is a rather rare occurrence in real-life. 'Happiness' levels off on a higher level means that the individual becomes a happier person. We thus learn from the model that the Dynamic Equilibrium Theory is capable of explaining that people adapt to some things, but not to others. The latter is the case, when the *change* of the 'happiness driver' is dependent on the 'happiness driver' *level* itself, as is the case in our example: the '*change in things money can buy'* (interest on investment) is dependent of the *level of 'things money can buy'* (account balance). So far, our analysis is restricted to monetary events. We thus find support for

Proposition 2:
The Classic Dynamic Equilibrium Theory is capable of showing dynamics of lasting happiness changes in case of exponentially changing happiness driver stocks.

People are also able to increase their level of happiness by increasing the frequency of positive stimuli of external events, which constitute for a Csikszentmihalyi Flow. In Scenario 7, a tri-athlete focuses on the latter as she makes sure she experiences a triathlon. After the individual has experienced such a Czikszentmihályi Flow, 'happiness' drops back to its initial value. By exposing herself repeatedly and regularly to emotional, short-term flow experiences, she can also substantially keep her happiness level up. We thus revise Proposition 3.

Proposition 3.1:
An individual can increase her happiness for a short-time by experiencing singular Czikszentmihályi Flows.

Proposition 3.2:
An individual can increase her average happiness for a prolonged period of time by experiencing repeated Czikszentmihályi Flows.

We made an additional conjecture when studying happiness dynamics of optimistic and pessimistic people. In Scenario 8 (Emotional Instabilities) we suggest that individuals are more emotionally stable when they are generally optimistic.[6] This observation leads to the following proposition.

[6] Recent economic research has shown that forward-looking agents are happier when they are optimistic (Brunnermeier and Parker, 2005).

Proposition 4:

Generally optimistic individuals experience less strong oscillations of happiness.

6. Discussion

The System Dynamics approach allows a systematic parameter variation to derive conclusions about the influence of different personality traits and external life events on happiness. It thus expands classic empirical research on happiness by introducing a dynamic aspect. Even though the model captures and integrates various aspects of happiness research in a holistic view, the model has drawbacks. As it is only a representation of reality, it cannot be complete. Thus, for example, active behavior and reactions of individuals lie outside of the model boundary. The model represents passive behavior of happiness under the influence of external events. Hence, the reason for deviations of people's happiness level may also be grounded in their active response to life events. KAHNEMAN (2003) argues that there are things we do adapt to and others we do not adapt to. We propose that we do adapt to all external events; however, people may take actions on behalf of some events, whose effects on happiness overlay the transient oscillations of the happiness stock due to external events.

Lastly, we provide an alternative explanation for why people do adapt to some things, but not to others. We provided examples for monetary long-term effects in Scenario 6 (Being Wealthy) and for emotional short-term flow effects in Scenario 7 (Let's Have Fun).[7] As in all other scenarios, the *change* in the happiness driver stock *level* is what constitutes for the change in happiness, not the level itself. In Scenario 6, this particular *change* is, however, determined by the happiness driver *level*, causing exponential growth of the happiness driver 'things money can buy' and a sustainable improvement of the happiness level. Hence, in those cases where the *level* of a happiness driver affects its own growth rate, the level of happiness is affected sustainably by the happiness driver level.

In Scenario 7, the Czikszentmihályi Flow directly affects the 'psychic income'. The effect may generate similar behavior to the one described in Scenario 6 (Being Wealthy) if the

[7] Thanks to Brad Morrison for suggesting the short-term and long-term differentiation in this context.

individual experiences the Czikszentmihályi flow repeatedly and regularly – although because of a different life event.[8]

However, we propose that individuals seeking to increase their happiness level should not attempt to do so by waiting for external events, as almost all examples of such yield only transient improvements of happiness. As the solution does not lie in external factors, all other possible ways of improving on individual's well-being must necessarily be determined by internal factors, i.e. personality traits.

We therefore propose a more promising way to improve happiness, which begins with accepting that most external life events do not contribute substantially to happiness, but training one's mind may do. Buddhist monks, for example, are known to have almost constant and very high happiness levels (Layard, 2005). In the case of monks, the high level of happiness is not due to high levels of the 'happiness drivers': monks are neither rich, nor of unusual good physical constitution, nor do they have families or huge networks of friends outside their community. They live a life of compassion towards the living beings on earth and train their mind to reject from any kind of anger and fear.

7. Summary

In this paper we present a dynamic model of an individual's happiness. The model represents the Dynamic Equilibrium Theory, postulated by BRICKMAN AND CAMPBELL (1971) and its variables and their relations based on findings from the literature on positive psychology. Insights from model runs support the Dynamic Equilibrium Theory. We also learn that a holistic view of the Dynamic Equilibrium Theory reveals that – against current insight from psychology research (Diener et al. 2006) – it also captures lasting changes in the happiness level as in Scenario 6 (Being very wealthy). This insight enhances the Dynamic Equilibrium Theory.

In the first chapter we laid out the theoretical background of happiness research. We defined the term 'happiness' and focused on established explanations for its dynamic behavior, in-

[8] Excitedly checking lottery numbers could be considered as a short-term flow experience. The increased account balance as a result of having won in the lottery is a longer-term 'happiness driver' effect.

cluding the approaches of the hedonic treadmill and the Dynamic Equilibrium Theory. In the subsequent Chapter 2, we postulated our research propositions.

In Chapter 3 we presented the simulation model. We laid out the model boundary and presented reference modes. We then introduced the feedback structure of the System Dynamics model, followed by a detailed explanation of the subsystems. The chapter closes with model validation.

In Chapter 4, we studied the influence of different external events on happiness and proved qualitative agreement of our results with empirical evidence. In addition to the reproduction of empirical results, our model helps scholars in System Dynamics and psychology to gain insight into the mechanisms that create happiness. This is done by establishing causal relationships between variables as described in psychology and by integrating them into a holistic model. We aggregated the structurally identical real-world happiness drivers (including health, income, family relationships, etc.) into the two stocks, 'things money can buy' and 'things money can't buy'. We divide possible life events into the two according kinds of external events, monetary and non-monetary events. By modeling effects of monetary events on happiness, we contribute to the discussion in happiness research on whether wealthy people are happier than poorer, i.e. whether *levels* of certain 'happiness drivers' contribute to happiness. Recent critique of the hedonic treadmill model has emerged, among others, from polls that found that richer people on average are happier than poorer people (Easterlin 2006). From the model we learn that this does not necessarily challenge the Dynamic Equilibrium Theory.

In Chapter 5, we revise our propositions according to the findings in Chapter 4. This is followed by a discussion on the findings. The main insight is that we identified both temporary and lasting effects to increase happiness.

8. Implications for Future Research

Currently, understanding people's happiness and especially the influence of external effects and other people's behavior on the individual's well-being is rather limited. Dynamic simulation may lead to further insight for scholars in the field of (positive) psychology and for policy-designers.

Future research with a simulation model could, for example, focus more on quantitative aspects. Once the structure of the mechanisms of happiness has been validated, scholars may focus on assessing real-world data. The model could be fed with empirical happiness data of individuals in order to derive the personality specific parameters. As System Dynamics models usually cover averages, Monte Carlo simulations could lead to further insight on how happiness among employees or whole societies might develop.

Scenarios could also be used to forecast happiness behavior for a specific individual or a society. Currently, individuals sense their level of well-being as a snapshot; this investigation would give a dynamic perspective on these persons' well-being. Consequently, if an individual is aware that an increasing happiness level will fall back to the normal level after relatively short time, she may proactively look for new external stimuli. This kind of active response behavior may be subject of a useful extension of the model.

Acknowledgements

We thank Prof. John Sterman, MIT, for discussing happiness in his Fall 2001 class "System Dynamics for Business Policy" at the MIT Sloan School of Management. The discussions initiated further thoughts on happiness that were analyzed in a seminar work at the Lehrstuhl für Planung at the Universität Stuttgart in 2006 and finally resulted in this paper. We thank Prof. Erich Zahn, Universität Stuttgart, for supporting this research in his class.

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Appendix

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{UTF-8}
Csikszentmihályi duration=
	1
	~	Day [1,1,1]
	~		|

Csikszentmihályi start=
	0
	~	Day [0,365,1]
	~		|

repeat=
	1
	~	Day
	~		|

Strength of Csikszentmihályi Flow=
	0
	~	Happiness Points/Day [0,10,1]
	~		|

end=
	730
	~	Day
	~		|

Effect of Happiness on Things Money Can't Buy=
	Impact of Happiness on Happiness Drivers*Impact of Happiness on Things Money Can't Buy
	~	Stock Points/Day
	~		|

Change in Happiness=
	Deviation from Normal Psychic Income Flow
	~	Happiness Points/Day
	~	Headey and Wearing (1991) argue that deviations from the Normal Flow of \
		Psychic Income make for changes in happiness. Change in Happiness = \
		Deviation from Normal Psychic Income Flow is the equivalent mathematical \
		formulation.
	|

Current Psychic Income Flow=
	Coefficient of Effect to Flow*Total Effect on Net Psychic Income Flow+ Csikszentmihályi Flow
	~	Happiness Points/Day
	~	This is the present total flow of psychic income, caused by changes of the \
		two happiness drivers stocks and the Csikszentmihályi Flow.
	|

Effect of Happiness on Things money can buy=
	Impact of Happiness on Happiness Drivers*Impact of Happiness on Things Money Can Buy
	~	Stock Points/Day
	~		|

Expectation Level of Things Money Can Buy=
	SMOOTH3(Things Money Can Buy,Adjustment Time for Expectation Level of Things Money Can Buy\
		)*Coefficient of Overoptimism of Things Money Can Buy
	~	Stock Points
	~	Expectations are assumed to be made up of a person's past experiences, \
		present wishes and future expectations. It is assumed to be best \
		represented by a three-stock system, as the authors observe that there is \
		a certain time lag associated with the adaptation of expectations to \
		actual stock levels. It is common sense in the psychology literature that \
		expectations tend to be somewhat higher than the levels actually achieved. \
		This fact is considered with the parameter "Coefficient of Overoptimism".
	|

Expectation Level of Things Money Can't Buy=
	SMOOTH3(Things Money Can't Buy,Adjustment Time for Expectation Level of Things Money Can't Buy\
		)*Coefficient of Overoptimism of Things Money Can't Buy
	~	Stock Points
	~	Expectations are assumed to be made up of a person's past experiences, \
		present wishes and future expectations. It is assumed to be best \
		represented by a three-stock system, as the authors observe that there is \
```

a certain time lag associated with the adaptation of expectations to \
actual stock levels. It is common sense that expectations tend to be \
somewhat higher than the levels actually achieved. This fact is considered \
with the parameter "Coefficient of Overoptimism".
|

Monetary event=
Time of things money can buy event*Strength of Monetary event*Things Money Can Buy
~ Stock Points
~ Positive monetary events can be a boost in pay or a lottery win. Negative \
monetary events can be losses from investments, the loss of one's car due \
to a hurricane, or the like. Naturally, the intensity (Strength of \
-monetary event) and length (Time of things money can buy event) of such \
events may differ. Furthermore, it seems reasonable to multiply the event \
with the current stock level. Thereby, the intensity parameter can be \
determined 'in % of the actual stock level', and, given the modulus of the \
intensity is kept between 0 and 1, the stock can not become negative. Note \
that, in contrary to the Happiness Stock, we do not use a 0-10 scale here.
|

"Non-monetary event"=
"Strength of Non-monetary event"*Time of things money can't buy event*Things Money Can't Buy
~ Stock Points
~ Positive non-monetary events can be, e.g., making new friends, being \
proposed to marry, getting a baby, or recovering from illness. Negative \
non-monetary events can be accidents with health effects, splitting up in \
a relationship, or the like. Naturally, the intensity (Strength of \
non-monetary event) and length (Time of things money can't buy event) of \
such events may differ. Furthermore, it seems reasonable to multiply the \
event with the current stock level. Thereby, the intensity parameter can \
be determined 'in % of the actual stock level', and, given the modulus of \
the intensity is kept between 0 and 1, the stock can not become negative. \
Note that, in contrary to the Happiness Stock, we do not use a 0-10 scale \
here.
|

Adjustment time monetary event=
1
~ Day
~ |

"Adjustment time non-Monetary event"=
1
~ Day
~ |

Change of Things Money Can't Buy=
Effect of Happiness on Things Money Can't Buy+"Non-monetary event"/"Adjustment time non-Monetary event"
~ Stock Points/Day
~ Changes in the Happiness Drivers can result either from feedback from \
Happiness (Effect of Happiness on Things Money Can't Buy) or from external \
events (Non-monetary event).
|

Time of things money can buy event=
PULSE(Start money, Duration money)
~ Dmnl
~ |

Duration money=
1
~ Day [1,1]
~ |

"Strength of Non-monetary event"=
0
~ Dmnl [-1,1,0.1]
~ Determines the strength of the event and is given as a fraction of the \
actual stock level. (e.g. 0.5 = 50%)
|

Things Money Can Buy= INTEG (
Change of Things Money Can Buy,
Init Tmcanb)
~ Stock Points
~ Aggregation of Happiness Drivers that are associated with the financial \
situation of an individual, such as socio-economic status and purely \

monetary wealth.
|

Strength of Monetary event=
0
~ Dmnl [-1,1,0.1]
~ Determines the strength of the event and is given as a fraction of the \
actual stock level. (e.g. 0.5 = 50%)
|

Start money=
0
~ Day [0,3650,1]
~ |

Change of Things Money Can Buy=
Effect of Happiness on Things money can buy+Monetary event/Adjustment time monetary event
~ Stock Points/Day
~ Changes in the Happiness Drivers can result either from feedback from \
Happiness (Effect of Happiness on Things Money Can Buy) or from external \
events (monetary event).
|

"Duration non-money"=
1
~ Day [1,1]
~ |

Init Tmcan'tb=
5
~ Stock Points
~ |

Init Tmcanb=
5
~ Stock Points
~ |

Time of things money can't buy event=
PULSE("Start non-monetary", "Duration non-money")
~ Dmnl
~ |

"Start non-monetary"=
0
~ Day [0,3650,1]
~ |

Change in Happiness from Things Money Can Buy=
(1/0.693147)*LN(Relative Stock Level of Things Money Can Buy+1)-1
~ Dmnl
~ This analytical nonlinear function translates changes in the happiness \
drivers stocks into psychic income flows. Thereby, its output is a measure \
for the change in Happiness. Special points of this function here are \
(0,-1) (high expectations with little achievements lead to strongly \
negative psychic income flows) and (1,0) (if achievements coincide with \
expectations, there is no effect on the psychic income flow) as well as an \
output of 1 for great inputs (high achievements, compared to expectations \
lead to high psychic income flows). These characteristics could be \
approximated by a table function as well.
|

Adjustment Time for Expectation Level of Things Money Can't Buy=
10
~ Day
~ Aspiration times for things money can buy are usually shorter than for \
things money can't buy.
|

Relative Stock Level of Things Money Can't Buy=
Things Money Can't Buy/Expectation Level of Things Money Can't Buy
~ Dmnl
~ Happiness effects from happiness drivers are assumed to be dependent on \
achievents, relative to expectations, as human beings are not able to make \
absolute judgments but only relative ones (Kahneman, see text body).
|

Change in Happiness from Things Money Can't Buy=
(1/0.693147)*LN(Relative Stock Level of Things Money Can't Buy+1)-1
~ Dmnl
~ This analytical nonlinear function translates changes in the happiness \
drivers stocks into psychic income flows. Thereby, its output is a measure \
for the change in Happiness. Special points of this function here are \
(0,-1) (high expectations with little achievements lead to strongly \
negative psychic income flows) and (1,0) (if achievements coincide with \
expectations, there is no effect on the psychic income flow) as well as an \
output of 1 for great inputs (high achievements, compared to expectations \
lead to high psychic income flows). These characteristics could be \
approximated by a table function as well.
|

Things Money Can't Buy= INTEG (
Change of Things Money Can't Buy,
Init Tmcan'tb)
~ Stock Points
~ Aggregation of Happiness Drivers that Money Can't Buy, such as Health, \
Social Networks and Family relationships, and the like.
|

Coefficient of Overoptimism of Things Money Can't Buy=
1.3
~ Dmnl
~ It is common sense in the psychology literature that expectations tend to \
be somewhat higher than the levels actually achieved. This fact is \
considered with the parameter "Coefficient of Overoptimism". The authors \
think it is reasonable to assume that expecatations are approximately 30 \
to 50 per cent higher than the levels actually achieved. Hence, the \
coefficient should be between 1.3 and 1.5.
|

Impact of Happiness on Things Money Can't Buy=
0.3
~ Dmnl
~ We assume that Happiness does have an effect on the Happiness Drivers. For \
example, happier people tend to report better health (Marmot, 2006), and \
happier people tend to be more open and find partners more easily (Frey \
and Stutzer (2002), p. 57). This parameter links Happiness to stocks such \
as Health, Social Networks and Family Relationships, which are here \
aggregated to 'Things Money Can't Buy'.
|

Happiness= INTEG (
Change in Happiness,
5)
~ Happiness Points
~ This is a qualitative measure of happiness that we are interested in. \
Notice that happiness is measurable in an objective way, e.g. by measuring \
the endorphine level in the person's blood or the intensity of brain \
activity in certain brain regions. Empirical research usually uses a scale \
of 0 (low happiness) to 10 (high happiness) when asking people questions \
on their overall satisfaction with life. Note that this scale is \
necessarily non-linear. A person, who is already very happy (10 Happiness \
Points) and experiences positive events can not report a higher happiness \
level, although she might want to do so. The same holds, vice versa, for \
the lower bound of the scale. Hence, the reader should not pay increased \
attention to violations of the 10 Happiness Points line in model runs, \
when extreme inputs are used. In our runs, we choose input values for \
which the model stays within the 0-10 Happiness Points scale.
|

Total Effect on Net Psychic Income Flow =
Change in Happiness from Things Money Can Buy+Change in Happiness from Things Money Can't Buy
~ Dmnl
~ Aggregation of the effects from all happiness drivers (in our case, the \
two aggregations 'Things Money Can Buy' and 'Things Money Can't Buy'. This \
is certainly an additive effect, as a stable Happiness Driver 1 does not \
mean that changes in Happiness Driver 2 have no effect on Happiness.
|

Coefficient of Overoptimism of Things Money Can Buy=
1.3
~ Dmnl
~ It is common sense in the psychology literature that expectations tend to \
be somewhat higher than the levels actually achieved. This fact is \

considered with the parameter "Coefficient of Overoptimism". The authors \
think it is reasonable to assume that expecatations are approximately 30 \
to 50 per cent higher than the levels actually achieved. Hence, the \
coefficient should be between 1.3 and 1.5.
|

Impact of Happiness on Happiness Drivers=
(1/0.693147)*LN(Relative Happiness+1)-1
~ Dmnl
~ This function, translating changes in "Happiness" in an "Impact of \
Happiness on Happiness Drivers" is the pendant to the function on the \
'left side' of the model, which translates Relative Stock Levels of Things \
Money Can('t) Buy to Changes in Happiness.
|

Impact of Happiness on Things Money Can Buy=
0.1
~ Dmnl
~ We assume that Happiness does have an effect on the Happiness Drivers. For \
example, happier people tend to be more successful in their jobs (Frey and \
Stutzer, 2002), and are therefore expected to have greater incomes.
|

Normal Happiness=
SMOOTH(Happiness,Normal Happiness Adjustment Time)
~ Happiness Points
~ The authors consider the impact of happiness on the happiness drivers not \
to be dependent on the absolute level of happiness (or a fractional \
dimensionless figure), but on a relative measure. See the comment on \
"Relative Stock Level of Things Money Can('t) buy). One might, for \
example, assume that happier people are more creative (numerous statements \
like this are to be found in the popular press). This does, though, \
obviously not hold for the absolute level of happiness: neither Mozart nor \
Kafka are believed to have been all too happy with their lives. The \
statement can thus only be understood for "relative happiness": it might \
very well be that Mozart and Kafka had their brightest moments in a \
moment of unusual happiness.
|

Normal Happiness Adjustment Time=
10
~ Day
~ Normal Happiness adapts to the current level of happiness. This is implied \
by empirical studies, reporting that people's reports on their happiness \
level in the past are biased. (The same holds for predictions of \
happiness. They are seldemly true.) See Kahneman (1999) or Gilbert (2006).
|

Relative Happiness=
Happiness/Normal Happiness
~ Dmnl
~ Relative Happiness is a way to evaluate one's present happiness level with \
regard to one's normal level of happiness. That is, values greater than 1 \
for "Relative Happiness" characterize states of unusually great happiness; \
values smaller than 1 characterize states of unusually small happiness.
|

Adjustment Time for Expectation Level of Things Money Can Buy=
5
~ Day
~ Aspiration times for things money can buy are usually shorter than for \
things money can't buy.
|

Relative Stock Level of Things Money Can Buy=
Things Money Can Buy/Expectation Level of Things Money Can Buy
~ Dmnl
~ Happiness effects from happiness drivers are assumed to be dependent on \
achievents, relative to expectations, as human beings are not able to make \
absolute judgments but only relative ones (Kahneman, see text body).
|

Normal Flow of Psychic Income Adjustment Time=
30
~ Day
~ Estimation of the authors. Headey and Wearing (1991) explain changes in \
the Happiness level with deviations from the normal flow of psychic \

income. This implies that there is some adaptation time. However, \
quantitative estimations are not given.
|

Coefficient of Effect to Flow=
1
~ Happiness Points/Day [0,3,0.1]
~ There is a lot of empirical data on correlations of (changes in) happiness \
drivers on Happiness given in the literature. This coefficient helps to \
translate these effects on Happiness in effects on the Psychic Income \
Flow. For qualitative purposes, one can run the model, setting the \
parameter to 1.
|

Csikszentmihályi Flow=
Strength of Csikszentmihályi Flow*PULSE(Csikszentmihályi start, Csikszentmihályi duration\
)
~ Happiness Points/Day
~ After the psychologist Csikszentmihályi, the greatest happiness comes \
>from absorbing oneself in an activity "outside oneself", in which one \
forgets time, and everything that surrounds one. This might be eating, \
sports, sex, work or other activities that are usually connected with \
following a certain goal. See Layard (2005), pp. 74-75 and Kahneman \
(1991), p.6, for reference.
|

Deviation from Normal Psychic Income Flow =
Current Psychic Income Flow-Normal Psychic Income Flow
~ Happiness Points/Day
~ Deviation Flow of Psychic Income. It is this value that is directly \
responsible for changes in Happiness. Headey and Wearing (1991) give the \
equation on p. 64. Note that the same happiness level can be realized \
either with high or low flows of psychic income. The modulus of the flow \
is meaningless.
|

Normal Psychic Income Flow =
SMOOTH3(Current Psychic Income Flow,Normal Flow of Psychic Income Adjustment Time)
~ Happiness Points/Day
~ |

****
.Control
**********~
Simulation Control Parameters
|

FINAL TIME = 365
~ Day
~ The final time for the simulation.
|

INITIAL TIME = 0
~ Day
~ The initial time for the simulation.
|

SAVEPER =
TIME STEP
~ Day [0,?]
~ The frequency with which output is stored.
|

TIME STEP = 0.125
~ Day [0,?]
~ The time step for the simulation.
|

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