# Macro Consumption and Equity Premium based Risk Aversion of Labor and Capitalists[†]

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**Abstract**

The equity premium puzzle holds that the coefficient of relative risk aversion is excessively high. Based on national account data we assign macro consumption to laborers, who consume their wages, and capitalists, who consume their rental income. Unlike micro based studies that try to account for limited stock market participation by using panel household-level data, our approach is based on longer time series and permits a comparison across countries. The results show that the estimates of risk aversion for stockholders is much lower than those for the representative agent and non-stockholders.

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**Keywords:** equity premium puzzle, limited stock market participation, jackknife, pooling
**JEL:**

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# 1 Introduction

Despite considerable research efforts over the last two decades, the equity premium puzzle christened by Mehra and Prescott (1985) is still with us today. Yet, our understanding of the puzzle has grown considerably. One strand of the literature, introduced by Mankiw and Zeldes (1991), has investigated the effect of limited stock market participation. Mankiw and Zeldes (1991) used micro panel data showing that the consumption of stockholders is quite distinct from the consumption of non-stockholders. In particular, the covariance between consumption and excess returns is larger for the stockholders than non-stockholders, implying that the resulting estimate of the coefficient of relative risk aversion (RRA) is lower. Thereby reducing the size of the puzzle.

As in any research program, some of the maintained assumptions in the micro panel data based investigations are stronger than ideal. For example, consumption is approximated with food consumption, which according to Attanasio and Weber (1995), is a dubious proxy for total consumption. Moreover, the panel data generally have a short time span covering the same households (in Attanasio and Weber (1995) there are only 13 observations). Finally, the approach suffers from measurement error as the distinction between stockholders and non-stockholders is static. Due to data limitations, someone is defined as a shareholder over the entire sample period if he owns shares in the final period. Likewise, if a person does not have stock in the final period, he is considered to be a non-stockholder in all periods.

In this paper we use macro data to distinguish between different sources of income and associated spending. This gives a longer time series than is available for the panel studies and enables an international comparison. We view the macro approach not as a substitute for, but as complementary to the micro-based approach. The idea is as follows. The stockholders consume only from their capital income, while the non-stockholders consume exclusively from their wages. The capital income and wage income are constructed from the categories of net national disposable income. Subsequently aggregate consumption is assigned to the two types of factor income in proportion to their income. These latter series are then used to compute the coefficient of relative risk aversion for both groups. The crucial maintained assumption in this approach is the assignment of expenditure in proportion with factor income derived from the national accounts.

As the stock market is associated with risk, one expects equity owners to have a lower RRA coefficient than wage earners. As a result, equity owners' coefficient of relative risk aversion should also be lower than one that is based on a representative agent model. Applying our model to a selection of OECD countries reveals that this is borne out. In particular, the average coefficient of relative risk aversion for stockholders is 62.3. In contrast, the average estimate for a single representative agent, 186.9, is much higher. The size of our data set enables us to calculate standard errors by means of the jackknife procedure.[1]

[1] There are only few other papers that report standard errors, notable exceptions are Cecchetti et al. (1993) and Vissing-Jorgenson (1999).

The individual country estimates have a wide band of uncertainty. By pooling the information from different countries we can reduce this uncertainty and the *world coefficient of relative risk aversion* of stockholders is shown to be within a range of values that most economists deem plausible. To reduce the uncertainty we also follow Campbell (1999) and present coefficients of relative risk aversion in which the correlation between excess returns and consumption is fixed at unity. In this case almost all the country-specific values for equity owners take on plausible values.

As we pointed out, our macro approach should be seen as complementary to the micro panel data based approach. Some of the flaws of the earlier research were overcome in later research, including Attanasio et al. (2002) and Brav et al. (2002). The notion of limited stock market participation is also widely used in calibration exercises, see e.g. Guvenen and Kuruscu (2006), Gomes and Michaelides (2008) and Guvenen (2009). These studies generally use low values for the RRA coefficient and then see whether their theoretical model is able to generate the historical equity premium. Our macro approach also has its maintained hypothesis, most notably the assignment of expenditure in proportion with the factor income share.

The remainder of this paper is organized as follows. Section 2 concisely introduces the canonical model. Our methodology of how to construct quarterly capital and labor income series using macroeconomic data is explained in the third section. Here we also discuss some drawbacks of our method and how standard errors for the estimates of the risk aversion coefficient can be obtained using a simple jackknifing approach. Section 4 discusses the data. The results of our approach are given in Section 5. In particular, we present estimates of the regular and adjusted RRA coefficient, their confidence intervals and the pooled estimates. The final section concludes.

## 2 Model

The focus of this paper is on constructing consumption series for stockholders and non-stockholders using only macroeconomic data. We stick to the original model except disaggregating the consumption growth into two parts. The model is explained in terms of a representative investor and aggregate consumption. But due to the aggregation theorem of Grossman and Shiller (1981), it applies just as well to a representative stockholder or non-stockholder and their respective consumption streams.

The canonical framework (Grossman and Shiller (1981), Hansen and Jagannathan (1991) and Cochrane and Hansen (1992)) assumes the existence of a representative investor that has a time-separable utility function defined over aggregate consumption. Under these assumptions, the Euler equation reads

$$1 = E_t[R_{i,t+1}\delta(C_{t+1}/C_t)^{-\gamma}]. \tag{1}$$

Here $R_i$ is the gross return on some asset $i$, $\delta$ is the subjective rate of time preference, $C$ is aggregate consumption and $\gamma$ is the RRA coefficient. Next, following Hansen and Singleton (1983), the simplifying assumption is made that asset returns and aggregate consumption are jointly conditionally lognormally distributed with constant variance. Taking logs of equation (1) and rewriting leads to

$$\mathrm{E}_t r_{i,t+1} = -\log\delta + \gamma \mathrm{E}_t \Delta c_{t+1} - \frac{\sigma_i^2 + (\gamma\sigma_c)^2 - 2\gamma\sigma_{ic}}{2}. \tag{2}$$

Small case letters denote logarithms; $\sigma_i^2$ and $\sigma_c^2$ are, respectively, the unconditional variance of the log returns and consumption innovations and $\sigma_{ic}$ is their unconditional covariance. Consider the implications of equation (2) for a riskless real asset. Obviously, the variance of its returns and its covariance with any random variable are zero, implying that the riskless real interest rate obeys

$$r_{f,t+1} = -\log\delta + \gamma \mathrm{E}_t \Delta c_{t+1} - \frac{(\gamma\sigma_c)^2}{2}. \tag{3}$$

Combing equations (2) and (3) gives

$$\mathrm{E}_t[r_{i,t+1} - r_{f,t+1}] + \frac{\sigma_i^2}{2} = \gamma\sigma_{ic}. \tag{4}$$

Equation (4) holds that expected excess returns of equity are equal to the amount of risk aversion times the covariance between consumption growth and excess returns minus a correction factor (i.e. a Jensen inequality term arising as we are using expectations of log returns). This expression permits a calibration of the risk aversion parameter $\gamma$ from estimates of the moments in equation (4). Most often US data is used to estimate these moments. As the US has historically been blessed with high equity returns and rather smooth consumption growth, typical values of $\gamma$ are high.[2]

By itself, this does not constitute a puzzle. To understand why these high estimates are disturbing, one needs to resort to other evidence regarding appropriate values for the RRA coefficient. For example, Mehra and Prescott (1985), after citing a number of studies, argue that values of $\gamma$ exceeding 10 are not plausible. An intuitive argument for this bound based on choice under uncertainty is given by Mankiw and Zeldes (1991, p. 105).

Now consider two agents, one relying on labor income, the other on income derived form share holding. Since the covariance is a linear operator, one can write

$$\sigma_{ic} = \alpha\sigma_{icL} + (1-\alpha)\,\sigma_{icK},$$

and where $\sigma_{icL}$ and $\sigma_{icK}$ are the covariance with excess returns and consumption growth of labor and capital owners respectively, while $\alpha$ is the average share of labor in aggregate consumption (assuming that deviations in $\alpha$ are uncorrelated with the excess returns). Denote the left hand side in (4) by $A$. Then the risk aversion parameters of the two types of agents simply equal $\gamma_L = A/\sigma_{icL}$ and $\gamma_K = A/\sigma_{icK}$, and where $\gamma_L$ and $\gamma_K$ are the coefficients of relative risk aversion.

[2] However, the equity premium is not a US phenomenon. Campbell (1999) shows the existence of the puzzle in a number of developed countries, where estimates of the RRA coefficient vary between -310 and well over 7000. Hence in some other countries it is even more of a puzzle!

In case these $\gamma_L \gg \gamma_K$, say, then $\sigma_{icL} \ll \sigma_{icK}$. By convexity of the inverse, it follows that in per capita terms

$$\gamma_K < \frac{A}{\alpha\sigma_{icL} + (1-\alpha)\,\sigma_{icK}} < \gamma_L.$$

The middle term is the aggregate coefficient of risk aversion. It is biased from the perspective of each of the two types of agents. Hence the rationale for trying to compute these coefficients separately.

## 2.1 absolute risk aversion

Instead of the power utility specification just above, consider the quadratic utility function

$$U(x) = A + Hx - \frac{D}{2}x^2.$$

This function can also be considered as the second order approximation of a more general utility function.

Consider a two period problem with first period budget constraint

$$Y + L = x + B + qS$$

and second period budget constraint

$$(1 + r_f)B + q_j S + M = x_j$$

for discrete states of nature $j = 1, ..., n$. Here $B$ and $S$ are respectively the holdings of bonds and stocks. The price of stock is respectively $q$ and $q_i$. Wealth is $Y$ and labor income is $L$ and $M$ in the first and second period. We assume that labor income is non-stochastic.

By the above, $\gamma$ can be written as

$$\gamma = \frac{x}{qS}\frac{E[Q - r_f]}{\sigma_Q^2}, \quad \text{with } Q \equiv \frac{q_j - q}{q},$$

where $Q$ is the return on equity with $q$ and $q_j$ the price of equity in the first and second period, respectively. The subscript $j$ indicates that the price of equity is uncertain and depends on the state that materializes in the second period. Furthermore, $I$ is the fixed net return on bonds and $x$ is first-period consumption.

Instead of a single representative agent, we define two groups, i.e. equity owners and wage earners. The coefficient of relative risk aversion for group $i$ is then measured as

$$\gamma_i = \frac{x_i}{qS_i}\frac{E[Q - r_f]}{\sigma_Q^2}, \quad \text{for } i = 1, 2.$$

If we label stockholders as the first group and non-stockholders as the second, then we expect $\gamma_1 < \gamma_2$ only if $\frac{x_1}{S_1} < \frac{x_2}{S_2}$. After some tedious algebra, the solution to the investment problem reads

$$x = \frac{H}{D} \quad \text{and} \quad S = \frac{(1 + r_f)(Y + L) + M - (2 + I)H/D}{q(1 + r_f) - E[q_j]}.$$

Under the assumption that both agents have identical utility functions and the same investment opportunities, this results shows that $S$ is, ceteris paribus, higher if the agent has more wealth compared to second-period labor income. In particular, consider the extreme cases of no labor income versus zero wealth

$$S\,|_{L=M=0} - S\,|_{Y=0} = \frac{(1+r_f)(Y-L)-M}{q(1+r_f)-E[q_j]}$$

Furthermore, if for comparison we restrict total labor income to equal initial wealth $Y = L + M$, then

$$S\,|_{L=M=0} - S\,|_{Y=0} = \frac{1+r_f}{q(1+r_f)-E[q_j]}(Y-L).$$

Hence, based on this specification, equity owners whose wealth is (much) higher than first-period labor income, invests more in equity. Given that first-period consumption only depends on the parameters of the utility function, the condition $x_1/S_1 < x_2/S_2$ is satisfied and so the RRA coefficient of stockholders is expected to be lower than for non-stockholders.

# 3 Methodology

This section describes how we implement the idea of constructing separate consumption streams for stockholders and non-stockholders using macroeconomic data. The starting point is national income. As shown in Table 1, net national disposable income is the sum of different components. The first item is labor income, substracting the third item from the second item yields capital income. But what about components (4) through (7)? How should these be assigned to capital and labor income?

Table 1: **Composition net national disposable income**

Notes: Modified version of Table 13 of the Annual National Accounts, provided by the OECD. In particular, net property income is the difference between property income received and property income paid. The same applies to net social contributions and benefits other than social transfers in kind and net current transfers. Note that figures are available for the total economy as well as separately for households and non-profit institutions serving households.

| | | |
|---|---|---|
| | (1) | Compensation of employees |
| +/+ | (2) | Gross operating surplus and mixed income |
| −/− | (3) | Consumption of fixed capital |
| +/+ | (4) | Net property income |
| +/+ | (5) | Net social contributions and benefits other than social transfers in kind |
| +/+ | (6) | Net current transfers |
| −/− | (7) | Current taxes on income, wealth etc. |
| | | Net national disposable income |

Assigning components (4-7) involves the following two issues. First, one would need to determine which fraction of each item to assign to equity owners and wage earners. Second, there is only annual information on these items; implying that either one needs to work with annual observations or find a way to accurately translate these observations into quarterly figures. Without much further information the assignment would be rather arbitrary. In the end we decided to disregarded net property income, net social contributions and benefits other than social transfers in kind, net current transfers and current taxes on income, wealth etc. in the construction of the income streams. Thus we propose to construct a quarterly proxy for disposable income based merely on the first three items. This is fairly rough, but expecting the alternative to be even harder to justify, we believe it is the best possible solution.

Compensation of employees is available on a stand-alone basis at the quarterly frequency. This is also the case for gross operating surplus and mixed income, and the consumption of fixed capital. But for items (2-3) the data is not split between households and non-profit institutions serving households (NPISHs), corporations and the general government. However, this distinction is available at the annual frequency. Hence we use annual data to compute which percentage can be attributed to households and then multiply this percentage with the quarterly series for both components. In other words, information is extracted from the annual data in order to assign part of the quarterly series to households.

The final step is to relate income to consumption. There are basically two approaches. We could (i) use these income series as a proxy for consumption or (ii) somehow translate these income figures into consumption streams. The second method has our preference, since it is well-known that consumption is much smoother than income (e.g. Campbell and Deaton (1989)). As a result, the covariance between excess returns and income growth is, ceteris paribus, higher vis-a-vis the situation in which consumption growth is used. From (4) it is obvious that a higher covariance translates into a lower estimate of the coefficient of relative risk aversion. Moreover, using income as a proxy for spending puts the comparison between the estimates for stockholders and nonstockholders on the one hand and the single representative agent specification (in which consumption is used) on unequal footing. In particular, when the estimates for equity owners are indeed lower than for the representative agent model it would not be clear what drives this result. Is it the use of income growth instead of consumption growth or is the consumption stream of stockholders fundamentally different?

Hence we choose to relate the two income streams to consumption streams. We assign aggregate consumption proportional to income of the factor. So current consumption is taken to be proportional to current income.

In sum, our approach comprises the following steps.

**Step 1** Use data on the composition of net national disposable income for both the total economy and separately for households to compute annual percentages of gross operating surplus and mixed income, and consumption of fixed capital that flows to households;

**Step 2** Multiply these percentages with quarterly series on gross operating surplus and mixed income, and consumption of fixed capital. This provides quarterly series for gross operating surplus and mixed income, and consumption of fixed capital;

**Step 3** Capital income is then formed by net operating surplus and mixed income;

**Step 4** Labor income is compensation of employees;

**Step 5** Assign consumption proportional to income.

The standard model is derived under the assumption that there is a representative agent whose utility is defined over aggregate consumption. Hence when empirically testing the consumption-based CAPM, one uses real aggregate consumption per capita. To the best of our knowledge, there is no time series on the number of (non)stockholders. This implies that we are not able to put our consumption streams for both groups in, respectively, per stockholder and per non-stockholder terms. Obviously, this is a potential drawback of our approach.

### 3.1 Drawbacks of the macro approach

There are a number of potential drawbacks of the approach that we follow. First, the proxy implemented to circumvent the issue of how to assign several components of net national disposable income to capital and or labor is likely the most debatable since several important elements of disposable income are disregarded. Nevertheless, the omitted components do not easily fit within either capital or labor income. This implies that if these elements are to be considered, they somehow need to be assigned to either or both of the two categories. As there is no straightforward method to do so, such an approach would be arbitrary. Moreover, we believe it would be much harder to justify. For example, which part of property income belongs to stockholders? Answering such a question requires detailed information on this type of income. In addition, this percentage is likely to vary over time, so we actually require a time series. Noting that such data would be needed not only for property income, but also for the other three components, implies that we have doubts about the feasibility of its implementation.

Currently we ignore property income, social contributions and benefits other than social transfers in kind, current transfers and current taxes (see Table 1). The motive is that these items more or less cancel out. Hence, in general, our proxy is reasonably accurate and the sum of capital income and labor income does not differ much from net national disposable income of households.

Table 2 presents some summary statistics. Note that national disposable income of households is only available at the annual frequency, so we take the sum of our quarterly series of capital and labor income over the year and compare that to the concept we try to proxy. As can be inferred, the average deviation is rather small for most countries.[3] Notable exceptions are Denmark,

[3] The deviation is computed in nominal terms and relative to net national disposable income for households.

Italy, the Netherlands and Sweden. Moreover, the proxy does not seem to suffer from a large bias in either direction as we see both negative as well as positive deviations. The variance of these deviations is also not too high. In our point of view, this shows that our proxy is plausible. In order to check whether the average deviation is low because negative and positive deviations cancel over time, the next two columns show the average absolute deviation and its variance. Given the small differences, this does not seem to be the case.

Table 2: **Summary statistics proxy**

Notes: *Obs* denotes the number of yearly observations. $\hat{\mu}(DEV)$ and $\hat{\sigma}^2(DEV)$ denote, respectively, the mean and variance of the deviation. This deviation is defined as the sum of quarterly capital and labor income over the year minus the annual value of net national disposable income for households. $\hat{\mu}(|DEV|)$ and $\hat{\sigma}^2(|DEV|)$ denote, respectively, the mean and variance of the absolute values of the deviation. All columns in percentage points. Mnemonics are as follows: Australia (AU), Austria (OE), Belgium (BG), Canada (CN), Czech Republic (CZ), Denmark (DK), Finland (FN), France (FR), Germany (BD), Italy (IT), the Netherlands (NL), Norway (NW), Sweden (SD), Switzerland (SW), the United Kingdom (UK) and the United States (US).

| Country | *Obs* | $\hat{\mu}(DEV)$ | $\hat{\sigma}^2(DEV)$ | $\hat{\mu}(\|DEV\|)$ | $\hat{\sigma}^2(\|DEV\|)$ |
|---|---|---|---|---|---|
| AU | 35 | -4.215 | 4.32 | 4.22 | 4.32 |
| OE | 10 | 3.203 | 1.88 | 3.20 | 1.88 |
| BG | 10 | 3.179 | 6.35 | 3.45 | 4.39 |
| CN | 35 | -5.208 | 15.29 | 5.45 | 12.64 |
| CZ | 9 | 5.883 | 10.97 | 5.88 | 10.97 |
| DK | 10 | 31.662 | 23.94 | 31.66 | 23.94 |
| FN | 15 | 8.643 | 14.89 | 8.64 | 14.89 |
| FR | 27 | 1.658 | 2.50 | 1.77 | 2.10 |
| BD | 10 | -3.152 | 5.77 | 3.24 | 5.13 |
| IT | 15 | -13.110 | 1.46 | 13.11 | 1.46 |
| NL | 15 | 15.789 | 6.15 | 15.79 | 6.15 |
| NW | 10 | 9.045 | 9.58 | 9.05 | 9.58 |
| SD | 10 | 25.412 | 15.81 | 25.41 | 15.81 |
| SW | 10 | 10.707 | 2.87 | 10.71 | 2.87 |
| UK | 10 | -4.900 | 11.96 | 5.00 | 10.84 |
| US | 35 | 1.006 | 3.88 | 1.73 | 1.83 |

This of course does not rule out the possibility that although these disregarded items more or less cancel out, this does not occur within the two consumption streams but across them. However, looking at these four items, it seems that this is not very likely. For example, stockholders will probably receive more property income, but because their income and wealth are also higher, they pay more taxes. Moreover, note that it is not the level of consumption that determines the value of the coefficient of relative risk aversion, it is the second moment of consumption growth that is paramount. This also provides an additional justification for our choice to assign consumption proportionally to income, the second issue deserving some more attention. As long as our proxy does well in capturing the dynamics of both income streams, the ultimate consumption growth series of both groups will also have the right dynamics since the proportional assignment causes the consumption streams to fully inherit their dynamics from the constructed income streams.

The third point deserving attention is the use of percentages derived from annual data to assign part of quarterly series to households. Using annual data on both households and the total economy allows us to compute the percentage that flows to households of gross operating surplus and mixed income and consumption of fixed capital. This can then be used to assign part of quarterly series to households. This means that we assume that the percentage is constant throughout the year. Although it is probable that this assumption does not hold for every time period and country, quarterly percentage fluctuations are probably not too large. Moreover, the percentages do change every year, so we capture any longer-term trend, only fluctuations within the year are disregarded. Therefore, we believe that it has limited influence on our analysis.

Finally, we are not able to put the consumption streams of equity owners and wage earners in per capita terms. We could use the findings of Poterba and Samwick (1995) about US stock ownership but this seems to be too much of a stretch since their analysis is based on three surveys. This implies that a time-series of stock ownership has to be based on just a few observations. In addition, such a series would be required for each country. Assuming that there is at least any information, there would probably be large differences between the surveys, making it hard to compare the estimates of the coefficient of relative risk aversion cross-country.

How does this last issue influence the estimate of $\gamma$ for both groups? Looking at equation (4), it is obvious that it affects the covariance between excess returns and consumption growth, i.e. the standard deviation of consumption growth and the correlation between excess returns and consumption growth. In Appendix B we show how these two terms are affected. One can determine the sign of the effect for the standard deviation of consumption growth. In particular, the sign depends on the correlation between consumption growth and population growth. If $\rho(\Delta c_{t+1}, \Delta p_{t+1}) > (<)\ 0$ then the standard deviation of consumption growth increases (decreases) when it is not considered per 'capita'. For the correlation between excess returns and consumption growth, the sign can not be determined and so the effect can be in either direction. Given that the influence on estimates of the coefficient of relative risk aversion depends on both terms as well as their relative magnitudes, the ultimate effect is ambiguous.

### 3.2 Standard errors

Studies about the equity premium puzzle usually only report the point estimates of the coefficient of relative risk aversion. To get an idea of the uncertainty surrounding such an estimate, Pozzi et al. (2010) introduce a simple method to construct standard errors for estimates of the RRA coefficient. Moreover, having standard errors implies that we are able to test whether estimates for both groups are statistically significantly different. Again, the following is written in general terms but applies to estimates of $\gamma$ for all three groups.

Our method of constructing standard errors uses the block-jackknife procedure, see e.g. Shao and Tu (1995). It is easy to implement and it can deal with the serial correlation that seems to be present in the consumption series of the canonical model, as well as in our constructed consumption series for both stockholders and non-stockholders. Let $n$ be the size of the sample, let $m$ denote the number of omitted observations in a resample and let $N$ denote the number of resamples. Note that the total number of resamples is $N = n-m+1$. To estimate the variance of $\hat{\gamma}_n$, the estimate of $\gamma$ based on all observations, one first deletes $m$ subsequent observations at a time and denotes the new estimate of the RRA coefficient by $\hat{\gamma}^{(i)}$. Then the $i$-th pseudovalue of $\hat{\gamma}_n$, denoted by $\tilde{\gamma}^i$, is defined as $\left[n\hat{\gamma}_n - (n-m)\hat{\gamma}^{(i)}\right]/m$. The resulting vector of pseudovalues across the resamples is used to estimate the variance of $\hat{\gamma}_n$, i.e.

$$S^2_{\hat{\gamma}_n} = \frac{m}{nN}\sum_{i=1}^{N}\left(\tilde{\gamma}^{(i)} - \frac{1}{N}\sum_{i=1}^{N}\tilde{\gamma}^{(i)}\right)^2. \tag{5}$$

This estimate can then be used to form a country-specific confidence interval (CI) for $\hat{\gamma}_n$. More specifically, the Quenouille-Tukey mean of the pseudovalues, see Shao and Tu (1995, p. 6), is the bias-corrected version of the estimate of $\gamma_n$ and the required critical value is taken from a $t$-distribution, with $N-1$ degrees of freedom (Miller, 1974).

### 3.3 Pooling

The cross-sectional dimension of our data set allows the computation of pooled estimators for each group, to which we refer as the world coefficient of relative risk aversion ($\gamma_w$). A priori, there is no reason to assume that the information contained in the country-specific estimates is equal, so using a weighted average seems to be a natural choice. As the block-jackknife procedure supplies the country-specific sample variances, the optimal (i.e. unbiased and variance minimizing) weights of Graybill and Deal (1959) can be used. These are defined as

$$w_j = \frac{1/S^2_{\hat{\gamma}_{n,j}}}{\sum_{j=1}^{k} 1/S^2_{\hat{\gamma}_{n,j}}}, \tag{6}$$

where $k$ denotes the number of countries. Confidence intervals for the pooled estimators are then formed by weighting the country-specific averages of the pseudo values to get $\hat{\gamma}_w$. It is straightforward to show that the variance of this estimate is given by

$$S^2_{\hat{\gamma}_w} = \frac{1}{\sum_{j=1}^{k} 1/S^2_{\hat{\gamma}_{n,j}}}. \tag{7}$$

Critical values are taken from a $t$-distribution with $k-1$ degrees of freedom.

## 4 Data

The methodology described in the previous section is applied to data for a selection of OECD countries, i.e. Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom and the United States. Various data limitations force us to drop the remaining 15 countries. For Iceland, Luxembourg and the Slovak Republic there is no suitable equity return data; they also miss vital information for the construction of the income series. The latter is also the reason why Chile, Hungary, Ireland, Japan, Korea, Mexico, New Zealand, Portugal and Turkey are not included in our analysis. Too few observations leads us to disregard Greece, Poland and Spain. The start of the sample period is country-specific, depending on data availability; the end of the timespan is restricted to the final quarter of 2004.

Implementation of our approach requires a large number of time series, both annual as well as quarterly series. If applicable, all series are in local currency. The annual series are obtained from the database of the OECD. All can be taken from the simplified non-financial accounts (Table 13) in the Annual National Accounts. We require gross operating surplus and mixed income, consumption of fixed capital and net national disposable income. These three series are in current prices and in twofold: for the total economy, and for households and NPISHs. Net national disposable income is only needed for the latter group.

Some quarterly series are also from the OECD. From the Quarterly National Accounts, the following series are needed. Net operating surplus and mixed income, consumption of fixed capital and compensation of employees; all in current prices, the latter also at quarterly levels. Private final consumption expenditure in constant prices is also from this source. The Consumer Price Index (all items) is from the Main Economic Indicators. For Australia this series is quarterly, for the other countries there is a monthly index; for these we use the value of the final month of the quarter. All these series are taken directly from the OECD database.

Finally, three series are from other sources and obtained through Datastream. Data to construct the equity return are from Morgan Stanley Capital International. For the riskfree rate, we use the best proxy available in the International Financial Statistics, provided by the IMF. When available, the 3-month T-bill rate (line 60C) is used; otherwise a money market rate (line 60B) is selected. Annual mid-year population figures are also taken from the IFS. More details about the construction of the real excess return and the transformation of the annual population figures into quarterly estimates are given in Appendix C.

## 5 Results

We first compute the coefficient of relative risk aversion (i.e. $\gamma$) for all three specifications and show what is the driving force behind the differences in point estimates. In addition, confidence intervals are constructed and we present the pooled estimates. In the second subsection we follow Campbell (1999) and show results based on an adjusted RRA coefficient (denoted by $\theta$) by setting the correlation between consumption growth and equity returns equal to unity. The argument is that the correlation term on the RHS of equation (4) is difficult to estimate accurately. Confidence intervals and pooled estimates are also presented for this other estimator.

To better judge the performance of our approach, the standard model with a single representative agent is also estimated. In order to keep the comparison fair, consumption growth is used instead of consumption growth per capita (see the discussion in Section 3.1). However, the influence on the results for this specification are quantitatively small and none of the qualitative conclusions are affected; its results are indicated by subscript $R$. This can also be seen as an indication that not computing the consumption streams of stockholders and non-stockholders in per recipient terms does not substantially influence our results.

## 5.1 Coefficient of relative risk aversion

Estimates of the coefficient of relative risk aversion based on equation (4) are presented in Table 3. Consistent with previous research (e.g. Campbell (1999)), the standard model delivers high values of $\gamma$. None of the estimates comes close to the highest value considered plausible. Coefficient values for stockholders (subscript $K$), shown in the next column, are in general closer to zero. With the exception of the Netherlands and the United Kingdom, all values of $\gamma$ are lower for stockholders than for the representative agent. We will return to this result later on. The outcomes in the final column indicate that estimates for non-stockholders (subscript $L$) are both negative as well as positive. However, remember that there is no a priori reason to believe that non-stockholders satisfy the first-order condition underlying the Euler equation, so estimates of $\gamma$ have no clear interpretation for this group.

Note that the estimate for the representative agent is in between those for the two subgroups for 8 out of the 16 countries. This might be somewhat surprising since both groups are implicitly part of the representative agent specifications. However, note that the relationship is not linear, i.e. the estimate for the representative agent is not a linear combination of the estimates for stockholders and non-stockholders. It is worth mentioning that any negative value for $\gamma$ is the result of a negative correlation between excess returns and the respective consumption growth (see Panel B of Table 4 and the discussion later on); for all countries the average excess return is positive over the sample period. This correlation is also the reason why stockholders for the Netherlands and the United Kingdom have such a high estimate; their correlation is near zero.

So far, our results clearly indicate that estimates for stockholders constitute less of puzzle compared to those based on the representative agent model. What drives this result? A glance at (4) reveals that the LHS is equal for all three groups, so any difference has to come from the only other unknown: the covariance between excess returns and consumption growth. In particular, it has to

Table 3: **Estimates of risk-aversion coefficient**

Notes: $\hat{\gamma}$ is the estimate of the coefficient of relative risk aversion based on equation (4). Subscripts refer to the three groups: the representative agent ($R$), stockholders ($K$) and nonstockholders ($L$). See Table 2 for an explanation of the country mnemonics.

| Country | Sample period | Obs | $\hat{\gamma}_R$ | $\hat{\gamma}_K$ | $\hat{\gamma}_L$ |
|---|---|---|---|---|---|
| AU | 1970Q1 - 2004Q3 | 139 | 137.66 | 23.13 | -1135.49 |
| OE | 1995Q2 - 2004Q3 | 38 | 1083.51 | 63.02 | -440.54 |
| BG | 1995Q2 - 2004Q3 | 38 | 355.03 | 152.86 | 493.34 |
| CN | 1970Q2 - 2004Q3 | 138 | 47.78 | 30.95 | 50.18 |
| CZ | 1996Q2 - 2004Q3 | 34 | -318.12 | 36.81 | -74.79 |
| DK | 1995Q2 - 2004Q3 | 38 | 129.43 | 108.99 | 130.38 |
| FN | 1990Q2 - 2004Q3 | 58 | 195.38 | 27.56 | 2312.13 |
| FR | 1978Q2 - 2004Q3 | 106 | 187.21 | 54.96 | 426.42 |
| BD | 1995Q2 - 2004Q3 | 38 | 532.32 | 54.40 | -777.71 |
| IT | 1990Q2 - 2004Q3 | 58 | 96.22 | 18.96 | -126.26 |
| NL | 1990Q2 - 2004Q3 | 58 | 156.55 | 580.14 | 141.49 |
| NW | 1995Q2 - 2004Q3 | 38 | -676.77 | -17.13 | 127.10 |
| SD | 1995Q2 - 2004Q3 | 38 | 182.62 | -3.03 | 18.16 |
| SW | 1995Q2 - 2004Q3 | 38 | 734.60 | 34.40 | -821.24 |
| UK | 1995Q2 - 2004Q3 | 38 | 74.06 | -210.20 | 61.13 |
| US | 1970Q2 - 2004Q3 | 138 | 72.59 | 40.25 | 89.04 |

be due to (i) differences in the standard deviation of consumption growth, (ii) differences in the correlation between excess returns and consumption growth or (iii) a combination of these two factors.

Table 4, Panel A gives the standard deviations of consumption growth for all three groups. As shown, the consumption growth of stockholders (column 3) is much more variable than for non-stockholders (column 4). On average, it is approximately a factor 3 higher. Comparing the standard deviations for the representative agent (column 2) on one hand and those for the two subgroups on the other hand reveals that, with the exception of the United States, the estimate is lowest for the representative agent model. This suggests that the two consumption streams are negatively correlated. So, based on this analysis, the United States is the only country for which consumption growth of both groups has gone hand in hand. In all other countries, consumption growth seems to be better characterized as a zero-sum game: positive consumption growth for stockholders implies negative consumption growth for non-stockholders and vice versa.

The other possible explanation comes from the correlation between excess returns and consumption growth, these are presented in Panel B of Table 4. Just like before, there is no a priori reason to expect the correlation between excess returns and the consumption growth of non-stockholders to satisfy certain conditions. We do expect the correlation for stockholders to be higher than for the representative agent because they are the group whose consumption stream is affected by changes in excess returns.

For the majority of the countries this is indeed, in an absolute sense, the case. Note the negative correlations for Norway, Sweden and the United Kingdom, which is difficult to explain from a theoretical perspective. The most likely explanation lies in the suggestion of Campbell (1999), who claims short-term measurement errors in consumption make the correlation difficult to measure accurately. Therefore, he also presents results for which this correlation has been set equal to one; an assumption that is also widely used in calibration exercises (e.g. Guvenen (2009)). In the next subsection we presents results based on this setting.

In sum, for most countries the correlation is indeed higher for stockholders than for the representative agent model, but in light of the discussion just above, one should be careful in emphasizing this too much. More importantly, from a quantitative point of view, it seems to be the higher standard deviation of consumption growth that drives the lower estimates of the coefficient of relative risk aversion for stockholders compared to the representative agent model.

Table 4: **Standard deviation and correlation**

Notes: $\hat{\sigma}_c$ is the estimated standard deviation of consumption growth and $\rho(eRe, c)$ is the estimated correlation between the excess return and consumption growth. Subscripts refer to the three groups: the representative agent ($R$), stockholders ($K$) and nonstockholders ($L$). See Table 2 and 3 for an explanation of the country mnemonics and sample period, respectively.

| | Panel A | | | Panel B | | |
|---|---|---|---|---|---|---|
| Country | $\hat{\sigma}_{cR}$ | $\hat{\sigma}_{cK}$ | $\hat{\sigma}_{cL}$ | $\rho(eRe, c_R)$ | $\rho(eRe, c_K)$ | $\rho(eRe, c_L)$ |
| AU | 1.570 | 7.881 | 2.36 | 0.08 | 0.10 | -0.01 |
| OE | 0.829 | 2.249 | 0.85 | 0.04 | 0.25 | -0.10 |
| BG | 1.066 | 3.477 | 1.25 | 0.12 | 0.08 | 0.07 |
| CN | 1.719 | 7.425 | 1.91 | 0.28 | 0.10 | 0.24 |
| CZ | 1.533 | 6.014 | 2.34 | -0.07 | 0.15 | -0.19 |
| DK | 2.352 | 10.368 | 2.52 | 0.17 | 0.05 | 0.16 |
| FN | 1.667 | 8.506 | 2.27 | 0.12 | 0.17 | 0.01 |
| FR | 1.129 | 4.357 | 1.35 | 0.17 | 0.15 | 0.06 |
| BD | 1.255 | 6.468 | 1.73 | 0.05 | 0.09 | -0.02 |
| IT | 1.458 | 3.440 | 1.73 | 0.10 | 0.21 | -0.06 |
| NL | 1.703 | 6.343 | 1.90 | 0.12 | 0.01 | 0.11 |
| NW | 2.333 | 23.642 | 3.61 | -0.02 | -0.07 | 0.06 |
| SD | 1.251 | 38.016 | 5.65 | 0.19 | -0.37 | 0.42 |
| SW | 0.935 | 7.642 | 0.99 | 0.07 | 0.19 | -0.06 |
| UK | 0.946 | 4.795 | 1.06 | 0.26 | -0.02 | 0.29 |
| US | 1.352 | 3.813 | 1.29 | 0.34 | 0.22 | 0.29 |

What is the uncertainty surrounding these point estimates? And are the estimates of both groups significantly different? To answer these questions, we apply the block-jackknife method of Pozzi et al. (2010) to construct 95% confidence intervals for all estimates of $\gamma$. Outcomes are presented in Table 5. As mentioned in Section 3.3, the mean of the pseudo values can be seen as the bias-corrected estimate of $\gamma$. For an easier comparison, these latter estimates are also shown. Comparing these estimates for each of the three groups reveals that the bias in the estimates is in general (relatively) small. In addition, the bias is not in a single direction. For all three groups, the division is almost equal between positive and negative bias. Interestingly, the bias is always in the same direction for each country. So when the bias in the estimate for the representative agent model is positive, it is also positive for the estimates of stockholders and non-stockholders. All in all, the bias in estimates of $\gamma$ is not too alarming.

The width of the confidence intervals varies considerably from country to country. It seems that the standard error is higher if the mean pseudo value (or point estimate) takes on a more extreme negative or positive value. For example, the mean pseudov alues of non-stockholders for Australia and Finland are the most extreme; they also have the largest width of all reported confidence intervals. Interestingly, the confidence interval for the United States is the only one that does not encompass negative values. Confidence intervals for the estimate of $\gamma$ for stockholders are the smallest, so besides the result that the point estimates for this group are lowest, they are also estimated with the highest precision. Given the general pattern between the level and standard error, this is not a surprising result.

Although, as can be inferred from the CIs, the mean pseudo values (or point estimates) differ considerably between stockholders and non-stockholders, this difference is not significant at statistically plausible levels. The confidence intervals are just too wide.

Finally, the standard errors for the country-specific risk aversion coefficients can be used to construct a pooled estimate, denoted by $\gamma_w$, by weighing individual estimates with the inverse of their relative uncertainty. The results are encouraging in the sense that the pooled estimate for stockholders is 0.3, hence well within the plausible range of between one and ten. Moreover, the accompanying 95% confidence interval is rather tight. For non-stockholders the estimate is outside of the plausible range and its confidence interval is less informative. The representative agent model has the highest estimate as well as the most uncertainty. Combined, these results seem to indicate that pooling is a very effective way to reduce the uncertainty in the estimate of the RRA coefficient, but not to such a degree that estimates are statistically different for stockholders and non-stockholders.

## 5.2 Adjusted coefficients of relative risk aversion

As mentioned, Campbell (1999) argues that short-term measurement error in consumption is the reason why the correlation between excess returns and consumption growth is difficult to measure accurately in the canonical model. To

Table 5: **Confidence interval for risk-aversion coefficient**

Notes: $\hat{\gamma}$ is the estimate of the coefficient of relative risk aversion based on equation (4). The mean pseudovalue is denoted by $\overline{PS}$. The confidence intervals are centered around the mean pseudovalue, the standard error is based on the square root of equation (5) and the critical value is taken from a $t$-distribution with degrees of freedom equal to $N-1$; see Section 3.2 for more details. Subscripts refer to the three groups: the representative agent ($R$), stockholders ($K$) and nonstockholders ($L$). See Table 2 and 3 for an explanation of the country mnemonics and sample period, respectively.

| Country | $\hat{\gamma}_R$ | $\overline{PS}_R$ | 95% CI | | $\hat{\gamma}_K$ | $\overline{PS}_K$ | 95% CI | | $\hat{\gamma}_L$ | $\overline{PS}_L$ | 95% CI | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AU | 137.66 | 143.45 | -91.25 | 378.16 | 23.13 | 24.11 | -15.33 | 63.55 | -1135.49 | -1183.29 | -3119.31 | 752.72 |
| OE | 1083.51 | 957.03 | -682.35 | 2596.41 | 63.02 | 55.66 | -39.69 | 151.02 | -440.54 | -389.11 | -1055.66 | 277.43 |
| BG | 355.03 | 307.49 | -213.78 | 828.76 | 152.86 | 132.39 | -92.04 | 356.82 | 493.34 | 427.28 | -297.07 | 1151.63 |
| CN | 47.78 | 50.46 | -23.87 | 124.79 | 30.95 | 32.68 | -15.46 | 80.82 | 50.18 | 52.99 | -25.06 | 131.04 |
| CZ | -318.12 | -262.31 | -888.19 | 363.56 | 36.81 | 30.36 | -42.07 | 102.78 | -74.79 | -61.67 | -208.81 | 85.47 |
| DK | 129.43 | 122.78 | -65.74 | 311.31 | 108.99 | 103.40 | -55.37 | 262.16 | 130.38 | 123.69 | -66.23 | 313.61 |
| FN | 195.38 | 234.20 | -48.51 | 516.91 | 27.56 | 33.04 | -6.84 | 72.92 | 2312.13 | 2771.50 | -574.09 | 6117.09 |
| FR | 187.21 | 180.20 | -10.23 | 370.63 | 54.96 | 52.90 | -3.00 | 108.81 | 426.42 | 410.45 | -23.30 | 844.20 |
| BD | 532.32 | 534.12 | -560.63 | 1628.87 | 54.40 | 54.58 | -57.29 | 166.45 | -777.71 | -780.34 | -2379.74 | 819.07 |
| IT | 96.23 | 119.36 | -253.50 | 492.22 | 18.96 | 23.52 | -49.95 | 96.99 | -126.26 | -156.63 | -645.92 | 332.66 |
| NL | 156.55 | 183.40 | -74.80 | 441.60 | 580.14 | 679.62 | -277.18 | 1636.43 | 141.49 | 165.76 | -67.60 | 399.11 |
| NW | -676.77 | -516.72 | -2084.22 | 1050.78 | -17.13 | -13.08 | -52.74 | 26.59 | 127.10 | 97.04 | -197.34 | 391.43 |
| SD | 182.62 | 173.12 | -133.51 | 479.75 | -3.03 | -2.87 | -7.95 | 2.21 | 18.16 | 17.22 | -13.28 | 47.71 |
| SW | 734.60 | 691.97 | -301.46 | 1685.40 | 34.40 | 32.40 | -14.12 | 78.91 | -821.24 | -773.58 | -1884.19 | 337.02 |
| UK | 74.06 | 55.71 | -201.39 | 312.81 | -210.20 | -158.12 | -887.79 | 571.55 | 61.13 | 45.98 | -166.22 | 258.19 |
| US | 72.59 | 76.13 | 5.10 | 147.15 | 40.25 | 42.21 | 2.83 | 81.59 | 89.04 | 93.38 | 6.25 | 180.51 |

Table 6: **Pooled results**

Notes: The pooled estimate of the RRA coefficient is denoted by $\gamma_w$, using weights specified according to equation (6). The confidence interval uses the square root of equation (7) as standard error and critical value from a $t$-distribution with $k-1$ degrees of freedom; see Section 3.3 for more details. Subscripts refer to the three groups: the representative agent ($R$), stockholders ($K$) and nonstockholders ($L$).

| Specification | Estimate | 95% CI | |
|---|---|---|---|
| $\hat{\gamma}_{wR}$ | 88.93 | 41.99 | 135.87 |
| $\hat{\gamma}_{wK}$ | 0.31 | -4.75 | 5.37 |
| $\hat{\gamma}_{wL}$ | 29.70 | 2.59 | 56.82 |

alleviate this problem, he fixes this correlation at a value of unity and presents estimates of this adjusted risk-aversion coefficient, which we denote by $\theta$. As this specification allows us to determine the extent to which the equity premium puzzle is due to the smoothness of consumption, it offers a method to figure out whether the more variable consumption growth of stockholders is enough to solve the puzzle.

As shown in Table 7, this seems to be the case for the majority of the countries under investigation. In particular, the estimates for Austria (15.7) and Belgium (12.6) are the only two that do not fall within the plausible range of below 10. The remaining estimates of $\theta$ for stockholders take on plausible values. This is in sharp contrast to the adjusted estimates of the RRA coefficient for the representative agent specification. Here the estimate for Italy (9.4) is just below the upper boundary, all other values are (well) above this threshold. Hence the smoothness of consumption growth for the representative agent specification is not high enough to explain the equity premium puzzle, but if one separates the consumption stream of stockholders and non-stockholders, it seems that the variability of stockholders' consumption growth helps considerably.

Our interest is not solely in point estimates. The standard deviation of such estimates is of equal importance. Applying the block-jackknife method to the adjusted estimates of the coefficient of relative risk aversion provides more informative confidence intervals, for two reasons. First, recall there is a relation between the value of the estimate and its standard deviation in the sense that more extreme estimates are accompanied by a higher level of uncertainty. Second, since the correlation between excess returns and consumption growth is fixed, this does not contribute to the uncertainty associated with the estimate of the adjusted RRA coefficient.

Before judging the uncertainty surrounding these adjusted estimates of the coefficient of relative risk aversion, we first focus our attention towards the possible bias in these point estimates, see Table 8. These results are qualitatively similar to those presented in Table 5. More specifically, (i) the bias is almost as likely positive as it is negative, (ii) the bias is always in the same direction for all three specifications and (iii) the direction of the bias corresponds directly to

Table 7: **Estimates of the adjusted risk-aversion coefficient**

Notes: $\hat{\theta}$ is the estimate of the adjusted coefficient of relative risk aversion based on equation (4), but with the implicit correlation term fixed at a value of unity. Subscripts refer to the three groups: the representative agent ($R$), stockholders ($K$) and nonstockholders ($L$). See Table 2 and 3 for an explanation of the country mnemonics and sample period, respectively.

| Country | $\hat{\theta}_R$ | $\hat{\theta}_K$ | $\hat{\theta}_L$ |
|---|---|---|---|
| AU | 11.56 | 2.30 | 7.71 |
| OE | 42.66 | 15.73 | 41.80 |
| BG | 40.99 | 12.56 | 34.84 |
| CN | 13.49 | 3.12 | 12.16 |
| CZ | 21.70 | 5.53 | 14.24 |
| DK | 22.46 | 5.10 | 20.99 |
| FN | 23.18 | 4.54 | 17.02 |
| FR | 31.80 | 8.24 | 26.68 |
| BD | 23.73 | 4.61 | 17.26 |
| IT | 9.37 | 3.97 | 7.91 |
| NL | 18.03 | 4.84 | 16.16 |
| NW | 12.58 | 1.24 | 8.12 |
| SD | 34.03 | 1.12 | 7.53 |
| SW | 52.81 | 6.46 | 50.12 |
| UK | 19.52 | 3.85 | 17.50 |
| US | 24.76 | 8.78 | 26.07 |

that in Table 5, i.e. for 7 countries the bias is negative for all 6 specifications, for the remaining 9 countries, this bias is always positive. Similarly to the situation with estimates of $\gamma$, the confidence intervals are smaller for stockholders than for the other two specifications and the US is the only country for which the CI does not contain negative values. As expected, all confidence intervals are smaller than their counterparts in Table 5; but, again, they do not give rise to significant differences between estimates.

Although estimates of $\theta$ are already estimated with higher precision than estimates of $\gamma$, we can reduce this uncertainty even more by pooling all country-specific information. Table 9 shows that the outcome for the stockholders is very appealing, the pooled point estimate is 2.3 and its 95% confidence interval is extremely small. The representative agent specification has an estimate that is just under 20, with a confidence interval that is not too large. In sum, these results show that if the consumption streams of stockholders and non-stockholders are separated, the correlation between excess returns and consumption growth is fixed and country-specific estimates are pooled in an optimal sense, there seems to be a solution to the equity premium puzzle. Notice that the confidence intervals for stockholders and non-stockholders do not overlap, implying that the pooled estimates differ significantly at the conventional level of 5%.

Table 8: **Confidence interval for the adjusted risk-aversion coefficient**

Notes: $\hat{\theta}$ is the estimate of the adjusted coefficient of relative risk aversion based on equation (4), but with the correlation term fixed at a value of unity. The mean pseudovalue is denoted by $\overline{PS^{\theta}}$. The confidence intervals are centered around the mean pseudovalue, the standard error is based on the square root of equation (5) applied to the adjusted risk-aversion coefficients and the critical value is taken from a $t$-distribution with degrees of freedom equal to $N-1$; see Section 3.2 for more details. Subscripts refer to the three groups: the representative agent ($R$), stockholders ($K$) and nonstockholders ($L$). See Table 2 and 3 for an explanation of the country mnemonics and sample period, respectively.

| Country | $\hat{\theta}_R$ | $\overline{PS^{\theta}}_R$ | 95% CI | | $\hat{\theta}_K$ | $\overline{PS^{\theta}}_K$ | 95% CI | | $\hat{\theta}_L$ | $\overline{PS^{\theta}}_L$ | 95% CI | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AU | 11.56 | 12.05 | -7.67 | 31.77 | 2.30 | 2.40 | -1.53 | 6.33 | 7.71 | 8.03 | -5.11 | 21.17 |
| OE | 42.66 | 37.68 | -26.87 | 102.23 | 15.73 | 13.89 | -9.91 | 37.69 | 41.80 | 36.92 | -26.32 | 100.16 |
| BG | 40.99 | 35.50 | -24.68 | 95.68 | 12.56 | 10.88 | -7.56 | 29.32 | 34.84 | 30.17 | -20.98 | 81.33 |
| CN | 13.49 | 14.25 | -6.74 | 35.23 | 3.12 | 3.30 | -1.56 | 8.16 | 12.16 | 12.84 | -6.07 | 31.75 |
| CZ | 21.70 | 17.89 | -24.80 | 60.59 | 5.53 | 4.56 | -6.32 | 15.45 | 14.24 | 11.74 | -16.28 | 39.76 |
| DK | 22.46 | 21.31 | -11.41 | 54.03 | 5.10 | 4.83 | -2.59 | 12.26 | 20.99 | 19.91 | -10.66 | 50.49 |
| FN | 23.18 | 27.78 | -5.76 | 61.32 | 4.54 | 5.45 | -1.13 | 12.02 | 17.02 | 20.40 | -4.23 | 45.02 |
| FR | 31.80 | 30.61 | -1.74 | 62.95 | 8.24 | 7.93 | -0.45 | 16.30 | 26.68 | 25.68 | -1.46 | 52.81 |
| BD | 23.73 | 23.81 | -25.00 | 72.62 | 4.61 | 4.62 | -4.85 | 14.09 | 17.26 | 17.31 | -18.17 | 52.80 |
| IT | 9.37 | 11.63 | -24.69 | 47.94 | 3.97 | 4.93 | -10.46 | 20.32 | 7.91 | 9.81 | -20.83 | 40.45 |
| NL | 18.03 | 21.13 | -8.62 | 50.87 | 4.84 | 5.67 | -2.31 | 13.66 | 16.16 | 18.93 | -7.72 | 45.58 |
| NW | 12.58 | 9.60 | -19.53 | 38.74 | 1.24 | 0.95 | -1.93 | 3.82 | 8.12 | 6.20 | -12.61 | 25.02 |
| SD | 34.03 | 32.26 | -24.88 | 89.40 | 1.12 | 1.06 | -0.82 | 2.94 | 7.53 | 7.14 | -5.51 | 19.79 |
| SW | 52.81 | 49.75 | -21.67 | 121.17 | 6.46 | 6.09 | -2.65 | 14.83 | 50.12 | 47.21 | -20.57 | 114.99 |
| UK | 19.52 | 14.69 | -53.09 | 82.46 | 3.85 | 2.90 | -10.47 | 16.27 | 17.50 | 13.17 | -47.59 | 73.93 |
| US | 24.76 | 25.97 | 1.74 | 50.20 | 8.78 | 9.21 | 0.62 | 17.80 | 26.07 | 27.34 | 1.83 | 52.84 |

Table 9: **Pooled results for the adjusted coefficients**

Notes: The pooled estimate of the adjusted RRA coefficient is denoted by $\hat{\theta}_w$, using weights specified according to equation (6). The confidence interval uses the square root of equation (7) as standard error and critical value from a $t$-distribution with $k-1$ degrees of freedom; see Section 3.3 for more details. Subscripts refer to the three groups: the representative agent ($R$), stockholders ($K$) and nonstockholders ($L$).

| Situation | Estimate | 95% CI | |
|---|---|---|---|
| $\hat{\theta}_{wR}$ | 19.670 | 10.88 | 28.52 |
| $\hat{\theta}_{wK}$ | 2.33 | 1.02 | 3.65 |
| $\hat{\theta}_{wL}$ | 12.99 | 6.75 | 19.23 |

# 6 Conclusion

Unlike previous research that attempts to explain the equity premium puzzle using the notion of limited stock market participation based on household-level data, our approach is based exclusively on macroeconomic data. The greatest advantages of our approach compared to previous studies is that we have longer timeseries (i.e. more observations) and given that these data are gathered by the OECD, the results can be compared more easily cross-country.

Despite these benefits, we must also draw the conclusion that limited stock market participation does not seem able to explain the puzzle by itself. Estimates for stockholders are much more in line with plausible values of the coefficient of relative risk aversion, so it goes a long way. It seems that this result is mainly due to the higher standard deviation of consumption growth for this group compared to that of non-stockholders and the combination of these two groups into a single representative agent; the correlation between excess returns and consumption growth plays at best a modest role. By using a simple jackknifing method we have been able to construct standard errors for these estimates. Although estimates of the coefficient of relative risk aversion are lower for stockholders, the difference does not appear to be significant. Using these country-specific estimates to compute pooled estimators reduces this uncertainty and provides encouraging results, i.e. the pooled estimate of stockholders is within the range of plausible values.

The supposition that the correlation between excess returns and consumption growth is easily distorted by short-term measurement errors in the latter plays a large role in the conclusion that our approach does not offer a full solution to the puzzle. Following the suggestion of Campbell (1999) and setting this correlation equal to a value of unity results in estimates that do not only vary less from country to country, for almost all countries they are in within the range of plausible values. Despite their more precise estimation, there is still too much uncertainty to obtain statistically significant differences between estimates for stockholders and non-stockholders. However, when the country-specific estimates are combined in an optimal way, we are able to draw the conclusion that the pooled estimate for stockholders is significantly lower than for non-stockholders.

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## Appendix A: Definitions Table 1

**Compensation of employees** Compensation of employees is the total remuneration, in cash or in kind, payable by an enterprise to an employee in return for work done by the latter during the accounting period.

Compensation of employees has two main components:

1. Wages and salaries payable in cash or in kind;
2. The value of the social contributions payable by employers: these may be actual social contributions payable by employers to Social Security schemes or to private funded social insurance schemes to secure social benefits for their employees; or imputed social contributions by employers providing unfunded social benefits.

**Gross operating surplus and mixed income** The operating surplus measures the surplus or deficit accruing from production before taking account of any interest, rent or similar charges payable on financial or tangible non-produced assets borrowed or rented by the enterprise, or any interest, rent or similar receipts receivable on financial or tangible non-produced assets owned by the enterprise.

Note: for unincorporated enterprises owned by households, this component is called "mixed income".

**Consumption of fixed capital** Consumption of fixed capital represents the reduction in the value of the fixed assets used in production during the accounting period resulting from physical deterioration, normal obsolescence or normal accidental damage.

**Net property income** Property income is the income receivable by the owner of a financial asset or a tangible non-produced asset in return for providing funds to or putting the tangible non-produced asset at the disposal of, another institutional unit; it consists of interest, the distributed income of corporations (i.e. dividends and withdrawals from income of quasi-corporations), reinvested earnings on direct foreign investment, property income attributed to insurance policy holders, and rent.

**Net social contributions & benefits other than social transfers in kind** Social contributions are actual or imputed payments to social insurance schemes to make provision for social insurance benefits to be paid. Social benefits other than social transfers in kind consist of all social benefits except social transfers in kind; in other words, they consist of: (a) all social benefits in cash — both social insurance and social assistance benefits — provided by government units, including social security funds, and NPISHs; and (b) all social insurance benefits provided under private funded and unfunded social insurance schemes, whether in cash or in kind.

**Net current transfers** Other current transfers consist of net premiums and claims for non-life insurance, current transfers between different kinds of government units, usually at different levels of government and also between general government and foreign governments, and current transfers (i.e. non-financial transfers) such as those between different households.

**Current taxes on income, wealth etc.** Most current taxes on income, wealth, etc. consist of taxes on the incomes of households or profits of corporations and taxes on wealth that are payable regularly every tax period (as distinct from capital taxes levied infrequently).

**Net national disposable income** National disposable income may be derived from national income by adding all current transfers in cash or in kind receivable by resident institutional units from non-resident units and subtracting all current transfers in cash or in kind payable by resident institutional units to non-resident units.

## Appendix B: Effect of not using "per capita" terms

The RRA coefficient is calibrated according to

$$\hat{\gamma} = \frac{\mathrm{E}_t[r_{i,t+1} - r_{f,t+1}] + \frac{\sigma_i^2}{2}}{\sigma_{ic}}.$$

Obviously, consumption only enters the denominator of this expression, so we do not have to consider how it will affect the numerator. The covariance can be decomposed as

$$\sigma_{ic} = \sigma_i \sigma_c \rho_{ic},$$

where $\rho_{ic}$ denotes the correlation between excess returns and real consumption growth per capita. This shows that we need to determine how not using "per capita" terms affects (1) the standard deviation of consumption and (2) the correlation between excess returns and consumption.

### Standard deviation consumption

For convenience, the derivation will be in terms of the variance instead of standard deviation. Moreover, we assume consumption is already in real terms. Using consumption in nominal terms just adds to the algebra, it does not affect our final result. The variance of real consumption growth is given by

$$\begin{aligned}\mathrm{Var}(\Delta c_{t+1}) &= \mathrm{Var}(c_{t+1} - c_t), \\ &= \mathrm{Var}(c_{t+1}) + \mathrm{Var}(c_t) - 2 \cdot \mathrm{Cov}(c_{t+1}, c_t).\end{aligned}$$

Using the fact that $c_t = \ln[C_t/P_t]$, where $C_t$ is real consumption and $P_t$ is population, this can be written as

$$
\begin{aligned}
\text{Var}(\Delta c_{t+1}) &= \text{Var}(\ln[C_{t+1}/P_{t+1}]) + \text{Var}(\ln[C_t/P_t]) \\
&\quad - 2 \cdot \text{Cov}(\ln[C_{t+1}/P_{t+1}], \ln[C_t/P_t]), \\
&= \text{Var}(c_{t+1} - p_{t+1}) + \text{Var}(c_t - p_t) \\
&\quad - 2 \cdot \text{Cov}(c_{t+1} - p_{t+1}, c_t - p_t), \\
&= \text{Var}(c_{t+1}) + \text{Var}(p_{t+1}) - 2 \cdot \text{Cov}(c_{t+1}, p_{t+1}) + \text{Var}(c_t) \\
&\quad + \text{Var}(p_t) - 2 \cdot \text{Cov}(c_t, p_t) - 2 \cdot \text{Cov}(c_{t+1}, c_t) \\
&\quad + 2 \cdot \text{Cov}(c_{t+1}, p_t) + 2 \cdot \text{Cov}(p_{t+1}, c_t) - 2 \cdot \text{Cov}(p_{t+1}, p_t).
\end{aligned} \tag{8}
$$

When consumption growth is not denoted in per capita terms, this expression boils down to

$$
\text{Var}(\Delta c^*_{t+1}) = \text{Var}(c_{t+1}) + \text{Var}(c_t) - 2 \cdot \text{Cov}(c_{t+1}, c_t). \tag{9}
$$

The difference between equations (8) and (9) is given by

$$
\begin{aligned}
\text{Var}(\Delta c^*_{t+1}) - \text{Var}(\Delta c_{t+1}) = &-\text{Var}(p_{t+1}) - \text{Var}(p_t) + 2 \cdot \text{Cov}(p_{t+1}, p_t) \\
&+ 2 \cdot \text{Cov}(\Delta c_{t+1}, \Delta p_{t+1}).
\end{aligned}
$$

Using that $\text{Var}(p_{t+1}) \approx \text{Var}(p_t)$ and $\text{Cov}(p_{t+1}, p_t) \approx \text{Var}(p_t)$ allows us to approximate this expression by

$$
\text{Var}(\Delta c^*_{t+1}) - \text{Var}(\Delta c_{t+1}) \approx 2 \cdot \text{Cov}(\Delta c_{t+1}, \Delta p_{t+1}).
$$

Thus the difference is approximately equal to two times the covariance between real consumption growth and population growth; thus implying that the sign is determined by their correlation. In particular, if $\rho(\Delta c_{t+1}, \Delta p_{t+1}) > (<) 0$ then the variance of consumption growth increases (decreases) when it is not considered in per capita terms.

### Correlation excess returns and consumption

Unfortunately there is no simple expression that shows the difference between the correlation terms. In per capita terms, the correlation equals

$$
\begin{aligned}
\rho(e_t, \Delta c_{t+1}) &= \rho(e_t, c_{t+1} - c_t) \\
&= \rho(e_t, c_{t+1} - p_{t+1} - c_t + p_t) \\
&= \frac{\text{Cov}(e_t, c_{t+1} - p_{t+1} - c_t + p_t)}{\sqrt{\text{Var}(e_t)}\sqrt{\text{Var}(c_{t+1} - p_{t+1} - c_t + p_t)}}.
\end{aligned} \tag{10}
$$

In case population growth is disregarded, it is given by

$$
\rho(e_t, \Delta c^*_{t+1}) = \frac{\text{Cov}(e_t, c_{t+1} - c_t)}{\sqrt{\text{Var}(e_t)}\sqrt{\text{Var}(c_{t+1} - c_t)}}.
$$

The difference, after decomposing the covariance in equation (10) and rewriting, is given by

$$\rho(e_t, \Delta c^*_{t+1}) - \rho(e_t, \Delta c_{t+1}) = \rho(e_t, \Delta c_{t+1}) - \frac{\rho(e_t, \Delta c_{t+1})\sqrt{\mathrm{Var}(\Delta c_{t+1})}}{\sqrt{\mathrm{Var}(\Delta c_{t+1} - \Delta p_{t+1})}} + \frac{\rho(e_t, \Delta p_{t+1})\sqrt{\mathrm{Var}(\Delta p_{t+1})}}{\sqrt{\mathrm{Var}(\Delta c_{t+1} - \Delta p_{t+1})}}.$$

As there is no way to split the denominator of the second and third term, the expression for the difference cannot be simplified any further. It is also not possible to determine the sign of the expression a priori. The reason is that the sign depends on the sign of the two correlation terms as well as the relative magnitudes of all terms in this expression. Hence, the effect on the correlation can not be determined analytically.

## Appendix C: Data issues

Some remarks regarding the data are in order. The first is that, in general, the data in the Annual National Accounts refers to calender years. There is one exception in the form of Australia, the data for this country is for their fiscal year which runs from July to June. Hence for Australia the annual percentages are computed for their fiscal year and appropriately matched to the quarterly data.

Second, the computation of the real excess return; the difference between the real equity return and the real riskfree rate. In order to compute the return on equity, two series are required: the end-of-month price-index (hereafter denoted by $P$, datatype PIL) and the end-of-month total return index ($R$, datatype RIL). The first step is to use the following definition to back out the monthly dividend yield (DY) at time $t$:

$$\frac{R_t}{R_{t-1}} \equiv \frac{P_t}{P_{t-1}}(1 + DY_t).$$

Next monthly dividends at time $t$ are computed by multiplying $P_t$ by the dividend yield at time $t$ and the quarterly return on equity ($Re$) is computed according to

$$Re_t = \left( \frac{P_t + \sum_{i=t-2}^{t} D(i)}{P_{t-3}} \right) - 1,$$

where $D(i)$ is the monthly dividend series, $P_t$ is the end-of-month price and $P_{t-3}$ is the price at the end of the previous quarter (hence $t-3$). Finally, log equity returns are computed as

$$re_t = log(1 + Re_t).$$

The second input series is the riskfree rate. As these are annualized and expressed as percentage points in the database, the log quarterly riskfree rates are computed according to

$$rf_t = log\left(\left(1 + \frac{Rf_t}{100}\right)^{\frac{1}{4}}\right).$$

These two returns are then made real by subtracting time $t$ inflation, denoted by $\pi_t$. This is simply the first difference of the logarithmic transformed CPI, i.e.

$$\pi_t = log(CPI_t) - log(CPI_{t-1}) = log\left(\frac{CPI_t}{CPI_{t-1}}\right).$$

It is important to note the timing of the variables is this respect. An investor earns $rf_t$ if he bought the asset at the end of the previous quarter and sells it at the end of the current quarter. This is why the real riskfree rate is computed as

$$rrf_t = rf_{t-1} - \pi_t.$$

The real equity return is simply $rre_t = re_t - \pi_t$. Our series of interest, the real excess return is then $er_t = rre_t - rrf_t$.

Third, the population series. As these figures are only available at an annual frequency (mid-year estimate), we need to construct a quarterly series with population estimates ourselves. In line with Campbell (1999), we assume constant growth rates between subsequent annual observations. As data refers to mid-year estimates, the annual observations are taken to represent the second quarter of each year.

Finally, for four countries, the riskfree rate has missing values towards the end of the sample period. Fortunately, in all cases appropriate series have been found that allow us to extrapolate the original series based on these substitutes. Below follows a short description of these four cases.

- Australia: Missing values from July 2002 onwards. We use data on the Australian interbank rate, this series has a correlation of 0.996 for the overlapping part with the original series;

- Austria: Missing values from January 1999 onwards. We use data on the 3 month interbank offered rate, this series has a correlation of 0.995 for the overlapping part with the original series;

- Denmark: Missing values from January 1989 onwards. We use data on T-bills taken from the Central Bank of Denmark, this series has a correlation of 1 for the overlapping part with the original series;

- Netherlands: Missing values from January 1999 onwards. We use on the call money rate, this series has a correlation of 1 for the overlapping part with the original series.