Research Article

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Adaptation and Loss Aversion in the Relationship Between GDP and Subjective Well-Being

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Abstract: We examine the roles of macro-level adaptation — including social comparison effects becoming more important over time — and macroeconomic loss aversion in the time-series relationship between national income and subjective well-being. Models allowing for these phenomena are applied to cross-country panel data. We find evidence for macroeconomic loss aversion that becomes more important over time: the effects of economic growth become small and statistically insignificant in the long run, whereas the effects of contractions are large and long-lasting. The results are consistent with the Easterlin paradox and point to it being explained by macro-level adaptation to economic growth. Our results highlight the importance of allowing for both dynamics to distinguish long-run from short-run effects and asymmetries to recognize the important effects of contractions. Failing to do the former leads to a misleading impression of the long-run relationship between economic growth and well-being.

Keywords: subjective well-being, life satisfaction, adaptation, loss aversion, GDP

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1 Introduction

Although empirical literature has documented statistical links between movements in a nation's GDP and its citizens' subjective well-being (SWB), today's long-term data still seem to confirm Easterlin's (1974) early observation that, despite

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substantial economic growth, there has not been a significant increase in SWB. Evidence for a zero long-run relationship between the gross domestic product (GDP) and SWB, together with evidence for a positive cross-sectional relationship both within and across countries, constitutes the Easterlin paradox. In the present study, we examine the time-series relationship between national income, as measured by GDP per capita, and the average national SWB using a panel of European countries. In particular, we apply the now standard asymmetric dynamic models to explore how the proposed behavioral mechanisms behind the Easterlin paradox — hedonic adaptation, social comparison effects, and macroeconomic loss aversion — are reflected in the relationship.

Empirical micro-evidence on hedonic adaptation and social comparisons implies that, at the macro-level, the effects of national income changes on the average national well-being wear off over time, which we call 'macro-level adaptation'. Specifically, macro-level adaptation arises because people adapt to the effects of changes in their income, and because a change in others' income takes time to have its full comparison effect (Di Tella, Haisken-DeNew, and MacCulloch 2010; Kaiser 2020; Vendrik 2013). Although there is disagreement about the relative importance of the two mechanisms, the micro-evidence from individual countries is consistent with the notion of significant or even complete macro-level adaptation. In line with the micro-evidence, evidence based on macro data from European countries suggests that well-being adapts to the effects of national income changes, and that the adaptation may be complete (Di Tella and MacCulloch 2008; Di Tella, MacCulloch, and Oswald 2003; Kaiser and Vendrik 2019).[1]

The third mechanism, macroeconomic loss aversion, means that the well-being responses to negative GDP changes are larger than the responses to positive changes.[2] De Neve et al. (2018) is the only previous study on macroeconomic loss aversion. However, their evidence for macroeconomic loss aversion is convincing because it is based on three different international surveys. Their analysis is limited to the short-run effects which mean that it is not known whether the large effects of economic contractions are long-lasting or are adapted to. De Neve et al. (2018) base the hypothesis of macroeconomic loss aversion on the general

1 Some of the macro studies model individual-level SWB and some other (such as ours) average national SWB. However, it is easy to see that the analyses are equivalent (and therefore comparable) as long as all the regressors are macro-level variables (though weights of country-years depend on sample sizes in micro models), which applies to the analyses of macroeconomic loss aversion as well.

2 Kahneman and Tversky's (1979) original notion of loss aversion was related to decision making, but the authors later note that knowledge of to what extent, and for how long, loss aversion is actually experienced would provide a criterion for evaluation of rationality of loss aversion in decision making (Tversky and Kahneman 1991).

tendency of people to be loss averse. Indeed, there are several micro studies on personal income changes and SWB that support the idea of asymmetric experiences of economic changes (Boyce et al. 2013; D'Ambrosio and Frick 2012; Di Tella, Haisken-DeNew, and MacCulloch 2010; Frijters, Johnston, and Shields 2011).

Despite the evidence for macro-level adaptation and macroeconomic loss aversion, no analysis incorporating both of these has been conducted.[3] The lack of such studies has two consequences. First, it is clear that ignoring one phenomenon may bias the results for the other. Therefore, it is not known how robust the findings on macro-level adaptation are to controlling for macroeconomic loss aversion, and vice versa. Particularly interesting from the perspective of the debate on the Easterlin paradox is the possible negative bias in the estimated long-run SWB effects of national income due to the omission of macroeconomic loss aversion. Second, nothing is known about whether there is macroeconomic loss aversion in the long run or whether adaptation to positive and/or negative changes leads to changes in the effect asymmetry. It has been hypothesized that adaptation to the effects of negative GDP changes may be different from adaptation to the effects of positive changes and some authors have called for research on this issue (e.g., De Neve et al. 2018; Easterlin 2009).[4]

In this paper, we adopt an empirical model, novel in the SWB literature, which incorporates both macro-level adaptation and macroeconomic loss aversion. Thus, we can contribute to the literature by avoiding biases arising from ignoring one of the phenomena, and by providing the first findings on long-run macroeconomic loss aversion. We use macro-level well-being data from the EB surveys and national income data. The data cover more than 30 countries and include annual observations for many of the countries over three or four decades. Thus, the data cover multiple recessions and periods of growth, which is ideal from the point of view of examining macroeconomic loss aversion in the long run.[5]

We find that the well-being changes associated with negative changes in national income are greater than those associated with positive changes. This asymmetry is observed both in the short run and in the long run, and it becomes more important over time. This stems from nations' complete adaptation to

3 At the micro-level, Frijters, Johnston, and Shields (2011) go some way towards allowing for both adaptation and loss aversion (but not social comparisons) by regressing life satisfaction on multiple lags of self-reported indicators of major positive and negative financial changes.

4 Some recent studies focusing on the SWB effects of negative income changes report that they are long-lasting. Hovi (2020) focusses on recessions experienced in one's youth and Clark, D'Ambrosio, and Ghislandi (2016) on personal income drops, especially those leading to poverty.

5 At the outset, a clear distinction between *short-run/long-run effects* (as in standard time series models) and *effects of short-run fluctuations and long-run growth* should be made. We focus on the former, as do the studies of adaptation listed above, but also provide results on the latter.

positive changes and non-existent or, at best, far from complete adaptation to negative changes. Our results suggest that the Easterlin paradox is explained by economic growth failing to lead to well-being improvements in the long-run. Although, according to our results, the negative well-being effects of economic contractions are not the reason for the paradox, they are so large and long-lasting that they are highly relevant from the point-of-view of further research and economic policy.

The key lesson for analysts of the GDP–SWB time-series relationship is that both macro-level adaptation and loss aversion need to be allowed for. When both are ignored and an SWB variable is simply regressed on a GDP variable, the positive short-run relationship is likely to lead to an illusion of a significant long-run relationship between economic growth and SWB. Failing to allow for loss aversion but allowing for adaptation seems to result in only a minimal bias in the estimated long-run growth–SWB relationship. However, this approach obscures the large and long-lasting effects of contractions. Finally, allowing for macroeconomic loss aversion but not for macro-level adaptation reveals the asymmetry but is likely to preserve the aforementioned illusion.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature, discusses the conceptual framework, and lays out our empirical approach. Section 3 describes the data and presents the results. Section 4 discusses our results and examines their robustness. Section 5 concludes.

2 Background, Conceptual Framework, and Empirical Strategy

2.1 The GDP–SWB Time-Series Relationship

GDP–SWB research has been inspired by Richard Easterlin's early finding that, although GDP had grown over time in the US, similar growth in SWB could not be observed (Easterlin 1974). GDP–SWB studies using cross-sections have revealed a positive relationship both within and across countries, and the resulting contradiction between the cross-section and time-series relationship has been labeled the 'Easterlin paradox'. Easterlin (2016) discusses the paradox and surveys the voluminous literature. Because we are interested in the time-series relationship, only part of the earlier literature is relevant here. For more information, the reader is advised to see Easterlin (2016) and the references cited therein.

Some recent papers, notably that of Stevenson and Wolfers (2008), have found that GDP and SWB are positively associated in time-series. Easterlin (2013, 2016) has argued that this relationship is driven by a relationship between short-run fluctuations of GDP around its trend and SWB, whereas trend growth differences between countries are not associated with SWB growth differences. He has produced analyses using various international data sets and shown that long-run growth trends of countries are indeed not associated with SWB growth trends (Easterlin 2016). Easterlin's argument is supported by other studies that distinguish between the effects of short-run cyclical fluctuations and long-run trend growth (Hovi and Laamanen 2016; Kaiser and Vendrik 2019). Di Tella, MacCulloch, and Oswald (2003) and Di Tella and MacCulloch (2008) apply dynamic models to EB data to distinguish the short-run relationship from the long-run one. Both of these studies find a positive short-run relationship and significant macro-level adaptation. In the former study, the results about the long-run are somewhat inconclusive due to the short time-series used, while the latter reports statistically insignificant long-run relationship for Europe as a whole.[6] Further, De Neve et al. (2018) present some results that are related to the long-run relationship. Specifically, when they control for the unemployment rate and inflation, GDP loses its statistical significance. As unemployment and inflation may be thought of as controls for the business cycle, that result points to a zero relationship between long-run growth and SWB. While documenting a zero relationship in the long run, many of the above papers, however, present evidence for a positive relationship between GDP and SWB in the short run.

De Neve et al. (2018) show that well-being is asymmetrically associated with GDP changes in the short run. They suggest that such macroeconomic loss aversion may be an explanation for the zero long-run relationship. However, for the relatively large effects of negative GDP changes to significantly contribute to the long-run GDP–SWB relationship, they must be long-lasting.[7] Although the question of persistence over time is yet to be answered, macroeconomic loss aversion should not be ignored when examining the GDP–SWB relationship, especially given that De Neve et al. (2018) use three large data sets that cover different parts of the world.

Taken together, the earlier evidence suggests that the GDP–SWB relationship is both different in the short run and the long run and asymmetric. From an empirical perspective, ignoring one (or both) of these features may bias any results

6 Both Kaiser and Vendrik (2019) and Di Tella and MacCulloch (2008) report that the result of a zero long-run relationship may not hold for all countries/groups of countries. However, some time series in the former study and all time series in the latter are relatively short, which means that conclusions about the long run must be treated with caution. For this reason, we check the robustness of our results to excluding short time series.

7 Hovi''s (2020) recent results point to recessions having long-lasting SWB effects.

pertaining to this relationship. For example, ignoring long-run asymmetry may make it seem as if economic growth does not increase SWB in the long run. Even if the earlier results are unbiased, negative changes being a minority of all GDP changes means that the long-run results may accurately reflect the average relationship but mask the possibly important long-run effects of negative changes. Clark, D'Ambrosio, and Ghislandi (2016) have shown this to be the case for the micro relationship between income and SWB.

Many theoretical explanations have been proposed for the stylized fact that the long-run relationship between economic growth and SWB is not different from zero. The three most prominent explanations are related to behavioral mechanisms. First, it has been argued that people adapt to changes in their own incomes. Second, social comparisons have been claimed to be behind the result, although only social comparisons that become more important over time would be compatible with the positive short-run relationship. The third prominent explanation, macroeconomic loss aversion, is more of an empirical feature, and the micro-mechanisms behind it are not known.

We model the GDP–SWB time-series relationship in the way that allows for macro-level adaptation and macroeconomic loss aversion, i.e., the features of that relationship observed in earlier studies. We next discuss these features and the micro-level mechanisms behind them. Because we study how the macro relationship reflects the mechanisms, we also need to elaborate how the micro-level effects produce features estimable from macro data. We also review the approaches in the earlier micro and macro literature to estimate such effects and explain how our approach combines them to control for the relevant mechanisms simultaneously.

2.2 Macro-Level Adaptation

In the SWB literature, adaptation to changes in circumstances has been studied by examining the short- and long-run well-being effects of these changes. It is considered a sign of complete adaptation if a permanent change in circumstances affects SWB in the short run but has a long-run effect of zero. In the case of less-than-complete adaptation, the short-run effect is larger than the long-run effect, but the long-run effect is not zero.

Previous micro studies examine adaptation either to discrete changes in circumstances, such as entering unemployment, or to changes in a continuous variable, such as income changes. Our focus is on dynamic modeling techniques similar to those used in the latter group of studies, which we discuss next.[8] Di Tella, Haisken-De New, and MacCulloch (2010) model adaptation to income with a finite distributed lag (DL) model. Vendrik (2013) applies autoregressive distributed lag (ARDL/ADL) models to study adaptation to income and points out that a model of adaptation can be improved in two ways by using ARDL instead of DL. First, ARDL models control for the effects of higher-order lags of income than the number of income lags included in the model. Second, ARDL models control for general autocorrelation in the dependent variable, so that adaptation to factors other than those included in the model are controlled for.[9] In line with Vendrik's (2013) argumentation, Clark (2018) proposes including a lagged dependent variable as one way to utilize panel data. In a recent study of adaptation, Kaiser (2020) applies both DL and ARDL models. Both DL and ARDL allow for the effect of an income change to vary as more time passes since the change. The period-to-period changes in the effect of income can be interpreted to be caused by changes in one's reference income or adaptation level, which makes DL and ARDL particularly well suited for adaptation modeling.[10]

To model macro-level adaptation, the same dynamic modeling techniques can be applied to macro data on national income and SWB. The earlier studies of macro-level adaptation studies have applied DL models to EB data (Di Tella and MacCulloch 2008; Di Tella, MacCulloch, and Oswald 2003; Kaiser and Vendrik 2019). Although the average micro-level adaptation to income is reflected as macro-level adaptation to national income, macro-level adaptation reflects other effects as well, with the most important being social comparisons. Clark, Frijters, and Shields (2008b) explain how adaptation and social comparisons constitute a more general phenomenon of income comparisons, also called relative/reference-income effects. Such effects work through one's own past income (adaptation) and

8 For a review of studies of the former type, see Clark et al. (2008a). Most of the micro studies on adaptation, including the ones we cite, have used the German Socio-Economic Panel and the British Household Panel Survey.

9 DL and ARDL are standard econometric models applied to time-series data to estimate effects that change over time. DL is a model with one or more lags of the regressor(s) included. ARDL is a model with one or more lags of the dependent variable included as regressors (usually in addition to lag[s] of regressor[s]). Alternative yet equivalent model representations are common (e.g., our ARDL models have differenced variables). DL model's estimated effect k periods from a change in a regressor are the sum of the coefficients until the kth lag of that regressor. Hence, the sum of all coefficients is the long-run effect. Formulas for ARDL model's effects are more complicated. See Vendrik (2013) for a thorough discussion of ARDL as a model of adaptation and its link to DL.

10 Wunder (2012) shows that this interpretation is correct in the case of complete adaptation by deriving an ARDL model from a theoretical adaptation-level/reference-income model. It can also be shown that the interpretation is correct in the case of less-than-complete adaptation (derivations available on request).

the incomes of others (social comparisons) that positively affect one's reference income (or income aspirations) which, in turn, negatively affects well-being (Clark, Frijters, and Shields 2008b). Adaptation is usually considered (and estimated) to take time due to the gradual adjustment of reference income. Arguably, reference income does not adjust to others' income overnight either, and the resulting gradually changing (intensifying) social comparison effects are reflected in the macro-level adaptation pattern. Indeed, both Vendrik (2013) and Kaiser (2020) find that the negative effect of reference-group income becomes larger over time. In sum, adaptation and social comparisons are taken into account in our macro-level estimates.[11] Thus, we provide estimates of the short- and long-run effects of aggregate income on aggregate life satisfaction; identifying the mechanisms behind macro-level adaptation and their relative importance is beyond the scope of this paper.

In the empirical part of the paper, we follow the above studies and adopt dynamic models. We test the hypothesis of complete macro-level adaptation to the short-run effects of GDP changes. Confirmation of the hypothesis would confirm the Easterlin paradox and suggest that it is caused by economic growth failing to improve well-being in the long-run. We also estimate a simple model which does not allow for macro-level adaptation to see if we can replicate Stevenson and Wolfers's (2008) finding of a positive association between GDP and SWB. Being able to replicate the result while confirming the hypothesis would mean that failing to control for macro-level adaptation yields misleading results concerning the GDP–SWB relationship. It is important to note that we are able to test the complete-adaptation hypothesis also while controlling for macroeconomic loss aversion, in which case confirming the hypothesis means that complete macro-level adaptation to the effects of economic growth instead of macroeconomic loss aversion is the explanation to the paradox. We now turn to how macroeconomic loss aversion is estimated and how differential adaptation to positive and negative GDP changes can be allowed for.

2.3 Macroeconomic Loss Aversion

Loss aversion in the context of SWB effects following changes in circumstances means that the effect of a positive change is smaller than the effect of a negative

11 At this point, we should note that although higher comparison incomes (i.e., adaptation and social comparisons) are usually hypothesized to be behind macro-level adaptation, economic growth may systematically bring about other negative externalities as well (such as environmental damage).

change of the same size. The few micro-level loss-aversion papers regressing SWB on personal or household income variables include positive and negative income changes as separate regressors (Boyce et al. 2013; D'Ambrosio and Frick 2012; Di Tella, Haisken-De New, and MacCulloch 2010). All these studies find that negative changes have larger impacts than positive changes.

Macroeconomic loss aversion, as defined by De Neve et al. (2018), means that changes in individual (and thus national mean) well-being due to GDP changes are asymmetric, with reactions to negative changes being larger. They find evidence for such asymmetry by, similarly to the micro studies of loss aversion, regressing SWB on positive and negative change variables. Some of this macro-level asymmetry may be a reflection of microeconomic loss aversion as GDP decreases are typically associated with more individual-level income losses than GDP increases. However, this is not likely to be the key mechanism, and De Neve et al. (2018) therefore discuss other potential mechanisms.[12] These potential mechanisms are unemployment, economic uncertainty, consumption reactions, future expectations, and financial distress; however, none of these is able to completely explain the asymmetry. Another mechanism, also mentioned by De Neve et al. (2018), was proposed earlier by Easterlin (2009), who argued that people's income aspirations rise with national income increases but may not fall, or may not fall as much, with decreases. This would lead to more macro-level adaptation to positive than to negative GDP changes. The following loss aversion would only emerge after the adaptation process has started, making this mechanism better suited to explaining long-run macroeconomic loss aversion. Even though the mechanisms are not yet known, macroeconomic loss aversion is a potentially important feature of the GDP–SWB relationship, including in the long run. As De Neve et al. (2018) acknowledge, results from the analyses of loss aversion to date are informative about the short run.[13] To the best of our knowledge, however, nothing is known about long-run macroeconomic loss aversion.

The long-run asymmetry does not need to be similar to the short-run asymmetry. It is clear that long-run macro-level asymmetry is determined by the short-run asymmetry and macro-level adaptation, which may be different for positive

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12 It is fairly easy to see that the regressors of the model are poor proxies for macro-level averages of the regressors of a micro-level loss aversion model and, therefore, unlikely to identify the micro parameters.

13 By 'informative about the short run', we can mean either that income changes measure short-run fluctuations, in which case information on the effects of such fluctuations is obtained, or that the coefficients of the income change variables capture the short-run effects of the income changes (as in certain representations of ARDL models, such as ours). The distinction between the two cases is the distinction made in footnote 5.

and negative GDP changes. Indeed, although some studies present evidence for complete micro-level and macro-level adaptation to income changes on average, the results obtained by some recent studies suggest that people do not adapt to negative economic changes such as income decreases and recessions (Clark, D'Ambrosio, and Ghislandi 2016; Hovi 2020). Because the asymmetry may be different in the long run than in the short run, regressing SWB on positive and negative income changes might not give an accurate description of what happens in the long run. For this reason, and also because not allowing for any long-run asymmetry may bias the short-run results, it is important to study asymmetries using a more flexible empirical framework.

In the present study, we test three novel hypotheses related to macroeconomic loss aversion. First, we test whether De Neve et al.'s (2018) finding that there is a short-run asymmetry is robust to controlling for macro-level adaptation and long-run asymmetry. Second, we test whether the asymmetry persists or disappears over time. It is obvious that persistent macroeconomic loss aversion is much more relevant both from the point of view of researchers trying to identify the mechanisms at play as well as from the perspective of policy makers. The third hypothesis, already presented in the previous subsection, is intimately related to the Easterlin paradox and its explanations: we test whether macro-level adaptation to economic growth is complete even after controlling for macroeconomic loss aversion. If this is the case, economic growth does not improve well-being in the long run — even in the absence of any contractions — and the paradox is explained by macro-level adaptation rather than macroeconomic loss aversion. If the final hypothesis is rejected, macroeconomic loss aversion at least partly explains the zero long-run relationship between GDP and SWB, raising a further question. How important are macro-level adaptation and macroeconomic loss aversion in explaining the paradox? It is important to note, however, that macroeconomic loss aversion being relevant is not conditional on its ability to explain the paradox. On the contrary, the combination of complete macro-level adaptation and long-lasting effects of contractions would mean that even long periods of economic growth cannot make up for the damage done by contractions.

2.4 Empirical Model and Estimation Strategy

As mentioned above, short- and long-run effects (and thus adaptation) can be estimated by DL or ARDL models. Our models, which allow for both a short-run and a long-run asymmetry, are ARDL models that make a distinction between positive and negative GDP changes.[14] Using such an asymmetric (more generally 'nonlinear') ARDL model is arguably the only known approach to estimating both short-run and long-run asymmetric effects.[15] A NARDL estimation equation can be regarded as an extension of a piecewise linear regression model equivalent to that used to study asymmetries by, for example, De Neve et al. (2018). The main difference is that a piecewise linear model estimates the short-run relationship whereas a NARDL model estimates both short- and long-run relationships. The regressors of the piecewise model are current (positive and negative) growth rates; thus, the current level of SWB is determined only by the current economic growth (and the next year's level only by the next year's growth, and so on). This means that the SWB effects of growth beyond the immediate effect are not estimated. In addition to the current (positive and negative) growth rates to capture short-run effects, a NARDL model also includes a lagged dependent variable and (lagged) level regressors to model an adjustment (i.e., adaptation) process and (possibly asymmetric) long-run effects. A key feature of a NARDL model is the level regressors, which are simply sums of past growth rates. It is rather intuitive that these variables capture the effects of past growth rates on current well-being.[16]

Based on the above discussion, a NARDL model is an appropriate empirical model for our purposes, as it allows for adaptation and loss aversion. We begin with a simple NARDL(1,1) model:

$$s_{i,t} = (1-\alpha)s_{i,t-1} + \beta\Delta y_{i,t} + \beta^{-}\Delta y_{i,t}D_{i,t} + \gamma y_{i,t-1} + \gamma^{-}y^{-}_{i,t-1} + \lambda_i + \eta_t + \epsilon_{i,t}, \quad (1)$$

The partial sum $y^{-}_{i,t-1} = \sum_{\tau=I_i}^{t-1} \Delta y_{i,\tau} D_{i,\tau}$ is the sum of negative changes in y from the first year of the sample (I_i for country i) until year $t-1$. Country fixed effects (λ_i) are essential for the model to work, because they control for the unknown country-specific pre-sample levels of the partial-sum variable.[17] Equation (1) is the autoregressive distributed lag representation of the nonlinear ARDL model originally introduced by Schorderet (2001, 2003) and later discussed at length by Shin, Yu,

14 A reader not interested in the technical estimation details can skip this and the next section. Figures 1 and 3 present the key results in the value-function framework familiar from the prospect theory literature (De Neve et al. 2018; Kahneman and Tversky 1979). Figure 2 presents the estimated effects and their statistical significance in an impulse–response graph. Section 4 discusses these results and their implications.

15 NARDL has become the standard approach for estimating asymmetric effects. For example, Eberhardt and Presbitero (2015) is a country-panel study using the NARDL approach.

16 This is not a feature specific to NARDL. In ARDL, also, the level variables capture the long-run effects and are, by definition, sums of their past changes.

17 Given that we have an unbalanced panel, the country average of the partial sum is weakly decreasing in the number of observations for that country. It is, thus, desirable to prevent identification from the country averages. This is achieved by controlling for country fixed effects.

and Greenwood-Nimmo (2014).[18] For now, the lag length is set to one in this baseline specification to illustrate the consequences of allowing for dynamic effects as clearly as possible; we will allow for longer lags later. Year fixed effects η_t are included in all specifications. Therefore, the estimated parameters are identified from the differences in time variation between countries.[19]

We are interested in and present the estimates of α, the speed of adjustment; β, the short-run effect of a positive change in y; $\beta + \beta^-$, the short-run effect of a negative change in y; γ/α, the long-run effect of a positive change in y; and $(\gamma + \gamma^-)/\alpha$, the long-run effect of a negative change in y. β^- and γ^- are measures of asymmetries in the short and long run, respectively. From the perspective of our adaptation/loss aversion framework, β and $\beta + \beta^-$ are the short-run effects as estimated in the earlier loss-aversion studies mentioned in Section 2.3. γ/α and $(\gamma + \gamma^-)/\alpha$ represent what is left of the short-run effects in the long run, after adaptation has occurred. Therefore, the extent of adaptation to GDP changes is shown by the difference between the short-run effect and the long-run effect. For example, $\beta > 0$ and $\gamma/\alpha = 0$ means that economic growth has a positive effect in the short run but a zero effect in the long run. In that case, the extent of adaptation equals β (i.e., the whole short-run effect). Finally, α is interpreted as the (general) speed of adaptation. For example, $\alpha = 0.2$ and a zero long-run effect would mean that 20% of the remaining effect of growth dissipates each year. In the case of less than complete adaptation (i.e., non-zero long-run effect), 20% of the deviation between what is currently left of the effect on top of the long-run effect dissipates.[20,21]

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18 These papers explain how such a within-model with partial sums works in estimating precisely what we want to estimate here. Note also that, usually, a NARDL model includes positive and negative changes and positive and negative partial sums. It is easy to see that our model is equivalent to such a model because $y_{i,t-1}$ is the sum of a country-specific constant and all changes in y from the beginning of the sample until $t - 1$. The usefulness of our representation lies in making the coefficients of the negative-change variables measures of the asymmetries.

19 We emphasize at this point that nothing in our approach guarantees that our estimates equal causal effects. Expressions such as 'the effect of' are used only to improve readability.

20 Though (as in any ARDL model) the lagged dependent variable primarily serves the purpose of controlling for autocorrelation. Note that here the speed of adaptation is restricted to be the same (α) for positive and negative GDP changes. However, this is not an essential restriction because the *extent* of adaptation is allowed to be different for positive and negative changes by including the GDP variable and the partial-sum variable. As we later introduce more flexibility, the speed of adaptation to GDP changes will be more flexibly estimated and can be different for positive and negative changes and at different temporal distances from the impact.

21 In the light of these interpretations, it is easy to see that a simple piecewise linear model is a special case that assumes no long-run effects and a speed-of-adaptation of one and, hence, complete and immediate (i.e., happening in one year) adaptation to the effects of both positive and negative growth.

It is known that estimating a fixed effects model with a lagged dependent variable using ordinary least squares may yield biased results (Nickell 1981). Therefore, in regressions in which we include the lagged dependent variable, we use the bias-corrected least squares dummy variables (LSDVC) method. The method was first developed by Kiviet (1995), and later recommended by Judson and Owen (1999) based on Monte Carlo results. We use the bias approximations for unbalanced panels proposed by Bruno (2005).[22]

3 Data and Analysis

3.1 Data

Estimating model (1) requires annual country-level data on well-being. The EB survey is the only international survey that includes an SWB question and has been conducted annually over several decades, thus covering multiple recessions and recoveries for many countries. The SWB question measures the evaluative dimension of well-being by asking people about their life satisfaction: '*On the whole, are you very satisfied (4), fairly satisfied (3), not very satisfied (2) or not at all satisfied (1) with the life you lead?*'[23] It should be noted that life satisfaction measures just one of the several dimensions of SWB, i.e., the evaluative dimension. Other dimensions, such as emotional well-being, hedonic well-being, or eudaimonia, and dimensions of well-being other than subjective ones, can be affected differently by the economy. For example, Kahneman and Deaton (2010) report that, at the micro-level in the US, high income is more strongly correlated with evaluative well-being (life satisfaction) than it is with emotional well-being. Graham and Nikolova (2015) obtain a similar result using international data from the Gallup World Poll. They find that income is more important for evaluative well-being (life satisfaction) than for hedonic well-being (happiness). Based on these results, we may conjecture that the estimated effects of GDP changes in our study are larger than they would be in the case of some other dimensions of well-being.

We use repeated cross-sections of individuals residing in 34 different European countries to calculate annual country-level population-weighted averages

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22 For an example of a paper adopting the bias-correction approach for an unbalanced country-panel of about the same length as ours, see Bloom et al. (2007).

23 EB's life satisfaction is the only SWB variable on which long continuous time series are available. Because other similar time series on SWB, or methods to draw inferences about the relevant relationships from series with gaps, are not available, EB data are the most useful for our purposes.

Table 1: Descriptive statistics.

Variable	n	Mean	SD	SD (within)	Min	Max
Life satisfaction (s)	674	2.99	0.34	0.10	2.02	3.71
GDP per capita in 2005 euros	674	23735	7910	5069	8632	52498
Economic growth (Δy)	674	0.019	0.032	0.031	−0.156	0.226
Conditional on being positive ($\Delta y \mid > 0$)	555	0.029	0.023	0.020	0.000	0.226
Conditional on being negative ($\Delta y \mid < 0$)	119	−0.028	0.030	0.023	−0.156	−0.001
Trend growth (ΔT)	674	0.021	0.008		0.010	0.041

of individuals' life satisfaction. We choose the surveys to be included in the following way. First, we define the EB member countries for each year. Second, in order to improve international comparability, we select only those surveys that have been conducted in all member countries of the year.[24] The number of years covered by the EB vary by country: the longest time series start in 1975, and most series end in 2015. Our GDP per capita data up to and including 2014 comes from the Penn World Tables. We extend the Penn World Tables data through 2020 using growth rates calculated from the IMF World Economic Outlook (April 2017) data and forecasts. We use only actual GDP data in estimating the life satisfaction models and, thus, we use the IMF estimations and projections only for the GDP trend extractions. We end up with an estimation sample of 674 country-year observations. Table 1 reports the descriptive statistics for the sample.[25] Our data confirm the well-known feature of SWB, i.e., that the between-country variation tends to be larger than the within-country variation. However, there is significant within-country variation in our data as the within standard deviation is almost one-third of the overall standard deviation. Due to the inclusion of country fixed effects in all models, it is this within variation that we model and identify the parameter estimates from. For the purpose of estimating asymmetries, a useful feature of the data is that more than one-sixth of the real GDP per capita changes are negative.

3.2 Results from Simpler Models

We start by estimating models obtained by imposing restrictions on the parameters of model (1). These models facilitate comparisons to earlier results and illustrate

24 There are some Eurobarometer surveys that have not been conducted in every member country.

25 For more information on the data and weighting, see the online appendix.

the effects of imposing different restrictions. We begin with the simplest possible model, a model with neither adaptation nor asymmetries. We then estimate a model allowing for adaptation but not for asymmetries. Next, we estimate a model with asymmetries but no adaptation. Finally, we estimate Equation (1) without any restrictions on the parameters. We also estimate the two no-adaptation models with trend growth as a control variable to allow comparisons to studies that make the short-run/long-run distinction by regressing SWB on the cycle and trend components of GDP.[26,27]

Table 2 presents the results. The upper panel shows the parameter estimates, and the lower panel presents the estimated effects. The first column reports results from a simple regression with the GDP variable as the regressor of interest. This model is obtained by assuming no adaptation, i.e., equal short- and long-run effects ($\alpha = 1$, $\beta = \gamma$, and $\beta^{-} = \gamma^{-}$) and no asymmetries ($\beta^{-} = \gamma^{-} = 0$). The coefficient estimate on the GDP variable is positive and statistically different from zero at the 5% level. This is the result reported earlier using EB data by Stevenson and Wolfers (2008) and critiqued by Easterlin in several papers. Column 2 adds the trend component of GDP (T_t) to make the short-run/long-run distinction as proposed by Easterlin. As expected, the coefficient on the GDP variable becomes much larger and more statistically significant because it is now estimating the relationship between short-run cyclical fluctuations and SWB.[28] In contrast, the estimated coefficient on trend growth is close to zero and statistically insignificant (see the lower panel). The distinction between the short run and the long run thus seems to be an important one.

Column 3 allows for adaptation but, by setting $\beta^{-} = \gamma^{-} = 0$, assumes no asymmetries. The model is thus a conventional ARDL model. The short-run coefficient, i.e., the first-year or immediate effect of a GDP change, is positive and statistically significant. The long-run effect is, however, close to zero and not statistically significant. The hypothesis of a positive short-run effect and complete

26 Although the adaptation models already take into account the short-/long-run distinction we also checked the robustness of the results from these models to the inclusion of the trend component.

27 We chose a trend estimation period longer than our SWB time-series to alleviate the impact of post-2007 crisis years. Specifically, the data begin five years prior to the beginning of the SWB data and end five years after it ends. Therefore, the trend is estimated for 1970–2020 for most countries. Due to data availability, the trend estimation period begins later for some countries.

28 The trend component attracts a negative sign. This does not mean that trend growth is harmful to well-being, but that the effect of trend growth is smaller than the effect of fluctuations around the trend (Hovi and Laamanen 2016; Kaiser and Vendrik 2019). For more on the interpretations, see the online appendix.

Table 2: Models of life satisfaction.

	Neither		Adaptation	Asymmetry		Both
	(1)	(2)	(3)	(4)	(5)	(6)
s_{t-1}			0.81***			0.76***
			(0.03)			(0.03)
y_t	0.33**	0.79***		0.22**	0.49**	
	(0.16)	(0.16)		(0.09)	(0.22)	
y_t^-				1.47***	1.25**	
				(0.37)	(0.56)	
Δy_t			0.66***			0.38**
			(0.13)			(0.15)
Δy_t^-						1.06***
						(0.31)
y_{t-1}			0.03			0.04
			(0.03)			(0.03)
y_{t-1}^-						0.32***
						(0.09)
T_t		−0.72***			−0.39	
		(0.24)			(0.29)	
α			0.19***			0.24***
			(0.03)			(0.03)
First-year effect of Δy	0.33**		0.66***	0.22**		0.38**
	(0.16)		(0.13)	(0.09)		(0.15)
First-year effect of Δy^-				1.69***	1.74***	1.43***
				(0.35)	(0.43)	(0.25)
Effect of cycle		0.79***			0.49**	
		(0.16)			(0.22)	
Long-run effect of Δy	0.33**		0.18	0.22**		0.14
	(0.16)		(0.17)	(0.09)		(0.13)
Long-run effect of Δy^-				1.69***	1.74***	1.45***
				(0.35)	(0.43)	(0.36)
Effect of trend growth		0.07			0.10	
		(0.18)			(0.11)	

Dependent variable: country-year average of life satisfaction (s). Notation: y = log of real GDP per capita; y^- = sum of negative changes of y from the first year of the sample; Δy^- = change of y if negative, otherwise zero; T = trend component of y; α = one minus the coefficient of s_{t-1}. OLS (cols 1, 2, 4, and 5) and bias-corrected (cols 3 and 6) estimates. n = 674. Country and year fixed effects included. Upper panel: coefficient estimates. Lower panel: estimated effects and hypothesis tests. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively. Standard errors in parentheses clustered at the country level (OLS models) or bootstrapped with 200 replications (bias-corrected models). The delta method applied where necessary. Authors' calculation based on Penn World Table 9.0 (www.ggdc.net/pwt), IMF World Economic Outlook April 2017 (https://www.imf.org/en/Data), and Eurobarometer surveys (https://zacat.gesis.org/webview/, see online appendix for details.

adaptation to it cannot be rejected.[29] Again, the short-run/long-run distinction turns out to be important, and it appears that the coefficient estimate from the simple regression of SWB on the GDP variable in column 1 is not informative about either the short-run effect or the long-run effect. We next turn to the issue of macroeconomic loss aversion. As we will see, the above results mask significant asymmetries.

Column 4 presents estimates from a model that allows for macroeconomic loss aversion but not for adaptation. The no-adaptation restriction means imposing $\alpha = 1$, $\beta = \gamma$, and $\beta^{-} = \gamma^{-}$, i.e., no difference between the short-run and long-run effects. Therefore, the explanatory variables are the GDP variable and a partial-sum variable, which is the sum of current and past negative GDP changes. The results point to a statistically significant aversion to macroeconomic losses. The effect of a negative GDP change (1.69) is more than seven times that of a positive change (0.22). Because these estimates reflect both short- and long-run effects, the results suggest that macroeconomic loss aversion is not solely a short-run phenomenon. When compared to the corresponding symmetric model (column 1), the coefficient for the GDP variable is smaller by one-third (0.22 vs. 0.33). This suggests that a coefficient such as that in column 1, often interpreted in the literature as the effect of economic growth, is inflated by the large effects of GDP decreases.

In column 5, GDP trend is allowed to have a different effect from that of fluctuations around it. The hypothesis that the effect of long-run growth on SWB is zero cannot be rejected (see the lower panel of Table 2). Although the implausible assumptions of the model make it only marginally useful in itself, some comparisons to the results in the other columns are interesting.[30] First, the asymmetry presented in column 4 does not disappear. The effect of a negative GDP change (1.74) is much larger than the effect of short-run fluctuations (0.49) and certainly larger than the effect of long-run trend growth (0.10). Second, the effect of short-run cyclical fluctuations (0.49) is smaller and less statistically significant than in the corresponding symmetric model in column 2 (0.79). This (similarly to the comparison of column 4 with column 1 above) suggests that imposing symmetry tends to lead to an overestimation of the effects of economic growth.

The results in columns 4 and 5 support the hypothesis that De Neve et al.'s (2018) finding of macroeconomic loss aversion is robust. The hypothesis that loss

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29 The estimated speed of adaptation, α, is 0.19, suggesting that adaptation is relatively slow. Also an earlier study by Blanchflower (2007) finds a coefficient of the lagged SWB variable close to one and, thus, slow adaptation in macro data (EB). However, this result should not be emphasized too much because, as we will later show, the adaptation pattern is not smooth enough to be described by a single speed parameter.

30 The problematic feature of the model is that it allows the effects of positive but not the effects of negative GDP changes to differ between the short- and long-run.

aversion is persistent seems also to be supported. Further, controlling for macroeconomic loss aversion tends to lead to smaller estimates of the effects of economic growth. We now move on to estimate the unrestricted model to see if these results are robust to controlling for both macro-level adaptation and macroeconomic loss aversion, both of which are important in the light of the results so far.

The results from estimating Equation (1) are presented in column 6 of Table 2. The short-run effects of positive and negative changes in GDP are estimated to be 0.38 and 1.43, respectively. The difference between the two parameters is statistically significant, indicating that there is significant loss aversion in the short run. The outcome of the adaptation process differs markedly between positive and negative GDP changes: the long-run effect of economic growth is, again, close to zero (0.14) and statistically insignificant, but the long-run effect of a negative GDP change (1.45) is slightly larger than the corresponding short-run estimate and statistically significant.[31] These results support the hypothesis of a zero long-run relationship between economic growth and SWB even when controlling for macroeconomic loss aversion. Yet, the short-run relationship is positive and statistically significant. Therefore, the results support the notion of macro-level adaptation to economic growth. Macro-level adaptation to growth being complete explains the Easterlin paradox while negative GDP changes are significantly associated with SWB both in the short run and in the long run. When it comes to macroeconomic loss aversion, we can replicate De Neve et al.'s (2018) finding of short-run asymmetry and the hypothesis that the finding is robust to controlling for long-run asymmetry and macro-level adaptation is supported. Our results also support the hypothesis that macroeconomic loss aversion is persistent. Actually, the asymmetry is estimated to be much more pronounced in the long run than in the short run. The large long-run effects of GDP decreases that cause the asymmery in the long run have went unnoticed by the literature so far.

We will discuss the results and their implications more after we have estimated a NARDL model that allows for more flexible adaptation modeling. This model is used to test the robustness of the results so far and potentially to get a more detailed picture of the relationships. But let us first turn to a graphical illustration of the results from the simpler NARDL model. The interesting questions concern the immediate and post-adaptation SWB effects of positive and negative GDP changes. Some care has to be taken in drawing conclusions about the short-run effects of GDP changes because the explanatory variable Δy is the sum of the change in the log of the real GDP's cycle component (ΔC) and the change in its trend component (ΔT). Because ΔT is, in the case of a linear trend, a country-specific constant, its effect is absorbed by the country fixed effect. Thus, the estimate of the

31 The estimated speed of adaptation (α) is, again, quite low.

short-run effect of a positive change in GDP is an estimate of the effect of a change in the cycle component.[32] When assessing the short-run effect of a GDP change, we need to make an assumption about the short-run effect of trend growth. There are two natural candidates for this effect: an effect equal to the estimated effect of the cycle component or a zero effect.[33] The former assumption is routinely made in the context of ARDL models. Although the assumption made does not affect the long-run results or their interpretations in any way, it is interesting from the point of view of SWB analyses because it affects the interpretation of the short-run coefficient and, thus, the implied adaptation process. Therefore, we examine the short-run effects of GDP changes separately under the two alternative assumptions.

Figure 1 presents two graphs of the short-run and long-run effects of the log of real GDP changes. The graph on the left assumes that the short-run effect of trend growth is equal to the effect of a change in the cycle component. In contrast, the graph on the right assumes that trend growth has a zero effect. In these graphs, we set trend growth to 2.1%, which is the average trend growth in our sample. The graph on the left points to adaptation to positive changes in GDP, as does the graph on the right once one takes into account the statistical insignificance of the long-run effect. Note that the graph on the right is in line with the idea that, in the short run, trend growth is classified as an expected macroeconomic gain, without which there is a 'foregone gain' effect (see Kahneman, Knetsch, and Thaler 1991). Thus, trend growth is needed to keep SWB constant and the economy not growing has a negative effect on SWB.[34] As the graph on the right shows, the foregone-gain effect is adapted to in the long run. Both graphs show that macroeconomic losses, i.e., negative changes in GDP, have visibly larger effects than a macroeconomic gains both in the short run and in the long run. The short- and long-run effects of losses are of similar magnitude, so we do not observe significant adaptation to losses. Overall, Figure 1 illustrates that there is adaptation to the effects of positive changes in GDP but that, in contrast, the relatively large effects of negative changes are not adapted to.

The results so far come from our baseline NARDL specification (1) which is restrictive in the sense that no lags beyond the first are included. This means that a

32 See the online appendix for a more thorough and formal discussion of these issues.

33 One way to obtain information on the plausibility of the two assumptions is to rely on between-country variation: we regressed countries' average SWB on trend growth rate. The resulting coefficient was negative and insignificant which points to the short-run effect of trend growth being zero.

34 Kőszegi and Rabin (2006) discuss reference-dependent preferences in the case of individual's reference point being expectations instead of the status quo. If trend growth determined the reference point in such a model, not achieving trend growth would have a much stronger negative effect because an experience of a loss rather than a foregone gain would follow.

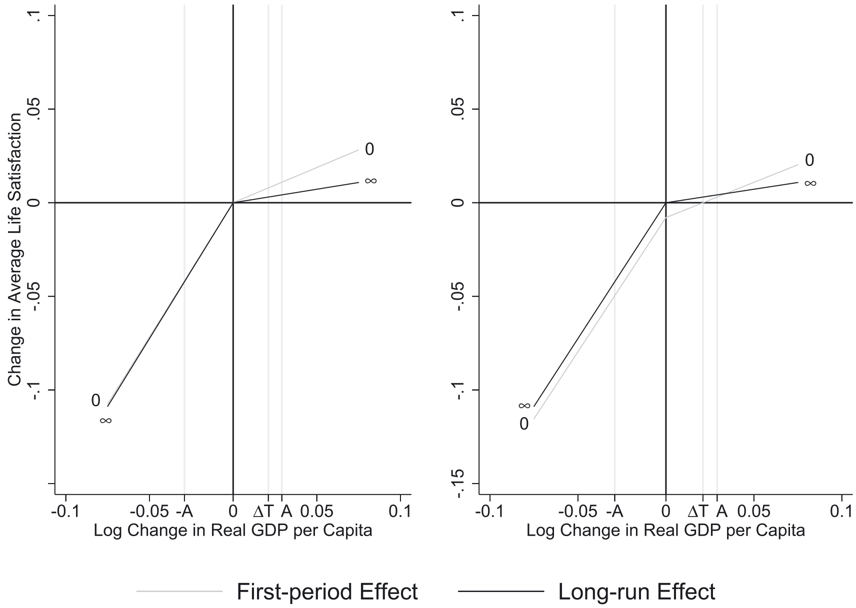

Figure 1: Effects of log of real GDP per capita changes on average life satisfaction. Left-hand panel: Trend growth assumed to have an effect in the short run. Right-hand panel: Trend growth assumed to have no effect in the short run. ΔT denotes the average trend growth of GDP in the sample (0.021) used to calculate the short-run effect sizes in the right-hand panel. A denotes the mean absolute growth of GDP in the sample (0.029). The lag associated with each line near the end of the line (the long-run effect is denoted by ∞).

smooth adaptation process is assumed, and we do not observe how the effects actually evolve over time. Moreover, our results suffer from omitted variables biases if the excluded lag variables are relevant and are correlated with the variables in the current model. Therefore, we next augment model (1) by including the necessary number of lags.

3.3 Results from a More Flexible Model

To allow for flexible short-run dynamics instead of adaptation at a constant speed, previous studies have included more lags than we did in our simple NARDL model (Di Tella and MacCulloch 2008; Di Tella, Haisken-De New and MacCulloch 2010; Di Tella, MacCulloch, and Oswald 2003; Kaiser 2020; Vendrik 2013). In this section, we follow the standard practice in estimating ARDL models by adding lagged first differences of the explanatory variables and the dependent variable into

Equation (1). We choose the number of lagged differences to be included according to the following model selection procedure. Start by estimating a model of the general form:

$$\begin{aligned} s_{i,t} = {} & (1-\alpha)s_{i,t-1} + \sum_{j=0}^{q-1}\left(\beta_j \Delta y_{i,t-j} + \beta_j^{-} \Delta y_{i,t-j} D_{i,t-j}\right) + \sum_{j=1}^{p-1} \phi_j \Delta s_{i,t-j} \\ & + \gamma \sum_{\tau=I_i}^{t-1} \Delta y_{i,\tau} + \gamma^{-} \sum_{\tau=I_i}^{t-1} \Delta y_{i,\tau} D_{i,\tau} + \lambda_i + \eta_t + \epsilon_{i,t}, \end{aligned} \tag{2}$$

where $q = 4$ and $p = 4$. Then test the joint significance of β_3 and β_3^{-} and the significance of ϕ_3.[35] Finally, drop the variables associated with insignificance at the 10% level and re-run the model. Again, the significances of the longest lags are tested for and the redundant variables are dropped. This procedure is repeated until both the β and β^{-} for the longest lag of the GDP variables and ϕ for the longest lag of the life satisfaction variable are statistically significant. Following this procedure, we ended up with a model with two lagged differences of GDP and three lagged differences of SWB. The results from estimating this model are reported in the second column of Table 3. To see how the results change due to the inclusion of further lags, we present results from a simpler NARDL(1,1) model using the same sample in the first column. It can be seen from the first column that the results for the smaller sample are very similar to the results for the full sample in Table 2.

The lower panel of Table 3 presents the dynamic effects over the first 10 years and the long-run effects of positive and negative GDP changes on SWB. Figure 2 illustrates the results by plotting the dynamic effects over the first 30 years following a positive (upper lines) and a negative (lower lines) unit change in GDP. Because, again, the short-run effect of trend growth cannot be estimated, we rely on the two alternative assumptions about that effect in Figure 2.[36] The left-hand panel makes the assumption that the short-run effect of trend growth equals the

35 We want to minimize the loss of panel observations and thus set the maximum lag length for the differenced variables to three, which means that we use GDP and life satisfaction information up to year $t - 4$. By doing this, we lose 101 observations in total from our sample. We also experimented with maximum lag lengths of 4 and 5 but ended up with similar results. These results are available upon request.

36 Because only the cyclical component of GDP has a short-run effect in the right-hand panel, we need to know how much of a unit change in GDP is cyclical. In our sample, the mean trend growth is 72% of the mean absolute GDP change. Therefore, the cyclical component changes by 0.28 for every positive ‘typical’ (unit) change in GDP. In contrast, the cyclical component changes by –1.72 for every negative ‘typical’ (unit) change. Note, however, that in the case of a negative unit change, –0.72 is a foregone gain and the remaining –1 a loss. We use these numbers to calculate the effects in the right-hand panel of Figure 2. We advise the reader also to consult Figures 1 and 3 and the online appendix to see how this works.

Table 3: More flexible model of life satisfaction.

	Simple		Flexible	
	(1)		(2)	
s_{t-1}	0.73***	(0.04)	0.78***	(0.03)
Δs_{t-1}			−0.13***	(0.04)
Δs_{t-2}			−0.04	(0.04)
Δs_{t-3}			0.07*	(0.05)
Δy_t	0.53***	(0.15)	0.43**	(0.17)
Δy_{t-1}			0.83***	(0.21)
Δy_{t-2}			−0.49***	(0.18)
y_{t-1}	0.04	(0.03)	0.03	(0.03)
Δy_t^-	0.98***	(0.34)	0.81**	(0.35)
Δy_{t-1}^-			−0.68*	(0.36)
Δy_{t-2}^-			0.43	(0.39)
y_{t-1}^-	0.43***	(0.12)	0.33**	(0.13)
First-year effect of Δy	0.53***	(0.15)	0.43**	(0.17)
Second-year effect of Δy	0.43***	(0.12)	1.14***	(0.20)
Third-year effect of Δy	0.36***	(0.10)	0.32*	(0.18)
Fourth-year effect of Δy	0.31***	(0.09)	0.39***	(0.15)
Fifth-year effect of Δy	0.27***	(0.10)	0.41***	(0.14)
Sixth-year effect of Δy	0.24**	(0.10)	0.29**	(0.13)
Seventh-year effect of Δy	0.22**	(0.10)	0.27**	(0.13)
Eighth-year effect of Δy	0.21*	(0.11)	0.25**	(0.13)
Ninth-year effect of Δy	0.19*	(0.11)	0.22*	(0.13)
10th-year effect of Δy	0.19*	(0.11)	0.21	(0.13)
⋮				
Long-run effect of Δy	0.16	(0.12)	0.13	(0.15)
First-year effect of Δy^-	1.51***	(0.11)	1.23***	(0.27)
Second-year effect of Δy^-	1.59***	(0.12)	1.32***	(0.27)
Third-year effect of Δy^-	1.64***	(0.26)	1.27***	(0.31)
Fourth-year effect of Δy^-	1.68***	(0.23)	1.45***	(0.29)
Fifth-year effect of Δy^-	1.71***	(0.24)	1.49***	(0.31)
Sixth-year effect of Δy^-	1.73***	(0.27)	1.52***	(0.35)
Seventh-year effect of Δy^-	1.75***	(0.30)	1.56***	(0.39)
Eighth-year effect of Δy^-	1.76***	(0.32)	1.58***	(0.43)
Ninth-year effect of Δy^-	1.77***	(0.34)	1.60***	(0.46)
10th-year effect of Δy^-	1.77***	(0.35)	1.62***	(0.49)
⋮				
Long-run effect of Δy^-	1.79***	(0.40)	1.68***	(0.60)

Dependent variable: country-year average of life satisfaction (s). Notation: y = log of real GDP per capita; y^- = sum of negative changes of y from the first year of the sample; Δy^- = change of y if negative, otherwise zero. Bias-corrected estimates. n = 573. Country and year fixed effects included. Upper panel: coefficient estimates. Lower panel: estimated effects and hypothesis tests. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively. Standard errors in parentheses bootstrapped with 200 replications. The delta method applied where necessary. Authors' calculation based on Penn World Table 9.0 (www.ggdc.net/pwt), IMF World Economic Outlook April 2017 (https://www.imf.org/en/Data), and Eurobarometer surveys (https://zacat.gesis.org/webview/, see online appendix for details).

short-run effect of the cyclical component of GDP. Notice that this standard assumption is also implicitly made in the effect calculations in Table 3. The right-hand panel of Figure 2, in contrast, makes the assumption that trend growth has a zero short-run effect. Black and gray lines show the effect estimates from the flexible model (column 2 of Table 3) and from the simpler model (column 1), respectively.

Although many of our findings remain unaltered, employing the more flexible specification reveals that the short-run dynamics cannot be satisfyingly described by a smooth adaptation pattern. For example, macro-level adaptation to a positive GDP change does not begin immediately after the change. Instead, the effect reaches its maximum in the second year, i.e., one year after the GDP change has occurred. Other macro-level studies using EB data have also found that the effect of a GDP change is largest in the year following the change (Di Tella and MacCulloch

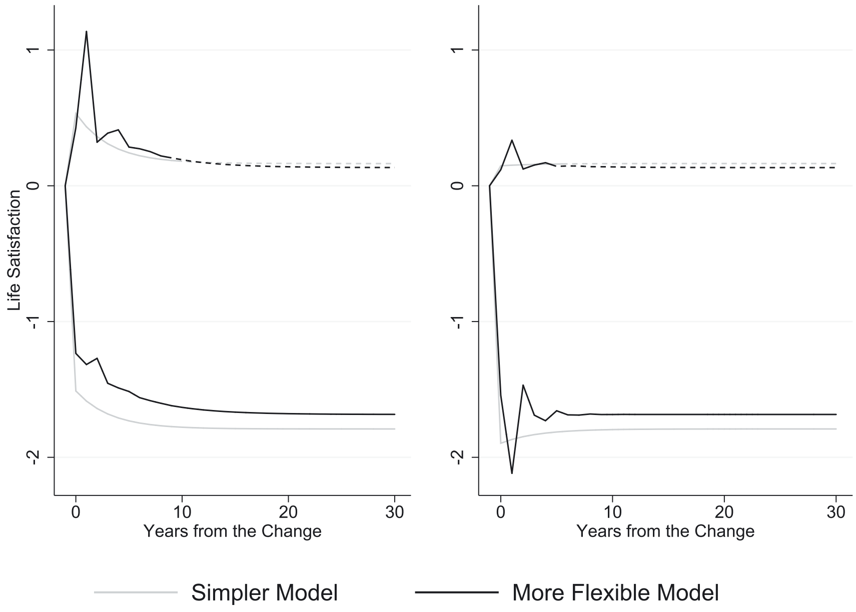

Figure 2: Dynamic effects of real GDP per capita changes on life satisfaction.
Left-hand panel: Trend growth assumed to have an effect in the short run. Right-hand panel: Trend growth assumed to have no effect in the short run. Effects calculated for one-unit change of the log of real GDP per capita. In the right-hand panel, trend growth is set to about 0.72 units based on the average trend growth of GDP (0.021) being about 72% of the mean absolute growth of GDP (0.029) in the sample. Gray lines based on the results in column 1 of Table 3. Black lines based on the results in column 2 of Table 3. Solid (dashed) line indicates statistical significance (insignificance) at the 10% level.

2008; Di Tella, MacCulloch, and Oswald 2003). This may be because many of the EB surveys are conducted in the first half of the calendar year, or because economic growth actually affects SWB with a lag. The effect of a positive GDP change is statistically significantly different from zero at the 10% level up until the ninth year after the GDP change and insignificant after that. Note also that most of the adaptation to growth occurs quickly, within only two years of the GDP change.

The lower lines in Figure 2 show that the effect of a negative GDP change is statistically significant and typically larger than that of a positive change. The asymmetry (macroeconomic loss aversion) is statistically significant in each year after a change, with the exception of the second year in the case of trend growth and cycle being assumed to have equal short-run effects (the left panel of Figure 2). The figure also shows that whether our results suggest that there is adaptation to the effects of negative GDP changes depends on what is assumed about the short-run effect of trend growth. In any case, this adaptation is not complete and thus the effects of negative GDP changes are large and long-lasting.

Figure 3 presents the effects of GDP changes of different sizes in the case of the more flexible model, plotted similarly to Figure 1. Assumptions about the effect of the trend growth are the same as in Figures 1 and 2.[37] In addition to the immediate effects (gray lines) and the long-run effects (black lines), we have drawn the maximum effect (dashed line). The number at the end of each line denotes the lag, i.e., years since the GDP change associated with the effect. As in Figure 1, we can see the role of foregone gains in the right-hand panel. The short-run asymmetry is larger when we assume the foregone-gain effect, as in Figure 2. In the right-hand panel, we also observe that for GDP drops larger than 'typical' (A), there is little to no adaptation to the maximum effect. Finally, Figure 3 points to long-run macroeconomic loss aversion for GDP changes of all sizes.

4 Discussion and Robustness

4.1 Discussion

Our results indicate that the relationship between GDP and SWB is influenced by both macro-level adaptation to positive GDP changes and macroeconomic loss aversion. We also show that the short-run macroeconomic loss aversion observed by De Neve et al. (2018) persists in the long run. In general, we can confirm many of

37 Because the marginal effect is independent of the size of the GDP change under the assumption made in the left-hand panels, the information in Figure 3 is the same as that in Figure 2 when it comes to the left-hand panels.

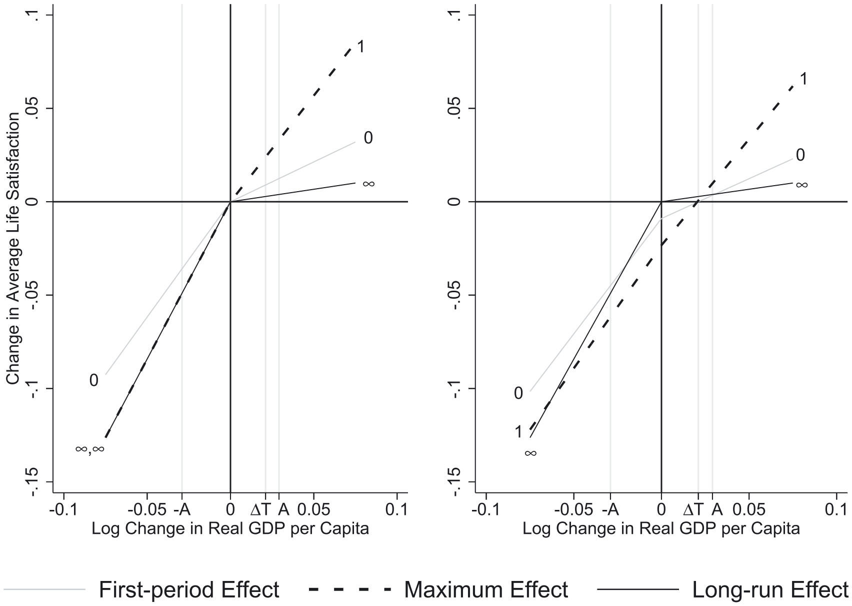

Figure 3: Effects of log of real GDP per capita changes on average life satisfaction: More flexible model.
Left-hand panel: Trend growth assumed to have an effect in the short run. Right-hand panel: Trend growth assumed to have no effect in the short run. ΔT denotes the average trend growth of GDP in the sample (0.021) used to calculate the short-run effect sizes in the right-hand panel. A denotes the mean absolute growth of GDP in the sample (0.029). The 'maximum effect' is the largest of the estimated effects (lags from zero to infinity) calculated at mean absolute growth A, or, in the case of negative changes, –A. The lag associated with each line near the end of the line (the long-run effect is denoted by ∞).

the findings of earlier studies, each of which examines only one of the two macro-level phenomena. Ignoring macro-level adaptation or, more generally, the difference between the short-run and the long-run relationship, has led to the misleading result that the long-run GDP–SWB relationship is positive. Ignoring long-run macroeconomic loss aversion has led to a failure to notice that macro-level adaptation to national income reductions is not complete. Our findings emphasize that the correct strategy when studying the income–SWB relationship, at least at the macro-level, is to allow for both dynamics and asymmetries. Results from our simpler models reveal that allowing for adaptation but ignoring asymmetries can lead one to conclude that any national income changes do not matter in the long run. Ignoring adaptation but allowing for asymmetries, however, can lead one to ignore the possibly complete macro-level adaptation. Further, specifications should be flexible enough so that effect dynamics, such as the effect peaking only after some time has passed from an income change, can be observed.

Although we are the first to document the larger long-run effects of negative compared to positive national income changes, results from some earlier studies point to such an asymmetry. Wolfers (2003) has shown that business cycle volatility, measured by variation in unemployment, is harmful to well-being. Our results suggest that business cycles are harmful because they are associated with national income reductions. A recent paper by Clark, D'Ambrosio, and Ghislandi (2015) presents micro-level evidence for negative effects of poverty entries on individuals' well-being. These effects persist even after the exit from poverty. Similarly, our results suggest that national income reductions have negative effects in the long run, despite a period of recovery following the reductions. Further, Clark (2016) points out in his review that people tend to adapt more, and more quickly, to positive than to negative events, which leads to people having a more general tendency to be loss averse in the long run. Our results show that the economic contractions are not (significantly or at all) adapted to.

Our results can help us understand why nations' SWB levels do not seem to grow in the long run although the economies are growing, as originally noted in the US by Easterlin (1974). Based on the statistical insignificance of the effect of a positive GDP change in the long run, one could argue that SWB does not grow with GDP simply because nations adapt completely to national income increases. Because GDP per capita may measure social comparison income, some part of the observed macro-level adaptation is likely to be due to the presumably negative effect of average income building up over time. Vendrik's (2013) and Kaiser's (2020) micro-level results point to these kinds of dynamics of social comparisons. Kaiser's (2020) results even suggest that people do not adapt to their own income, and if that is the case, social comparisons (or possibly other negative externalities from economic growth) explain our macro-level adaptation result.

Although macro-level adaptation is behind the zero long-run relationship between GDP and SWB, our results emphasize the significance of macroeconomic loss aversion both in the short run and in the long run. The effects are too large to be ignored by policy makers interested in promoting well-being. To get an idea of the economic significance of well-being losses, consider an economic contraction of 10%. According to our estimates, this leads to an 0.168-unit decrease in SWB, i.e., 1.68 times the within-country standard deviation of SWB in our data and roughly half of the overall standard deviation. This effect might seem large but it is not implausible in the light of the very low, even unprecedented, levels of life satisfaction in some European countries since the Great Recession (see, for example, Figure A.1. in De Neve et al. 2018). Future studies should investigate the transmission mechanisms that lead economic contractions to greatly harm well-being.

4.2 Robustness Checks

Below we will discuss the results from different robustness checks based on possible econometric issues and earlier studies. We conducted the checks for the flexible NARDL model which includes lagged differences of SWB and GDP. In all robustness checks, we chose the number of lagged differences to be included based on the procedure described in Section 3.3.[38]

Country-panel studies often use country-clustered standard errors to correct for autocorrelation that could bias statistical inference. We have used LSDVC to avoid Nickell bias but, unfortunately, country-clustered errors are not available with that method. To check robustness, we tried using standard least squares dummy variables (LSDV) with country-clustered errors, which led to results similar to the ones reported above. In the LSDV results, the coefficient of the lagged level of life satisfaction was around 0.7, which is smaller than in the LSDVC results, but the estimates of the long-run effects of positive and negative changes in GDP were of similar magnitude. This means that the key results were qualitatively similar. We also ran LSDV models both with and without country-clustering to get an idea of how the lack of clustering might affect our LSDVC results. Not clustering did not affect the significance of the coefficients in the case of LSDV, which might indicate that the same is true for LSDVC.

As we have employed the LSDVC method, we have had to choose the accuracy of the bias approximation and the instrument set for the initial estimator. We have used bias approximation that is accurate to order $O(T^{-1})$. Although this should, on average, account for 90% of the true bias, approximations with higher order terms are available for situations in which the number of cross-sectional units is not very large (Bruno 2005). Furthermore, we have used all available lags as instruments for the initial estimator which, according to Roodman (2009), may lead to biases that can be alleviated by using less instruments, preferably by collapsing the instruments. Thus, any remaining bias in our estimates could be further reduced by using a more accurate bias approximation and reducing the number of instruments. To check robustness, we re-estimated using bias approximation that is accurate to the (maximal) order of $O(N^{-1}T^{-2})$ and reducing the number of instruments from 450 to 39 by collapsing. We also tried changing the initial estimator from a difference GMM to a system GMM, again with the highest order bias approximation and collapsed instruments. These analyses yielded similar estimates as those obtained without the modifications. Most importantly, the estimated short-run and long-run effects of positive and negative changes and their statistical significances were similar, so our conclusions do not change.

38 The results discussed in this section are available from the authors upon request.

Two features of our data set may raise concerns from the point of view of the robustness of our results. First, many of the negative GDP changes in the sample occur during the latest economic crisis, so the results may be largely driven by that crisis. However, estimations excluding the post-2007 years yielded very similar results. A second potential source of concern may be that the sample is highly unbalanced and many of the time-series are quite short. Some earlier studies using EB (e.g., De Neve et al. 2018) focus on longer-serving EB countries. We tried limiting the sample to the longer time-series. We started with the eight original EB member countries (Belgium, Denmark, France, the UK, Ireland, Italy, Luxembourg, the Netherlands) and then added the longest available time-series one by one until all the EU-15 countries were included. Our main result on the long-run asymmetry proved robust to these changes. The long-run effect of a positive GDP change became statistically significant at the 10% level when we included only the longest eight time-series, but otherwise the qualitative results on the long-run effects remained similar. Note that because countries with the longest time-series are Western European, the above also indicates robustness to excluding Eastern Europe from the data set.

There are some inconsistencies in the way life satisfaction has been surveyed in the EB over the years. For example, the question wording is different in some surveys. Our models include year fixed effects to control for such changes, as well as for different field work months and different preceding questions in different years. However, to make sure that our results are not nevertheless affected by the inconsistencies, we created two data sets in which the total number of country-year observations is the same as in the baseline data set but some of the country-year averages of life satisfaction are calculated excluding some surveys.[39] In the first alternative data set, we excluded surveys where the wording of the life satisfaction question is different from the standard one (44.3OVR, 52.1, and 56.1). In the second alternative data set, we also aimed to minimize the number of different preceding questions, following Kaiser and Vendrik (2019). Thus, we also excluded surveys 3, 6, 20, 22, 24, 26, 28, 32, 34, 71.1, 76.3.[40] Using the alternative data sets yielded similar key results as using the baseline data set: long-run and short-run asymmetries; an insignificant long-run effect of economic growth and a significant long-run effect of contractions (the magnitude was also similar).

Our paper belongs to the group of studies in which the focus is on the GDP–SWB relationship. However, especially in the long run, various other changes that

39 A complete list of the surveys used in our baseline data set is reported in the online appendix.
40 Our baseline data set is based on a smaller set of surveys than Kaiser and Vendrik's (2019) because we only include those surveys that were conducted in every country that was participating EB that year.

influence well-being occur in economies which could cause omitted variable bias in our results. First, demographic variables in particular have been shown to be associated with well-being in numerous studies. Importantly, Kaiser (2020) has recently shown that controlling for the dynamic effects of household size and partner employment make the adaptation-to-income result disappear at the micro-level. Second, economic variables other than GDP are likely to be important, and they are likely to be strongly correlated with GDP. Some earlier studies that have examined the relationship between GDP and SWB have controlled for some individual-level or macro-level variables, such as age, gender, employment status, the rate of unemployment, or inflation (De Neve et al. 2018; Di Tella and MacCulloch 2008; Di Tella, MacCulloch, and Oswald 2003; Stevenson and Wolfers 2008). Some of these studies have included control variables to check the robustness of their results. However, many of the control variables can be seen as being determined by the economy, measured by GDP. In such a case, the effect of GDP on SWB is mediated through the other variables (like unemployment), or the variables are the transmission mechanisms. Nevertheless, we followed the previous studies of Di Tella, MacCulloch, and Oswald (2003), Di Tella and MacCulloch (2008), and De Neve et al. (2018) and checked the robustness of the estimated relationships to controlling for macroeconomic variables. In particular, we controlled for the unemployment rate (from Eurostat) and the rate of inflation (from the OECD).[41] Although the effect sizes of the GDP change variables became somewhat smaller (an indication of some mediation), controlling for unemployment and inflation did not change the qualitative results. Clark (2016) has proposed that there might be a link between adaptation (as the cause for the Easterlin paradox) and economic inequality. Inequality might also be a by-product of economic growth, in which case it may be a source of negative externalities which, in turn, affect the long-run GDP–SWB relationship. Therefore, we tested the robustness to controlling for inequality. We used three alternative measures of the Gini coefficient from two different databases: Gini with Eurostat as the source (WIID; 398 observations); Gini with constant source and constant detailed resource concept within-country (not required to be constant across countries) (WIID; 429 observations); and Gini (SWIID; 567 observations).[42] The key results proved robust

41 We lost 43 observations because the Eurostat and OECD data do not cover the whole sample. Dropping these observations and re-estimating the GDP–SWB model yielded results similar to those in Table 3.

42 The SWIID measure has the advantage of fewer missing observations but also a minor disadvantage (lag lengths had to be based on the statistical significance of individual variables instead of the joint significance).

to controlling for inequality and it, therefore, seems that inequality neither is an important omitted variable in our analysis nor mediates the GDP–SWB link.

We also tried to control for variables not likely to be determined by GDP but that may affect SWB. In particular, we checked the robustness of our results to controlling for age and gender (e.g., Stevenson and Wolfers 2008 have controlled for these variables). We controlled for the population weighted country-year averages of eight variables: three gender dummies (male, female, no answer); a quartic in age; and a dummy for missing age. This strategy did not lead to significant changes in the results. Finally, to check whether Kaiser's (2020) finding regarding household size and adaptation is important for macro-level results, we tried controlling for the average household size and its lag, but that did not change the results.

5 Conclusions

Earlier studies of the effects of income on SWB using micro data have found evidence for adaptation, social comparisons and loss aversion. Other studies have found that reflections of these phenomena can be observed in the relationship between national income and SWB. We adopted an empirical framework which allows for macro-level adaptation — including effects of social comparisons — and macroeconomic loss aversion to study the macro relationship. The approach has the advantage of avoiding biases arising from ignoring either macro-level adaptation or loss aversion. More importantly, this approach allowed us to present the first evidence of long-run asymmetries in the effects of national income on well-being.

According to the results, positive changes in national income have effects on well-being in the short run but these effects wear off over time. Negative changes are incompletely, if at all, adapted to. There is a large short-run and an even larger long-run asymmetry in the effects of national income changes. These results shed new light on reasons behind the Easterlin paradox. The zero long-run relationship between GDP and SWB identified in earlier studies is not explained by economic contractions offsetting the well-being gains from economic growth. This is because nations adapt to the well-being gains of economic growth over time.

The main implication of our results is that the large and long-lasting effects of economic contractions need to be both studied more and taken into account by future well-being research. More studies are needed because almost nothing is known of the mechanisms through which these effects operate. Future micro and macro studies of the relationship between income and well-being and the related transmission mechanisms need to control for the (presumably large) effects of contractions. In their original study of macroeconomic loss aversion, De Neve et al. (2018) have suggested that policies could aim at minimizing the risk of contractions. At least until more is known about the underlying mechanisms, the same can be suggested based on our results. When it comes to the implications of our complete macro-level adaptation result, some studies on the mechanisms exist. Micro studies suggest that hedonic adaptation and social comparisons may be important, although other mechanisms e.g., externalities (such as environmental damage) brought about by economic growth cannot be ruled out. As ours is the first study that controls for long-run macroeconomic loss aversion, the sensitivity of the earlier results on the mechanisms behind macro-level adaptation has not been analyzed.

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