OULUN YLIOPISTO
UNIVERSITY of OULU

OULU BUSINESS SCHOOL

Tuukka Holster

EQUITY RISK PREMIUM IN THE FINNISH STOCK MARKETS

Master's Thesis
Finance
1/2018

UNIVERSITY OF OULU
Oulu Business School

ABSTRACT OF THE MASTER'S THESIS

Unit Faculty of Finance			
Author Tuukka Holster		Supervisor Hannu Kahra	
Title Equity risk premium in the Finnish stock markets			
Subject Finance	Type of the degree Master	Time of publication 1/2018	Number of pages 65

Abstract

This thesis examines the realized equity premium and the equity risk premium puzzle in Finland during the years from 1913 to 2015. In the U.S. data, it has been noted that the attempt to connect the stock market and consumption data in the context of the consumption-based asset pricing model (CCAPM) leads to an implausibly high risk aversion parameter. The CCAPM restricts also the behavior of the risk-free rate, leading to what is termed the risk-free rate puzzle. We first present the properties of the consumption and stock market returns data, estimate the parameter values implied by the CCAPM for the Finnish data, use a dividend growth model to estimate the unconditional expected equity risk premium and finally examine the short-term predictability of dividend growth and the equity premium.

We find that the joint equity premium and the risk-free rate puzzle does exist also in the Finnish data, though linking the realized average excess return to consumption data does not require a very high value for the risk aversion parameter. Because of the historically high inflation, the real risk-free rate has been very low, and correspondingly, the realized equity premium has been high in Finland. However, the high volatility of consumption growth does much to mitigate the puzzle. Also, the dividend growth estimate of the unconditional expected equity risk premium is not much less than the realized average excess return. We find evidence of short-term predictability in both dividend growth and the realized equity premium.

Keywords
Equity risk premium puzzle, consumption-based asset pricing, CCAPM, predictability.

Additional information

CONTENTS

FIGURES

TABLES

1 INTRODUCTION

The equity risk premium, the premium that equity is expected to earn over riskless assets, is one of the most important numbers in financial economics: it is an important input both in asset allocation decisions and determining the required return on investment projects (Welch 2000). Our understanding of the level of the equity premium and how it varies through time has strong implications for individual portfolio allocation, management of pension money and even the funding of social security in some countries (Cochrane 1998).

As a theoretical issue, the equity premium puzzle has been one of the central questions of financial economics since the seminal paper by Mehra and Prescott (1985). They find that the return earned in the U.S. stock markets in excess of return on the risk-free rate has been far too much to be explained in the context of the conventional consumption-based models of asset pricing. Mehra (2008) reports that the return on US equity index from 1889 to 2005 was 7.67 percent. Comparing this with the real return of 1.31 percent on relatively riskless assets yields a realized excess return of 6.36 percent. Different data and methodologies yield somewhat different returns, but without challenging the central result. As noted above, the puzzle is not one of purely academic interest, but our understanding of it influences a wide range of everyday financial decisions.

It is not surprising that equity should earn a premium over relatively risk-free government debt obligations, or even corporate bonds. Compared to bonds, stocks have exhibited higher average volatility over time, and equity can only earn return after bondholders have been paid. Stocks (and corporate bonds) can also be expected to earn a premium over risk-free bonds because of default risk. Thus, Mehra (2003) stresses that the puzzle is quantitative, not qualitative in nature. However, if investors had investing horizons longer than a few years and knew beforehand that equity would earn such a high premium, why would they ever invest in government bonds and bills? How much does the greater volatility matter if equity outperforms so handsomely over the decades? The excess return earned on stocks is therefore a puzzle not only in the context of conventional theory, but it is astonishing also from a practical point of view.

Discussion on the topic is often made unnecessarily abstruse by confusing terminology (Arnott 2011). The difference between the expected equity premium and the realized excess return on equity should be made clear. The expected equity premium is the expected return on equity minus the risk-free rate: $E_t(R_{t+1}) - R^f_{t+1}$, where the expectation concerning returns occurring during time $t+1$ is formed at time t. The realized excess return on equity is the realized stock return minus the realized risk-free rate during time t: $R_t - R^f_t$. We will refer to the expected equity premium also simply as the (ex-ante or forward-looking) equity premium or equity premia. We call the realized excess return on equity also simply the (historical) excess return, the realized equity premium or the ex-post equity premium.

Note that the definition of the expected equity premium above is very general. We use the subscripts to emphasize that it might be any period t when the expectations are formed – which is not necessarily today. In fact, academicians are usually interested in what we might further denote as the historical expected equity premium, which refers to what was historically expected at time t for the equity premium to be in period t+1, where both t and $t+1$ are bygone periods. We often also talk of the (unconditional) average of the historical expected equity premium, by which we mean the average of the expectation over the past periods $t, t+1, \dots, T$. Practitioners, naturally, are more interested in what the equity premium is going to be in the future, which we could call the expected future equity premium: then time t is today and $t+1$ is some future period. In this thesis, the length of the period is always one year. One reason that the terminology may appear confusing is that very often, both the historical expected equity premium and the expected future equity premium are estimated as the average realized excess return. However, that is not innocuous, and there are different estimation methods.

Because of the possibly large survivorship and success bias in the U.S. stock markets, it would be misleading to focus solely on them. The U.S. stock market has survived while many other stock markets have failed, yielding a cumulative total return of -100 percent. On the top of that, the U.S. stock market might just have been very lucky compared to rest of the world. (Dimson, Marsh & Staunton 2008). However, comprehensive studies have addressed the realized equity premium on various markets, and have generally found that the puzzle is not specific to the U.S. stock market history. Some authors also contend that realized excess returns do not correspond to the historical expected equity premium. Also, a large literature tries to modify the theory to better fit the historical excess returns. We return to the topic below in section 2.

High realized excess returns have been documented also in the Finnish equity markets. Vaihekoski and Nyberg (2014b) report the average historical real excess return for 1912-2009 to be 10.14 percent, calculated as the annual real stock market return of 9.99 percent minus the real return on short-term money market assets of -0.15 percent. This is considerably higher than average excess returns in the U.S. stock markets, which was 6.36 percent for 1889-2005 (Mehra 2008). The problem with researching smaller stock markets, like that of Finland, is that high quality data is often unavailable: compared to the U.S. stock market, the data usually covers a shorter period and is less reliable (Dimson et al. 2008). However, with the increased interest on the realized equity risk premium, constructing local stock market indices has gained some popularity (Nyberg & Vaihekoski 2010).

In this study, we examine the equity premium puzzle in the Finnish stock market and compare the results to the well documented equity premium puzzle of the U.S. stock markets. Besides reporting the equity premium puzzle with the realized excess returns, we also examine whether the realized returns on the Finnish stock markets have exceeded the historical expectations. In connection with that, we test whether the short-term dividend growth and the equity premium have been predictable. Predictability is important in the context of the equity premium, because predictability of the equity premium implies that it is time-varying. In the context of predictability, we will use interchangeably the expressions equity premium and excess returns: predictability is about forecasting what the future excess returns are, which really is the forming of the expectation concerning the equity premium. The research questions are

- Does the equity premium puzzle exist in the Finnish stock market and consumption data,

- Is there reason to believe that the average realized excess return exceeds the unconditional expected equity premium in Finland,
- Is there evidence of predictability of either annual dividend growth or the equity premium in Finland, especially with the dividend-price ratio.

The equity premium puzzle has not been comprehensively analyzed in the Finnish stock market. Nyberg and Vaihekoski (2014b) calculate the average realized excess return, but they do not relate stock market returns to consumption data to examine the historical equity premium in its theoretical context. We find that the joint equity risk premium and the risk-free rate puzzle does exist in the Finnish data, though by itself, relating the realized excess returns to consumption data does not require a very high value for the risk aversion parameter. We also find that estimating the equity premium by a simple dividend growth model in the vein of Fama and French (2002) yields a value very similar to the average realized excess return. Additionally, we report that there is some evidence of short-term predictability in both dividend growth and realized annual excess returns.

The paper is organized as follows: Section 2 reviews the literature on the equity premium puzzle. In section 3, we discuss the data and methodology used. Section 4 presents the empirical results and section 5 concludes. We save some results to a mathematical appendix to avoid cluttering the text with lengthy derivations.

2 CONSUMPTION-BASED ASSET PRICING AND THE EQUITY PREMIUM

The first part of this section introduces the standard consumption-based asset pricing model, and explains how it leads to the equity premium puzzle when confronted with U.S. data. After that, studies on the equity premium in other markets are discussed. In the final part, different explanations for the equity premium are discussed.

2.1 Consumption-based asset pricing model and the equity premium puzzle

Any value of observed excess return is a puzzle only in the context of some theory which it does not fit. The theoretical framework of the equity risk premium puzzle is the consumption-based asset pricing model (CCAPM), first studied by Rubinstein (1976) and Lucas (1978). In these models, the quantity of an asset’s risk is measured by the covariance between the excess return on the asset and consumption growth, while the price of risk is the coefficient of relative risk aversion of the representative consumer. The consumption-based asset pricing model thus gives a framework in which to evaluate the level of equity premium on the basis of fundamental economic variables. As a comparison, the CAPM, which is the classical model for explaining cross-sectional differences in asset returns, takes the market premium as given and relates returns of individual assets to it (Cochrane 2005: 464-465).

Unfortunately, the large historical excess return on stocks cannot be explained by the standard consumption-based asset pricing model when taking into account other stylized facts, including the low volatility of consumption growth, the low correlation of consumption growth and stock market returns and the low level and volatility of interest rates (Cochrane 1998). Moreover, empirical tests show that the model is unable to explain cross-sectional equity returns (Cochrane 2005: 41-43), and in explaining systematic risks of assets, it has largely been replaced by less ambitious return-based models (Ludvigson 2011), such as the multi-factor models of Fama and French (1993, 2017). However, such models can only explain asset returns in terms of other asset returns; to explain why the level of stock market returns and interest rates are such as they are, we need models that relate asset returns to the rest of the macroeconomy and microeconomic decision making. In the decades after Mehra and

Prescott (1985) published their findings, many modifications have been proposed, and recent empirical studies seem to offer more promising results (Ludvigson 2011).

We start by setting up the standard model, and then discuss its problems in the U.S. data, and consider related puzzles. We concentrate for simplicity on a two-period model, as in Cochrane (2005: 3-22), with notation following closely Cochrane's. More general presentations of the model in the context of the equity premium puzzle can be found in, for example, Mehra (2003) and Mehra and Prescott (2008).

2.1.1 The standard consumption-based asset pricing model

The standard consumption-based asset pricing model takes the consumption-saving decision of a consumer and derives the pricing relation from the resulting first order condition. Concentrating for simplicity on a two-period model, we can write the consumer's consumption-saving decision as

$$\max u(c_t) + E_t[\beta u(c_{t+1})] \quad s.t. \qquad c_t = e_t - p_t\xi,$$

$$c_{t+1} = e_{t+1} + x_{t+1}\xi.$$

u(c) is utility as a function of consumption c, E_t denotes conditional expectation at time t, β the subjective time-discount factor, e the consumption level when the consumer does not buy any units of the asset, p_t and x_{t-1} are the first-period price and second-period payoff, respectively, and ξ is the amount of the asset bought by the consumer. The above maximization problem simply says that the consumer aims to maximize his or her utility in terms of consumption in both the first and the time-discounted second period by adjusting the amount ξ of the asset bought. Substituting the constraints into the objective function, setting the derivative with respect to the decision variable ξ equal to zero and then solving for p_t, we obtain

$$p_t = E_t\left[\beta \frac{u'(c_{t+1})}{u'(c_t)} x_{t+1}\right]. \tag{1}$$

The equation states that price of the asset is equal to its future payoff discounted with the marginal rate of substitution $m_{t+1} = \beta u'(c_{t+1})/u'(c_t)$ (also called the stochastic discount factor). For empirical work, returns are more interesting than prices, and we can manipulate equation (1) to solve for return as a function of covariance between the return on the asset and consumption. Divide by price to obtain

$$1 = E_t(m_{t+1}R_{t+1}). \tag{2}$$

Equation (2) states that after discounting, gross return R_{t+1} on any asset should equal one. Because the equation applies to risk-free assets as well, and the risk-free rate is known beforehand by definition, we can take it out of the expectations in equation (2) to find that it equals $R_t^f = 1/E_t(m_{t+1})$. Using the definition of covariance and dividing by $E_t(m_{t+1})$, we finally find that the expected risk premium on any asset equals

$$E_t(R_{t+1}) - R_{t+1}^f = -R_{t+1}^f cov(m_{t+1}, R_{t+1}). \tag{3}$$

Equation (3) implies that the expected risk premium on any asset is proportional to covariance of the asset’s return with the marginal utility of consumption. If the covariance is negative, as might be the case for stocks, the expected risk premium is positive. If the covariance is positive, as one would expect from insurance, the expected risk premium is negative. In the case that there is no covariance between the asset’s return and the marginal utility of consumption, the return on the asset is simply equal to the risk-free rate. As consumption and marginal utility of consumption move into opposite directions (at least with the standard assumptions for utility functions), we could as well say that expected risk premiums are higher for assets with higher covariance with consumption. Such assets increase the volatility of investors’ consumption stream, which makes them require a lower price to compensate for the increased consumption risk. We have written the covariance term using plain returns, not excess returns, but as the risk-free component of returns is uncorrelated with the marginal utility of consumption by definition, the result is of course the same.

2.1.2 The equity premium puzzle

The model can easily be related to aggregate market data with the Hansen-Jagannathan bounds (Hansen & Jagannathan 1991). According to the model, the relation between returns and the discount factor presented in (3) should hold true for any asset and investor and at any time. It is a simple utility maximization condition. However, we would like to relate the model to aggregate market data, and so we need to assume a representative consumer. The functional form often chosen for utility is a power utility function specified as

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma},$$

of which the first derivative with respect to consumption is $u'(c) = c^{-\gamma} > 0$ and the second $u''(c) = -\gamma c^{-\gamma-1} < 0$. This form leads to utility that is strictly increasing in consumption but at a decreasing speed. With the power utility function, the curvature parameter γ controls simultaneously for risk aversion and intertemporal substitution. (Cochrane 2005: 12). Such a power utility function links the discount factor strongly to consumption growth. This type of utility function also assumes that utility is state-separable and time-separable: the representative consumer has preferences such that his consumption in one state of nature (or at one time) are not affected by his consumption in another state of nature (or at another time). To obtain simple closed-form solution, we also assume that consumption growth is log-normally distributed, though the results do not rest on this assumption (Mehra 2003).

Denote the marginal rate of substitution with m_{t+1}. The relation in (3) must hold also unconditionally if it holds conditionally, and by covariance decomposition we obtain

$$\frac{E(R)-R^f}{\sigma_R} = -\rho_{m,R}\frac{\sigma_m}{E(m)}, \tag{4}$$

where σ_R is the standard deviation of return on the risky asset, σ_m is the standard deviation of the marginal rate of substitution and $\rho_{m,R}$ is the correlation between the marginal rate of substitution and return on the risky asset. Correlations are between -1 and 1, and therefore we obtain

$$\left|\frac{E(R)-R^f}{\sigma_R}\right| \leq \frac{\sigma_m}{E(m)} \approx \gamma\sigma_{\Delta lnc}, \tag{5}$$

where the approximation uses the assumed power utility and log-normality of consumption growth (full derivations are in the appendix). The equation states that in absolute value, the Sharpe ratio of return on the risky asset must be less than or equal to the standard deviation of the marginal rate of substitution divided by its expected value. Because this holds for any asset, it also holds for the market portfolio. Then the approximation says that the Sharpe ratio of the market has to be (approximately) less than or equal to the risk aversion parameter times the standard deviation of the growth rate of consumption. The riskier the economy is because of more volatile consumption, or the more risk averse consumers are, the higher is the Sharpe ratio demanded from the market (Cochrane 2005: 21).

Cochrane (2005: 21) reports that in the postwar U.S data, the Sharpe ratio of the market has been around 0.5. Growth in aggregate nondurables and services consumption has had a relatively low standard deviation of 1% over the same period (Cochrane 2005: 21). From (5), we then see that a risk aversion parameter of around 50 is needed to accommodate these numbers, if we assume that the first inequality holds as an equality. If the inequality holds as a strict inequality (if the correlation between consumption growth and market return was less than 1), then an even larger risk aversion is needed! In fact, Cochrane reports a correlation of 0.2 between aggregate consumption growth and U.S. stock market returns. Fama and French (2002) report a quite much lower Sharpe ratio of 0.31 for long-term U.S. data (1872-2000). Dimson et al. (2008) find a value bit larger value of 0.37 for the years 1900-2005. It then seems that using a longer sample might reduce the estimated risk aversion parameter somewhat due to a lower Sharpe ratio, but in any case, the numbers imply a very high risk aversion.

2.1.3 The interest rate puzzle and predictability

Forgetting for a moment that there is a large body of work documenting the risk aversion parameter to be less than 10 (Mehra 2003), we could simply allow for a high risk-aversion. However, that will not work even within the consumption-based asset pricing theory: the most important evidence against this comes from the relation the theory postulates between consumption growth and interest rates (Cochrane 2005: 457-458, Weil 1989). With a power utility function, $R_t^f = 1/E_t(m_{t+1})$ becomes $R_t^f = \beta\left(\frac{c_{t+1}}{c_t}\right)^{\gamma}$. Using again the assumed log-normality of consumption growth, we obtain for the risk-free rate the following result:

$$ln\,R_t^f = r_t^f = \delta + \gamma E_t\,(\Delta lnc_{t+1}) - \frac{\gamma^2}{2} var_t(\Delta lnc_{t+1}), \tag{6}$$

where we define the (continuous) subjective time discount rate by $\beta = e^{-\delta}$. The full derivations are again left to the appendix. Here $\gamma E_t(\Delta lnc_{t+1})$ is the term controlling for intertemporal substitution while $\frac{\gamma^2}{2} var_t(\Delta lnc_{t+1})$ captures precautionary savings (higher consumption volatility means more reason to fear for a bad tomorrow and thus save). Cochrane (2005: 458) and Mehra and Prescott (2008) report that the real risk-free rate (and therefore, the logarithmic rate) have been relatively stable and around 1% in the United States. Using for consumption growth the mean of 1% and standard deviation of 1%, as reported by Cochrane, and a risk aversion of $\gamma = 50$ as implied as a lower bound by the model with the stock return data, we find with equation (6) that a subjective discount rate of around -37% is needed for a 1% risk-free rate. However, a subjective time discount rate of around 1% is usually deemed reasonable, corresponding to a time discount factor $\beta \approx 0.99$ (Cochrane 2005: 458). We end up either with a very high risk-free rate or preferences where agents prefer strongly to consumer later rather than sooner (Weil 1989).

Another possibility is to use an even larger risk aversion so that the second-order parameter γ^2 in equation (6) controlling the ‘precautionary savings’ term overpowers the ‘intertemporal substitution’ term and we thus achieve both a low risk-free rate and also a high equity premium from equation (5) at the same time. However, as the parameter γ controls also intertemporal substitution, this means that the representative consumer is then very averse to substituting consumption over time. If we had even just $\gamma = 50$ in equation (6), it would multiply even small variations in expected consumption growth to have a large effect on the risk-free rate (a large change in interest rates required to make the consumer willing to substitute consumption over time). Then differences in consumption growth over time and across countries should be accompanied with high variation in real interest rates, but in fact, they are quite stable (Mehra 2003, Cochrane 1998, 2005: 458).

Predictability of the equity premium has generated much discussion in financial economics during the last decades. We will return to the topic below, but for now, the effect that predictability has on the consumption-based asset pricing model should be noted. Predictability implies that the equity premium is time-varying. The model can accommodate time-varying equity premium, but it adds additional complications. Applying the Hansen-Jagannathan bound conditionally, from equations (4) and (5),

$$E_t(R_{t+1}) - R^f_{t+1} \approx \gamma_t \sigma_t(\Delta lnc_{t+1}) \sigma_t(R_{t+1}) \rho_t(m_{t+1}, R_{t+1}) \qquad (7)$$

the equity premium varies, if the correlation between the stock market returns and the discount factor m varies, if the stock market volatility varies, if the consumption volatility varies or if risk aversion varies. The subscripts t mean that these are expectations of future values formed today based on current information. Of course, this notation allows also for the view that the equity premium is unpredictable – then these conditional moments equal their unconditional counterparts: the best way of predicting the future value is to assume it will equal its historical average.

Similarly, the Sharpe ratio varies over time, because the time-variation in expected returns does not seem to be matched by identical movements in the stock return volatility. This movement in the Sharpe ratio must then be matched by movement in the market-discount factor correlations, consumption volatility or risk aversion. With time-varying correlations being hard to interpret, predictability implies that either consumption volatility or risk aversion is time-varying. The U.S. data does not show much variation in consumption volatility, so time-varying risk aversion would be an attractive feature in any theory that tries to solve the shortcomings of the standard consumption-based asset pricing model. (Cochrane 2005: 462-465).

2.2 Theoretical solutions to the puzzle

There are two ways in which the equity premium puzzle can be solved: either the standard theory is wrong and needs significant modifications, or the high excess returns of the past are “wrong” and the equity premium will turn out to be much less in the future (Cochrane 1998, Dimson 2008). We begin by taking a brief look at the wide range of proposed theoretical solutions. These include modifications of preferences of the representative agent, heterogenous investors and market frictions. More comprehensive treatments of the topic can be found in, for example, Kocherlakota (1996) and Mehra (2003).

2.2.1 Preference modifications

The most obvious way of alleviating the joint problem of the equity premium and risk-free rate is loosening the link between risk aversion and aversion to intertemporal substitution by having independent coefficients for them in the utility function, for this link is no theoretical necessity (Mehra 2003). This is achieved by the recursive preferences of Epstein and Zin (1991), however, such simple modifications can mitigate the risk-free rate puzzle, but not so much the equity premium puzzle: high risk aversion is still required (DeLong & Magin 2009, Kocherlakota 1996).

A more extensive way of modifying preferences is including habit formation in the utility function, as done by Abel (1990), Constantinides (1990) and Campbell and Cochrane (1999). Habit can form with respect to average consumption (external habit) or with respect to past consumption (internal habit). With an internal habit, utility is a decreasing function of past consumption: utility gained from a given level of current consumption is lower the higher the level of past consumption. Campbell and Cochrane specify the surplus consumption ratio as $S_t = (C_t - X_t)/C_t$, where X_t is the current habit level, which is a slowly moving process dependent on past consumption, and they include a chance of a recession into their model. When the consumer’s consumption is close to his habit level, then minor changes in consumption are magnified into large changes in marginal utility. As a result, the consumer exhibits time-varying risk aversion: when consumption is close to habit, as during an economic downturn, risk aversion increases drastically.

Because equity has poor returns during recessions, precisely when risk aversion is high, it is in less demand than in the standard consumption-based model. Conversely, precautionary savings creates additional demand for risk-free assets, which drives the risk-free rate downwards. Additionally, time variation in risk aversion can account for the variation seen in stock prices. This model is ingenious in turning the relatively small variations in consumption and the relatively low consumption-stock correlation seen empirically to large effects with respect to the equity risk premia. However, the average risk aversion is still high (Cochrane 2005: 473) and it is not self-evident that consumers really exhibit the large countercyclical variations in risk aversion required (Mehra 2003).

At the extreme end of preference modifications, theories in the behavioral tradition propose that investors are subject to psychological biases which make them more sensitive to losses than gains and incapable of implementing an appropriate long-term investment strategy (Salomons 2008, DeLong & Magin 2009). In these models, the equity premium is not compensation for risk. Benartzi and Thaler (1995) suggest that investors are inherently myopic, which makes them too concentrated on the short-term volatility of equity as a measure of riskiness and they therefore require higher equity premium than a long-term analysis would warrant (though the long-term safety of equity is a contentious issue itself – see Arnott (2011)). Barberis, Huang and Santos (2001) present a model based on the prospect theory of Kahneman and Tversky (1979) and the ‘house money effect’ of Thaler and Johnson (1990): the representative consumer is loss averse and her utility depends on both consumption and change in portfolio value. Then her risk aversion increases when the value of her portfolio goes down, which pushes the required return on equity upwards. Time-varying risk aversion can then account for equity premia predictability in this model too. The conclusions seem surprisingly similar to those of Campbell and Cochrane (1999), even though the motivation of the model is completely different.

2.2.2 Heterogenous investors and market frictions

Models of heterogenous investors abandon the usual assumption of a representative agent. During the sample period, only a small subset of the population held stocks (Mankiw & Zeldes 1991), and therefore it seems reasonable to assume that investors are heterogenous. However, just assuming heterogenous investors who are subject to idiosyncratic income shocks is no solution: the individuals will then simply trade away the shocks (Cochrane 2005: 477), and in any case, the pricing equation (1) holds for any investor, and it is unlikely that consumption of any individual is so much more volatile than aggregate consumption that it can account for the puzzle.

Constantinides and Duffie (1996) circumvent these difficulties by defining a model in which heterogenous consumers are subject to permanent income shocks that cannot be insured against, for example job loss. The chance of such shocks increases in recession, which is precisely the time when stocks tend to have poor returns. Because consumers are then effectively holding equity risk through their human capital, they require a high premium for holding stocks. Cochrane (2005: 474-481) comments that this model too requires large risk aversion: labor market risk correlated with the stock market does not seem to be enough.

Constantinides, Donaldson and Mehra (2002) extend the model of heterogenous agents to include life-cycle considerations. The wage income of the middle-aged consumers is known, and therefore equity returns drive fluctuations in their consumption. They then require high equity premia. Equity is less correlated with consumption for young people, whose wage income is still uncertain. Young consumers would then prefer to invest heavily in equity to smooth lifetime consumption. However, the model incorporates market frictions in that young investors cannot borrow against their future wage income, and stocks are then exclusively priced by middle-aged investors, resulting in a high equity premium.

It seems that there is a common thread running through many of these different models. The high observed excess return on stocks is due to equity having weak returns during the periods when investors are in dire straits and risk aversion is high, whether this is due to consumption being close to habit, as in Campbell and

Cochrane (1999), or the probability of a large and permanent negative income shock is high, as in Constantinides and Duffie (1996), or simply because investors strongly dislike the persistent negative returns that equity portfolios often go through during recessions, as in Barberis et al. (2001). However, so far, no model has obtained universal approval (Mehra 2003, DeLong & Magin 2009).

2.3 Empirical solutions to the puzzle

The other line of research has challenged the use of U.S. stock market data. The research on the equity premium has focused on U.S. data, probably mostly due to data availability and quality (Nyberg & Vaihekoski 2014). High-quality international data has mostly consisted of MSCI indices, and for most countries, those start as late as 1970 (Dimson et al. 2008). The argument is that either the realized excess returns on successful stock markets are biased upwards (an ex-post bias) or that the expected equity premium was biased upwards as a compensation for disaster risk (an ex-ante bias).

2.3.1 Survivorship bias and the international experience

Brown, Goetzmann and Ross (1995) note that a stock market has had to survive to the present day for researchers to be able to study long and continuous stock indices: survival of the return series imparts a bias to the ex-post excess returns. The U.S. stock market survived through the 20th century to become the largest market in the world, while many other stock markets, such as those of the Imperial Russia, closed yielding a cumulative return of -100%. Even amongst those that have survived, the economic success of the United States raises questions to whether U.S. data might suffer from a serious survivorship bias. Empirical support for the argument of Brown et al. is presented by Jorion and Goetzmann (1999). They find that over the years 1921-1996, U.S. equities had the highest annual geometric real return of a set of 39 countries: 4.3%, while the median was 0.8%.

However, their data is suspect. Jorion and Goetzmann (1999) were not able to collect data on dividend yields and interest rates, and they therefore calculate the equity premium as the nominal capital gain minus the rate of inflation. This relies on the assumption that the cross-sectional variation in dividend yields minus the real interest rate is small, an assumption that Dimson et al. (2008) maintain does not hold. Dimson et al. collect high-quality data on 19 countries from 1900 to 2005 and find that calculated either arithmetically or geometrically, the return on U.S. equities is larger than average, but not dramatically so: the annual geometric mean of the ex-post equity premium relative to bills in the U.S. was 5.5%, the average was 4.8% while the market capitalization weighted world index earned 4.7%. They estimate that these 19 countries account for around 90% of the world market capitalization in 1900. It is clear then that the equity premium puzzle is not confined to the U.S. stock markets. Dimson et al. note that (with arithmetic averages, as is customary) using the world index and this longer time period, we end up near the original “puzzling” realized equity premium of 6%, as reported by Mehra and Prescott (1985).

It could still be that even though the success bias of U.S. equity is then accounted for, the world market data of Dimson et al. (2008) still suffers from a survivorship bias, because it only includes return data on markets that survived for the whole period. However, Dimson et al. argue that at most, survivorship bias amounts to 0.1% per annum in geometric terms, a negligible number. Li and Xu (2002) also present a theoretical argument that the ex-ante probability of long-term survival of a market had to be very small for the survivorship bias to have a significant effect. The history of the world’s financial markets suggest that the probability is in fact quite large. One could of course always argue that the probability was really very small and we just were extremely lucky, but that seems far-fetched. Also, it is not clear that better economic performance has translated into higher equity returns. Ritter (2005) finds that the cross-country correlation of real stock returns and per capita GDP growth over 1900-2002 is negative or at least insignificant. Furthermore, the effect of economic growth on bills and bonds might be different from its effect on equity returns, rendering the effect on the equity risk premium difficult to assess.

Dimson, Marsh and Staunton continue to update their indices, which contain the most comprehensive information available on the long-term worldwide ex-post equity premium. They now include 23 countries for years 1900-2016, with the last ten years having reduced the premium somewhat: annual geometric means are 5.5% for the U.S. and 4.2% for the market capitalization weighted world index (Dimson, Marsh and Staunton 2017). Siegel (2014: 75-92) offers an even longer perspective for U.S. equity returns, from 1802 to 2012. He reports that over those two centuries, the annual geometric mean of the excess return on U.S. stocks over Treasury bills has been around 3.9%, somewhat less than Dimson et al. report from the year 1900 on. However, Falkenstein (2012: 63) and Dimson et al. (2008) caution that the 19th century data used by Siegel is suspect to survivorship bias and omitted dividends.

A number of studies have investigated the international equity risk premium with the MSCI indices, having then a much shorter time period but a larger set of countries to analyze. Salomons and Grootveld (2003) find that emerging markets have experienced both higher excess returns and higher Sharpe ratios than developed markets. They also report that the ex-post equity premium has been time-varying also in emerging markets. Similarly, Shackman (2006) reports that emerging markets have had higher excess returns but he finds that Sharpe ratios have been lower in emerging markets than in developed markets. Donadelli and Prosperi (2011) find higher realized excess returns for emerging markets as well.

At least Stulz (1999) and Henry (2000) have argued that the return expected on domestic equity should decrease with the degree of market integration due to increased possibilities for international diversification. It is important to note that if the expected return decreases due to opening of the financial markets, then the adjustment period will see higher realized returns due to the upwards repricing of stocks. However, Salomons and Grootveld (2003) find no evidence of a structural break in equity premium occurring around market liberalizations. Conversely, Shackman (2006) hypothesizes that expected returns would be lower in emerging markets due to high domestic demand for stocks. He also provides empirical support for the hypothesis that the degree to which a country is integrated to global markets is positively correlated with the realized excess return on the domestic stock market. In any case, it is evident that also when compared to emerging markets over the few previous decades, the excess return on U.S. equities has not been extraordinarily large.

2.3.2 Catastrophic crashes

Closely related to the survivorship bias argument discussed in the last segment, Rietz (1988) and Barro (2006) argue that the large excess return might be due to a small possibility of catastrophic outcomes that investors account for in pricing, but which does not show up in the sample. A long enough sample would include a sufficient number of such shocks so that the realized premium would no longer diverge from our theoretical expectations. Such a catastrophic loss could be, for example, a war that devastates the productive capability of the country, or a political development that leads to closing of the stock market. Barro and Ursùa (2008) provide evidence on macroeconomic crises in 24 countries since 1870, defining a crisis as a drop of 10% or more in consumption or GDP. They find that this evidence implies an annual disaster probability of 3.5% with a mean size of 21-22%, which could account for a large equity risk premium.

Whereas the survivorship bias argument imparts a bias to the ex-post excess returns on equity, the disaster argument leads to a higher ex-ante expected equity premium. Looking backwards to a history that includes fewer disasters than was expected, the effect on realized returns is of course the same. A major problem with the disaster hypothesis is that such crises would have to be limited equity markets, and have no effect on bills and bonds (Mehra 1988, DeLong & Magin 2009). However, historically, many crises have wiped out government bond and bill holdings due to inflation and defaults, while having had only a transient effect on equity markets (Mehra 2003).

2.3.3 Ex-post versus ex-ante expected returns and equity premia predictability

Whether U.S. returns are used or not, an important branch of research has criticized focusing on past excess returns as a measure of the equity premium. These studies make a clear distinction between what the investors expected in history and what subsequently realized. Did investors really expect the subsequent high excess returns to realize, and deemed the risk too high to take? Mehra and Prescott (1985) and the theoretical literature following them straightforwardly substituted average realized excess returns for the expected equity premium, but this is reasonable only if the equity risk premium is stationary (Van Ewijk, De Groot & Santing 2012). Only then is it meaningful to take averages and speak of unconditional means. If the expected equity premium is nonstationary, for example, due to changing risk aversion among investors, then the historical average will be misleading. Some other tool must then be found for both analyzing the historical expected premium for academic purposes and the expected future premium for practical purposes. Typically, the tool used is some form of a dividend growth model, inspired by Gordon (1962). For a more comprehensive analysis of different methods of equity premium estimation, see Duarte and Rosa (2015) and Damodaran (2016).

Some studies endeavor to directly estimate the path of the historical expected equity premium, as done by Blanchard, Shiller and Siegel (1993), Jagannathan, McGrattan and Scherbina (2000), Claus and Thomas (2001), Arnott and Bernstein (2002), Ilmanen (2003) and Bogle and Nolan (2015). The idea is to model the objective expected equity premium rather than hoped-for returns, the difference being that the objective expectations have some basis on ex-ante information. In these studies, the point-in-time expectation of the equity premium is defined as the sum of the dividend yield and measures of the expected growth, minus the expected risk-free rate. Conveniently, the ending value of the expected equity premium gives a forecast of the future equity premium. Here the expectations are usually obtained as some composite of the past averages and ex-ante regressions of future values on past values, though also analyst forecasts are used, as in Claus and Thomas. However, they find that analyst forecasts of cash flow growth tend to be biased upwards. Typically, these studies find that the path of the expected equity premium has been under the path of the realized excess return, for example, due to capital gains from increasing valuation multiples (such as the price-dividend ratio) feeding into realized excess returns. Expansion in the price-dividend ratio means that investors today are willing to pay more for a dollar of dividends.

Also, regular surveys of finance professionals, as in Graham and Harvey (2016) and its predecessors, are used to directly estimate the future equity premium. However, these are only available for recent years, and tend to measure more hoped-for returns than the objective expected equity premium (Greenwood & Shleifer 2014).

The difficulty with these models is the evidence on predictability. Can the future equity premium be predicted today? Traditionally, it was thought that dividend growth varies but the equity premium is a constant, while it is now generally thought that dividend growth is constant but the equity premium is time-varying (Ilmanen 2011). A voluminous literature investigates whether accounting ratios such as the dividend-price ratio and other variables can predict future returns. Suppose that the equity premium is predictable with the dividend-price ratio and dividend growth is a constant. Then we could simply create an ex-ante prediction of the equity premium with the current dividend-yield and a past average of the dividend growth rate. If the equity premium is not predictable, then the best forecast of the future equity premium at any point-in-time is the past average of the equity premium up to that point.

For example, Fama and French (1988) report that the dividend yield predicts long-run stock returns and Lettau and Ludvigson (2001) find that deviations from the shared trend between consumption, asset holdings and labor income forecast the equity premium at business cycle frequencies. However, Welch and Goyal (2007) find that the in-sample predictability of the equity premium is with most predictor variables weak, has been decreasing during recent decades and is mostly centered around extraordinary events, such as the 1973-1975 oil crisis. Out-of-sample predictability, which is important for any findings of in-sample predictability to be economically useful, they report to be nearly non-existent. Then return predictability seems to be an illusion, caused by relentless data mining of the same U.S. stock return sample.

Campbell and Thompson (2007) and Campbell (2008) mostly confirm the results of Welch and Goyal (2007), but they find that imposing theoretical restrictions of steady-state valuation models, such as those of the Gordon (1962) growth model, can significantly improve out-of-sample predictability. They find that some valuation ratios then outperform the historical mean in forecasting the future equity premium. Cochrane (2011) argues that if the dividend-price ratio is stationary, as seems to be the case empirically, variations in it must predict either expected dividend growth or expected returns. The dividend-price ratio varies through time due to variations in the conditional expectations of the future dividend growth and stock returns, as noted by

Campbell and Shiller (1988). Suppose that the dividend-price ratio is currently relatively low. Then for it to revert closer to its unconditional mean, either future dividend growth must be high or future returns must be low (due to low or negative growth in prices). Due to the scarcity of evidence of dividend growth predictability, Cochrane then concludes that variations in the dividend-price ratio must correspond to variations in expected returns.

Note that we mentioned above that increasing valuation multiples have been feeding into realized excess returns, while here we said that the dividend-price ratio has empirically been stationary. The evidence seems mixed, but while it may be so that the dividend-price ratio has moved over time from one regime to another, it must then at least be mean reverting within regimes (Fama & French 2002). It is not reasonable that the dividend-price ratio is nonstationary, because then either the expected dividend growth or the expected stock return is a non-stationary process than can wander off to infinity!

Not everyone agrees that it is purely variation in the expected equity premium which drives the dividend-price ratio (Ilmanen 2011). Welch and Goyal (2007) comment that Cochrane (2011) does not seem to consider the possibility that predictability could vary through time and that it could be variation in both the expected equity premium and the expected dividend growth that affect the dividend-price ratio, making both more difficult to detect. There is some evidence of predictability of cash flows too, if scarcer: Lettau and Ludvigson (2005) find predictability of dividend growth, and interestingly Arnott and Asness (2003) report that high payout ratios predict high earnings growth. Again, it seems that there is yet no clear consensus. It should be noted that all the evidence on return predictability points to the direction that if there is return predictability, it is on horizons longer than one year and increases with time. It might be possible to forecast that on the bottom of the recession, the expected equity premium is high due to the probable rebounding of the stock prices, but it is not possible to forecast returns tomorrow!

Other studies, namely Fama and French (2002), Ibbotson and Chen (2003) and Dimson et al. (2008) give up on estimating the conditional path of the historical premium, and simply analyze the historical excess return and try to separate it into expected and unexpected parts, all with somewhat different methods. They then argue that the expected part is a good estimate of the true historical expected premium and that the unexpected part is a windfall for equity investors. Ibbotson and Chen and Dimson et al. deem the historical expansion in the valuation multiples as unexpected and find the mean of the historical expected equity premium to be somewhat lower than the historical average excess return.

Fama and French (2002) first note that as an identity, the realized (arithmetic) average excess return can be decomposed into sum of the average dividend yield, the average rate of capital gain and the average risk-free rate over the period:

$$A(ER_t) = A(D_t/P_{t-1}) + A(GP_t) - A(R_t^f), \tag{8}$$

where D_t is the dividend paid during time t, P_{t-1} is the price at the end of period $t-1$, GP_t is the rate of capital gain over period t, RF_t is the risk-free rate over period t and $A(\,)$ stands for the arithmetic average over all the t considered. If the dividend-price ratio is stationary, then over a sufficiently long period of time, the geometric mean of the dividend growth rate must approach the geometric mean of the capital growth rate. This is most readily understood by considering the dividend-price ratio a constant: then any changes in either variable must be matched by an identical change in the other, otherwise, the ratio would not stay constant. Then the capital growth term in (8) can be proxied with the mean dividend growth over the period to obtain an alternative estimate of the expected return. The same logic applies to any variable that is cointegrated with the stock price.

What the historical excess return from (8) and any such fundamental valuation model derived from it can be used to estimate is the unconditional mean of the historical expected equity premium. Then the same condition applies to them all: stationarity of the equity premium is required for meaningful inference, but if the equity premium is non-stationary but mean reverts within regimes, then the estimates from fundamentals are likely to be a better estimate of the historical average expected equity premium than the historical average excess return is (Fama & French 2002).

Fama and French (2002) find that the estimates from fundamentals are lower than the historical excess return on U.S. equity, though still too much to account fully for the puzzle. They then report that it is the expansion of valuation multiples due to decreasing expected returns that has caused the difference, and deem the realized returns from valuation multiple expansion to be unexpected. Cornell, Arnott, and Moroz (2009) extend the analysis on U.S. equities a few years forward and find that there has been convergence in the estimates of the models used by Fama and French. Vivian (2007) extends the analysis of to the UK stock markets and finds similar results as Fama and French did for the U.S. data.

What has driven this decrease in expected returns, reported in all the studies above? Asness (2000) reports that relative to the volatility of bond returns, the volatility of stock returns has decreased. McGrattan and Prescott (2001) propose that reductions in personal income tax rates since 1960s have led to increasing demand for equities. As another institutional determinant of equity demand, McGrattan and Prescott (2003) note that the loosening of regulatory restrictions governing pension fund allocations in the 1970s has switched asset demand from bonds and bills towards equity, leading to unexpected capital gains through equity repricing. Lettau, Ludvigson and Wachter (2007) argue that the decrease in macroeconomic volatility during recent decades has driven expected returns down and stock prices up. Not everyone agrees that this decrease in expected returns is permanent: the expected stock return might just be very slowly mean reverting (Fama & French 2002).

In any case, focusing on the ex-ante expected returns has not been able to fully account for the large equity premium: the increase in valuation levels (equivalently, decrease in expected returns) has not been large enough. For example, Fama and French (2002) report that the unconditional expectation of the equity premium from their dividend growth model is 2.55% for 1951-2000 in the U.S. stock markets. However, the studies have quite uniformly concluded that the expected equity premium for the 21st century is both lower than the realized excess return during the second half of the 20th century, and even lower than what the expected equity premium was in the past, due to the decreased dividend-yield. Correcting the dividend yield for stock buybacks increases the expected equity premium somewhat, but net of new equity issuance the effect is not large (Arnott & Bernstein 2002).

3 DATA AND METHODOLOGY

In this section, we will first discuss the data used and then continue with the methods used in the empirical analysis.

3.1 Data on Finnish stock markets and overall economy

Data availability has presented a significant problem for long-term analysis of the Finnish stock market. Stock indices covering the pre-1970 period have been problematic due to poor coverage of stocks and dividends (Nyberg & Vaihekoski 2010). Helsinki Stock Exchange’s own HEX/OMX-index is available from commercial databases like Datastream starting from January 1991, which is only a fraction of its history. Similarly, a dividend yield series for the whole stock market can be calculated from the official total return and stock price indices only starting from January 1992. Fortunately, during the past few years, data on both total stock returns and dividend yields has come available.

The time series used include a stock market return index, the price-dividend ratio of the market index, growth rate of the dividends paid on the market index, money market rates, inflation and consumption per capita growth rates. Data covers the years 1912-2015 for all series but the price-dividend ratio and dividend growth, which end in 1988. Most of the data used in the study is provided by Vaihekoski and Nyberg, and most of it is from time series constructed by them (Nyberg & Vaihekoski 2010, 2011, 2014a, 2014b). The exceptions are data on the size of population and consumption, which are provided by Statistics Finland and originally collected by Hjerppe (1989). The money market data is obtained from Bank of Finland.

3.1.1 Stock market returns

For the period from December 1912 to December 1969, we use the monthly value-weighted all-share total return index for the Finnish stock market constructed by Nyberg and Vaihekoski (2009). From January 1970 to December 1990, we use the WI-index by Berglund, Wahlroos and Grandell (1983). Starting from January 1991 to the end of 2015, the HEX-index is used. The indices are used to create an annual returns series for the period.

For their stock index, Nyberg and Vaihekoski (2010) collect month end price (bid offer) and dividend data for every stock that was listed in the Helsinki Stock Exchange at some point during the years 1912-1969. They collect the data from a variety of sources, including newspapers (Mercator, Kauppalehti and Helsingin Sanomat), the ledger book of the exchange (the iron book), Kock and publications by Finnish banks, including KOP Bank and OKO bank. They also collect other data needed to construct the indices, including yearly equity capital and nominal stock values to calculate time series for the number of stocks for each of the listed stock series, and splits and issues to account for their effect on prices and dividends. Nyberg and Vaihekoski then calculate the monthly percentage stock returns for stock *i* at time *t* as:

$$R_{i,t} = \frac{P_{i+t}+D_{i+t}}{P_{i,t-1}} - 1, \tag{9}$$

where $P_{i,t}$ denotes price of the stock at time t adjusted for any splits and issues that might have occurred during the period, $P_{i,t-1}$ is the price at time $t-1$ and $D_{i,t}$ is the cash dividend paid during the period. To gain the monthly value-weighted average return for the stocks included in the index, they simply sum the market capitalization weighted individual stock returns. Using the monthly returns, Nyberg and Vaihekoski (2010) calculate the value-weighted total return index value for month $\mathrm{t} = 1, 2, \ldots, \mathrm{T}$ as:

$$I_t = 100(1 + R_1)(1 + R_2) \ldots (1 + R_T), \tag{10}$$

where I_t denotes the index value and R_t the monthly value-weighted return on the index. For a more comprehensive documentation, including the full list of references they use, see Nyberg and Vaihekoski (2010).

The WI-index and HEX/OMX-index are similarly constructed value-weighted indices, with adjustments for dividends, splits and issues. While the index by Nyberg and Vaihekoski (2010) is monthly, the WI-index is daily. Aside from this, the most important difference is between the WI-index and HEX-index: the WI-index assumes reinvestment of dividends in the particular stock, while in the HEX-index, dividends are assumed to be reinvested in the whole market. (Nyberg & Vaihekoski 2010, 2011).

By taking annual returns from the three indices, we obtain an annual net stock return series for the Finnish stock market from 1913 to 2015. To create the stock return series, solve for the return for year $\mathrm{t} = 1, 2, \dots, \mathrm{T}$ from equation (10):

$$R_t = I_t / I_{t-1} - 1, \tag{11}$$

where R_t and I_t are defined as before.

3.1.2 The dividend-price ratio, dividend yield and dividend growth rates

For the period from 1913-1988, we use the monthly value-weighted dividend-price series constructed by Nyberg and Vaihekoski (2014a). Nyberg and Vaihekoski call it the dividend yield: they define dividend yield as the ratio of the dividends paid during the previous twelve months to the price today, which is more commonly called the dividend-price ratio, while dividend yield is often defined elsewhere as the ratio of the dividend paid during the year to the beginning of the year price. Because of data availability, we are forced to use this dividend-price ratio also as the dividend yield.

Nyberg and Vaihekoski calculate dividend yields for individual stocks by summing the cash dividends paid on the stock during the previous twelve months and then dividing this sum by the current month-end stock price. They calculate the cash dividends used as the product of dividend rates and nominal stock values, adjusted for splits and issues. Nyberg and Vaihekoski then calculate the value-weighted dividend yield on the market as the market capitalization weighted average of the individual dividend yields. For more information, see Nyberg and Vaihekoski (2014a).

For the annual dividend growth, for the years 1913-1988 we use dividend growth series provided by Nyberg and Vaihekoski, which they calculate from their data on cash dividends paid on individual stocks. Unfortunately, specific documentation does not exist for the dividend growth series.

3.1.3 Money market rates

Following Nyberg and Vaihekoski (2014b), we proxy the risk-free rate with the Finnish Helibor one-month rate from January 1990 until the end of 1998 and the Euribor one-month rate for 1999-2015, provided by the Bank of Finland. The rate used for a given month is the rate on the last day of the month. The period before 1987 is problematic, because a properly functioning money market did not exist before that in Finland. For this reason, the Bank of Finland's base rate is used for the years 1913-1989 (for the last two years, because of data availability). This is not innocuous, as the base rate is not a market-determined rate at which investors could have borrowed and lent; however, the highest interest rates offered on short-term savings accounts by Finnish banks followed the base rate closely. (Nyberg & Vaihekoski 2014b). Nyberg and Vaihekoski calculate the risk-free rate of return for month t as follows:

$$rf_t = \frac{1}{1+i*d}, \tag{12}$$

where *i* denotes the money market rate at the end of the previous month and *d* the number of days between the end of month *t-1* and *t* divided either by 365 (for Helibor and the base rate) or 360 (for Euribor). In other words, *d* is the parameter that turns annual rates to monthly rates. For complete documentation, see Nyberg and Vaihekoski (2014b). To obtain an annual series of the risk-free rate, we take an average of the monthly risk-free rates for that year.

3.1.4 Inflation

For inflation, we use the monthly data collected and provided by Nyberg and Vaihekoski (2014b) from the end of 1912 to June 2014. For the years 1912-1913, they use the annual cost of living index published by Hjerppe (1989). From 1914 to the end of 1920, they use an unofficial cost of living index calculated by the Research Office of the Ministry for Social Affairs, which is calculated on a quarterly basis for the years 1914-1919 and on a monthly basis for 1920. Inflation is calculated as the rate of change of the cost of living indices. For the years when no monthly data is available, they assume that the intervening months between the data points have constant inflation, and simply interpolate the monthly inflation that produces the actual compounded quarterly or annual rate of inflation. Starting from January 1921, Nyberg and Vaihekoski use the official monthly cost of living index. We extend the series to the end of 2015 with the same official cost of living index obtained from Statistics Finland. The real variables Y_t used in the study are calculated from the corresponding nominal variables y_t as $Y_t = \frac{1+y_t}{1+Inf_t}$, where Inf_t is the rate of inflation during period t.

3.1.5 Consumption per capita

The series for real consumption per capita is obtained by dividing a volume index of consumption with a population series, both obtained from Statistics Finland and originally published by Hjerppe (1989). As a robustness test, we compare our consumption per capita series with that used in Barro and Ursúa (2008) for years 1860 to 2006, and find that the two series have a correlation of 0.999. However, our consumption data is not ideal. The theory relates asset returns to the flow of nondurables consumption and services, however, such data does not exist for the early decades of the 20th century. Our consumption series is per capita consumption expenditure, and includes food, beverages, tobacco, clothing, the flow of housing services and other assorted private consumption, which includes also durable components.

3.2 Methodology

Below we discuss the methodological choices made in this thesis: calculating the dividend growth model estimate of the unconditional expected equity premium, the

OLS regression and testing for stationarity and the calculations of the rates of returns.

3.2.1 The dividend growth model

We estimate the unconditional expected equity risk premium following Fama and French (2002) as

$$E(ER) = A(D_t/P_t) + A(GD_t) - A(R_t^f), \tag{13}$$

where the connection to equation (8) should be clear: assuming the stationarity of the dividend price ratio, the growth rate of the dividends should approach the rate of capital gain. However, as discussed above, because of data availability, we are forced to use the dividend-price ratio D_t/P_t instead of the dividend yield D_t/P_{t-1}.

The motivation of this model is somewhat loose. In the case that the dividend-price ratio is stationary, it should produce an estimate of the historical expected equity premium equal to the average realized excess return, as discussed above. If the dividend-price is nonstationary, under what conditions is it plausible that the dividend growth model of Fama and French (2002) is a better estimate of the average historical equity premium than the average historical excess return? It does not seem plausible that the dividend-price could be nonstationary due to the equity premium or the dividend growth being unit root processes, but the dividend-price ratio could appear nonstationary, if either the dividend growth or the historical equity premium has had structural breaks, while still being stationary processes within regimes. If only dividend growth has had structural breaks, then both the average historical excess return and the dividend growth model will still provide a similar estimate of the stationary equity premium.

If it is the equity premium that has had structural breaks due to equity repricing, as maintained by Fama and French (2002), then the average historical expected equity premium will of course not be well defined for the whole sample. However, in this case, as the dividend growth model is unaffected by effects the repricing has on capital gains, we would expect it to better estimate the return expected by investors throughout the sample: capital gains due to repricing is a byproduct of changes in the expected return, not part of the expected return. Fama and French provide also some circumstantial evidence for this using accounting data, which we will have to bypass due to data availability

3.2.2 OLS regressions

The ordinary least squares (OLS) regression is used in the empirical part for forecasting excess returns and dividend growth with other economic variables. Hayashi (2000: 109-113) lists the large sample assumptions of the OLS procedure:

- A1. Linearity of the relationship between the dependent variable and the regressors.
- A2. Ergodic stationarity of the stochastic process producing the observations of both the dependent variable and the regressors.
- A3. Predetermined regressors: the regressors are orthogonal to the contemporaneous error term.
- A4. The covariance matrix of the regressors is nonsingular and hence finite.
- A5. The product of the error term and the regressor vector is a martingale difference sequence, so that the error term must be serially uncorrelated.

When utilizing the least squares regression, it should somehow be verified that the assumptions are reasonable in that specific case. It should also be noted that these are the large sample (asymptotic) assumptions – the finite sample assumptions, which are valid for any sample size, are much stricter.

3.2.3 Calculations of rates of growth and returns annually and long-term expected wealth

Different studies differ in their choice of methodologies, which makes it difficult to compare the equity premium estimates obtained. The use of arithmetic versus geometric differences is one point of contention. It is customary to calculate real variables by taking a geometric difference between the nominal value of the variable and inflation, that is, by calculating the real variable Y_t from the corresponding nominal variable y_t and inflation Inf_t as $Y_t = \frac{1+y_t}{1+Inf_t}$. On the contrary, excess returns of equity over the risk-free rate are usually calculated with arithmetic differences, that is, by calculating the excess return ER_t from the corresponding equity returns R_t and the risk-free rate $R^f{}_t$ as $ER_t = R_t - R_t^f$. We follow this convention. Dimson et al. (2008) differ here and calculate excess returns as a geometric difference.

As a related matter, the means of the variables (most importantly, returns) can be calculated either as an arithmetic average or a geometric average. It is usually thought that the geometric mean produces a better estimate of the historical long-term average, as it is the rate that produces the final value of the portfolio; however, when estimating future returns, the arithmetic average is more appropriate, as the geometric average is downward biased estimate of single-period returns (Brooks, 2014). Jacquier, Kane and Marcus (2003) show that if the historical average is used as a forecast of future portfolio return, both the arithmetic and geometric averages are biased, and the optimal estimate is a weighted average of the arithmetic and geometric rates. In this thesis, arithmetic averages are used.

In academic literature, it is customary to calculate the excess return of equity relative to short-term government or commercial bills as a proxy for the risk-free rate. More practically oriented papers, for example Arnott and Bernstein (2002) and Ilmanen (2003), often calculate excess returns relative to bonds because bonds and stocks have more similar duration. However, from the theoretical point of view, bonds are not a good proxy for the risk-free rate especially due to their inflation risk. For some time periods in the past, even government bills were far from a riskless investment: consider the government debt of the Russian Empire, of which Finland was a part of until 1917. We follow the academic custom of calculating the excess return relative to short rates.

4 EMPIRICAL RESULTS

4.1 The realized consumption per capita and excess returns on equity

Figure 1 presents the volume of consumption per capita in Finland from 1861 to 2015. Consumption started increasing fast after the Second World War, but has seen a few drops after that, most dramatically during the depression in the beginning of the 1990´s and during the financial crisis of 2008. After the crisis, consumption per capita seems to have levelled off.

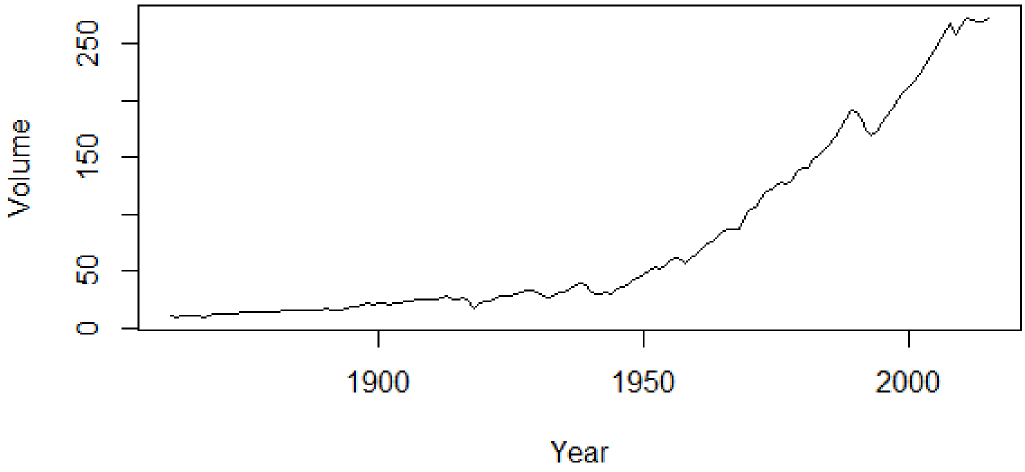

Figure 1: Real consumption per capita in Finland from 1861 to 2015.

More interesting from the point of view of consumption-based asset pricing is the growth rate of consumption per capita and the volatility of the growth rate. Figure 2 presents the annual growth rate of consumption per capita from 1861 to 2015. Looking at the picture, it seems immediately evident that the growth rate has varied a lot, and also its volatility has fluctuated through time. The growth rate was very volatile during the first half of the 20th century, with highly negative growth rates during the First World War, The Great Depression of the early 1930's and the Second World War. After the war, the volatility of the growth rate seems to have decreased.

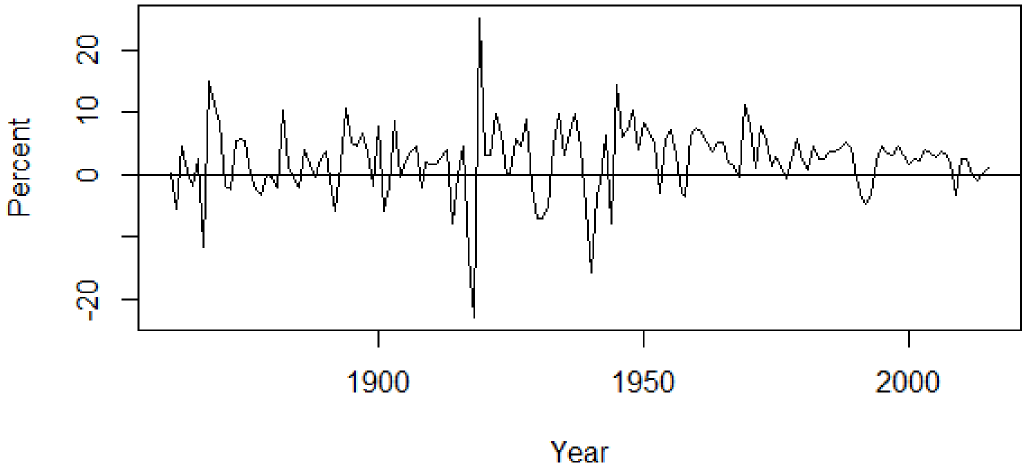

Figure 2. The annual growth rate of real consumption per capita in Finland from 1861 to 2015.

Because we only have data on annual stock returns starting from 1913, and are therefore restricted to examining the equity premium puzzle in the period starting then, we present summary statistics separately for the period after and before 1913. We also show the results separately for the periods 1913-1960 and 1961-2015.

Table 1. Descriptive statistics for annual real consumption per capita growth in Finland

	Summary statistics		Autocorrelation				Heterosced.
Period	Mean (%)	σ (%)	ρ_1	ρ_2	ρ_3	Ljung-Box	McLeod-Li
1861-1912	1.88 %	4.86 %	0.000	-0.163	-0.119	0.794	0.032
1913-1960	2.21 %	8.10 %	0.100	-0.098	0.049	0.444	0.038
1961-2015	2.66 %	2.88 %	0.427	0.064	0.134	0.030	0.044
1913-2015	2.45 %	5.89 %	0.149	-0.067	0.058	0.075	<0.001

The table presents the arithmetic average, standard deviation (σ) and autocorrelation (ρ_i) up to three lags for the annual consumption per capita growth in Finland. Also shown are the p-values for the Ljung-Box (Ljung & Box 1978) and McLeod-Li (McLeod & Li 1983) tests for autocorrelation and conditional heteroskedasticity, with 6 lags used. The null hypothesis is that of no autocorrelation/heteroskedasticity.

Table 1 presents descriptive statistics for annual consumption per capita growth in Finland. The numbers show that the mean of the growth rate has increased monotonically from one subperiod to the next, as it seemed purely from looking at figure 1. The mean consumption growth for 1913-2015 is 2.45%. The volatility of the consumption growth has also fluctuated. It was 4.86% in the first subperiod, increased substantially during the second one to 8.10%, before dropping to 2.88% in the last 50 years of the sample. Interestingly, the autocorrelation of consumption growth also varies from one subperiod to the next. The autocorrelation coefficients are very low and statistically insignificant for 1861-1912 and 1913-1960, but the subperiod 1961-2015 shows statistically significant autocorrelation at the 5% level (the *p*-value of the test statistic is 0.03). However, the autocorrelation seems to be confined to the first lag, which has a positive coefficient of 0.427. The whole period from 1913 to 2015 does not show statistically significant autocorrelation. Mehra and Prescott (2008) note that positive serial correlation in consumption growth will worsen the equity premium puzzle, as then the equity premium will decline with increasing risk aversion.

As mentioned above, Cochrane (2005: 463) reports that the U.S. consumption growth data does not show much conditional heteroskedasticity. However, we find for all the subperiods statistically significant heteroskedasticity at the 5% level, and with a higher number of observations, the whole period 1913-2015 shows statistical significance at the 1% level. This is formal evidence of our observations above that the volatility of the consumption growth seems to be time-varying. It is important in that time-varying consumption growth volatility can make it easier to explain time-variation in the equity premium, insofar as the changes in volatility regimes fit the pattern of the realized equity premium well. However, when comparing to the results obtained with the U.S. data, it should be kept in mind that our consumption data is not exactly nondurables and services consumption, but includes also durable elements. If the consumption of durables is more volatile, as would seem likely, then it could be driving the findings of conditional heteroskedasticity.

We have annual stock market data only starting from 1913. We calculate the excess return as real stock returns minus the real interest rate, but it should make no difference whether real or nominal returns are used. The realized annual excess return of stocks over the risk-free rate (as proxied by the short rates) is shown in figure 3. The realized excess return seems to be stationary but varies widely, having commonly fluctuated between 50% and -30%. The excess return reached unprecedented highs at the end of the 1990's, just before the tech-bubble of 2000. This underscores the danger inherent in extrapolating recent excess returns to the future as an estimate of the expected equity premium.

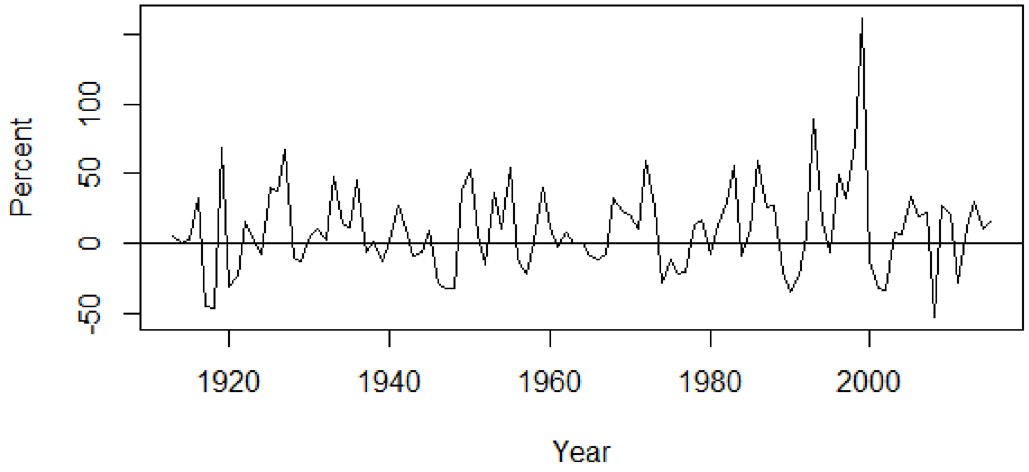

Figure 3. The realized annual excess return on equity in Finland from 1913 to 2015.

Table 2 reports descriptive statistics on the realized excess returns plotted above and related variables for the period 1913-2015. We also divide the sample period to four subperiods, each around a quarter-century long. The table shows that inflation has been at times very high, averaging 15.31% during the first subperiod (years 1913-1940), but has decreased monotonically from one subperiod to the next. The volatility of inflation has decreased even more drastically, averaging 45.92% in the first subperiod and only 1.66% in the last. Still, the historical average inflation over the whole sample is very high at 9.66%.

The real risk-free rate has been very low and on average negative. The average over the whole sample is only -0.11%, with the two first subperiods yielding negative real returns, the rate actually reaching a low of -0.40% during 1941-1965. The last two subperiods show positive albeit very small real risk-free rates, probably reflecting the more stable inflationary environment during the latter half of the sample. The volatility of the real risk-free rate shows the same development, being very high relative to the average rate during the first subperiod, but decreasing to just 0.27% in the last subperiod. It could be argued that these results call into question using the money market rates as a proxy for the risk-free rate: it seems that it has incorporated a substantial inflation risk. Would investors really have invested at that rate, fully expecting it to yield a negative return?

Table 2. Annual real returns in Finland and related statistics

Means of annual values of variables (%)					
Period	Inf_t	R^f_t	R_t	ER_t	$Sharpe_t$
1913-1940	15.31 %	-0.22 %	7.37 %	7.58 %	0.25
1941-1965	12.81 %	-0.40 %	4.89 %	5.29 %	0.21
1966-1990	8.18 %	0.04 %	9.89 %	9.85 %	0.36
1991-2015	1.66 %	0.17 %	17.61 %	17.44 %	0.40
1913-2015	9.66 %	-0.11 %	9.86 %	9.97 %	0.31
Standard deviations of annual values of variables (%)					
1913-1940	45.92 %	2.41 %	30.64 %	29.08 %	
1941-1965	21.14 %	1.26 %	24.88 %	24.65 %	
1966-1990	4.36 %	0.31 %	27.04 %	26.97 %	
1991-2015	1.17 %	0.27 %	43.94 %	43.95 %	
1913-2015	26.37 %	1.41 %	32.30 %	31.83 %	

The first panel of the table presents the arithmetic averages for inflation (Inf_t), the real risk-free rate (R^f_t) as proxied by money market rates net of inflation, the real stock return (R_t), the excess return of stocks over the risk-free rate ($ER_t = R_t - R_t^f$) and the Sharpe ratio ($Sharpe_t = \frac{ER_t}{\sigma_R}$) in Finland. The second panel presents the corresponding standard deviations.

The real stock returns have been very high in Finland, averaging 9.86% from 1913 to 2015. It seems that equity has been a good hedge for the high inflation. Stock returns were higher during 1913-1940 than 1941-1965, a period consisting of much of the Second World War and the early years of the Cold War, a dangerous time for Finland as a neighbor of the Soviet Union and especially the future of its stock market. Returns were close to the sample average during 1966-1990, and finally reached a high of 17.61% during 1991-2015, and if we looked at even shorter subperiods, we would find that much of these returns occurred during the 1990's: the average over 1990-2000 is 38.42% (not shown)! The volatility of stock returns has also fluctuated through time, somewhat analogously to the average return: it decreased from the first subperiod to the second one, and increased then during the third and especially the last subperiod. As a robustness check, we compared our results to Nyberg and Vaihekoski (2014b) and found their numbers very similar, though their sample ends in 2009.

The average annual excess return over 1913-2015 is 9.97%. This is considerably more than what Fama and French (2002) report for U.S. stocks: 5.57% for the period 1872-2000, though the invariably differing sample periods used in different studies make comparisons difficult. Excess returns have followed very closely the same pattern as real stock returns due to the low level and variability of the real risk-free rate. It is also reflected in the behavior of the realized Sharpe ratio. The Sharpe ratio was much lower during the first two subperiods, averaging only 0.21 during the second period but reaching an average of 0.4 during the period 1991-2015. It seems that the volatility of stock returns has increased less than stock returns. The average Sharpe ratio over the full sample is 0.31, the same what Fama and French (2002) report for U.S. stocks for the period 1872-2000. After the Second World War, the U.S. Sharpe ratio seems to have been a bit higher than in Finland. Cochrane (2005: 456) reports a Sharpe ratio of around 0.50 in postwar U.S. data, while from table 2, it seems to have been somewhere between 0.30 and 0.40 in Finland.

The realized equity premium and the volatility of the consumption growth have a small and negative correlation coefficient of -0.07 (not reported in a table), while based on equation (7), we would expect for the correlation to be positive. It then seems that the conditional heteroskedasticity found in consumption growth does not help in explaining time variation in the realized equity premium.

4.2 The equity premium and the risk-free rate puzzles

We can then test how well the information presented above fit the consumption-based asset pricing model. We proxy the unconditional moments by their sample counterparts, so for example, the unconditional expected return *E(R)* is proxied by the sample average of the realized stock return R_t in table 2. Using the whole sample from 1913 to 2015, equation (5) can be rearranged to yield

$$\gamma \approx \frac{E(R)-R^f}{\sigma_R}\frac{1}{\sigma_{\Delta lnc}} \approx \frac{0.31}{0.0589} \approx 5.2$$

on the boundary, meaning that $\gamma \approx 5.2$ is a lower bound for the risk aversion parameter. The theoretical solution contains the standard deviation of logarithmic consumption while our table reports consumption in ordinary numbers, but we can report that it makes practically no difference which is used. For the U.S. data, we noted above that a value for the risk aversion parameter of around 50 is needed to fit the data for the postwar period (though possibly less for a longer sample with a lower Sharpe ratio). With the risk aversion parameter usually estimated from microeconomic data to be less than 10 and typically believed to be around 2 (Mehra 2003), it seems that in Finland, the equity premium puzzle is not much of a puzzle at all!

However, this is not quite the whole story. If we look at a more recent period, for example, the last two subperiods in table 2, we see that the average Sharpe ratio is around 0.38 for 1966-2015. For the period 1961-2015, the standard deviation of consumption growth is 2.88%. Of course, the period is not completely same, but assuming that the volatility of consumption growth is around the same for 1966-2015, we obtain a lower bound of $\gamma \approx 0.38/0.0288 \approx 13.2$ for the risk aversion parameter. A period with less consumption growth uncertainty and higher risk-adjusted returns (in the form of Sharpe ratio) leads to a higher estimate for the risk aversion parameter. Does lower consumption risk lead to a higher equity premium, and therefore, higher Sharpe ratios? On the basis of the consumption-based asset pricing model, we would believe the reverse: lower consumption volatility leads to a lower equity premium required. However, during the period when the decreasing expected equity premium feeds into increasing valuation levels, we will actually see higher realized excess returns. This could be affecting also the Finnish data during the latter half of the sample. In any case, compared to the U.S. experience, an estimated risk aversion parameter of 13.2 is still very low, though higher than the usual microeconomic estimates.

As mentioned above, our estimate is a lower bound for the risk aversion parameter, which holds when the correlation between the discount factor and stock returns equals 1. Cochrane (2005: 457) notes that the correlation between consumption and stock returns is around 0.2 in the U.S. data. We find that in the Finnish data, the correlation between consumption and stock returns is 0.28 (not shown in tables), somewhat higher than what Cochrane reports for the U.S. data. Then, relaxing the unrealistic assumption that the discount factor and returns on the market portfolio are perfectly correlated, a risk aversion of $\gamma \approx \frac{1}{0.28} * 5.2 \approx 18.6$ is implied. Again, this is higher than what other data allows for, but nothing compared to the results with U.S. data.

Equation (6) can be rearranged to yield an estimate for the time discount rate δ. Using the above estimate $\gamma \approx 5.2$ for the risk aversion parameter and moving again to unconditional expectations,

$$\delta = \ln R^f - \gamma E(\Delta lnc_{t+1}) + \frac{\gamma^2}{2} var(\Delta lnc_{t+1}) \approx -0.0011 - 5.2 * 0.0245 + \frac{5.2^2}{2} * 0.0589^2 \approx -0.082,$$

where we again used ordinary growth rates from table 1. With logarithmic consumption growth, we obtain the slightly higher estimate $\delta \approx -0.071$. The estimate $\delta \approx -0.082$ corresponds to a time discount factor of $\beta \approx e^{0.082} \approx 1.085$. We would expect the time discount rate to be positive and the time discount factor to be under 1. A negative time discount rate means that the representative consumer prefers later consumption to earlier consumption! This is not an impossibility, but seems very unlikely. The real risk-free rate is so low that a low risk aversion parameter is not enough to elevate the time discount rate over zero.

If we used the estimate that we obtained from the latter half of the sample, $\gamma \approx 13.2$, then we would obtain the estimate $\delta \approx -0.023$, which, while still negative, is not so bad. Arbitrarily choosing $\gamma \approx 14.6$, we obtain a sensible estimate $\delta \approx 0.01$, corresponding to $\beta \approx 0.99$. However, if we estimate the risk aversion parameter from the latter half of the sample, it seems that we should then take also the other values from that period. Because consumption volatility is significantly lower during the latter half, we then obtain even more negative time discount rates. In any case, arbitrarily fitting a higher risk aversion parameter into the equation is useless in the sense that then it does not fit the stock market data, and all the problems that a high risk aversion parameter leads to, as discussed above in the context of the U.S.

literature, resurface. As a reasonable answer, taking the consumption data as it is, we would like to see a positive but small real risk-free rate and a risk aversion parameter under 1. Because the estimate of the risk aversion parameter is increasing in expected excess returns, a lower estimate of the equity premium would also help.

This discussion illustrates that the equity premium puzzle should always be examined in conjunction with the risk-free rate puzzle. Just looking at the realized equity premium and the volatility of consumption growth, we do not find that an unreasonable risk aversion is needed for the data to fit. However, due to the very low level of the real risk-free rate, the joint equity premium and risk-free rate puzzle is clearly present in the Finnish data.

4.3 The unconditional annual expected equity premium

Though we did not obtain an enormously large estimate for the risk aversion parameter, we noted above that a lower estimate of the historical expected equity premium would help to bring it down further and therefore obtain a more reasonable estimate for the time discount rate. Could it be the case also in the Finnish stock markets that the historical realized excess returns have exceeded expectations, as argued, for example, by Fama and French (2002) for the U.S. data? Below, we estimate the unconditional expected equity premium using the dividend growth model. Because of data availability, we are restricted to the period 1913-1988.

Figure 4 presents the annual real dividend growth in Finland from 1913 to 1988. The series seems reasonably stationary, with a few spikes during the wars. The 1950s was a period of strong dividend growth, while during the 1960s, real dividends seem to have decreased. Compared to the earlier decades, the 1970s and 1980s seem to have had a more stable real dividend policy.

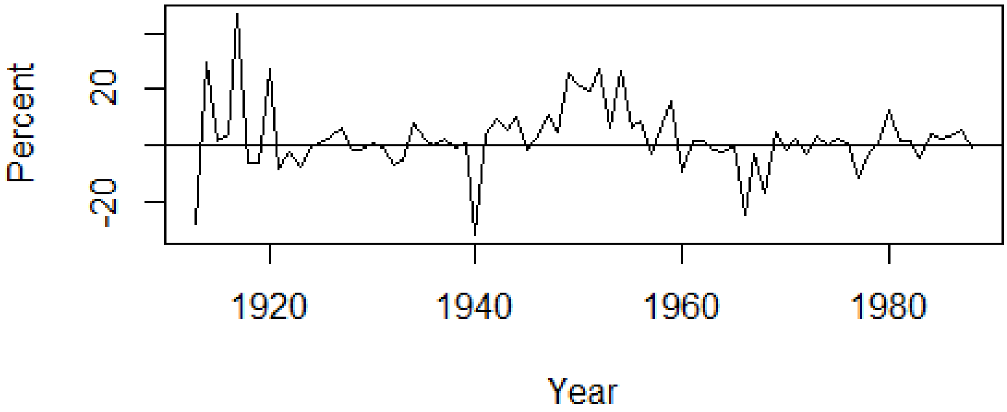

Figure 4. Annual real dividend growth in Finland from 1913 to 1988

The dividend-price ratio in Finland for years 1913-1988 is shown in figure 5. The horizontal line corresponds to the mean ratio. The dividend-price ratio has fluctuated widely: the ratio was high before the Second World War, very low during the war and had an increasing trend until the late 1970s, when it started again to decrease. At the end of the period, the dividend-price ratio is less than half of its mean value.

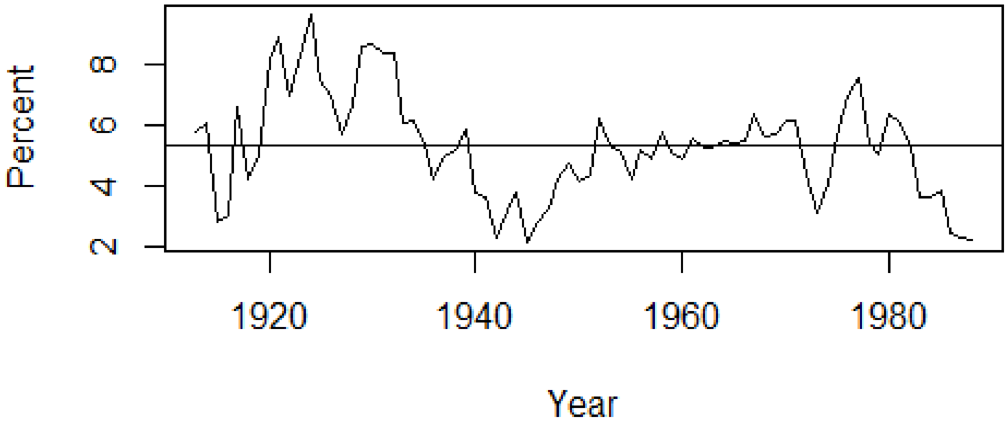

Figure 5. The dividend-price ratio in Finland from 1913 to 1988

Table 3 documents additional statistics on the Finnish stock markets. It shows the averages and standard deviations of the growth rate of dividends, the dividend-price ratio, the dividend growth model estimate of the unconditional expected real stock return and the corresponding estimate of the real expected equity premium, using equation (13). The risk-free rate and the realized excess returns are reproduced from table 2, with the period starting in 1966 now ending in 1988. The results are surprising: the dividend growth estimate of the real expected equity premium is actually higher than the realized excess return for two periods, 1913-1940 and especially 1941-1965. Because the dividend yield is a common element in both, this can only happen if the capital gain is less than the growth rate of dividends. This would mean that at the same time as dividends have been growing strongly, expected returns have increased sufficiently so as to bring prices and realized returns down. This can happen, for example, if investors regard the risk of the market closing down completely to be so high that they require a high compensation for holding stocks, regardless of high dividend growth.

Table 3. The estimated expected annual equity premium and related statistics

Means of annual values of variables (%)

Period	GD_t	D_t/P_t	RD_t	R^f_t	E(ER)	ER_t
1913-1940	1.10 %	5.32 %	7.47 %	-0.22 %	7.68 %	7.58 %
1941-1965	8.05 %	4.50 %	12.55 %	-0.40 %	12.95 %	5.29 %
1966-1988	-0.80 %	4.95 %	4.15 %	0.00 %	4.15 %	13.11 %
1913-1988	2.81 %	5.32 %	8.14 %	-0.21 %	8.35 %	8.50 %

Standard deviations of annual values of variables (%)

Period	GD_t	D_t/P_t	RD_t	R^f_t	E(ER)	ER_t
1913-1940	14.76 %	1.84 %	15.09 %	2.41 %	15.97 %	29.08 %
1941-1965	9.81 %	1.10 %	10.00 %	1.26 %	9.76 %	24.65 %
1966-1990	7.76 %	1.52 %	7.57 %	0.29 %	7.62 %	25.50 %
1913-1988	11.88 %	1.72 %	11.93 %	1.63 %	12.33 %	26.46 %

The first panel of the table presents the arithmetic averages for real dividend growth (GD_t), the dividend-price ratio (D_t/P_t) the dividend growth estimate of the expected real stock return $\left(RD_t = \frac{D_t}{P_t} + GD_t\right)$, the real risk-free rate (R^f_t) as proxied by money market rates net of inflation, the dividend growth estimate of the real expected equity premium ($E(ER) = A(RD_t) - A(R^f_t)$) and the excess return of stocks over the risk-free rate ($ER_t = R_t - R^f_t$). The second table presents the corresponding standard deviations.

Another possibility is data problems: we use the ratio of dividends paid during the year to the end of the year stock price as both the dividend-price ratio and dividend yield, while equation (8) would require the ratio of dividends paid during the year to the beginning of the year price (which is usually called the dividend yield). However, without data on cash dividends and price indices, we have to proxy the dividend yield with the dividend-price ratio. Looking at the full available sample 1913-1988, the expected equity premium estimate from the dividend growth model, 8.35 percent, is only a little less than the realized excess return, 8.50 percent. If we suppose that the results are approximately correct, not too much biased by data problems, then it is clear that at least for the first 75 years of the sample 1913-2015, it is not the case that the dividend growth model estimate of the unconditional expected equity premium is much less than the realized excess return. Still, looking at the decreasing dividend-price ratio in figure 5, it is difficult to believe that decreasing expected returns have not been feeding into the realized excess returns.

Also, as table 2 shows, the decades after that have seen average excess returns over double that from 1913 to 1988. Because of data availability, we need to omit the most interesting period. Also, we have used only dividend growth as the fundamental indicator of expected capital gain and other variables, such as earnings growth, could be used for comparison, were the data available.

4.4 Predictability of dividend growth and the equity premium

Finally, we briefly examine whether there is evidence of dividend growth or excess return predictability in the Finnish data. Again, data availability restricts the analysis to the period 1913-1988. Table 4 presents results from a regression of dividend growth on past dividend growth, the dividend-price ratio and stock returns. These variables are also used by Fama and French (2002) in forecasting dividend growth. In the first panel, variables known at time *t-1* are used to predict dividend growth at time *t*, and in the second panel, variables known at time *t-2* are used to predict dividend growth at time *t*.

Table 4. Regressions to forecast annual real dividend growth in Finland, 1913-1988

	Forecasting one period forward				
	Intercept	GD_{t-1}	D_{t-1}/P_{t-1}	R_{t-1}	Adj. R^2
Coefficient	0.123	0.044	-1.884	0.109	0.138
t-statistic	3.171	0.519	-3.215	2.313	
	Forecasting two periods forward				
	Intercept	GD_{t-2}	D_{t-2}/P_{t-2}	R_{t-2}	Adj. R^2
Coefficient	0.144	0.160	-2.137	-0.058	0.112
t-statistic	3.198	1.105	-2.957	-1.287	

The first panel of the table presents the coefficients and the corresponding *t*-statistics from the OLS regression of annual real dividend growth on intercept, past period real dividend growth, dividend-price ratio and returns on stocks: $GD_t = a_0 + a_1 GD_{t-1} + a_2 \frac{D_{t-1}}{P_{t-1}} + a_3 R_{t-1} + \varepsilon_t$. The second panel presents the coefficients and the corresponding *t*-statistics from the OLS regression of annual real dividend growth on intercept, real dividend growth, dividend-price ratio and returns on stocks two periods ago: $GD_t = b_0 + b_1 GD_{t-2} + b_2 \frac{D_{t-2}}{P_{t-2}} + b_3 R_{t-2} + \varepsilon_t$. Also adjusted R^2 from the regressions are shown. The *t*-statistics use the Newey-West (Newey & West 1987, 1994) standard errors.

Past dividend growth does not seem to help in predicting future dividend growth, but the dividend-price ratio seems to be a statistically significant predictor of future dividend growth both one and two periods forward: in the first regression, the coefficient on D_{t-1}/P_{t-1} is -1.884, in the second regression, the coefficient on D_{t-2}/P_{t-2} is -2.137. Note that the sign is right: a currently high dividend-price ratio predicts lower dividend growth in the future. This in contrary to the majority of evidence on the U.S. markets, where the dividend-price ratio has been found to be unable to predict dividend growth. Past stock returns also seem to have some minor forecasting ability one period forward, but not after that.

We can also report that results are similar for a regression of dividend growth simultaneously on all three variables observed both at time *t-1* and *t-2* in that the second lag of dividend-price ratio is the strongest predictor, but the first lag falls below the threshold of statistical significance (even at the 10% level). Also, then the coefficient on the second lag of dividend growth itself is significant, as are the coefficients on both lags of stock returns, all at the 5% level. Predictability does not seem to be very robust to different regression equations: regressing dividend growth on two or more lags of the dividend-price ratio (and nothing else) drives out all statistical significance. Regressing dividend growth on the risk-free rate proxy and inflation was also tested, but these were found to have no predicting power. These further regression settings are not reported in a table.

Table 5 presents results on regression of realized excess returns on past dividend growth, dividend-price ratio and excess returns. These are predictor variables that are used by, for example, Welch and Goyal (2007). Again, the first panel contains results from the regression on variables observed at time *t-1*, and the second panel contains results from the regression on variables observed at time *t-2*.

Table 5. Regressions to forecast annual excess returns, 1913-1988

	Forecasting one period forward				
	Intercept	GD_{t-1}	D_{t-1}/P_{t-1}	ER_{t-1}	Adj. R^2
Coefficient	-0.087	-0.130	3.052	0.151	0.015
t-statistic	-0.787	-0.446	1.630	1.202	
	Forecasting two periods forward				
	Intercept	GD_{t-2}	D_{t-2}/P_{t-2}	ER_{t-2}	Adj. R^2
Coefficient	-0.235	0.264	5.945	-0.091	0.134
t-statistic	-1.288	1.016	2.113	-1.115	

The first panel of the table presents the coefficients and the corresponding *t*-statistics from the OLS regression of realized annual excess returns on intercept, past period real dividend growth, dividend-price ratio and excess returns on stocks: $GD_t = a_0 + a_1 GD_{t-1} + a_2 \frac{D_{t-1}}{P_{t-1}} + a_3 ER_{t-1} + \varepsilon_t$. The second panel presents the coefficients and the corresponding *t*-statistics from the OLS regression of realized annual excess returns on intercept, real dividend growth, dividend-price ratio and excess returns on stocks two periods ago: $GD_t = b_0 + b_1 GD_{t-2} + b_2 \frac{D_{t-2}}{P_{t-2}} + b_3 ER_{t-2} + \varepsilon_t$. Also adjusted R^2 from the regressions are shown. The *t*-statistics use the Newey-West (Newey & West 1987, 1994) standard errors.

Variables observed at time *t-1* seem to be unable to forecast excess returns at time *t*: not one of them is statistically significant even at the 10% level, and the R-squared of the regression is very low, just 1.5%. However, in the regression on variables observed at time *t-2,* the coefficient on the dividend-price ratio is large (5.945) and highly significant with a *t*-value of 3.33. The sign is right: for a high dividend-price ratio to return to mean, there must be high price growth and therefore returns in the future. As further evidence, regressing excess returns simultaneously on two lags of dividend growth, dividend-price ratio and excess returns yields a similar result, with the only statistically significant predictor being the second lag of the dividend-price ratio with the very large coefficient of 10.34. Also, the predictability of the realized equity premium with the dividend-price ratio seems much more robust to that of dividend growth: regressing excess returns on two or more lags of the dividend-price ratio (and nothing else) yields the result that the coefficient on the second lag is always statistically significant even at the 1% level, with no other lags having any predictive power. It is noteworthy that longer lags of the dividend-price ratio seem to have no predictive ability, but unlike Cochrane (2011), we try to explain only annual excess returns, not long horizon excess returns. Regressing excess returns on the risk-free rate proxy and inflation was also tested, but as with dividend growth, these were found to have no predicting power. Again, these further regression settings are not reported in a table.

In table 6 we present regression diagnostics to analyze whether the OLS assumptions are likely to hold in these cases. At the 5% level, only the regression of dividend growth on the first lags of dividend growth, the dividend-price ratio and excess returns ($GD_t(1)$) has serial correlation in the residual series. However, the first excess returns forecasting regression $ER_t(1)$ is a borderline case with a *p*-value of 0.059 for the Breusch-Godfrey test statistic.

Table 6. Serial correlation and heteroskedasticity in the forecasting regression residuals

	$GD_t(1)$	$GD_t(2)$	$ER_t(1)$	$ER_t(2)$
Breusch-Godfrey	0.002	0.542	0.059	0.359
Breusch-Pagan	0.669	0.221	0.285	0.358

The table presents the *p*-values for the Breusch-Godfrey (Breusch 1978, Godfrey 1978) test for serial correlation and the Breusch-Pagan (Breusch & Pagan 1979) test for heteroskedasticity in the regression residuals of the regressions presented in tables 4 and 5. $GD_t(1)$ refers to the first regression in table 4 and $GD_t(2)$ to the second, and analogously for ER_t and table 5. The null is that of no autocorrelation/heteroskedasticity.

Serial correlation in the residuals is serious in that it violates the OLS assumption A5 discussed in section 4.2.2. Encouragingly, not one of the regressions has heteroskedasticity in the residuals. In any case, the *t*-statistics in tables 4 and 5 use the Newey-West standard errors, which should mitigate the effects of residual serial correlation and heteroskedasticity. We can report that it has very little effect on the results concerning predictability whether the Newey-West standard errors are used.

Table 7 presents the augmented Dickey-Fuller unit root test statistics for the dividend growth, dividend-price ratio and excess return series. The second panel contains the critical values for the test statistic. For the dividend growth and excess return series we can reject the null of unit root. Our intuition based on figure 3 is then proven correct: the realized excess returns seem stationary. However, somewhat surprisingly, we cannot reject the presence of a unit root in the dividend-price ratio series. Again, this is serious in that it violates the OLS assumption A2 (ergodic stationarity). Also, note that our dividend growth estimate of the unconditional expected equity risk premium rests on the stationarity of the dividend-price ratio, but this is not issue for the purpose the model is used in this thesis, as discussed above in section 3.2.1.

Table 7. Stationarity of the series

	GD_t	D_t/P_t	ER_t
Dickey-Fuller test statistic	-4.39	-1.14	-5.90
	Critical values for test statistics:		
	1 % level	5 % level	10 % level
	-2.6	-1.95	-1.61

The first panel presents the test statistics for the augmented Dickey-Fuller unit root test (Dickey & Fuller 1979) for the three time series used in the regressions of tables 4 and 5: dividend growth (GD_t), dividend-price ratio (D_t/P_t) and excess returns (ER_t). The second panel presents the critical values for the test, which are obtained from Dickey and Fuller (1981). The null is that there is a unit root, and the alternative is that of stationarity.

Consider then the effects on OLS inference: suppose that the dividend-price ratio has a unit root. Then the OLS estimator of the coefficient of the dividend-price ratio is still consistent, but its asymptotic distribution is nonstandard so that usual inference does not apply (Hayashi 2000: 557-562). If it is not stationary, and does not contain a unit root, but is trend stationary, then the coefficient is consistent, and its asymptotic distribution is standard (Hayashi 2000: 160-164). However, we find that the augmented Dickey-Fuller test does not reject the null of unit root in the dividend-price ratio even when allowing for a linear time trend (results omitted), so while the estimator is consistent, inference concerning its statistical significance is left somewhat indecisive.

5 CONCLUSIONS

We find that relating the realized excess returns to consumption data does not require an extraordinarily high value for the risk aversion parameter. However, due to the low value of the realized real risk-free rates, the joint equity premium and the risk-free rate puzzle is present in the Finnish data. Moreover, it could well be that the relatively high volatility that we see in the Finnish consumption growth data is due to our definition of consumption, which includes durable elements. The same disclaimer applies to our finding that the consumption growth in Finland has exhibited conditional heteroskedasticity. However, it could also be argued that even if exaggerated by durables consumption, the findings are a plausible character of the Finnish data. It should be noted there are reasons to believe that consumption growth was relatively more stable in the United States 20th century: though the U.S. was harder hit by the Great Depression, Finland went through gaining independence and a civil war in the aftermath of the First World War, and unlike the U.S, did not end up on the winning side of the Second World War. If it is possible to clean the consumption data of durable elements, replicating this analysis with the more correct data would be an interesting exercise for future research, as would be fitting the more recent models to Finnish data.

We do not find the realized excess returns to be, on average, much higher than estimates of the unconditional expected equity premium obtained by a dividend growth model similar to that of Fama and French (2002) in Finland for the period 1913-1988. Again, a caveat to this finding is our data: we are forced to use the dividend-price ratio to proxy for the dividend yield. The sample period is also very limited in that it excludes the years after 1988, while especially the very high returns of the 1990s would be interesting to include. For future research, including also the later years with a complete dividend growth and dividend yield data would be interesting.

We find some evidence of predictability for both dividend growth and the equity premium using the dividend-price ratio, which differs from both the traditional textbook view of the ratio predicting cash flows but not returns, and from the modern view of return predictability but no cashflow predictability, as espoused by Cochrane

(2011) and others. The predictability of the equity premium is evidence in support of the view that it is time-varying. We find very little evidence of predictability with other variables, including past returns and dividend growth rates. However, our analysis on predictability is very brief, as we only run forecasting regressions for one-year growth rates and excess returns in Finnish equity market data for the period 1913-1988. It should also be noted that we consider purely in-sample predictability: regressing the dependent variable on the independent variables over the whole period uses information that was not available to the investors during the period. For a more comprehensive look at predictability, also out-of-sample tests should be performed, as done by Goyal and Welch (2003) and Welch and Goyal (2007).

In the U.S. data, the strongest return predictability evidence has been found for longer return horizons, such as five-year returns (Cochrane 2011). In that sense, for return predictability, it is very encouraging to see evidence of short horizon predictability. Unfortunately, we are unable to reject the presence of a unit root in the dividend-price ratio, which confounds statistical inference concerning the significance of the forecasting regression coefficient. Also, the period 1913-1988 yields 76 observations for annual returns, and it is not clear whether this constitutes a sample large enough so that the large sample OLS theory is applicable. Again, in future research, using a longer sample and analyzing predictability of longer horizon returns could be entertained.

Estimating the equity risk premium and solving the equity premium puzzle remains an important area of research, and recent years have seen some original work which it was not possible to discuss here. Avdis and Wachter (2017) propose a maximum likelihood estimator of the equity premium, which uses the information contained in prices and dividends. The term structure of equity has gained some interest recently: Croce, Lettau and Ludvigson (2014) find that in their model, a large equity premium arises only if the term structure of equity is upward sloping, which contradicts the U.S. data. Van Binsbergen and Koijen (2017) provide a literature review on the recent work on the term structure of equity. Mehra (2011) contends that borrowing constraints, a better choice for the risk-free rate and recognizing the difference between lending and borrowing rates solves the puzzle. Not all agree that equity markets really offer very high returns relative to their riskiness, as stocks have underperformed over some extended periods (Arnott 2011) and some find that from an investor's perspective, equity volatility can actually be higher over longer than shorter periods (Pástor & Stambaugh 2012). It seems that in addition to theoretical refinement, the equity premium puzzle has led to more rigorous empirical work and tools for practice. We hope to have shed some light on the historical stock market experience in Finland.

REFERENCES

Abel, A. B. (1990). *Asset prices under habit formation and catching up with the Joneses* (No. w3279). National Bureau of Economic Research.

Antell, J. & Vaihekoski, M. (2015). Expected Return and Conditional Asset Pricing: A New Testing Approach. Working paper. Hanken School of Economics and University of Turku.

Arnott, R. D. (2011). Equity risk premium myths. In: Hammond, P. B., Leibowitz, M. L. & Siegel, L. B. (ed.). *Rethinking the Equity Risk Premium.* The Research Foundation of the CFA Institute, 71-100.

Arnott, R. D. & Asness, C. S. (2003). Surprise! Higher dividends = higher earnings growth. *Financial Analysts Journal*, 59(1), 70-87.

Arnott, R. D. & Bernstein, P. L. (2002). What risk premium is "normal"? *Financial Analysts Journal*, 58(2), 64-85.

Asness, C. S. (2000). Stocks versus bonds: explaining the equity risk premium. *Financial Analysts Journal*, 56(2), 96-113.

Avdis, E., & Wachter, J. A. (2017). Maximum likelihood estimation of the equity premium. *Journal of Financial Economics*, 125(3), 589-609.

Barberis, N., Huang, M. & Santos, T. (2001). Prospect theory and asset prices. *The Quarterly Journal of Economics*, 116(1), 1-53.

Barro, R. J. (2006). Rare disasters and asset markets in the twentieth century. *The Quarterly Journal of Economics*, 121(3), 823-866.

Barro, R. J. & Ursúa, J. F. (2008). *Macroeconomic crises since 1870* (No. w13940). National Bureau of Economic Research.

Benartzi, S. & Thaler, R. H. (1995). Myopic loss aversion and the equity premium puzzle. *The Quarterly Journal of Economics*, 110(1), 73-92.

Berglund, T., Wahlroos, B., & Grandell, L. (1982). *KOP: s och UNITAS generalindex för Helsingfors fondbörs i ljuset av ett nytt värdevägt index*. [Svenska handelshögskolan.] Institutionen för allmän företagsekonomi, Institutionen för nationalekonomi.

Blanchard, O. J., Shiller, R., & Siegel, J. J. (1993). Movements in the equity premium. *Brookings Papers on Economic Activity*, 1993(2), 75-138.

Bogle, J. C. & Nolan, M. W. (2015). Occam's Razor Redux: Establishing reasonable expectations for financial market returns. *The Journal of Portfolio Management*, 42(1), 119-134.

Breusch, T. S. (1978). Testing for autocorrelation in dynamic linear models. *Australian Economic Papers*, 17(31), 334-355.

Breusch, T. S., & Pagan, A. R. (1979). A simple test for heteroscedasticity and random coefficient variation. *Econometrica: Journal of the Econometric Society*, 1287-1294.

Brooks, C. (2014). *Introductory Econometrics for Finance*. Cambridge: Cambridge University Press.

Brown, S. J., Goetzmann, W. N. & Ross, S. A. (1995). Survival. *The Journal of Finance*, 50(3), 853-873.

Campbell, J. Y. (2008). Estimating the equity premium. *Canadian Journal of Economics/Revue canadienne d'économique*, 41(1), 1-21.

Campbell, J. Y. & Cochrane, J. H. (1999). By force of habit: A consumption-based explanation of aggregate stock market behavior. *Journal of political Economy*, 107(2), 205-251.

Campbell, J. Y. & Shiller, R. J. (1988). The dividend-price ratio and expectations of future dividends and discount factors. *The Review of Financial Studies*, 1(3), 195-228.

Campbell, J. Y., & Thompson, S. B. (2007). Predicting excess stock returns out of sample: Can anything beat the historical average? *The Review of Financial Studies*, 21(4), 1509-1531.

Claus, J., & Thomas, J. (2001). Equity premia as low as three percent? Evidence from analysts' earnings forecasts for domestic and international stock markets. *The Journal of Finance*, 56(5), 1629-1666.

Cochrane, J. H. (1998). *Where is the market going? Uncertain facts and novel theories* (No. w6207). National Bureau of Economic Research.

Cochrane, J. H. (2005). *Asset Pricing: Revised Edition*. Princeton university press.

Cochrane, J. H. (2011). Presidential address: Discount rates. *The Journal of Finance*, 66(4), 1047-1108.

Constantinides, G. M. (1990). Habit formation: A resolution of the equity premium puzzle. *Journal of Political Economy,* 98(3), 519-543.

Constantinides, G. M., Donaldson, J. B. & Mehra, R. (2002). Junior can't borrow: A new perspective on the equity premium puzzle. *The Quarterly Journal of Economics*, 117(1), 269-296.

Constantinides, G. M. & Duffie, D. (1996). Asset pricing with heterogeneous consumers. *Journal of Political Economy*, 104(2), 219-240.

Cornell, B., Moroz, M., & Arnott, R. D. (2009). The Equity Premium Revisited. Working Paper. California Institute of Technology and the Research Affiliates, LLC.

Croce, M. M., Lettau, M., & Ludvigson, S. C. (2014). Investor information, long-run risk, and the term structure of equity. *The Review of Financial Studies*, 28(3), 706-742.

Damodaran, A. (2016). Equity risk premiums (ERP): Determinants, estimation and implications–The 2016 Edition. Working paper. New York University.

DeLong, J. B. & Magin, K. (2009). The US equity return premium: past, present, and future. *The Journal of Economic Perspectives*, 23(1), 193-208.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American statistical association*, 74(366a), 427-431.

Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica: Journal of the Econometric Society*, 1057-1072.

Dimson, E., Marsh, P. & Staunton, M. (2008). The worldwide equity premium: A smaller puzzle. In: Mehra, R. (ed.). *Handbook of the equity risk premium.* (1st edition). Oxford: Elsevier B.V., 467-514.

Dimson, E., Marsh, P. & Staunton, M. (2017). *Credit Suisse Global Investment Returns Yearbook 2017.* Zurich: Credit Suisse.

Donadelli, M. & Prosperi, L. (2011). The equity risk premium: Empirical evidence from emerging markets. Working Paper. Goethe University Frankfurt and University of Toulouse.

Duarte, F., & Rosa, C. (2015). The equity risk premium: a review of models. *Economic Policy Review*, 2, 39-57.

Epstein, L. G. & Zin, S. E. (1990). 'First-order'risk aversion and the equity premium puzzle. *Journal of Monetary Economics*, 26(3), 387-407.

Falkenstein, E. G. (2012). *The Missing Risk Premium: Why Low Volatility Investing Works*. Eric Falkenstein.

Fama, E. F., & French, K. R. (1988). Dividend yields and expected stock returns. *Journal of Financial Economics*, 22(1), 3-25.

Fama, E. F. & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics*, 33(1), 3-56.

Fama, E. F. & French, K. R. (2002). The equity premium. *The Journal of Finance*, 57(2), 637-659.

Fama, E. F. & French, K. R. (2017). International tests of a five-factor asset pricing model. *Journal of Financial Economics*, 123(3), 441-463.

Godfrey, L. G. (1978). Testing against general autoregressive and moving average error models when the regressors include lagged dependent variables. *Econometrica: Journal of the Econometric Society*, 1293-1301.

Gordon, M. J. (1962). *The investment, financing, and valuation of the corporation*. RD Irwin.

Goyal, A., & Welch, I. (2003). Predicting the equity premium with dividend ratios. *Management Science*, 49(5), 639-654.

Graham, J. R. & Harvey, C. R. The Equity Risk Premium in 2016. Working paper. Duke University and National Bureau of Economic Research.

Greenwood, R. & Shleifer, A. (2014). Expectations of returns and expected returns. *The Review of Financial Studies*, 27(3), 714-746.

Hansen, L. P. & Jagannathan, R. (1991). Implications of security market data for models of dynamic economies. *Journal of Political Economy*, 99(2), 225-262.

Hayashi, F. (2000). Econometrics. Princeton: Princeton University Press.

Henry, P. B. (2000). Stock market liberalization, economic reform, and emerging market equity prices. *The Journal of Finance*, 55(2), 529-564.

Hjerppe, R. (1989). *The Finnish economy 1860-1985: Growth and structural change.* Bank of Finland, Helsinki.

Ibbotson, R. G. & Chen, P. (2003). Long-run stock returns: Participating in the real economy. *Financial Analysts Journal,* 59(1), 88-98.

Ilmanen, A. (2003). Expected returns on stocks and bonds. *The Journal of Portfolio Management*, 29(2), 7-27.

Ilmanen, A. (2011). Time Variation in the Equity Risk Premium. In: Hammond, P. B., Leibowitz, M. L. & Siegel, L. B. (ed.). *Rethinking the Equity Risk Premium.* The Research Foundation of the CFA Institute, 101-116.

Jacquier, E., Kane, A. & Marcus, A. J. (2003). Geometric or arithmetic mean: A reconsideration. *Financial Analysts Journal*, 59(6), 46-53.

Jagannathan, R., McGrattan, E. R., & Scherbina, A. (2000). The Declining US Equity Premium. *Federal Reserve Bank of Minneapolis Quarterly Review*, *24*(4), 3-19.

Jorion, P. & Goetzmann, W. N. (1999). Global stock markets in the twentieth century. *The Journal of Finance*, 54(3), 953-980.

Kahneman, D. & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica: Journal of the Econometric Society*, 263-291.

Kocherlakota, N. R. (1996). The equity premium: It's still a puzzle. *Journal of Economic Literature*, 34(1), 42-71.

Lettau, M., & Ludvigson, S. (2001). Consumption, aggregate wealth, and expected stock returns. *The Journal of Finance*, 56(3), 815-849.

Lettau, M. & Ludvigson, S. C. (2005). Expected returns and expected dividend growth. *Journal of Financial Economics*, 76(3), 583-626.

Lettau, M., Ludvigson, S. C. & Wachter, J. A. (2007). The declining equity premium: What role does macroeconomic risk play? *The Review of Financial Studies*, 21(4), 1653-1687.

Li, H. & Xu, Y. (2002). Survival bias and the equity premium puzzle. *The Journal of Finance*, 57(5), 1981-1995.

Ljung, G. M., & Box, G. E. (1978). On a measure of lack of fit in time series models. *Biometrika*, 65(2), 297-303.

Lucas Jr, R. E. (1978). Asset prices in an exchange economy. *Econometrica: Journal of the Econometric Society*, 1429-1445.

Ludvigson, S. C. (2011). *Advances in consumption-based asset pricing: Empirical tests* (No. w16810). National Bureau of Economic Research.

Mankiw, N. G. & Zeldes, S. P. (1991). The consumption of stockholders and nonstockholders. *Journal of Financial Economics*, 29(1), 97-112.

McGrattan, E. R. & Prescott, E. C. (2001). *Taxes, regulations, and asset prices* (No. w8623). National Bureau of Economic Research.

McGrattan, E. R. & Prescott, E. C. (2003). Average debt and equity returns: Puzzling? *The American Economic Review*, 93(2), 392-397.

McLeod, A. I., & Li, W. K. (1983). Diagnostic checking ARMA time series models using squared-residual autocorrelations. *Journal of Time Series Analysis*, 4(4), 269-273.

Mehra, R. (2003). The equity premium: why is it a puzzle? (corrected). *Financial Analysts Journal*, 59(1), 54-69.

Mehra, R. & Prescott, E. C. (1985). The equity premium: A puzzle. *Journal of Monetary Economics*, 15(2), 145-161.

Mehra, R. & Prescott, E. C. (1988). The equity risk premium: A solution? *Journal of Monetary Economics*, 22(1), 133-136.

Mehra, R. Prescott, E. C. (2008). The Equity Premium: ABCs. In: Mehra, R. (ed.). *Handbook of the Equity Risk Premium.* (1st edition). Oxford: Elsevier B.V., 1-36.

Mehra, R. (2011). The equity premium puzzle revisited. In: Hammond, P. B., Leibowitz, M. L. & Siegel, L. B. (ed.). *Rethinking the Equity Risk Premium.* The Research Foundation of the CFA Institute, 148-153.

Newey, W. K., & West, K. D. (1987). Hypothesis testing with efficient method of moments estimation. *International Economic Review*, 28, 777-787.

Newey, W. K., & West, K. D. (1994). Automatic lag selection in covariance matrix estimation. *The Review of Economic Studies*, 61(4), 631-653.

Nyberg, P., & Vaihekoski, M. (2010). A new value-weighted total return index for the Finnish stock market. *Research in International Business and Finance*, 24(3), 267-283.

Nyberg, P., & Vaihekoski, M. (2011). *Descriptive analysis of Finnish equity, bond and money market returns* (No. 14/2011). Bank of Finland, Helsinki.

Nyberg, P., & Vaihekoski, M. (2014a). *Descriptive analysis of the Finnish stock market: Part II* (No. 10/2014). Bank of Finland, Helsinki.

Nyberg, P. & Vaihekoski, M. (2014b). Equity premium in Finland and long-term performance of the Finnish equity and money markets. *Cliometrica*, 8(2), 241.

Pástor, Ľ., & Stambaugh, R. F. (2012). Are stocks really less volatile in the long run? *The Journal of Finance*, 67(2), 431-478.

Rietz, T. A. (1988). The equity risk premium a solution. *Journal of Monetary Economics*, 22(1), 117-131.

Ritter, J. R. (2005). Economic growth and equity returns. *Pacific-Basin Finance Journal*, 13(5), 489-503.

Rubinstein, M. (1976). The valuation of uncertain income streams and the pricing of options. *The Bell Journal of Economics*, 407-425.

Salomons, R. (2008). A theoretical and practical perspective on the equity risk premium. *Journal of Economic Surveys*, 22(2), 299-329.

Salomons, R. & Grootveld, H. (2003). The equity risk premium: emerging vs. developed markets. *Emerging Markets Review,* 4(2), 121-144.

Shackman, J. D. (2006). The equity premium and market integration: Evidence from international data. *Journal of International Financial Markets, Institutions and Money*, 16(2), 155-179.

Siegel, J. J. (2014). *Stocks for the Long Run* (5th edition). New York: McGraw-Hill.

Stulz, R. M. (1999). Globalization, corporate finance, and the cost of capital. *Journal of Applied Corporate Finance*, 12(3), 8-25.

Thaler, R. H. & Johnson, E. J. (1990). Gambling with the house money and trying to break even: The effects of prior outcomes on risky choice. *Management science*, 36(6), 643-660.

Van Binsbergen, J. H., & Koijen, R. S. (2017). The term structure of returns: Facts and theory. *Journal of Financial Economics*, 124(1), 1-21.

Van Ewijk, C., De Groot, H. L. & Santing, A. J. (2012). A meta-analysis of the equity premium. *Journal of Empirical Finance*, 19(5), 819-830.

Vivian, A. (2007). The UK equity premium: 1901–2004. *Journal of Business Finance & Accounting*, 34(9-10), 1496-1527.

Weil, P. (1989). The equity premium puzzle and the risk-free rate puzzle. *Journal of Monetary Economics*, 24(3), 401-421.

Welch, I. (2000). Views of financial economists on the equity premium and on professional controversies. *The Journal of Business*, 73(4), 501-537.

Welch, I. & Goyal, A. (2007). A comprehensive look at the empirical performance of equity premium prediction. *The Review of Financial Studies*, 21(4), 1455-1508.

MATHEMATICAL APPENDIX

The Hansen-Jagannathan bounds

Start from $1 = E(mR)$ and use the definition of covariance $E(mR) = E(m)E(R) + cov(m, R)$ and then that $cov(m, R) = \rho_{m,R}\sigma_m\sigma_R$ to obtain

$$1 = E(m)E(R) + \rho_{m,R}\sigma_m\sigma_R \Leftrightarrow E(R) - R^f = -\rho_{m,R}\sigma_R\frac{\sigma_m}{E(m)}$$

$\Leftrightarrow \frac{E(R)-R^f}{\sigma_R} = -\rho_{m,R}\frac{\sigma_m}{E(m)}$, where we also used that $R^f = 1/E(m)$.

Now $\sigma_m/E(m) > 0$, and so $\left|\frac{E(R)-R^f}{\sigma_R}\right| = |\rho_{m,R}|\frac{\sigma_m}{E(m)}$,

where $|\rho_{m,R}| \leq 1$, and therefore $\left|\frac{E(R)-R^f}{\sigma_R}\right| \leq \frac{\sigma_m}{E(m)}$.

Using the power utility $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$, $m_{t+1} = \beta\frac{u\prime(c_{t+1})}{u\prime(c_t)} = \beta\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}$, which shows that the assumed utility function results in a strong relation between the discount factor and consumption growth. Now $\sigma_m^2 = var\left[\beta\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\right] = \beta^2 var\left[\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\right]$ and $E(m_{t+1}) = E\left[\beta\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\right] = \beta E\left[\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\right]$ because β is a constant. Then

$\frac{\sigma_m}{E(m)} = \frac{\sqrt{\left[var[\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\right]}}{E\left[\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\right]}$. Then using the definition of variance,

$var\left[\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\right] = E\left[\left(\frac{c_{t+1}}{c_t}\right)^{-2\gamma}\right] - \left[E\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\right]^2$. Using then the assumption that consumption growth is log-normally distributed, we note that $\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}$ is log-normally distributed (raising to a power preserves log-normality) and correspondingly $ln\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma} = -\gamma(\Delta lnc_{t+1})$ is normally distributed, with then

$exp[-\gamma(\Delta lnc_{t+1})]$ being log-normal. Using then rules for calculating moments of a log-normally distributed variable, we obtain

$$E\left[\left(\frac{C_{t+1}}{C_t}\right)^{-2\gamma}\right] - \left[E\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}\right]^2 = exp[-2\gamma E(\Delta lnc_{t+1}) + 2\gamma^2 var(\Delta lnc_{t+1})] -$$

$$exp[-2\gamma E(\Delta lnc_{t+1}) + \gamma^2 var(\Delta lnc_{t+1})].$$

Then $\frac{\sigma_m}{E(m)} = \sqrt{exp[\gamma^2 var(\Delta lnc_{t+1})] - 1}$. The exponential function can be defined as the following power series:

$$exp[\gamma^2 var(\Delta lnc_{t+1})] = \sum_{n=0}^{\infty} \frac{[\gamma^2 var(\Delta lnc_{t+1})]^n}{n!} = 1 + \gamma^2 var(\Delta lnc_{t+1}) + \frac{[\gamma^2 var(\Delta lnc_{t+1})]^2}{2} + \cdots$$ and thus

$\frac{\sigma_m}{E(m)} = \sqrt{\gamma^2 var(\Delta lnc_{t+1}) + \frac{[\gamma^2 var(\Delta lnc_{t+1})]^2}{2} + \cdots}$, where the higher-order terms become insignificantly small when $\gamma^2 var(\Delta lnc_{t+1})$ is a small number, and $\gamma^2 var(\Delta lnc_{t+1}) \geq 0$, so we obtain the approximation $\frac{\sigma_m}{E(m)} \approx \gamma\sigma_{\Delta lnc}$.

The risk-free rate puzzle

With a power utility function, the gross risk-free rate is $R_t^f = \beta\left(\frac{c_{t+1}}{c_t}\right)^{\gamma}$. Assuming log-normally distributed consumption growth, $-\gamma(\Delta lnc_{t+1})$ is normally distributed. Then $R_t^f = \frac{1}{\beta}[E_t(exp(-\gamma\Delta lnc_{t+1}))]^{-1}$. Denote $\beta = e^{-\delta}$ and use the rule for calculating the first moment of a log-normally distributed variable:

$R_t^f = e^{\delta}\left[exp\left(-\gamma E(\Delta lnc_{t+1}) + \frac{\gamma^2}{2} var(\Delta lnc_{t+1})\right)\right]^{-1}$, where we also used that $var[-\gamma(\Delta lnc_{t+1})] = \gamma^2 var(\Delta lnc_{t+1})$, because γ is a constant.

Then $lnR_t^f = r_t^f = \delta + \gamma E(\Delta lnc_{t+1}) - \frac{\gamma^2}{2} var(\Delta lnc_{t+1})$.