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**Abstract**

This paper is broadly concerned with understanding the role of evolutionary efficiency in happiness realization. Towards this end, we examine the (distributive and) non-linear effects of inertia in a cross-country setting. We develop a general model of happiness inertia and study its properties in a stochastic and non-linear environment. This allows us to map out the net effects of evolutionary efficiency through 'adaptive capability' in an environment where stochastic shocks are both mean reverting and non mean-reverting. Our empirical estimation for a set of developed economies demonstrate that the adjustment of realized happiness to a stochastic non-mean reverting shock is non-linear implying the involvement of complex socio-economic processes in happiness perception. Moreover, we also find that the adjustment of current level of happiness to the past follows a heterogeneous distribution once again indicating that the extent of temporal (inter-)dependence is non-unique across the happiness distribution. Our results hold interesting policy implications.

**Key Words:** Evolutionary efficiency; cross-country life-satisfaction; inertia; non-linearity
**JEL Classifications:** C3, D31, D63, I31, N30, O52, P5.

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# 1 Introduction

Life-satisfaction[1] data is now increasingly used in cross-national studies and policy making as a preferable substitute for GDP to understand the magnitude of net welfare gain from various socio-economic measures (see for instance, Mishra et al., 2014). However, life-satisfaction is a very complex indicator, the sources of realization of which are often weighed by dynamic interdependence among psychological, societal, health, and economic gradients. While it is practically impossible to accommodate the myriads of such indicators in a single theoretical and empirical framework, it is nevertheless possible to capture the broad effects of their co-movements within new/developed theory. For instance, it is commonly believed that the various psychological determinants governing happiness perception can be modelled by the concept of 'inertia'. The latter - as recently emphasized in Rayo and Becker (2007), Bottan and Truglia (2011), and Mishra et al. (2014) - provides a theoretically plausible empirical basis to understand how the past level of realized happiness affects its current level. The dynamic interdependence between past and present happiness levels - captured in terms of evolutionary efficiency and autoregressive habit - can easily accommodate a host of psychological, economic, and health related factors, which otherwise would have required separate modelling. It is therefore important to characterize 'inertia' and examine its properties within flexible methodological and estimation environments.

Our specific interest lies in modelling happiness inertia from two perspectives. First, we intend to allow a non-linear dependence structure between current and past level of happiness. Linear adjustments between present and past happiness levels accounts for only a linear trend component implying that irrespective of whatever happens to our life and environment, our perception of happiness is governed by a fixed factor, the broad effects of which are often irreversible and unchangeable. For instance, certain minimum income and social circumstances are necessary for individuals to carry on living, which we call survivability. The latter is a necessary condition for persistence of a stable happiness minimum which is carried forward monotonically over time. There is also a significant non-linear component of perceived happiness - which to our phenomenal world - govern the most in our lives. For instance, while fixed bare minimum income is necessary for the lowest ceiling of happiness for survival, the growth of happiness is invariably affected by relative income and a host of socio-economic and psychological factors. The contribution of these factors to happiness growth is often so enormous that it can render the trend component of happiness as irrelevant and insignificant. The overall effects of all these factors are characteristically non-linear and thus, the dependence between current and past happiness levels should be studied in a non-linear environment.

Second, while it is natural to assume a non-linear dependence between current and past happiness levels, one may often wonder whether such dependence is unique across the entire distribution of happiness perception. It is possible that the magnitude of dependence between them is greater at the lower end of happiness distribution than at higher level. The possibil-

[1]Throughout the paper 'life-satisfaction' and 'happiness' would be used interchangeably and would broadly present the dynamics of subjective well-being.

ity of such heterogeneous nature of dependence may imply that individuals display varying ability to adjust to stochastic shocks at different stages of their happiness levels. Following psychological theory, we already know that a negative stochastic shock to an individual whenever he is very unhappy will have a far more detrimental effects on his future happiness perception than when this shock is imparted whenever he is happy. Following Rayo and Becker (2007) and Mishra et al. (2014) this would mean that the speed at which individuals' happiness evolves (that is, evolutionary efficiency a la Rayo and Becker, 2007) is significantly determined by the state of happiness the individual is currently dwelling. To sum up, modelling happiness inertia in an environment of non-linearity and distributional heterogeneity would enable us to capture the true dynamics of happiness evolution and help us an informed policy making. These two objectives form the core of the present paper.

The rest of the paper proceeds as follows. In Section 2, we present our model and discuss various theoretical properties. Section 3 presents our empirical construct which we use to estimate happiness inertia for a long-time series data of 20 developed countries. In this section, we also discuss the various empirical results. Finally, Section 4 concludes with the main findings with some policy implications.

## 2 Model

Our model closely follows Rayo and Becker (2007) and extended to accommodate features of non-linearity and heterogeneity as in Mishra et al. (2014). Our model underlines the importance of three characteristics. *First*, while we reckon that the hedonic impact of sustained changes in economic conditions has a tendency to diminish over time, such changes are also heterogeneously distributed over happiness distribution. *Second*, the individual's prior expectations of his own success in achieving higher happiness levels also remains largely constant across countries. *Third*, while happiness is volatile, it tends to revert over time to a relatively stable long-term mean. In essence, the three characters described above stress that inertia lies at the core of evolution of happiness.

Following the construct in the recent literature, we posit that habit persistence determines - to a large extent - how individuals perceive their current state of happiness. Persistence or broadly, the evolution of happiness for agent $i$ at time $t$ is therefore described by the following autoregressive (AR) process:

**Definition 1** ***Inertia and evolutionary efficiency****: Life-satisfaction ($h_{it}$) evolves as: $h_{it} = \psi_{it} + \theta_{it}$, where $\psi_{it}$ represents the efficiency level with which happiness is achieved (this indicates adaptive capability of the agent $i$ to stochastic shocks at time $t$). The autoregressive process, $\theta_{it}$ is represented by $\theta_{it} = \sum_{s=1}^{\infty} \alpha_{i,s}\theta_{i,t-s} + \epsilon_{it}$. Then, happiness for agent $i$ is given by $L_{it} = \psi_{it} + \sum_{s=1}^{\infty} \alpha_s\theta_{i,t-s} + \epsilon_{it}$.*

The AR structure of happiness (as presented in definition 1) is supposed to provide a more direct prediction of the hedonic adaptation hypothesis. Keeping in mind the objective of this paper, we study happiness across economies. Hence, $i$ in our setting represents countries.

We hold that individuals in country $i$ could potentially adapt more gradually over time, or even adapt only to a partial extent (i.e., when the sum of $\alpha_s$ coefficients is smaller than 1). Following this, when $\theta_t$ follows a process where a stochastic shock takes long time to taper-off, then the autoregressive habit of life satisfaction would imply that history dependence matters, i.e., a shock in the remote past if converges slowly to the long-run mean, then its impact on the life-satisfaction series would entail a non-linear convergence rate to its own steady state. The individuals in this country would take long-time to adjust to changing socio-economic environment and that the adjustment process turns out to be non-linear.

### 2.1 Characterizing the effects of inertia by habituation channels

Definition 1 presented above provides a general direction by which one can characterize evolutionary efficiency of happiness. Evolution indicates adaptive capability of an agent in response to a changing and uncertain environment. Evolutionary efficiency then implies the rate at which an agent adjusts to such an environment. While considering human happiness, it is natural to recognize that the adaptive capability varies widely across individuals based on their own genetic characteristics. However, assuming a deterministic genetic characteristics across individuals, we can study the evolutionary efficiency of happiness based on two habituation channels. These channels are partial expressions of the following core model as in Bottan and Truglia (2011):

$$h_{i,t} = \sum_{r=1}^{R} \alpha_r h_{i,t-r} + \sum_{q=1}^{Q} \beta_q X_{i,t-q} + \gamma_i + \psi_t + \epsilon_{i,t} \tag{1}$$

In (1) $X_{i,t}$ is a vector of time varying control variables, $Q$ and $R$ are the number of lags to be considered, $\gamma_i$ are fixed effects, and $\psi_t$ corresponds to time effects. Note also that (1) has two main components: First, component $X_{i,t}$ describing *habit persistence*, such that happiness at $t$ is affected by factors such as income, social status, etc. Second, component $h_{i,t-r}$ describes inertia. That is, in addition to other variables that affect current state of happiness, the latter is also determined (non-linearly) by its past level. Departing from Rayo and Becker (2007) and Bottan and Truglia (2011), we assume that both sets of predictors of $h_{it}$ interact with social and institutional processes thus allowing path dependence in happiness to occur when a contingent historical event triggers a subsequent sequence that follows a relatively deterministic pattern in happiness. In other words, the conditional happiness distribution needs to be fully characterized along the time path, which is the leading objective of this paper.

Then the two habituation channels are:

**General habituation and conditional autoregressive habits**:

$$h_{i,t} = \alpha h_{i,t-1} + \beta X_{i,t} + \gamma_i + \epsilon_{i,t} \tag{2}$$

As before $X_{i,t}$ is a vector of control variables of happiness, such as social position of the individuals. Assuming that these control variables are held constant at $X_i^s$, then the steady-state of happiness is given by $h_i^s = \beta X_i^s/(1-\alpha)$. The contemporaneous effects of changing the control variables is given by $\hat{\beta}$, while the effect in the long-run is given by estimated values of the parameters: $\hat{\beta}/(1-\hat{\alpha})$.

**Specific habituation and conditional autoregressive habits**:

In this case, we allow happiness to depend only on habit persistence controls, for example, by past and present values of individual income, such that

$$h_{i,t} = \beta_1 X_{i,t} + \beta_2 X_{i,t-1} + \gamma_i + \epsilon_{i,t} \tag{3}$$

Despite the presence of dynamic structure in the happiness model in (3), the model is less informative in comparison to (2) because the innate psychological trait of past dependence on happiness level is missing.

## 2.2 Non-linear path dependence and inertia

The autoregressive characterization of happiness in terms of both general and specific habituation can possess an important feature: that the dependence structure can be allowed to be characteristically non-linear. Putting differently, current level of happiness depends on the past level of happiness non-linearly. Indeed, past high level of unhappiness may get reflected in a certain level of unhappiness at present but in most likelihood this can have a reverse ripple effect on the current level. Moreover, current level of happiness can be described by past happiness at more than one lag period (defying the assumption of Markovian habit). Then, a stochastic shock in the remote past can affect current happiness and the effect can be modeled through non-linear interaction.

An important mechanism through which we can introduce non-linearity in the habituation channels is to assume the following free functional form:

$$h_{it} = \sum_{j=1}^{p} f_j(h_{i,t-r}; \mathbf{x}_{it}^j) + \mu_i + \varepsilon_{it}, \qquad i = 1, \cdots, N; \quad t = 1, \cdots, T. \tag{4}$$

where $h_{it}$ denotes the happiness variable, $h_{i,t-r}$ denotes past level of happiness, $\mathbf{x}_{it}^j$ are $j$ explanatory variables for $j = 1, \cdots, p$, the $f_j$ are unknown univariate functions to be estimated; $\mu_i$ is unobserved individual specific effects for which we allow arbitrary correlation with $\mathbf{x}_{it}^j$. As evident, the function $f_j(.)$ contains variables which correspond to both general and specific habituations. The specification above also allows us to capture non-linearities and heterogeneity in the effect of explanatory variables on the response variable. In this formulation, we make no assumption on $\mathbb{E}(\mu_i | h_{i,t-r}; \mathbf{x}_{it}^j)$ for any set of dates $t = 1, \cdots, T$. We assume that errors $\varepsilon_{it}$ are independent and identically distributed, but no restriction is placed on the temporal variance structure. A detailed estimation procedure and properties of the above model is presented in Azomahou and Mishra (2008).

Following the above construct, we can now investigate if cross-country happiness converges non-linearly to their respective steady-state. Setting $i = 1$ with $t$ as large, we can represent the non-linear path dependence in a reduced form equation without any explicit effects of $x_t$. The starting point is to consider an autoregressive process (of order 1, AR(1)) for happiness ($h_t$) series following Definition 1.

$$h_t = \alpha + \rho h_{t-1} + \epsilon_t \tag{5}$$

for $t = 1, \ldots, T$, and $0 < |\rho| < 1$, $\alpha = (1 - \rho)h$, $\epsilon_t$ is a white noise, and $h$ is the long-run equilibrium level of happiness. Then the convergence of each country to its own steady state happiness level can be estimated by half-life which is defined as the number of years required for the deviation at an initial level, $h_0$, to dissipate by half, i.e.,

$$\Gamma = \frac{\ln(1/2)}{\ln|\rho|} \tag{6}$$

In the above, the impulse response function (IRF) of the AR(1) model is given by $\rho^\Gamma \delta = \delta/2$. Moreover, note that $\Gamma$ becomes greater than unity only if the speed of adjustment is slower than that of the AR(1) model with $|\rho|$ = 0.5. As $|\rho|$ approaches unity, the speed of adjustment $\ln|\rho|$ approaches zero from the left, and half-life $h$ approaches infinity, implying the absence of convergence of happiness towards steady-state happiness level. However, this simple linear half-life measure of happiness omits relevant complex interaction dynamics, which we have argued contribute significantly to non-linearity.

The idea of non-linear deviations of happiness from steady-state level is mainly justified by the presence of complex social economic interactions, decision making and implementation processes. Being multidimensional in nature, happiness is influenced by both autoregressive habit or habit persistence, and inertia, i.e., dynamic interdependence of happiness between present and past happiness level. Looking at from habit persistence perspective, happiness at time $t$ is then determined by other social and economic factors at $t - 1$. Putting together, $h_t = f(h_{t-1}, \bar{X}_{t-1})$, where the component, $h_{t-1}$ represents inertia, and $\bar{X}_{t-1}$ represents habit persistence. Due to this complex characterization of happiness evolution, the deviations of

happiness from steady-state level is non-linear. Therefore, it is logical to test for local speed of convergence of happiness from non-linear perspective.

Recall that the speed of adjustment for a linear model (as well as its half-life) is constant and does not depend on the initial level $h_0$, or the size of shock $\delta$. In this environment, half-life for happiness implies that the time needed for the initial deviation $\delta$ for happiness to become $\delta/2$ is shorter than the time for $\delta/2$ to become $\delta/4$ and both lengths now depend on $h_0$ and $\delta$ (Shintani, 2006). Under non-linear environment then,

$$h_t = g(h_{t-1}) + \epsilon_t \tag{7}$$

where $g(h_{t-1})$ is a conditional mean function $E(h_t|h_{t-1})$. The non-linear local half-life based on the initial happiness level, $h_0$, then becomes:

$$\Gamma(h_0) = \frac{\ln(1/2)}{\ln|Dg(h_0)|} \tag{8}$$

where

$$Dg(h_0) = \lim_{\delta \to 0} \frac{g(h_0 + \delta) - g(h_0)}{\delta} \tag{9}$$

This procedure describes how happiness process adjusts non-linearly following stochastic shocks, the implications of which are of interest to academics and policy practitioners. A summary measure of happiness persistence can be constructed by using the average local speed of convergence of happiness, i.e., $g^* = \frac{\ln(1/2)}{\lambda}$, where $\lambda$ is the largest Lyapunov exponent that measures stability of the dynamic system in terms of the sensitive dependence on initial conditions. In our case, $\lambda \equiv \lim_{t\to\infty} T^{-1} \sum_{t=1}^{T} \ln|Dg(h_{t-1})|$.

The non-linear happiness evolution model $h_t = g(h_{t-1}) + \epsilon_t$ can be estimated by using the non-parametric regression technique without the specification of functional form. To estimated $\lambda$ from data, Nychka et al. (1992) have proposed a sample analogue estimator based on the non-parametric method. Following this, then the estimate of $m^* = \frac{\ln(1/2)}{T^{-1}\sum_{t=1}^{T} \ln|\hat{D}g(h_{t-1})|}$, where $\hat{D}g(h_{t-1})$ is a non-parametric estimator of the first derivative of the non-linear happiness dependence, $g(h_{t-1})$ and $T$ is the sample size. In Shintani and Linton (2003), it is shown that the Lyapunov exponent based on the local quadratic regression converges to zero when the true process is random walk, or in our case, $g(h_{t-1}) = h_{t-1}$ with an *iid* error. This implies that $\hat{m}^*$ is also consistent in the sense that it diverges to infinity for a unit root or non-stationary long-memory case.

### 2.3 Heterogeneity in the distribution of autoregressive habit

The heterogeneity in the distributive effects of inertia can be modelled following on the work of Koenker and Xiao (2006). If we denote the $\tau$-th quantile of $\epsilon_t$ as $Q_\epsilon(\tau)$ and let $Q_{h_t}(\tau)|h_{t-1}$

denote the $\tau$-th conditional quantile of $h_t$ conditional on $h_{t-1}$, then:

$$Q_{h_t}(\tau|h_{t-1}) = Q_\epsilon(\tau) + \rho h_{t-1} \tag{10}$$

Let $\rho_0(\tau) = Q_\epsilon(\tau), \rho_1(\tau) = \rho$, and define $\rho(\tau) = (\rho_0(\tau), \rho_1(\tau))^\intercal$, $x_t = (1, h_{t-1})^\intercal$, we have $Q_{h_t}(\tau|h_{t-1}) = x_t^\intercal \rho(\tau)$.

In this model the $\tau$-th conditional quantile function of the response $h_t$ is expressed as a linear function of lagged values of the response. Estimation of the linear quantile autoregressive model involves solving the problem:

$$\min_{\rho \in R^2} \sum_{t=1}^{n} (\alpha_\tau(h_t - x_t^\intercal \rho) \tag{11}$$

where $\alpha_\tau(\epsilon) = \epsilon(\tau - I(\epsilon < 0))$. Solutions to the above equation is called $\tau$-th autoregression quantile: viewed as a function of $\tau$ we will refer to $\hat{\rho}(\tau)$ as the QAR(1) process (Koenker and Xiao, 2006).

In the following section, we will estimate, using a long time series happiness data for 12 developed countries, both non-linear and quantile auto-regressions.

# 3 Empirical analysis

## 3.1 Data

The empirical illustrations carried out in this section use time series data for life-satisfaction (1971-2007) for twelve countries which shares socio-culturally affinities.[2] Lu and Gilmour (2004) and Veenhoven (2012) stress that the components of perceived happiness vary significantly across countries differentiated by cultural similarities and social expectations. In particular, it has been observed that whereas Asians concentrate more on role obligation and dialectical balance, Euro-Americans focus more on personal accountability explicit pursuit. A single index of life-satisfaction that compares these two sets of nations may lend to biased inferences because of the inability to control for unobserved socio-cultural characteristics in the estimation process. Since we are interested in understanding dynamic interdependence in happiness across nations, we would like to limit our sample to similar socio-cultural characteristics so that the estimated parameters are comparable, unbiased and consistent. Moreover, for the type of analysis we are interested in, we required a sizeable time series data the length of which will be sufficient enough to study persistence behavior. Under these binding conditions, we have gathered consistent time series data for 12 European countries.

Happiness is measured here by overall life satisfaction, the response to the question 'All things considered, how satisfied are you with your life as a whole these days". The data have been compiled from various sources, such as the World Values Survey (World and Euro-

[2]We sincerely thank Richard Easterlin and Laura Angelescu for kindly sharing their data set for the present study.

pean Values Surveys Four-Wave Integrated Data File 2006; World Values Survey 2005 Official Data File V.20081015, 2008), Eurobarometer (retrieved from http://zacat.gesis.org), and Latinobarometer (retrieved from http://www.latinobarometro.org). We have adjusted for survey differences in the number of response categories by rescaling to a 1-10 scale. To rescale from a 1-4 to a 1-10 response scale, a response of 4 corresponds to a response of 10, a response of 1 on 1-4 scale corresponds to 1-10 scale. Required linear transformation with the formula, $y = 3x - 2$ (where $y$ represents life satisfaction in World Value Survey (WVS) scale, and $x$ represents life satisfaction on the non-WVS scale) was used. Easterlin and Angelescu (2009, 2010) discuss the transformation technique, merits and demerits of various data sources with respect to time and cross-sectional variations. In the regression results the slope coefficients are those based on the rescaled responses.

In order to match the annual observations of GDP per capita and other variables listed below, we date the observations on life satisfaction, not at the actual survey dates. We must also stress that the data constructed here - even though has been cross-checked using published sources for overall similarity in trend - may not still be faultless. Mainly because, irrespective of whatever transformation technique one may apply, the definitional and conceptual differences in happiness in various survey bias our conclusions.[3] For instance, whereas World Value Survey (WVS) refers as life-satisfaction in 'these days', Eurobarameter asks 'taking all things together would you say you are very/quite/not very/not at all happy?' However, since our empirical analyses uses aggregate data (the mean for a specific country), such differences may not sharply affect the general conclusions.

It is essential to emphasize here that the question on life satisfaction may change over time. In cases, we have uneven data, we have followed Easterlin and Angelescu (2009, 2010) to pool the data and use dummy variables for the different segments to account for the difference in response level attributable to the change in survey questions. Additionally, the context of the life satisfaction question may change. In the Eurobarometer, for example, there are a few surveys in which a question on satisfaction with finances is inserted before that on overall life satisfaction. People generally are less satisfied with their finances than with life in general, and the replacement of a neutral question with one on financial satisfaction tends to bias downward responses on life satisfaction. We have deleted the life satisfaction observations in the years that are so biased.[4]

### 3.2 Results of non-linear path dependence and characteristics of inertia

In this section, we present results of non-linear half-life estimation (see the preceding section for detailed description of the methodology). Table 1 present these results. As can be observed, the estimated local speed of convergence of happiness envisage interesting patterns. On the one hand, quite similar values between the two measures are obtained for France, UK, Lux-

[3]Many thanks to the anonymous referee for underlining the importance of the same while interpreting our results.

[4]For robustness check we have also collected data from the World Happiness Database and have re-estimated our models. The results - despite some minor change in values - do not alter the conclusions of the paper.

embourg, Ireland, Greece, Portugal, and Denmark. On the other hand, somewhat shorter half-lives are obtained with a nonparametric/non-linear measure for Italy, Germany, Ireland, Spain, and Denmark. The largest reduction is observed in the case of Spain and Italy. In case of Spain, the half-life based on the conventional linear measure is 6.037 which is approximately three times more than with the non-linear estimated (1.855). Similarly, for Italy the linear measure is 5.038, that is more than 5 years. This is twice as high as non-linear measure (2.392). Moreover, Germany's linear half-life estimate (3.427) is twice higher than its non-linear estimate (1.263). What do the convergence speed imply for linear and non-linear measures? Whenever there is largest reduction in speed of convergence in happiness data with respect to a non-linear measure, it implies that the linear measure overestimated the speed of local convergence of happiness to its own steady-state. Relatedly, whenever similarity in convergence speed was found for both linear and non-linear measures, the estimated speed has been approximately exactly represented. However, the presence of significant difference between linear and non-linear estimates of convergence implies that for all countries, a stochastic exogenous shock to happiness series would not taper off linearly, rather it would leave some effects on the historical trajectory of the series.

Even if there is only moderate difference between linear and non-linear persistence measures, it does not imply that the adjustment process is well-approximated by the linear process. This point becomes clearer if we look further at the shape of the local speed of adjustment, $\ln |Dm(\hat{h}_{t-1})|$, and the exact half-life based on non-linear IRFs. The patterns are presented in Figures 1-3. The respondents for a specific country is averaged to produce mean life-satisfaction for that country at each time period. As evident, a quadratic convergence pattern of happiness is prominent for Luxembourg, Denmark, Belgium, and Ireland. For Netherlands, UK, Italy, France, and Germany, the local speed of convergence is still non-linear but the extent of non-linearity is higher than that for the former set of countries. This could imply that stochastic shocks of varying magnitudes are governing the dynamics of happiness trajectory for different countries. Additionally, the non-linear estimates of half-life-like convergence evince that no single country's happiness processes converge linearly to their steady-states. Rather, the evidence of non-linear convergence speed (albeit with different degrees among nations) provide motivation to further investigate the potential role of various factors and their dynamic interdependence over time.

### 3.3 Evidence of non-linearity in happiness inertia and QAR results

Before characterizing inertia in a quantile setting, it is necessary to understand the motivation behind doing so. Indeed, following psychological literature, a common expectation about the (conditional) distribution of happiness is that it is multi-modal, i.e., one may find clusters of happy and unhappy economies (see for instance, Okulicz-Kozaryn, 2011). Existence of such clusters has important implications, especially noting that they normally reflect the existence of multiple equilibria or happiness poverty-trap. In other words, in the world distribution of life-satisfaction some countries are likely to be trapped under low-level of life satisfaction and

Table 1: Linear and non-linear half-life convergence

| Variables/ Estimator | Half life using Linear AR model | | Half-life using Nonlinear IRF | |
|---|---|---|---|---|
| | *Half-life* | *95% CI* | *Half-life* | *95% CI* |
| Belgium | 2.003 | [1.078, 5.906] | 1.381 | [0.920, 2.771] |
| Netherlands | 1.339 | [0.694, 3.567 ] | 1.358 | [1.037, 1.966] |
| Luxembourg | 1.453 | [0.757, 3.799] | 1.767 | [1.211, 3.264] |
| France | 1.868 | [0.964, 6.092] | 1.713 | [1.267, 2.641] |
| Italy | 5.038 | [2.316, 10.50] | 2.392 | [1.415, 7.742] |
| UK | 0.773 | [0.376, 1.653] | 0.807 | [0.596, 1.252] |
| Greece | 1.691 | [0.792, 7.405] | 1.586 | [1.032, 3.422] |
| Portugal | 2.037 | [0.941, 12.125] | 2.133 | [1.440, 4.115] |
| Spain | 6.037 | [2.989, 78.568] | 1.855 | [1.061, 7.364] |
| Ireland | 1.483 | [0.841, 3.385] | 1.285 | [0.932, 2.068] |
| Denmark | 2.599 | [1.353, 9.950] | 2.317 | [1.713, 3.578] |
| Germany | 3.427 | [0.703, 3.427] | 1.263 | [0.772, 3.470] |

some at high-level equilibria. Such equilibria provide evidence of non-unique socio-economic policies. From policy perspectives, understanding the existence and stability of such equilibria are important as strategic policies can be adopted to escape this trap and help economies in making transition from low level of life-satisfaction to higher level (see for instance, the recent European Commission's strategy).

to begin with, we have plotted first, for all countries taken together the evolution of variance of happiness over time. In Figure 1, the left hand side graph presents the plot of variance of all countries' happiness series against time. The variance shows a U-shaped pattern: beginning in 1970 (which had the highest variance), subsequent years depicted a decline in variance (falling to the lowest in 1990s). Since this year, he variance has been rising although with some unstable pattern. Overall, it can be concluded that, variance of happiness has never experienced a constant growth. Rather, as it appears, the spread of happiness from its mean has been rising since the last two decades indicating - although indirectly - the influence of uncertain environment countries are sailing through. The right hand side of Figure 1 presents the QAR plot of the aggregate happiness data for 12 countries together. As expected, a high past dependence of happiness level is observed at low quantile (for instance, at $\tau = 0.2$). At higher quantiles, the effect of inertia is steadily falling indicating that the when happiness level is at its highest, path dependence has little role to play in the realization of current level. This further implies that the extent of path dependence can be sensitive at lower quantiles, that is at lower levels of happiness.

But, do the country-specific estimates evince the same characteristics? In general, looking at Figures 2-7, it can be observed that the AR coefficients are not constant for all countries. While for some, fitted at low quantiles, the process behaves like a random walk, a strong mean

reversion is observed for high quantiles. This asymmetry suggests the process of happiness realization is heteroskedastic, i.e., the variance in the lower end is higher than in the higher end so we get fan like figure instead of parallel lines. Among 12 countries while Luxembourg, France, Germany, Irelands display a declining effects of inertia at higher quantiles, other countries, in particular - for instance - Spain, UK, and Portugal depict reverse trend. that is, at higher quantiles, we observe a near perfect dependence between current and past happiness levels. For the rest of the countries, there is a mixed pattern: until 50th quantile, while for some inertia is stable, it turns unstable at higher quantile indicating the influence of complex factors in happiness perception.

Figure 1: Quantile AR coefficients and variance for all countries: Variance [left] and QAR [right].

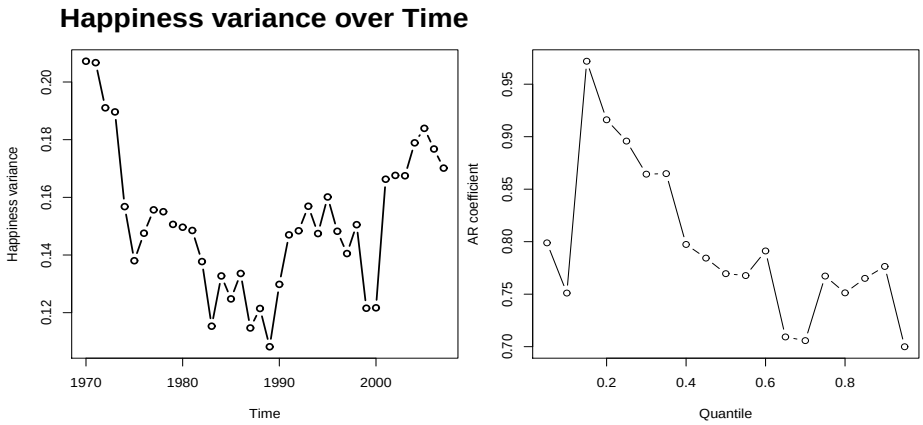



Figure 2: Quantile AR coefficients: Belgium [left] and Denmark [right].

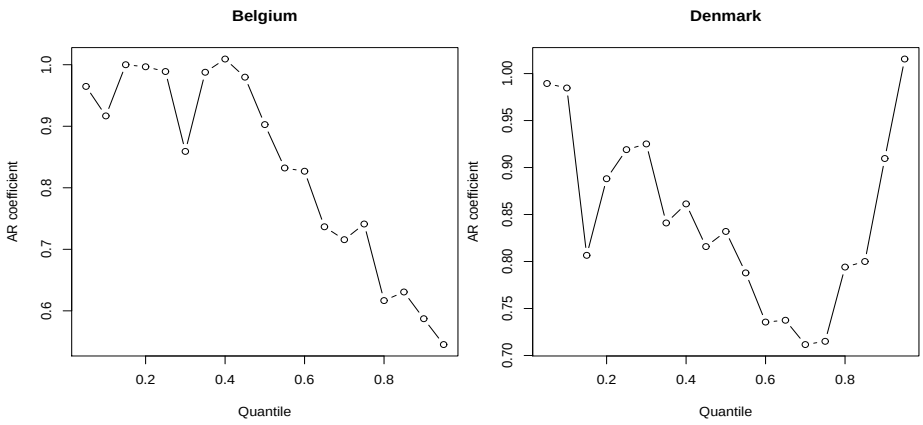


Figure 3: Quantile AR coefficients: France [left] and Germany [right].

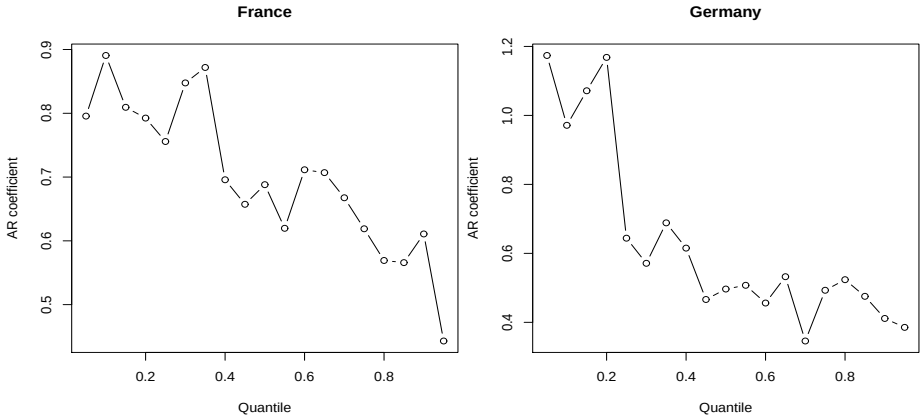



Figure 4: Quantile AR coefficients: Greece [left] and Ireland [right].

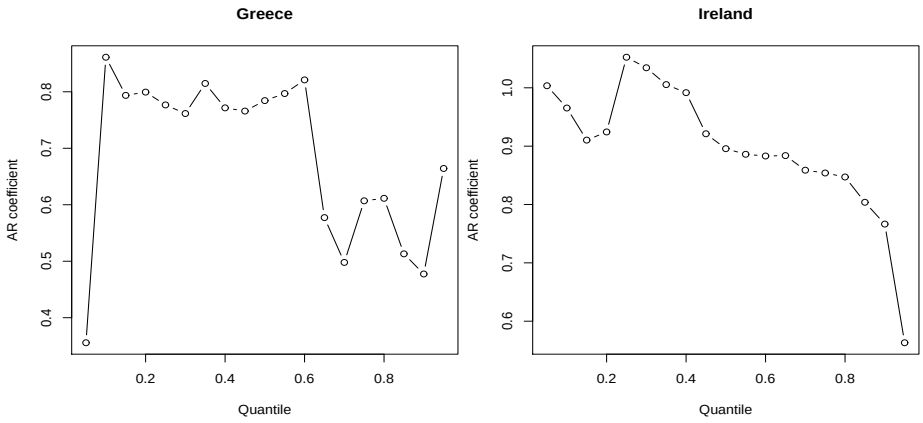



Figure 5: Quantile AR coefficients: Italy [left] and Luxembourg [right].

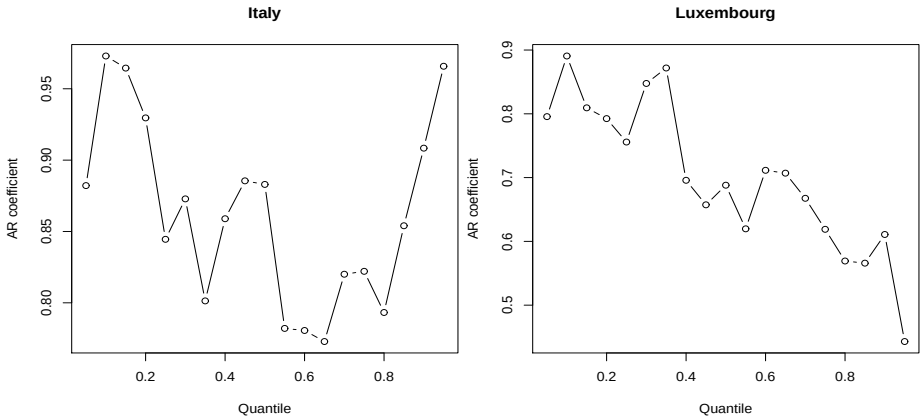


Figure 6: Quantile AR coefficients: Netherlands [left] and Portugal [right].

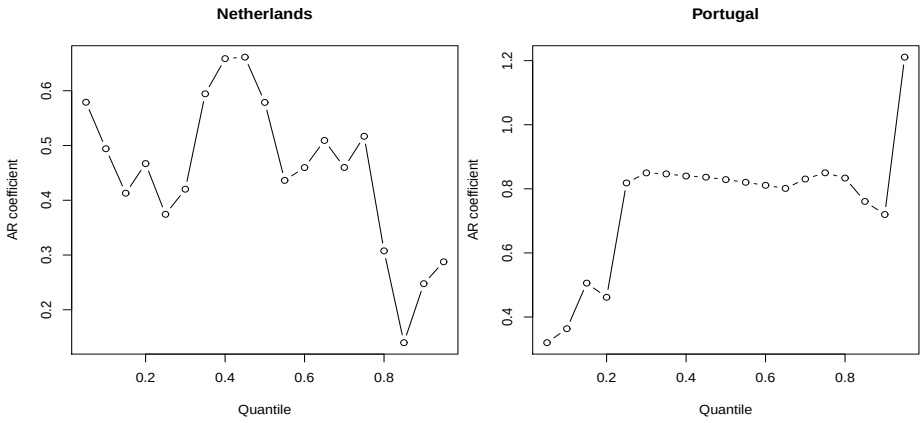
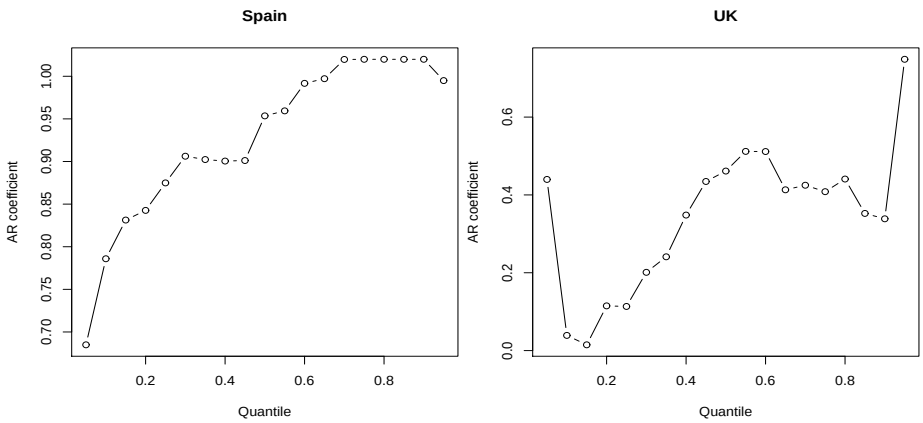



Figure 7: Quantile AR coefficients: Spain [left] and UK [right].



## 4 Conclusions

This paper attempted at building a flexible methodological and empirical framework for characterizing evolutionary efficiency of happiness. We outlined two directions. We argued that while non-linear path dependence in happiness is important for understanding the inherent complex nature of happiness perception, its distributive effects across quantiles is equally relevant.

Our theoretical framework put forward the significance of habituation and understanding its properties in evolutionary perspective. We demonstrated that the rate at which agents adopt to current socio-economic environment depends non-linearly on inertia, that is, the perceived level of happiness in the past. The adjustment of past to the present is non-linear and distributed heterogeneously implying the necessity of a non-unique policy intervention. Our empirical examination of 12 European countries confirmed the theoretical predictions.

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