Loss Aversion at the Aggregate Level Across Countries and its Relation to Economic Fundamentals

Reto Foellmi, Adrian Jaeggi and Rina Rosenblatt-Wisch

SNB Working Papers
1/2018

SCHWEIZERISCHE NATIONALBANK
BANQUE NATIONALE SUISSE
BANCA NAZIONALE SVIZZERA
BANCA NAZIUNALA SVIZRA
SWISS NATIONAL BANK

Legal Issues

ISSN 1660-7716 (printed version)
ISSN 1660-7724 (online version)

Loss Aversion at the Aggregate Level Across Countries and its Relation to Economic Fundamentals*

Reto Foellmi† Adrian Jaeggi‡ Rina Rosenblatt-Wisch§

6 February, 2018

Abstract

Preferences are important when thinking about macroeconomic problems and questions. Differences in preferences might, for example, explain cross-country variations in economic fundamentals.

In recent years, differences in preferences across countries and cultures have been studied more frequently, usually concentrating on micro evidence. However, it is an open question as to how differences in average preferences affect the aggregate economy. Coming from a macroeconomic perspective, we test whether preferences stated in Kahneman and Tversky's prospect theory, namely, reference point dependence and loss aversion, prevail on the aggregate and whether the average degree of loss aversion differs across countries.

We find evidence of loss aversion for a broad set of OECD countries, while the average loss aversion clearly differs across these countries. We find little evidence that these differences could be explained by micro evidence. Furthermore, we analyse whether the different degrees of loss aversion correlate with economic fundamentals such as the level of GDP and consumption per capita. We find that indeed loss aversion is negatively correlated with GDP and consumption per capita and positively correlated with consumption smoothing.

JEL-Classification: E21; O41
Keywords: preferences, loss aversion; prospect theory; GMM

*We would like to thank an anonymous referee, seminar participants at the Swiss National Bank and at the University of St. Gallen. The views expressed in this paper are those of the authors and do not necessarily represent those of the Swiss National Bank.

†University of St.Gallen, Department of Economics, SIAW-HSG, Bodanstrasse 8, CH-9000 St.Gallen
‡University of St.Gallen, Department of Economics, SIAW-HSG, Bodanstrasse 8, CH-9000 St.Gallen
§Swiss National Bank, Börsenstrasse 15, CH-8022 Zürich, Switzerland

1 Introduction

Preferences are important features in macroeconomic modelling. Differences in preferences might correlate with aggregate economic fundamentals. In recent years, differences in preferences across countries and cultures have been studied more frequently. Several papers found differences in preferences across cultures and/ or countries using evidence generated at the micro level, in the form of surveys or experiments (see e.g. Rieger, Wang and Hens, 2015; Herrmann, Thöni and Gächter, 2008; Vieider et al., 2015).

To gain progress in determining whether differences in preferences matter for aggregate outcomes, our paper approaches this from the opposite direction: We start from a purely macroeconomic perspective and test whether preferences, namely, reference point dependence and loss aversion, two key elements of Kahneman and Tversky's prospect theory, vary across countries by only using a macroeconomic time series. To do so, we follow Rosenblatt-Wisch (2008), in which she introduced prospect theory in a stochastic version of the Cass-Koopmans-Ramsey optimal growth model. The preferences of the representative agent in that model are given by the experimentally validated prospect utility function of Kahneman and Tversky (1979) and Tversky and Kahneman (1992). She then tested the model with US data and found evidence of loss aversion in a US macroeconomic time series, in line with the values found by Kahneman and Tversky (1979) and Tversky and Kahneman (1992).

Our contribution is two-fold. First, we test empirically for loss aversion across countries for the aggregate economy. We find that loss aversion prevails at the aggregate level in all countries and that the average degree of loss aversion clearly differs across countries. To check whether these degrees of loss aversion could be explained by micro data, we apply the cultural dimensions constructed by Hofstede, Hofstede and Minkov (2010) and data from the World Values Survey. Because of the large heterogeneity of the data, we find little statistical evidence that either the Hofstede dimensions or the World Values Survey data can explain the cross-country variations in the estimated loss aversion.

Second, we analyse whether the different degrees of loss aversion correlate with economic fundamentals such as GDP and consumption per capita. We find that indeed, according to our analysis, loss aversion is negatively correlated with GDP and consumption per capita and is positively correlated with consumption smoothing. These empirical results are in line with the theoretical ones found by Foellmi, Rosenblatt-Wisch and Schenk-Hoppé (2011).

We concentrate on two key elements of Kahneman and Tversky's experimentally validated prospect theory, namely, reference point dependence and loss aversion. In a recent survey on thirty years of prospect theory, Barberis (2013) notes that the concept of loss aversion relative to a reference point could be promising when thinking about macroeconomics. Focusing on these two aspects of prospect theory, namely, reference point dependence and loss aversion, is common for analysing the aggregate level. Barberis, Huang and Santos (2001) apply these aspects in order to assess the aggregate stock market behaviour, and Benartzi and Thaler (1995) study the equity premium under loss aversion. The paper by Berkelaar, Kouwenberg and Post (2004) uses GMM to estimate loss aversion in the aggregate U.S. stock market. They find an implied loss aversion coefficient of the same size as the one found by Tversky and Kahneman (1992).[1] Kahneman and Tversky (1979) formulated their theory on individual choice under uncertainty. The above-cited papers find loss aversion even in aggregate market data. Brooks and Zank (2005), Kőszegi and Rabin (2006) and Abdellaoui, Bleichrodt and Paraschiv (2007) found experimental evidence of loss aversion at the aggregate level. In addition, loss aversion and thinking in differences have also been found in purely deterministic models (see e.g. Thaler, 1980; Kahneman, Knetsch and Thaler, 1990; Tversky and Kahneman, 1991). Chen, Lakshminarayanan and Santos (2006) find, in an experiment with Capuchin monkeys, that these two behavioural biases even extend beyond species and may be innate, rather than learned.

The rest of the paper is structured as follows. Section 2 reviews the model. Section 3 discusses the data. Section 4 estimates loss aversion across countries, presents the results and tries to explain differences by applying cultural dimensions constructed by Hofstede, Hofstede and Minkov (2010) and/ or data from the World Values Survey. Section 5 analyses whether and in what manner differences in loss aversion correlate with economic fundamentals. Section 6 then concludes the paper.

[1] Berkelaar, Kouwenberg and Post (2004) deliberately abstract from other aspects of prospect theory, such as the power function, since it is difficult to disentangle the effects of loss aversion and risk aversion. For the same reason, they do not apply subjective decision weights.

2 The Model

In the macroeconomic model, we assume a non-time-separable utility function, as inspired by Kahneman and Tversky's prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992). The subsequent empirical section then tests whether loss aversion can be found in macroeconomic time series. For this aim, we will estimate the Euler equation predicted by the non-standard prospect utility function. To apply GMM when estimating the stochastic Euler equation, we assume a parametric form of loss aversion.

In Kahneman and Tversky's prospect theory, agents value their prospects in terms of gains and losses relative to a reference point. They are loss averse, which means that they are more averse to losses than gain seeking on the other hand. Furthermore, they perform subjective, non-linear probability transformations whereby they allot higher weights to small probabilities and lower weights to high probabilities. Kahneman and Tversky originally propose a value function that is concave in the region of gains and convex for losses. The basic idea on how to capture loss aversion is the fact that the value function must be steeper in the loss region.

The setup of our model follows Rosenblatt-Wisch (2008). While this model is influenced by some long-standing ideas derived from the field of psychology, it does not attempt to implement all aspects of prospect theory. The focus lies on loss aversion and on thinking in differences. The value function is linear for losses and gains, with a kink at the reference point. The agent generates utility out of negative or positive changes in consumption. This piecewise-linear approximation and the replacement of subjective probability weighting by objective probabilities is a widely accepted approach, particularly in regard to analysing markets on an aggregate level (see e.g. Aït-Sahalia and Brandt, 2001; Barberis, Huang and Santos, 2001; Berkelaar, Kouwenberg and Post, 2004). Berkelaar, Kouwenberg and Post (2004) deliberately abstract from the power function, since it is difficult to disentangle the effects of loss aversion and risk aversion. For the same reason, they do not apply subjective decision weights.

Taking these thoughts into account, one can define a piecewise-linear prospect utility function:

$$u(\Delta c_t) = \begin{cases} \Delta c_t & \text{if } \Delta c_t \geq 0, \\ \lambda \Delta c_t & \text{if } \Delta c_t < 0, \end{cases} \tag{1}$$

where $\Delta c_t = c_t - c_{t-1}$. The individual cares about consumption differences but weighs losses more heavily, with the parameter $\lambda > 1$ capturing loss aversion. Formally, marginal utility is positive everywhere but larger in the loss region: $0 < \frac{\partial u(\Delta c_t)}{\partial \Delta c_t} < \frac{\partial u(-\Delta c_t)}{\partial(-\Delta c_t)}$ for $\Delta c_t \neq 0$.

In every period, the individual realizes a certain level of consumption and correspondingly a level of the capital stock. This consumption level then becomes the new reference point. Hence, the reference point is dynamically updated: The level realized in every period serves as the new reference point. This choice of the reference point is also in line with the dynamic updating scheme of, e.g., Barberis, Huang and Santos (2001).[2] Benartzi and Thaler (1995) show that the equity premium puzzle with loss averse agents can be explained if these agents monitor the performance of their portfolios every eight months (given a piecewise-linear value function and a loss aversion coefficient of 2.25) or every year (given Tversky and Kahneman's (1992) cumulative prospect theory).

In our analysis, we account for possible sources of psychological influence in the GMM estimations in Section 4 and run our estimations for different reference-updating horizons, namely, a quarterly, half-yearly and annual updating scheme.

How the reference point is updated exactly is an on-going debate (see e.g. Barberis, 2013). Kőszegi and Rabin (2006, 2007, 2009) developed expectations-based reference-dependent preferences. In their works, agents' expectations form the reference point. In addition, utility is generated not only out of gains and losses but also through levels in consumption. Pagel (2017) recently applied these ideas to a life-cycle consumption model. Gneezy et al. (2017), on the contrary, provide some evidence on the limitation of expectations-based reference dependence. The application of expectations-based reference dependence to a macroeconomic framework like ours would significantly increase the degrees of freedom, particularly when estimating the parameters across countries. For simplicity and tractability, we focus on two main aspects of prospect theory: loss aversion and

[2] In Barberis, Huang and Santos (2001), the reference point is also influenced by history, but the idea of a dynamic status quo is incorporated in their approach.

thinking in differences. Foellmi, Rosenblatt-Wisch and Schenk-Hoppé (2011) show that a utility function defined over these two aspects generates transitional dynamics different from the standard Cass-Koopmans-Ramsey model. Namely, it leads to excess consumption smoothing and can cause the economy to stay in a steady state of low consumption and low capital.[3] In addition, the length of our macroeconomic times series limits the simultaneous estimation of several parameters. We will come back to this issue in Section 4.

Thus, given this prospect utility function, the social planner[4] solves

$$\max_{\Delta c_t, k_{t+1}} E \sum_{t=0}^{\infty} \beta^t u(\Delta c_t) \tag{2}$$

subject to the constraint

$$f(k_t) + (1-\delta)k_t = c_t + k_{t+1}, \tag{3}$$

where the production function $f(k_t)$ is strictly increasing and concave, and the production shocks A_t (introduced later) are assumed to enter into the production function in a multiplicative manner. β is the discount factor, and $0 < \beta < 1$.

Δc_t can be expressed as

$$\Delta c_t = f(k_t) + (1-\delta)k_t - k_{t+1} - f(k_{t-1}) - (1-\delta)k_{t-1} + k_t. \tag{4}$$

Substituting the constraint into the objective function, the social planner's problem becomes

$$\max_{k_{t+1}} E \sum_{t=0}^{\infty} \beta^t u(f(k_t) + (1-\delta)k_t - k_{t+1} - f(k_{t-1}) - (1-\delta)k_{t-1} + k_t). \tag{5}$$

This can be solved under the condition that there is an interior solution to the above problem. Having linear utility, corner solutions could be an issue. However, the social

[3]Foellmi, Rosenblatt-Wisch and Schenk-Hoppé (2011) also include utility out of levels in consumption, but they show that the different dynamics compared to the standard case only stem from the prospect utility part, namely, loss aversion and thinking in differences.

[4]Markets are complete, and agents behave competitively, so the First Fundamental Theorem of Welfare Economics holds.

planner approach unites maximization of households and firms. Even though utility is linear with $\lambda > 1$, the production function is concave and, hence, the social planner chooses an interior solution.

The stochastic Euler equation has the following form

$$\frac{\partial u(\Delta c_t)}{\partial \Delta c_t} = E_t \left\{ \begin{array}{c} \beta \frac{\partial u(\Delta c_{t+1})}{\partial \Delta c_{t+1}} \left(\frac{\partial f(k_{t+1})}{\partial k_{t+1}} + (1-\delta) + 1 \right) \\ -\beta^2 \frac{\partial u(\Delta c_{t+2})}{\partial \Delta c_{t+2}} \left(\frac{\partial f(k_{t+1})}{\partial k_{t+1}} + (1-\delta) \right) \end{array} \right\}. \quad (6)$$

Equation (6) deviates from the standard Euler equation in a stochastic Cass-Koopmans-Ramsey model. Consumption is no longer time-separable since the objective function is now dependent not only on c_t and c_{t+1} but also on c_{t+2}. Previous decisions about consumption and capital move the reference point, and this influences current and future expected utility. Thus, current marginal utility is compared not only to marginal utility in the next period but also to marginal utility thereafter.

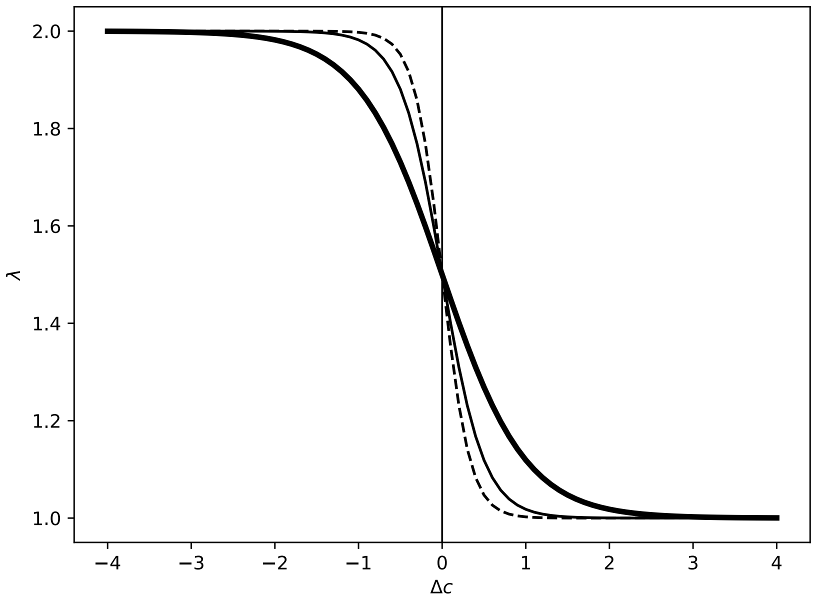
We will estimate the stochastic Euler equation using the Generalized Method of Moments. GMM goes back to Hansen and Singleton (1982), who introduced the concept of testing the implications of stochastic Euler equations directly using that method. One advantage of GMM is that it does not require full specification of the underlying economy. It is an econometric estimation procedure in which it is possible to estimate parameters in dynamic objective functions without explicitly having to solve for the stochastic equilibrium. GMM estimation allows us to derive parameter estimation of the stochastic Euler equation and to test for overidentification. Similarly, Aït-Sahalia and Brandt (2001) derive an asset pricing Euler equation for loss averse investors, which is then used for GMM estimation and Berkelaar, Kouwenberg and Post (2004) use GMM to estimate loss aversion in the aggregate U.S. stock market.

To apply GMM, the function to be estimated must be continuously differentiable. However, as noted above, the utility function in equation (1) is not differentiable at the reference point. To perform GMM, Rosenblatt-Wisch (2008) therefore assumes a smooth parametric auxiliary function such that the utility function is also differentiable at the kink. This can be done by setting up the loss aversion coefficient as a switching function. Under the assumption of loss aversion, λ in equation (1) should be greater than 1 in the loss area and exactly 1 in the gains area. Its value should switch as close as possible to the reference point. Such a switching function $f(\cdot)$ for the loss aversion coefficient λ can be represented by

$$f(\Delta c) = 1 + \frac{\lambda - 1}{1 + e^{\mu \Delta c}}, \tag{7}$$

where μ represents the speed of switching.

Figure 1: Switching Function



Note: μ responsible for the switching speed around the reference point with $\mu = 2$ (bold line), $\mu = 4$ (solid line) and $\mu = 6$ (dashed line).

The higher μ is, the faster the switching around zero (see Figure 1). As required by the assumption of loss aversion, the function $f(\Delta c)$ approaches 1 for $\Delta c > 0$ and λ for $\Delta c < 0$. Thus, expression (7) yields a smooth function to express the loss aversion coefficient λ in the model. Inserting (7) for λ in the piecewise-linear utility function (1) and denoting the parameterized marginal utility by $\hat{u}'(\cdot)$ gives

$$\hat{u}'(\Delta c) = 1 + \frac{\lambda - 1}{1 + e^{\mu(\Delta c)}} - \frac{(\lambda - 1)\, \mu \Delta c_t e^{\mu \Delta c_t}}{(1 + e^{\mu \Delta c_t})^2}. \tag{8}$$

Plugging equation (8) into the Euler equation yields

$$1+\frac{\lambda-1}{1+e^{\mu\Delta c_t}}-\frac{(\lambda-1)\,\mu\Delta c_t e^{\mu\Delta c_t}}{(1+e^{\mu\Delta c_t})^2}=$$
$$E_t\left\{\begin{array}{l}\beta\left(1+\frac{\lambda-1}{1+e^{\mu(\Delta c_{t+1})}}-\frac{(\lambda-1)\mu\Delta c_{t+1}e^{\mu\Delta c_{t+1}}}{(1+e^{\mu(\Delta c_{t+1})})^2}\right)\left(\frac{\partial f(k_{t+1})}{\partial k_{t+1}}+(1-\delta)+1\right)\\ -\beta^2\left(1+\frac{\lambda-1}{1+e^{\mu\Delta c_{t+2}}}-\frac{(\lambda-1)\mu\Delta c_{t+2}e^{\mu\Delta c_{t+2}}}{(1+e^{\mu\Delta c_{t+2}})^2}\right)\left(\frac{\partial f(k_{t+1})}{\partial k_{t+1}}+(1-\delta)\right)\end{array}\right\}. \tag{9}$$

This is the form we need in order to apply GMM. It can be easily seen that we receive the standard Euler equation of the Cass-Koopmans-Ramsey model when we set $\lambda = 1$ in (9). This yields $1 = \beta E_t\left(\partial f(k_{t+1})/\partial k_{t+1} + 1 - \delta\right)$, which is the first order condition of the corresponding Cass-Koopmans-Ramsey model with linear utility.[5] Thus, testing for $\lambda = 1$ is also an implicit test against/ for the standard Ramsey model.

The production side of the model is specified as follows. The supply side is hit by technological shocks, specified as Solow residuals in the data, which creates the uncertainty in the economy. Output is assumed to be produced with a Cobb-Douglas production function

$$F(A_tK_t, L_t) = Y_t = A_tK_t^{\alpha}L_t^{1-\alpha} \tag{10}$$

and in intensive form, dividing by L_t, this gives

$$f(k_t) = y_t = A_tk_t^{\alpha}, \tag{11}$$

where $y_t = Y_t/L_t$ and $k_t = K_t/L_t$. Taking logs and first differences, the Solow residual can then be expressed as

$$\Delta\ln(A_t) = \Delta\ln(y_t) - \alpha\Delta\ln(k_t), \tag{12}$$

where α represents the capital share in the production function.

The depreciation rate is set to $\delta = 1$.[6] Introducing the Cobb-Douglas type production function into the Euler equation and setting the depreciation rate $\delta = 1$ yields:

[5] See also Rosenblatt-Wisch (2005).

[6] The depreciation rate enters the calculations of the capital formation stock data (OECD basis) and is as such a part of our physical capital available in the production process.

$$
\begin{aligned}
1+\frac{\lambda-1}{1+e^{\mu\Delta c_t}}-\frac{(\lambda-1)\,\mu\Delta c_t e^{\mu\Delta c_t}}{(1+e^{\mu\Delta c_t})^2}=&\\
E_t\left\{\begin{array}{c}\beta\left(1+\frac{\lambda-1}{1+e^{\mu(\Delta c_{t+1})}}-\frac{(\lambda-1)\mu\Delta c_{t+1}e^{\mu\Delta c_{t+1}}}{(1+e^{\mu(\Delta c_{t+1})})^2}\right)\left(\alpha A_{t+1}k_{t+1}^{\alpha-1}+1\right)\\ -\beta^2\left(1+\frac{\lambda-1}{1+e^{\mu\Delta c_{t+2}}}-\frac{(\lambda-1)\mu\Delta c_{t+2}e^{\mu\Delta c_{t+2}}}{(1+e^{\mu\Delta c_{t+2}})^2}\right)\alpha A_{t+1}k_{t+1}^{\alpha-1}\end{array}\right\}&. \quad (13)
\end{aligned}
$$

Our estimations will be built on this Euler equation.

3 Data

We use quarterly data from 1950 (or the year when they first became available) to 2015, obtained from Datastream. Table 4 in the Appendix documents the countries we included and their abbreviations used in the figures, along with the information regarding which years are covered in the sample. The data for GDP, consumption and capital stock originate from the OECD, while data for labour are mostly provided by the respective national statistical offices. GDP is measured at constant prices and is seasonally adjusted, as are consumption and the measure for capital stock. Consumption is approximated by private final consumption, whereas we use gross fixed capital formation to measure the capital stock. Labour is measured by total employment, and the exact definitions might differ from country to country. The data for labour are seasonally adjusted as well. GDP and its components are reported in the currency of their respective country, and labour is measured in volumes. We transform GDP, consumption and capital into their intensive form by dividing by labour. The Solow residual is then calculated from a Cobb-Douglas form production function.

The following countries are included in our analysis: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, EU, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, and the United States.

Due to data availability, the sample sizes might differ considerably across countries. However, to make results comparable across countries, we prefer using the same data source, if possible, for all countries, which comes at the price of having fewer data points for some countries.

4 Loss Aversion Across Countries

4.1 Estimation: Loss Aversion Coefficients Across Countries

We estimate equation (13) using GMM. An advantage of GMM estimation is that we do not have to know, or to specify, the full economic setting of the underlying economy.

It would be desirable to jointly estimate loss aversion λ, the capital share α and the discount factor β in equation (13), since these parameters might vary across countries. However, the data at hand are not sufficient to estimate these three parameters jointly. GMM does no longer converge in most specifications when estimating more than one parameter. We set the capital share α equal to 0.33 and μ equal to 0.1, for computational efficiency. α equal to 0.33 is a standard value.[7] As a robustness check, we also perform our calculations for α equal to 0.2 and 0.5. The results remain robust (see Figure 9 in the Appendix).

For the discount factor β, we use four different values: 0.90, 0.95, 0.97 and 0.99. We hold the discount factor constant across countries, which is the common approach in current DSGE modelling across countries (see e.g. Justiniano and Preston, 2009).[8]

We only report results if we have at least 15 observations, which is true for all countries if we use the full sample. As a special case, we are also investigating whether the loss aversion coefficients across countries have converged over time, with a particular interest in the Euro Area countries after the introduction of the Euro as a single currency. We, therefore, also estimate equation (13) for two sub-samples (pre-2000 and post-2000). However, for the pre-2000 sub-sample, we do not have enough observations for Poland, Czech Republic, Romania, Bulgaria, Malta, Croatia, Cyprus, Lithuania and Greece.

For the specifications of the estimation, we follow the strategy used in Rosenblatt-

[7] See, for example, Abel and Bernanke (2001) or Hall and Taylor (1997).

[8] Our data only covers well-developed OECD countries with well-integrated financial markets. The discount factor in stochastic models represents a long-run average real return on risky and riskless assets. One could think of a broad portfolio, or from a finance point of view of the market portfolio. With global financial integration this market portfolio can be assessed by each country and should therefore be similar across countries.

Wisch (2008). In the baseline specification, we estimate equation (13) without additional moment conditions. As a robustness check, we also introduce additional moment conditions in which we use lagged values as instruments: Assuming individuals form expectations rationally, they use information from period t to form expectations about period $t + 1$ but no information from earlier periods. Hence, lagged variables are not correlated with the error terms. In total, we consider seven different specifications concerning the moment conditions. As mentioned, the baseline version is the one without instruments. The other six specifications include lagged values of consumption differences, capital and combinations of it, to formulate additional moment restrictions.

In macroeconomic time series, it is common for the error terms to be correlated over time. Therefore, to allow for heteroscedasticity and autocorrelation in the residuals, we use a heteroscedasticity-and autocorrelation-consistent (HAC) weighing matrix (in case we use instrumental variables) as well as HAC standard errors, using the Bartlett kernel with 4 lags. We use an iterative GMM estimator since it might be more efficient in finite samples (Hall, 2005, p. 88–94), and, as is often the case with macroeconomic time series, our empirical investigation is performed in small samples, which makes this strategy particularly appealing (Hansen, Heaton and Yaron, 1996).

Furthermore, we verify that all input series are stationary, since GMM relies on the stationarity of the components. The null hypothesis of a unit root (tested by the augmented Dickey-Fuller test) can be rejected for all input series for all countries considered. The consumption series are first-difference stationary. We define the Solow residual in terms of growth rates for technological progress together with the growth rate of capital productivity. Using the exponential of the Solow residual generates a stationary time series for the production part of our Euler equation.

4.2 Results: Loss Aversion Coefficients Across Countries

First, we confirm the results found in Rosenblatt-Wisch (2008) for a large set of OECD countries. In general, it seems to hold true that we can track loss aversion in an aggregate time series for different countries and across various specifications of the estimated model. Second, and as expected, we find that larger values of β lead to lower estimates of the loss aversion parameter. As documented in Rosenblatt-Wisch (2008), a higher value for β as well as a higher degree of loss aversion imply that the individual is hurt more by future losses. Hence, β and λ work in the same direction, which implies that when fixing a data point, the higher β is, the lower λ has to be and vice versa. This result is confirmed in the data, across specifications as well as across countries.

Table 1 presents the results in detail for one country, namely, the United States. We estimate various specifications with and without instrumental variables. To keep the exposition tractable, some further results are included in the Appendix. The estimates are very similar to those found in Rosenblatt-Wisch (2008). Overall, the results reveal highly significant estimates of the loss aversion coefficient.

Table 1: Results for the US Without Additional Moment Restrictions

Reference point adj.	1 quarter	2 quarters	4 quarters
$\beta = 0.90$			
λ	1.949***	2.516***	4.441***
Stv Dev	0.129	0.306	1.146
p value	0.000	0.000	0.003
$\beta = 0.95$			
λ	1.589***	1.913***	3.011***
Stv Dev	0.096	0.206	0.739
p value	0.000	0.000	0.007
$\beta = 0.97$			
λ	1.428***	1.652***	2.388**
Stv Dev	0.083	0.166	0.553
p value	0.000	0.000	0.012
$\beta = 0.99$			
λ	0.820***	1.339***	1.670*
Stv Dev	0.043	0.124	0.347
p value	0.000	0.006	0.054
Nobs	243	243	243

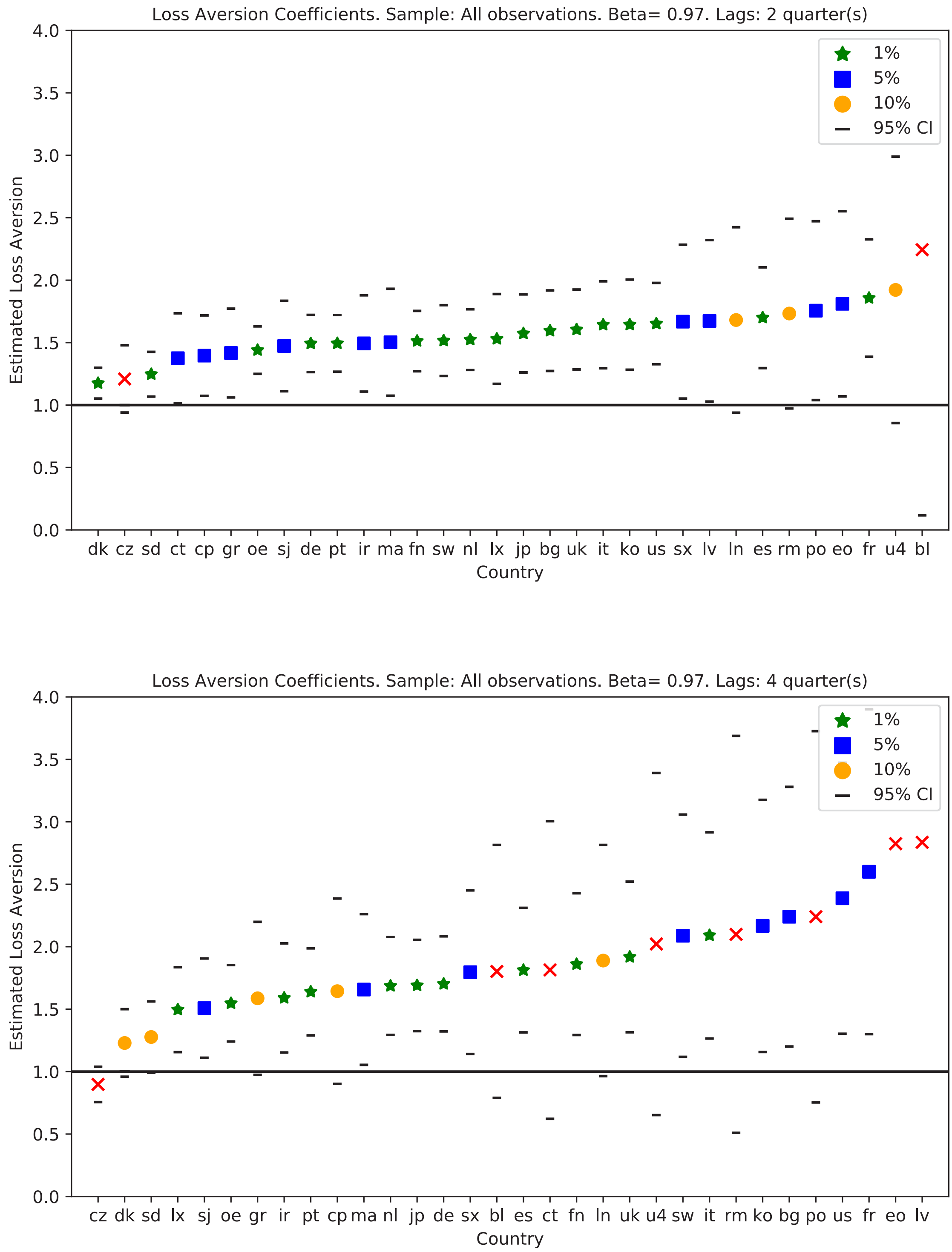
Note: *,**,*** denote statistical significance at the 1%, 5% and 10% level.

Tables 6 and 7 in the Appendix show the results for the United States when using lagged consumption (Table 6) and lagged capital stock (Table 7) as an instrument. The results documented in Table 1 can be confirmed. For the specification with $\beta = 0.97$, the loss aversion coefficient is estimated to be 1.3 for the semi-annual updating scheme and 2.2 for the annual update scheme, when using lagged consumption as the instrument. These numbers change slightly to 1.6 and 2.4, respectively, when using lagged capital stock as the instrument. All estimates are highly significant. These estimates are close to Tversky and Kahneman's experimentally supported value of 2.25 for the loss aversion coefficient.

These findings carry over to a broad set of OECD countries: Basically, all estimates are above 1, indicating loss aversion and are statistically significant. Figure 2 summarizes the results for the estimates resulting from the specifications without instruments for a discount factor of $\beta = 0.97$ and from semi-annual as well as annual reference point updating (for tractability we will use these two specifications as our baseline results for the rest of the paper). We find loss aversion in all countries. The results are somewhat stronger for the semi-annual reference point updating scheme compared to the annual updating scheme.

Furthermore, not only do we find loss aversion in all countries, but we also find cross-country differences in the degree of loss aversion. This holds particularly true for larger updating horizons. Even though the order of the countries when ranked according to their estimated loss aversion coefficient is subject to changes across different specifications, we observe that some country groups are often clustered together at similar loss aversion coefficients.

Figure 2: Estimated Loss Aversion Across Countries



Note: Figure in the top (bottom) panel shows results for semi-annual (annual) reference point updating.

Finally, we test for convergence of loss aversion across countries, comparing the pre-2000 and post-2000 samples. We do not find robust evidence for differences in loss aversion when comparing the pre-2000 sample with the post-2000 sample. Our data do not suggest that we see cross-country convergence in loss aversion. Figure 8 in the Appendix shows the estimated loss aversion coefficients for the pre-2000 and the post-2000 sample, using $\beta = 0.97$ and a semi-annual as well as an annual reference-point updating scheme. Visual inspection does not suggest that the variation in the estimates along the post-2000 axis is smaller than along the pre-2000 axis. To underpin this finding, we report the results from a variance comparison test in Table 8 in the Appendix. There, we test whether the standard deviations of the cross-country estimates are significantly different for the two samples. As the last column reveals, we can reject the null-hypothesis that the standard deviations are the same for only three specifications with an updating horizon of one quarter—the specifications in which the standard deviations across countries are very small. For all other specifications, we do not find any evidence that loss aversion has converged.

Conceivably, institutional settings and loss aversion are closely inter-linked. In Table 9 in the Appendix, we repeat the variance comparison test for the sample of countries within the Euro Area only, accounting for the fact that Euro Area countries' preferences could have become more identical after the year 2000, i.e., after having formed a monetary union, or differently said, after having changed the institutional settings. Table 9, however, shows that convergence in preferences has not taken place to date. We cannot reject the null-hypothesis that the standard deviations of the estimates in the two sub-samples are the same for most specifications.

To sum up, the results found in Rosenblatt-Wisch (2008) for the United States basically carry over to other countries: We consistently find loss aversion coefficients that exceed one (indicating individuals are loss averse), and interestingly, we also find pronounced variation in the size of the loss aversion coefficients across countries.

Can these differences in loss aversion at the aggregate level across countries be explained by micro evidence? We investigate this question in the next subsection. Specifically, we check how our estimated loss aversion coefficients are related to the cultural dimensions reported by Hofstede, Hofstede and Minkov (2010), as well as how they relate to some key questions from the World Values Survey (WVS).

4.3 Possible Reasons for Different Loss Aversion Across Countries

This subsection analyses how the variation in loss aversion coefficients at the aggregate level is matched with micro evidence.

As our first source of micro evidence, we consider the six cultural dimensions reported by Hofstede, Hofstede and Minkov (2010) and investigate whether they correlate with our estimated values. This approach follows Wang, Rieger and Hens (2016), who, in experiments, show that loss aversion and the "Hofstede Dimensions" are related.

As our second source of micro evidence, we use data from the World Values Survey to see whether they have any explanatory power for our estimated loss aversion coefficients.

To uncover the statistical link between our estimated loss aversion and either the Hofstede cultural dimensions or the values from the WVS, we estimate

$$LA_j = cons + \gamma \times culture_j + \epsilon_j \tag{14}$$

applying OLS. LA_j is the estimated loss aversion coefficient for country j, while $culture_j$ is a culture variable from the Hofstede or WVS data.

4.3.1 Data: Hofstede (2010) and World Values Survey

The Hofstede, Hofstede and Minkov (2010) dimensions consist of six variables: *Power Distance Index (PDI)*, *Individualism versus Collectivism (IDV)*, *Masculinity versus Femininity (MAS)*, *Uncertainty Avoidance Index (UAI)*, *Long Term Orientation versus Short Term Normative Orientation (LTO)* and *Indulgence versus Restraint (IND)*. The data result from surveys conducted in several years. However, the data do not have any time dimension; it is a cross-section rather than a panel. Table 2 briefly introduces and describes these variables; more information about the variables can be obtained from Geert Hofstede's website (see source of Table 2).

Table 2: Summary Description of the Hofstede Variables

Variable	Description
Power Distance Index	Measures the degree to which less powerful individuals accept that power is distributed unequally. People living in societies with a high Power Distance accept a hierarchical order in which everyone has his or her place.
Individualism vs. Collectivism	Measures the degree of individualism, i.e., to what degree members of a society are only expected to take care of themselves and their family. People living in societies with a high degree of individualism define their self-image as "I", whereas people in collectivist societies define themselves as "We".
Masculinity vs. Femininity	Measures the importance of achievement and material success in society. Masculine societies tend to be competitive, while feminine societies are more consensus-oriented.
Uncertainty Avoidance Index	Measures the degree to which the members of society feel uncomfortable with uncertainty or ambiguity. Societies with a higher score want to try to control the future, while societies with a low score just let the future happen.
Long Term Orientation	Measures how societies value the future in terms of the present and past. Societies that score low view social change with suspicion, while societies with a high score encourage thrift and education to prepare for the future.
Indulgence vs. Restraint	Measures to what degree human drives are regulated by social norms. Indulgent societies allow free gratification of drives related to enjoying life and having fun. In restraint societies, gratification is regulated to a stronger degree by strict social norms.

Source: Hofstede, Hofstede and Minkov (2010); Geert Hofstede's website: `https://geert-hofstede.com/national-culture.html`. More detailed information about the six variables, as well as the measurement of the variables, can be found there.

Descriptive statistics for the Hofstede variables used here are provided in part I of Table 5 in the Appendix. Wang, Rieger and Hens (2016) use only the first four of these dimensions to establish a link between them and loss aversion, mostly on the individual level. They find that individuals with a higher value for PDI and IDV are more loss averse and that individuals living in countries with a higher value for MAS are more loss averse. However, they do not include LTO and IND in their paper.

Our second source, the World Values Survey[9], includes more than 800 individual questions. Hence, we are required to select some "key" variables that we consider to have an impact on our estimate of loss aversion. Table 3 lists our selected variables, while we provide descriptive statistics in part II of Table 5 in the Appendix. *Variable* is how we name them, and *Code* is the code for the question asked in the WVS data. *Description* is a short description of the content of the variable. The variables are selected partly because we think they are important for economic outcomes and partly because they were used in earlier economic studies. For example, the question we selected to measure time preferences, A038, was used in Galor and Oezak (2016) to proxy for long-term orientation or patience.

[9]The WVS data can be obtained from `http://www.worldvaluessurvey.org/wvs.jsp`

Table 3: Selected Variables from the World Values Survey

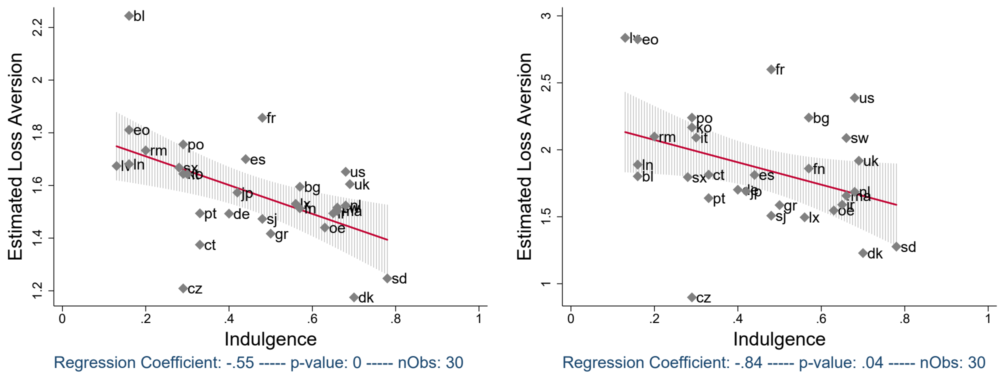
Variable	Code	Description
Work	A030	Important child qualities: hard work
Timepref	A038	Important child qualities: thrift, saving money and things
Trust	A165	Most people can be trusted
Optimism	A170	Satisfaction with your life
Ideas	A189	Schwartz: It is important to this person to think up new ideas and be creative
Status	A190	Schwartz: It is important to this person to be rich
Security	A191	Schwartz: It is important to this person to live in secure surroundings
Altruism	A193	Schwartz: It is important to this person to help the people nearby
Risk	A195	Schwartz: It is important to this person to be adventurous and to take risks
Environment	A197	Schwartz: It is important to this person to look after the environment
Tradition	A198	Schwartz: It is important to this person to value tradition
Genderroles	C001	Jobs scarce: Men should have more right to a job than women
Freedom	E010	National goals: free speech
Equality	E035	Income equality
Politics	E039	Competition: good or harmful
Immigration	E143	Immigration policy
Religion	F050	Belief in God
Fatecontrol	F198	Fate versus control
National	G006	Pride in nationality

For these variables, we compute the average for each country, i.e., for each country and question pair, we take the simple mean to reduce individual observations to one observation per country, similar to Hofstede, Hofstede and Minkov (2010)'s calculations of country averages for individual questions that constitute one dimension (see, for example, Hofstede, Hofstede and Minkov (2010, p. 55)). This procedure yields, for each country, an estimated loss aversion parameter, six Hofstede dimension values and 19 values from the World Values Survey. We then normalize the data on the Hofstede dimensions, as well as the World Values Survey data, by subtracting the minimum of each variable and then dividing by the difference of the maximum and the minimum. Therefore, all values lie between zero and one.

4.3.2 Relation Between Loss Aversion and Culture & Values

Comparing the six Hofstede dimensions with our estimates of loss aversion, we find that our estimates of loss aversion do not significantly correlate with the four dimensions shown in Wang, Rieger and Hens (2016). Interestingly, however, for our main specifications with $\beta = 0.97$, indulgence, one of the dimensions not used by Wang, Rieger and Hens (2016) seems to be significantly negatively correlated with our estimate of loss aversion. Figure 3 shows this relationship.

Figure 3: Estimated Loss Aversion and Indulgence

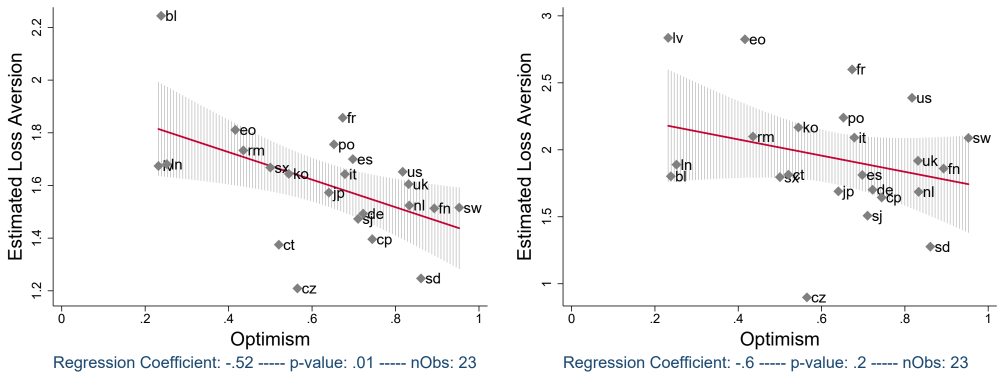


Note: Figure in the left (right) panel shows results for semi-annual (annual) reference point updating.

The left panel in Figure 3 uses the estimated loss aversion coefficient with a semi-annual updating scheme, whereas the right panel uses the results from the specification with an annual scheme. Indulgence measures how individuals are able to control their impulses. A lower score implies that individuals are more restrained (i.e., more able to control their impulses and desires), which is related to a higher degree of loss aversion. Furthermore, we find that long-term orientation, the last remaining dimension and not shown in Wang, Rieger and Hens (2016), is positively correlated with loss aversion. However, the link is not statistically significant. The results for indulgence and long-term orientation seem to be in line with the status quo bias that loss aversion induces (see Samuelson and Zeckhauser, 1988). The more loss averse an agent is, the higher is his status quo bias. The status quo bias can be interpreted as a long-term orientation and as not being tempted by short-sighted impulses and desires.

For the selected indicators from the World Values Survey, a similar picture emerges: Most of the variables do not seem to be statistically significantly correlated with our estimates of loss aversion. One indicator that seems to have some explanatory power for loss aversion is optimism: Pessimistic people show higher loss aversion. This relationship is shown in Figure 4.

Figure 4: Estimated Loss Aversion and Optimism



Note: Figure in the left (right) panel shows results for semi-annual (annual) reference point updating.

Again, the result seems intuitively plausible. Taking risks and moving away from the status quo could generate gains but might also generate losses. Pessimistic people would expect a higher likelihood for losses in general, and these losses loom large because of loss aversion. Therefore, pessimistic people would prefer the status quo, and a high status quo bias goes hand in hand with high loss aversion.

However, overall, we find little statistical evidence that either the Hofstede dimensions or the World Values Survey data can explain the cross-country variance in the estimated loss aversion coefficients, at the aggregate level. This could be because the power of our statistical tests is limited because we only have a small number of observations. Alternatively, due to large heterogeneity and as noted by, e.g., Becker et al. (2015) or Frey and Gallus (2014), simple aggregation of micro evidence might not be able to successfully gauge preferences, at the aggregate level.

5 Loss Aversion and its Relation to Economic Fundamentals

Previous studies investigating individual preferences suggest that these might influence a country's growth trajectory (Becker et al., 2015). For example, a lower level of patience might reduce a country's savings rate, which in turn will lower its accumulated capital. Foellmi, Rosenblatt-Wisch and Schenk-Hoppé (2011) find that an economy with loss averse agents might be stuck in a steady state with low consumption and low capital because loss averse individuals are reluctant to reduce consumption today in order to achieve a higher steady state tomorrow. Furthermore, they show that the presence of loss aversion leads to stronger consumption smoothing.

Hence, we investigate whether our estimated loss aversion coefficients (again with the specification of $\beta = 0.97$) are correlated with a series of economic fundamentals series, such as GDP per capita, consumption, savings rates, inflation, investment shares, monetary aggregates and long-term interest rates. Furthermore, we also look at correlations between unemployment benefits and financial openness with loss aversion. Since the estimated loss aversion coefficients are constant over time, we select the economic fundamentals from the year 2010 as well as the year 2000 to exclude potential effects of the crisis. Furthermore, we look at averages over the years as well as fluctuations of these variables over the years, in order to capture long-term trends as well as business cycle fluctuations of these variables.

As we only have 32 observations, we look at bivariate relationships. Obviously, many other factors affect a country's growth trajectory or other economic fundamentals, while driving loss aversion at the same time. However, due to data limitations, this section focuses on correlations only. By doing so, we shed some light on potential links between loss aversion and economic fundamentals, without claiming any causal relationship.

5.1 Data

We retrieve data for the economic fundamentals from standard macroeconomic data sources. For the long-term interest rates, we use 10-year government bond yields from the OECD database. For the monetary aggregates, we use the broad money (M3) index taken from the OECD database as well. From the same database, we include data on the replacement ratio (for a single individual having worked full time) and an index of financial services restrictions to proxy financial openness. Real GDP and consumption are taken from the Penn World Tables (Version 8.1) and adjusted to per-capita terms, using population data from the same database.[10] Additionally, from the Penn World Tables, we take shares of household consumption and government consumption. Finally, we use annual inflation, broad money (M3) as a % of GDP and savings rates reported in the World Development Indicators (WDI), provided by the World Bank. Summary statistics

[10] We use GDP and consumption data from the Penn World Tables here as a standard source for macroeconomic data. Note, that they are only available at annual frequency, which is sufficient for the exercise in this section. For the estimations of the loss aversion parameters, we used quarterly data from the OECD database.

for these variables can be found in part III of Table 5 in the Appendix. For the loss aversion coefficients, we use our point estimates, using the baseline specifications without additional moment restriction, a discount factor of $\beta = 0.97$ and semi-annual and annual reference point adjustments.

5.2 Results

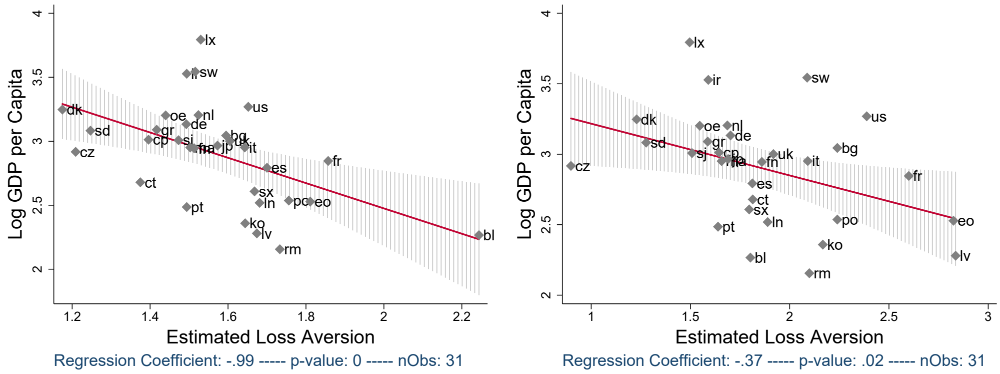
We investigate the statistical link between the economic fundamentals introduced above and the estimated loss aversion, applying OLS. Hence,

$$Y_j = cons + \theta \times LA_j + v_j, \tag{15}$$

where Y_j is any economic fundamental in country j, either at a given point in time (i.e., in either the year 2000 or 2010), or the average over time, or (in the case of consumption smoothing) the standard deviation over time. LA_j again is the estimated loss aversion in country j.

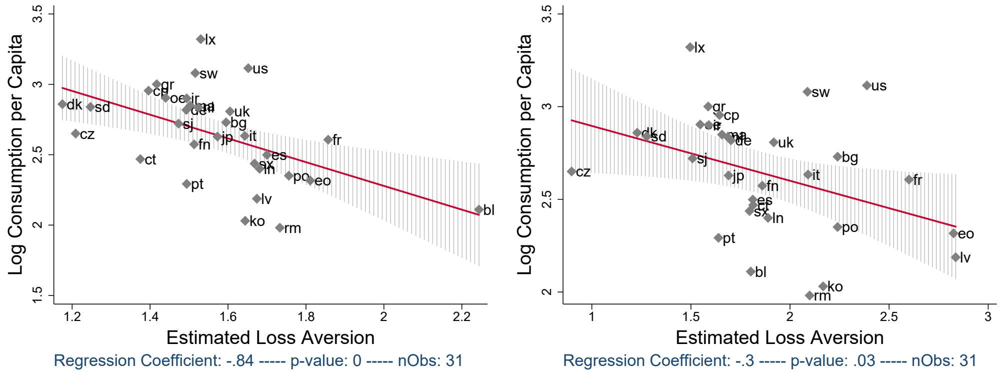
Among the economic fundamentals investigated, we find a consistent and significant effect for GDP per capita and consumption: Less loss aversion is significantly correlated with higher consumption levels as well as GDP per capita. Figures 5 and 6 summarize this result. Here, we use the average of GDP per capita over the same sample for which we have data to estimate the loss aversion coefficient. For Switzerland, for example, we have data from 1970 onward to estimate the Euler equation (see Table 4 in the Appendix), and, hence, we calculate, in this case, the average GDP per capita since 1970. Again, the left panel uses semi-annual reference point updating, whereas the right panel uses annual updating.

Figure 5: Estimated Loss Aversion and Average GDP per Capita



Note: Figure in the left (right) panel shows results for semi-annual (annual) reference point updating.

Figure 6: Estimated Loss Aversion and Average Consumption per Capita



Note: Figure in the left (right) panel shows results for semi-annual (annual) reference point updating.

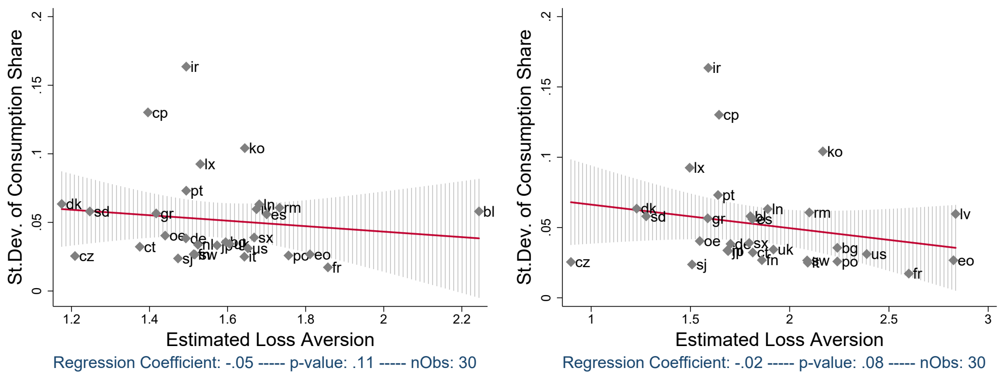
These results do not change qualitatively when using data of the year 2000 or data of the year 2010, instead of taking the average over time. We find empirical evidence for the theoretical predictions that higher loss aversion relates to lower income and consumption.

Concerning the savings rate, we find a negative correlation between loss aversion and the savings rate, in line with what theory would predict. However, the correlation is statistically insignificant in most specifications.

For inflation, the relationship with loss aversion is positive in all specifications, but the correlation is not significant. The results are similar for the long-term interest rate and the measure of financial regulation (i.e., financial openness is related to lower levels of loss aversion). For the broad money stock M3 and the replacement rate, no patterns can be observed.

What about consumption smoothing? Theory predicts that a higher degree of loss aversion goes hand in hand with more consumption smoothing. Therefore, we calculate the standard deviation of the share of household consumption in output over the years for each country in our sample. This gives a simple measure of the fluctuations in consumption shares. We expect a negative correlation between this measure and loss aversion.[11] Figure 7 illustrates this finding.

Figure 7: Estimated Loss Aversion and Fluctuations in Consumption



Note: Figure in the left (right) panel shows results for semi-annual (annual) reference point updating.

Looking at the raw correlation, the two measures seem to be negatively correlated, but the relationship is not significant. However, it is likely that a high level of GDP is both negatively correlated with loss aversion and negatively correlated with fluctuations in consumption. Indeed, if we include average GDP over the years in our estimation (by adding average GDP as an additional regressor to equation (15)), the link between the standard deviation of consumption over time and estimated loss aversion becomes statistically stronger. Note that the statistical link found is stronger than suggested by Figure 7 because we need to control for GDP. As indicated at the bottom of the figures, using semi-annual reference point updating, the p-value is 0.11, whereas with annual reference point updating, it is 0.08. Hence, we find some indicative evidence for a link between loss aversion and consumption smoothing, as theory would suggest.

[11]We exclude Malta here, since its standard deviation of consumption is very large and therefore this data point is a huge outlier.

6 Conclusions

Preferences of agents matter when thinking about macroeconomic modelling and economic developments. In this paper, we find evidence for loss aversion for a broad set of OECD countries, at the aggregate level. The average degree of loss aversion clearly differs across these countries. To understand these differences, we explore the correlation between loss aversion and macroeconomic fundamentals. We find that GDP per capita and consumption levels are significantly and negatively related to our estimates of loss aversion, in line with what theory would predict. Furthermore, we find a higher degree of consumption smoothing in countries with a higher loss aversion.

To gain more insights on the link between institutions and preferences, we also checked whether loss aversion has converged over time, and, in particular, among Euro Area countries after the introduction of the Euro as the single currency. This seems not to have taken place to date.

To understand the underlying reasons of how reference points are formed, it would be interesting to incorporate expectations-based reference dependence. However, such an approach would increase the degrees of freedom substantially, in particular, when estimating the parameters across countries. The data at hand is not sufficient to perform this exercise. However, as time goes by, the length of the macro time series extends. We, therefore, leave this exercise to future research.

References

Abdellaoui, Mohammed, Han Bleichrodt, and Corina Paraschiv Paraschiv. 2007. "Loss Aversion under Prospect Theory: A Parameter-Free Measurement." *Management Science*, 53(10): 1659–1674.

Abel, Andrew B., and Ben S. Bernanke. 2001. *Macroeconomics.* Addison Wesley Longman, Boston.

Aït-Sahalia, Yacine, and Michael W. Brandt. 2001. "Variable selection for portfolio choice." *Journal of Finance*, 56: 1297–1351.

Barberis, Nicholas C. 2013. "Thirty Years of Prospect Theory in Economics: A Review and Assessment." *Journal of Economic Perspectives*, 27(1): 173–196.

Barberis, Nicholas, Ming Huang, and Tano Santos. 2001. "Prospect Theory and Asset Prices." *The Quarterly Journal of Economics*, 116(1): 1–53.

Becker, Anke, Thomas J. Dohmen, Benjamin Enke, Armin Falk, David Huffman, and Uwe Sunde. 2015. "The Nature and Predictive Power of Preferences: Global Evidence." CEPR Discussion Papers.

Benartzi, Shlomo, and Richard H. Thaler. 1995. "Myopic Loss Aversion and the Equity Premium Puzzle." *The Quarterly Journal of Economics*, 110(1): 73–92.

Berkelaar, Arjan B., Roy Kouwenberg, and Thierry Post. 2004. "Optimal portfolio choice under loss aversion." *Review of Economics and Statistics*, 86: 973–987.

Brooks, Peter, and Horst Zank. 2005. "Loss averse behavior." *Journal of Risk and Uncertainty*, 31: 301–325.

Chen, M. Keith, Venkat Lakshminarayanan, and Laurie R. Santos. 2006. "How Basic Are Behavioral Biases? Evidence from Capuchin Monkey Trading Behavior." *Journal of Political Economy*, 114(3): 517–537.

Foellmi, Reto, Rina Rosenblatt-Wisch, and Klaus Reiner Schenk-Hoppé. 2011. "Consumption paths under prospect utility in an optimal growth model." *Journal of Economic Dynamics and Control*, 35(3): 273–281.

Frey, Bruno S., and Jana Gallus. 2014. "Aggregate Effects of Behavioral Anomalies: A New Research Area." *Economics, Psychology and Choice Theory*, 8(18).

Galor, Oded, and Oemer Oezak. 2016. "The Agricultural Origins of Time Preference." *American Economic Review*, 106(10): 3064–3103.

Gneezy, Uri, Lorenz Goette, Charles Sprenger, and Florian Zimmermann. 2017. "The limits of Expectations-based reference dependence." *Journal of the European Economic Association*, forthcoming.

Hall, Alastair R. 2005. *Generalized method of moments.* Oxford University Press Oxford.

Hall, Robert E., and John B. Taylor. 1997. *Macroeconomics.* Norton, New York.

Hansen, Lars Peter, and Kenneth J. Singleton. 1982. "Generalized Instrumental Variables Estimation of Nonlinear Rational Expectations Models." *Econometrica*, 50(5): 1269–1286.

Hansen, Lars Peter, John Heaton, and Amir Yaron. 1996. “Finite-Sample Properties of Some Alternative GMM Estimators.” *Journal of Business & Economic Statistics*, 14(3): 262–280.

Herrmann, Benedikt, Christian Thöni, and Simon Gächter. 2008. “Antisocial Punishment Across Societies.” *Science*, 319(5868): 1362–1367.

Hofstede, Geert, Gert Jan Hofstede, and Michael Minkov. 2010. *Cultures and Organizations - Software of the Mind.* McGraw-Hill Education Ltd.

Justiniano, Alejandro, and Bruce Preston. 2009. “Monetary Policy and Uncertainty in an Empirical Small Open Economy Model.” Federal Reserve Bank of Chicago, Working Paper 2009-21.

Kahneman, Daniel, and Amos Tversky. 1979. “Prospect Theory: An Analysis of Decision under Risk.” *Econometrica*, 47(2): 263–291.

Kahneman, Daniel, Jack L. Knetsch, and Richard H. Thaler. 1990. “Experimental tests of the endowment effect and the coase theorem.” *Journal of Political Economy*, 98: 1325–1348.

Kőszegi, Botond, and Matthew Rabin. 2006. “A model of reference-dependent preferences.” *Quarterly Journal of Economics*, 121: 1133–1165.

Kőszegi, Botond, and Matthew Rabin. 2007. “Reference-dependent risk attitudes.” *American Economic Review*, 97: 1047–1073.

Kőszegi, Botond, and Matthew Rabin. 2009. “Reference-Dependent Consumption Plans.” *American Economic Review*, 99(3): 909–936.

Pagel, Michaela. 2017. “Expectations-based reference-dependent life-cycle consumption.” *Review of Economics Studies*, 84: 885–934.

Rieger, Marc Oliver, Mei Wang, and Thorsten Hens. 2015. “Risk Preferences Around the World.” *Management Science*, 61(3): 637–648.

Rosenblatt-Wisch, Rina. 2005. “Optimal capital accumulation in a stochastic growth model under loss aversion.” NCCR FINRISK Working Paper 222, University of Zurich.

Rosenblatt-Wisch, Rina. 2008. “Loss aversion in aggregate macroeconomic time series.” *European Economic Review*, 52(7): 1140–1159.

Samuelson, William, and Richard Zeckhauser. 1988. “Status Quo Bias in Decision-making.” *Journal of Risk and Uncertainty*, 1(1): 7–59.

Thaler, Richard H. 1980. “Toward a positive theory of consumer choice.” *Journal of Economic Behavior and Organization*, 1: 36–60.

Tversky, Amos, and Daniel Kahneman. 1991. “Loss aversion in riskless choice: A reference-dependent model.” *Quarterly Journal of Economics*, 106: 1039–1061.

Tversky, Amos, and Daniel Kahneman. 1992. “Advances in prospect theory: Cumulative representation of uncertainty.” *Journal of Risk and Uncertainty*, 5(4): 297–323.

Vieider, Ferdinand M., Mathieu Lefebvre, Ranoua Bouchouicha, Thorsten Chmura, Rustamdjan Hakimov, Michal Krawczyk, and Peter Martinsson. 2015. "Common Components of Risk and Uncertainty Attitudes Across Contexts and Domains: Evidence from 30 Countries." *Journal of the European Economic Association*, 13(3): 421–452.

Wang, Mei, Marc Oliver Rieger, and Thorsten Hens. 2016. "The Impact of Culture on Loss Aversion." *Journal of Behavioral Decision Making*, 30(2): 270–281.

A Appendix

A.1 Descriptive Statistics

Table 4: Countries and Sample Composition

Code	**Country**	**First Year**
us	United States	1955
uk	United Kingdom	1959
fr	France	1950
de	Germany	1962
u4	EU28	1995
gr	Greece	2000
ir	Ireland	1990
it	Italy	1960
pt	Portugal	1960
es	Spain	1961
sd	Sweden	1960
nl	Netherlands	1960
jp	Japan	1960
ko	Korea	1970
sw	Switzerland	1970
bg	Belgium	1960
sx	Slovakia	1993
sj	Slovenia	1995
dk	Denmark	1969
oe	Austria	1969
eo	Estonia	1995
lv	Latvia	1995
fn	Finland	1960
rm	Romania	1997
bl	Bulgaria	2000
ma	Malta	2000
ct	Croatia	2002
lx	Luxembourg	1985
cp	Cyprus	1999
ln	Lithuania	1998
po	Poland	1995
cz	Czech Republic	1994

Table 5: Descriptive Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Part I: Hofstede Variables:					
Power Distance	51.03	20.14	11.00	100.00	30
Individualism	57.53	19.23	18.00	91.00	30
Masculinity	47.33	24.33	5.00	100.00	30
Uncertainty Avoidance	70.17	21.86	23.00	100.00	30
Long Term Orientation	59.43	19.57	24.00	100.00	30
Indulgence	44.90	19.64	13.00	78.00	30
Part II: World Values Survey Variables:					
Trust	1.68	0.14	1.36	1.89	23
Work	0.53	0.26	0.10	0.90	23
Tradition	2.96	0.59	2.12	4.15	17
Immigration	2.48	0.16	2.23	2.82	20
Ideas	2.87	0.37	2.09	3.63	17
Status	4.48	0.31	4.07	4.98	17
Security	2.73	0.41	1.96	3.51	17
Altruism	2.47	0.45	1.67	3.41	16
Risk	4.05	0.37	3.41	4.84	17
Environment	2.58	0.36	2.00	3.29	17
Optimism	6.66	0.93	4.90	8.11	23
Politics	3.79	0.55	2.91	5.03	23
Freedom	1.71	0.24	1.35	2.05	9
Equality	5.40	0.81	4.21	7.06	23
National	1.80	0.25	1.37	2.22	23
Religion	0.72	0.18	0.42	0.97	20
Fatecontrol	6.61	0.49	5.59	7.44	14
Genderroles	1.93	0.09	1.76	2.18	23
Timepref	0.41	0.10	0.23	0.60	23
Part III: Economic Fundamentals Variables:					
Log GDP per Capita	3.22	0.43	2.36	4.05	31
Log Consumption per Capita	2.95	0.34	2.25	3.59	31
CPI Inflation in %	1.77	1.40	-1.07	6.09	32
Share of Government Consumption	0.20	0.05	0.08	0.28	31
Share of Household Consumption	0.58	0.09	0.42	0.77	31
10y interest rate in %	4.08	2.03	1.15	10.34	25
Savings Rate in %	21.34	6.64	5.58	39.35	32
Broad money (M3) / GDP	161.45	231.17	37.98	911.21	13
Replacement Rate in %	58.91	14.07	29.40	86.40	29
Financial Regulation Index * 100	1.37	1.83	0.00	6.70	27

Notes: Descriptive statistics include only those countries that are in our sample to estimate the loss aversion coefficient.

The Hofstede Variables measure a country's score for each of the six dimensions on a scale from 0 to 100. As an example, consider the Power distance. Societies with a high degree of Power Distance accept that there is a hierarchical order in which everyone has his or her place. In our sample, the lowest score for Power Distance is 11 for Austria, indicating that Austrians have strong demands for equalization of power.

The World Value Survey Variables we use here are country averages. The values for the variables start at 1 (indicating "disagreement" with the question asked) and go up to a maximum of 10, depending on the question. As an example, consider the Trust variable. The statement given to the individuals is "Most people can be trusted", with possible answers "1: Most people can be trusted" and "2: Cannot be too careful".

The economic fundamentals variables reflect some conditions in the countries examined in our sample. For tractability and to keep interpretation simple, we here report the data for the year 2010.

A.2 Additional Regression Output

Table 6: Results for the US, Using Lagged Consumption as an Instrument

Reference point adj.	1 quarter	2 quarters	4 quarters
$\beta = 0.90$			
λ	1.914***	2.071***	5.394**
Stv Dev	0.308	0.404	1.858
p value	0.003	0.008	0.018
$\beta = 0.95$			
λ	1.544**	1.493***	3.143**
Stv Dev	0.233	0.186	1.054
p value	0.019	0.008	0.042
$\beta = 0.97$			
λ	1.381*	1.285***	2.219**
Stv Dev	0.198	0.108	0.619
p value	0.054	0.008	0.049
$\beta = 0.99$			
λ	0.760	1.091***	1.360**
Stv Dev	0.153	0.035	0.178
p value	0.117	0.008	0.043
Nobs	243	243	243

Note: *,**,*** denote statistical significance at the 1%, 5% and 10% level.

Table 7: Results for the US, Using Lagged Capital as an Instrument

Reference point adj.	1 quarter	2 quarters	4 quarters
$\beta = 0.90$			
λ	1.978***	2.514***	4.387***
Stv Dev	0.132	0.307	1.134
p value	0.000	0.000	0.003
$\beta = 0.95$			
λ	1.611***	1.909***	2.968***
Stv Dev	0.100	0.205	0.726
p value	0.000	0.000	0.007
$\beta = 0.97$			
λ	1.448***	1.648***	2.352**
Stv Dev	0.087	0.165	0.540
p value	0.000	0.000	0.012
$\beta = 0.99$			
λ	1.245***	1.335***	1.644*
Stv Dev	0.073	0.121	0.333
p value	0.001	0.006	0.053
Nobs	241	241	241

Note: *,**,*** denote statistical significance at the 1%, 5% and 10% level.

A.3 Loss Aversion for Different Sub-Samples

Table 8: Estimated Loss Aversion for Different Sub-Samples

			Mean		St.Dev.		
β	Lag	Nobs	Pre-2000	Post-2000	Pre-2000	Post-2000	p-Value
0.90	1	23	1.98	1.83	0.26	0.17	0.06
0.90	2	23	2.52	2.30	0.58	0.49	0.43
0.90	4	20	3.55	3.09	1.31	1.42	0.73
0.95	1	23	1.60	1.52	0.16	0.11	0.05
0.95	2	23	1.90	1.79	0.37	0.30	0.30
0.95	4	20	2.48	2.26	0.73	0.75	0.90
0.97	1	23	1.44	1.38	0.12	0.08	0.04
0.97	2	23	1.64	1.57	0.28	0.22	0.21
0.97	4	20	2.03	1.90	0.49	0.50	0.93
0.99	1	23	1.10	1.07	0.22	0.19	0.56
0.99	2	23	1.33	1.25	0.19	0.22	0.52
0.99	4	20	1.50	1.47	0.23	0.31	0.23

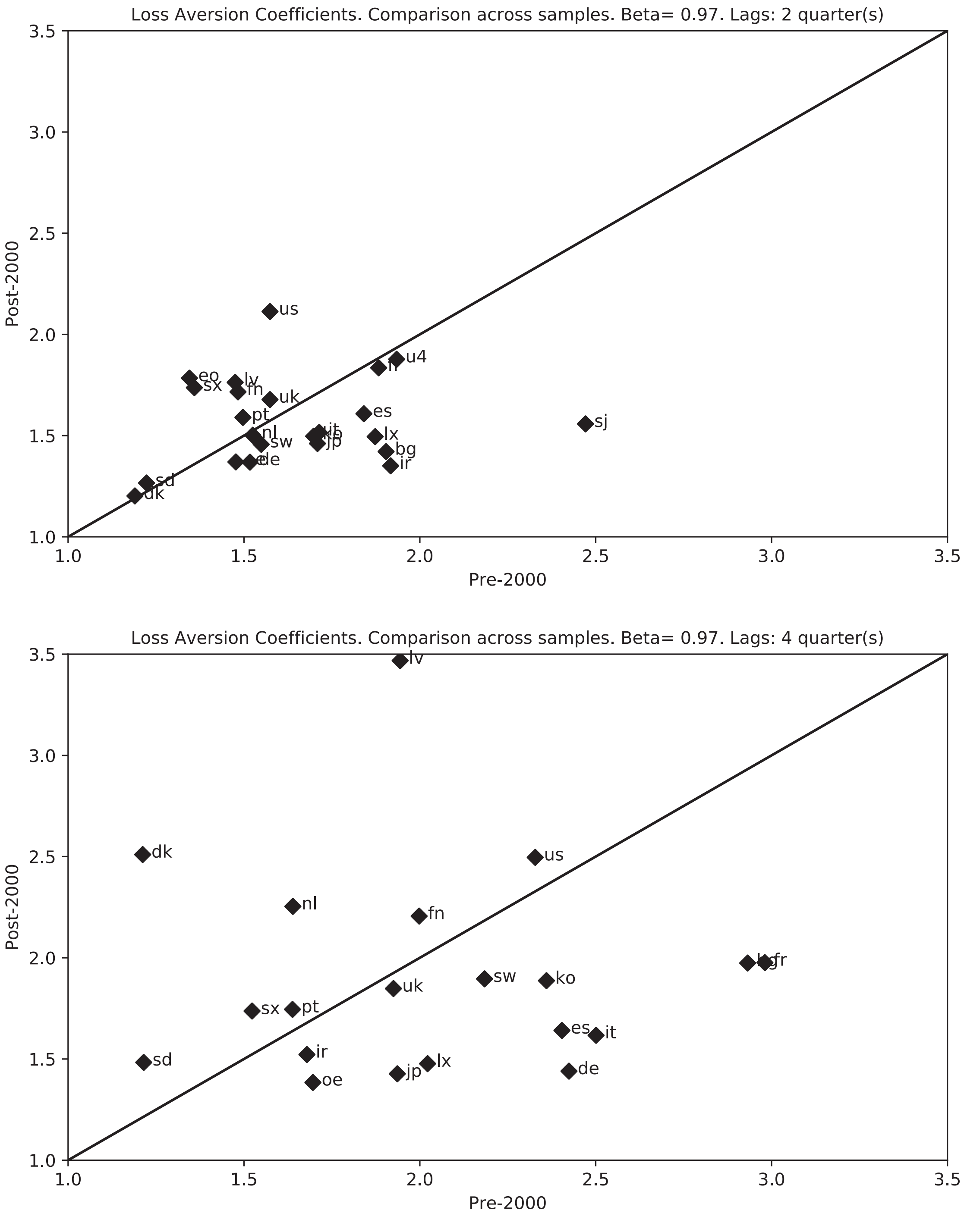
Notes: The table reports an overview of the point-estimates for the different countries. For example, in the column Mean Pre-2000, the cross-country mean of the estimated loss aversion coefficient for the years prior to 2000 is reported, while St.Dev. reports the standard deviation across the cross-country estimates. p-Value reports the p-value from a variance comparison test in which the tested hypothesis is that the standard deviations are not the same.
Extreme outliers have been removed from the sample.

Table 9: Estimated Loss Aversion for Different Sub-Samples: Euro Area Countries

			Mean		St.Dev.		
β	Lag	Nobs	Pre-2000	Post-2000	Pre-2000	Post-2000	p-Value
0.90	1	17	1.97	1.77	0.27	0.13	0.01
0.90	2	17	2.49	2.21	0.63	0.41	0.10
0.90	4	15	3.48	3.04	1.49	1.55	0.89
0.95	1	17	1.60	1.49	0.17	0.09	0.01
0.95	2	17	1.89	1.74	0.41	0.25	0.06
0.95	4	15	2.43	2.24	0.83	0.82	0.98
0.97	1	17	1.43	1.36	0.13	0.07	0.01
0.97	2	17	1.63	1.53	0.32	0.19	0.04
0.97	4	15	1.99	1.90	0.56	0.55	0.96
0.99	1	17	1.12	1.05	0.21	0.18	0.51
0.99	2	17	1.33	1.22	0.22	0.23	0.87
0.99	4	15	1.48	1.47	0.26	0.34	0.32

Notes: The table reports an overview of the point-estimates for the different countries. For example, in the column Mean Pre-2000, the cross-country mean of the estimated loss aversion coefficient for the years prior to 2000 is reported, while St.Dev. reports the standard deviation across the cross-country estimates. p-Value reports the p-value from a variance comparison test in which the tested hypothesis is that the standard deviations are not the same.
Extreme outliers have been removed from the sample.

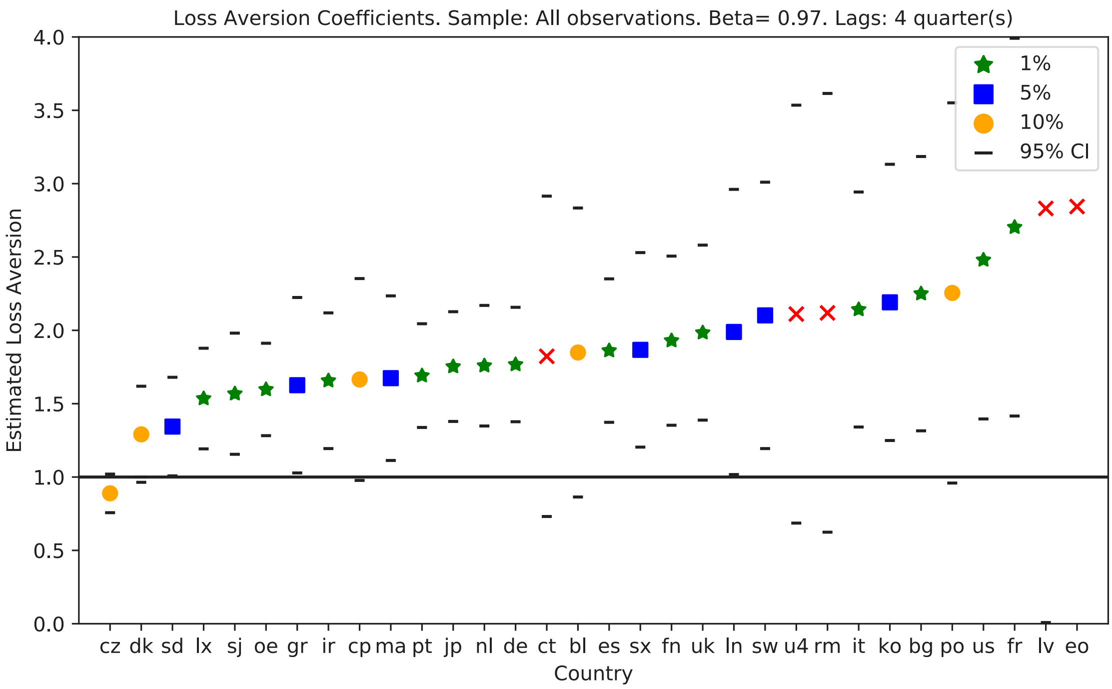
Figure 8: Estimated Loss Aversion Before and After 2000

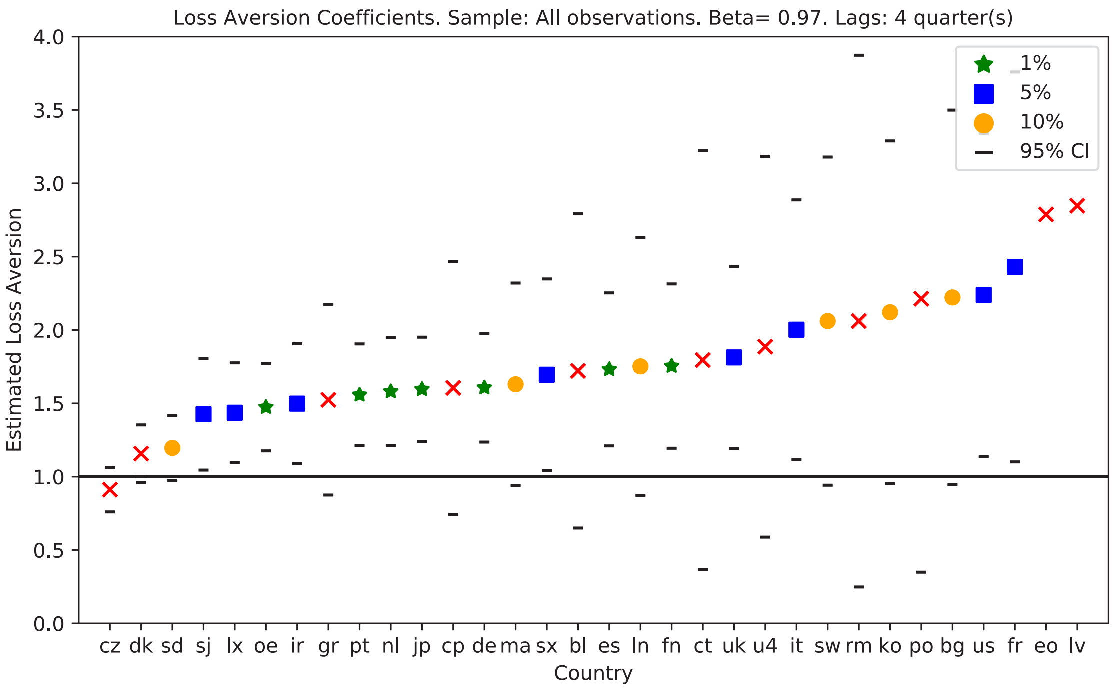


Notes: The figure in the top (bottom) panel shows results for semi-annual (annual) reference point updating. The significance classification is taken from the estimation where we use the full sample.

A.4 Robustness of the estimates with respect to the capital share

Figure 9: Estimated Loss Aversion Across Countries: Robustness





Note: The figure in the top (bottom) panel shows results for $\alpha = 0.2$ ($\alpha = 0.5$). For both figures, we use an annual updating of the reference point.

Recent SNB Working Papers

2018-1 Reto Foellmi, Adrian Jaeggi and Rina Rosenblatt-Wisch: Loss Aversion at the Aggregate Level Across Countries and its Relation to Economic Fundamentals

2017-18 Gregor Bäurle, Sarah M. Lein and Elizabeth Steiner: Employment Adjustment and Financial Constraints – Evidence from Firm-level Data

2017-17 Thomas Lustenberger and Enzo Rossi: The Social Value of Information: A Test of a Beauty and Non-Beauty Contest

2017-16 Aleksander Berentsen and Benjamin Müller: A Tale of Fire-Sales and Liquidity Hoarding

2017-15 Adriel Jost: Is Monetary Policy Too Complex for the Public? Evidence from the UK

2017-14 David R. Haab, Thomas Nitschka: Predicting returns on asset markets of a small, open economy and the influence of global risks

2017-13 Mathieu Grobéty: Government Debt and Growth: The Role of Liquidity

2017-12 Thomas Lustenberger and Enzo Rossi: Does Central Bank Transparency and Communication Affect Financial and Macroeconomic Forecasts?

2017-11 Andreas M. Fischer, Rafael Greminger and Christian Grisse: Portfolio rebalancing in times of stress

2017-10 Christian Grisse and Silvio Schumacher: The response of long-term yields to negative interest rates: evidence from Switzerland

2017-9 Petra Gerlach-Kristen, Richhild Moessner and Rina Rosenblatt-Wisch: Computing long-term market inflation expectations for countries without inflation expectation markets

2017-8 Alain Galli: Which indicators matter? Analyzing the Swiss business cycle using a large-scale mixed-frequency dynamic factor model

2017-7 Gregor Bäurle, Matthias Gubler and Diego R. Känzig: International inflation spillovers - the role of different shocks

2017-6 Lucas Marc Fuhrer: Liquidity in the Repo Market

2017-5 Christian Grisse, Signe Krogstrup and Silvio Schumacher: Lower bound beliefs and long-term interest rates

2017-4 Toni Beutler, Robert Bichsel, Adrian Bruhin and Jayson Danton: The Impact of Interest Rate Risk on Bank Lending

2017-3 Raphael A. Auer, Andrei A. Levchenko and Philip Sauré: International Inflation Spillovers Through Input Linkages

2017-2 Alain Galli, Christian Hepenstrick and Rolf Scheufele: Mixed-frequency models for tracking short-term economic developments in Switzerland

2017-1 Matthias Gubler and Christoph Sax: The Balassa-Samuelson Effect Reversed: New Evidence from OECD Countries

2016-19 Jens H. E. Christensen and Signe Krogstrup: A Portfolio Model of Quantitative Easing

SCHWEIZERISCHE NATIONALBANK
BANQUE NATIONALE SUISSE
BANCA NAZIONALE SVIZZERA
BANCA NAZIUNALA SVIZRA
SWISS NATIONAL BANK