Demographics and Asset Prices

Carlo A. Favero, A. Gozluklu, A. Tamoni

February 10, 2010

Contents

1 Context and Rationale for the Proposed Research 1

2 Research Agenda 6

2.1 The role of demographic variables in the dynamic dividend growth model. ............................................. 6
2.2 Demographics and the term structure of stock market risk . . . . 6
2.3 The International Evidence ................................................................. 8
2.4 Demographics and the long-run behaviour of bond and stocks . . 8

3 Resources 9

1 Context and Rationale for the Proposed Research

The objective of our research proposal is to assess the role of demographic trends as a pricing factor for the stock market.

Most of the available evidence on stock market returns predictability can be framed within the dynamic dividend growth model proposed by Campbell and Shiller (1988). This model uses a loglinear approximation to the definition of returns on the stock market.

Under the assumption of stationarity of the log of price-dividend ratio, total stock market returns, \( r_{s_{t+1}} \), can be approximated by the relation derived by linearizing \( \ln \left( 1 + e^{p_{t+1} - d_{t+1}} \right) \) around its steady state value \( P/D \):

\[
r_{s_{t+1}} = \Delta d_{t+1} + k - \rho \left[ d_{t+1} - \overline{d} \right] + \left[ d_{t} - \overline{d} \right]
\]

where \( \rho = \frac{P/D}{1 + P/D} \), \( \overline{d} = \ln (D/P) \). By iterating (??) forward for \( m \) periods, and taking expectations, we have:

\[
E_t \sum_{j=1}^{m} \rho^{j-1} (r_{s_{t+j}}) = d_{t} - \overline{d}p + E_t \sum_{j=1}^{m} \rho^{j-1} (\Delta d_{t+j}) + \rho^m E_t \left[ d_{t+m+1} - \overline{d} \right] \quad (1)
\]
(1) states that, for \( m \) sufficiently large such that \( \rho^m E_t (pd_{t+m+1}) \approx 0 \), long-run stock market expected returns
\[
E_t \left[ \sum_{j=1}^{m} \rho^{j-1} \left( r_{t+j}^e \right) \right]
\]
depend on the deviation current dividend-price from a multiple of its steady state value and on future expected dividend growth
\[
E_t \left[ \sum_{j=1}^{m} \rho^{j-1} (\Delta d_{t+j}) \right].
\]

The dynamic dividend growth model delivers a number of predictions.

(i) The model is based on the assumption of stationarity of the (log) dividend-price ratio. Consistently with such an assumption, under the maintained hypothesis that stock market returns, and dividend-growth are covariance-stationary, Eq. (1) says that the log of the price-dividend ratio is stationary (the log of price and the log of dividend are cointegrated with a (-1,1) cointegrating vector), and that deviations of (log) prices from the common trend in (log) dividends summarize expectations of either stock market returns, or dividend growth or some combination of the two.

(ii) The forecasting performance of the dividend yield for stock market returns depends crucially on the forecasting performance for dividend growth. Note that when the dividend yield predicts expected dividend growth perfectly, then the proposition that returns are not predictable holds in the data.

(iii) The model implies the predictability of long-run returns. The model clearly states that the dividend/price ratio should have predictive power for \( m \)-period ahead stock market returns, for sufficiently large \( m \) so that the transversality condition can be applied and the last term in equation (1) becomes of negligible importance. The model predicts that the predictability of stock market returns should increase with the horizon at which they are defined.

The empirical investigation of the dynamic dividend growth model has established a few empirical results:

(i) \( dp_t \) is a very persistent time-series and forecasts stock market returns and excess returns over horizons of many years (Fama and French (1988), Campbell and Shiller (1988), Cochrane (2001, Ch. 20), and Cochrane(2007)).

(ii) \( dp_t \) does not have important long-horizon forecasting power for future discounted dividend-growth (Campbell (1991), Campbell, Lo and McKinlay(1997) and Cochrane(2001)).

(iii) the very high persistence of \( dp_t \) has led some researchers to question the evidence of its forecasting power for returns, especially at short-horizon. Careful statistical analysis that takes full account of the persistence in \( dp_t \) provides little evidence in favour of predictability of stock-market returns and excess returns based on the log-dividend-price ratio (Nelson and Kim, 1993; Stambaugh, 1999; Ang and Bekaert, 2007; Valkanov, 2003; Goyal and Welch, 2003 and Goyal and Welch 2008). Structural breaks have also been found in the relation between \( dp_t \) and future returns (Neely and Weller(2000) and Paye and Timmermann(2006), Rapach and Wohar(2006)).

(iv) A recent strand of the empirical literature has related the contradictory evidence on the dynamic dividend growth model to the potential weakness of
its fundamental hypothesis that log dividend-price ratio is a stationary process (Lettau & Van Nieuwerburgh, 2008, LVN henceforth). LVN use a century of US data to show evidence on the breaks in the constant mean $\overline{dp}$.

References


2 Research Agenda

Our research programme has several research lines:

2.1 The role of demographic variables in the dynamic dividend growth model.

Can the structural breaks found by LVN in the dividend-price process be related to demographic trends? A theoretical model by Geanakoplos, Magill and Quinzii (2004, henceforth, GMQ) predicts that a specific demographic variable, MY, the ratio of middle-aged to young population, explains fluctuations in the dividend yield.

GMQ consider an overlapping generation model in which the demographic structure mimics the pattern of live births in the US, that have featured alternating twenty-year periods of boom and busts. They conjecture that the life-cycle portfolio behaviour (Bakshi&Chen, 1994), which suggests that agents should borrow when young, invest for retirement when middle-aged, and live off from their investment once they are retired, plays an important role in determining equilibrium asset prices. Consumption smoothing by the agents, given the assumed demographic structure, requires that when the MY ratio is small (large), there will be excess demand for consumption (saving) by a large cohort of retirees (middle-aged) and for the market to clear, equilibrium prices of financial assets should adjust, i.e. decrease (increase), so that saving (consumption) is encouraged for the middle-aged. As the dividend/price ratio is negatively related to fluctuations in prices, the model predicts a negative relation between this variable and MY. When the GMQ model is taken to the data via the conjecture that fluctuations in MY could capture a slowly evolving mean in $d_p_t$ within the dynamic dividend growth model, strong evidence is found in favour of using this variable together with the dividend/price ratio in long-run forecasting regressions for stock market returns.

2.2 Demographics and the term structure of stock market risk

Demographic trends are important to determine the long-run behaviour of the stock market, while it is difficult to imagine a relationship between high-frequency fluctuations in stock market prices and a slow-moving trend determined by demographic factors.

The prediction of the theoretical model by GMQ is that, the ratio of middle-aged to young population, MY, captures the slow moving but time-varying mean of the US dividend price ratio. A forecasting model for stock market returns over a century of US annual data that uses as predictors the dividend price ratio and MY strongly dominates all alternative models and the over-performance increases with the investment horizon.
The fact that a slow moving variables determined by demographics has very little impact on predictability of stock market returns at high frequency but a sizeable and strongly significant impact at low frequency has some obvious consequences on the slope of stock market risk, defined as the conditional variance and covariance per period of asset returns. When demographic trends are used to model the slow moving fluctuations in the dividend-price ratio a natural decomposition of this variable into an high volatility "noise" component, reflecting high-frequency stock market fluctuations, and a low-volatility "information" component reflecting the slowly evolving long-run trend. The dominance of the "noise" component at high frequency and of the information component at low frequency should lead naturally to a positive relation between predictability of returns and forecasting horizon and to a negatively sloped term structure of risk.

While the positive relation between predictability of returns and the forecasting horizon is widely recognized in the literature, the negative slope of the term structure of stock market risk is a controversial issue.

In describing the "verdict of history" on asset returns on a long-sample(1802-1996) of US historical data J.J.Siegel(1998,pp.32), pointed out that "...stocks are riskier than fixed-income investment over short-term holding periods. But once the holding period increases to between 15 and 20 years, the standard deviation of average annual returns,..., become lower than the standard deviation of average bond and bill returns...".

This statement on unconditional second moments has been strengthened by Campbell-Viceira(2002, 2005) who exploited the predictability of returns by estimating VAR models for returns and predictors and by using VAR-based multiperiod iterated forecasts to find that the conditional variance of stock return does not grow in proportion with the investment horizon but it grows more slowly. As a consequence the term-structure of stock market risk is downward sloping and the findings by Siegel on the property of the unconditional distribution of stocks returns are extended and strengthened when the conditional distribution of returns is used to measure stock market risk.

However, the downward sloping term-structure of stock market risk, has been recently questioned by Pastor-Stambaugh(2008,2009) who show that, allowing for coefficient uncertainty and imperfect predictors in a Campbell-Viceira type of VAR, the conditional variance of stock returns does increase with the horizon and it can even exceed the unconditional variance and the current variance.

In this paper we argue that such a controversy is a by-product of the use of the VAR framework that is not capable, by its nature, to eliminate the effect of the noise component at lower frequencies. The intuitive explanation for this result is as follows. VAR are specified for high-frequency, one-period, returns and conditional expectations for multi-period returns are then obtained via the aggregation of multi-step ahead one-period iterated forecasts, then conditional variances are derived from the backward solution of the reduced form model. We show that when predictors for stock market return can be decomposed in a slow moving information component, dominant at low frequencies, and a noise component, dominant at high frequency, then the forward solution
of the dynamic dividend growth model (Campbell-Shiller, 1988) would naturally progressively eliminate the noise component as the horizon increases. Direct regressions of returns at different horizon on the relevant predictors would capture this feature of the model, while VAR based multiperiod iterated forecasts do not. We shall then proceed to derive the term structure of stock market risk by combining direct regressions, fully consistent with the forward looking nature of the dividend growth model, with the use of demographic trends to capture the slow moving information component in the dividend-price ratio. This strategy has the potential of making the term structure of stock market risk more steeply descending than that usually found in the VAR literature for two reasons. First, the information component in the dividend price ratio is explicitly modeled by making it function of a slow-moving highly predictable variable. As a consequence, the speed of mean reversion of deviation of the dividend-price from its demographic trend is much faster than that of the dividend-price itself and the elimination of the effect of the "noise" component occurs more quickly as the forecasting horizon increases. Second, the use of direct regression does naturally progressively eliminate the relevance of the noise component from the distribution of returns at lower frequencies.

2.3 The International Evidence

Most of the available evidence on predictability and the term structure of stock market risk concentrates on US data. We think it is very important to provide some international evidence on the issue with special reference to the role of demographics variables. To this end it is crucial to use for other countries annual data for a century of observations as it has been done for the US case.

2.4 Demographics and the long-run behaviour of bond and stocks

In the GMQ model bond and stock are perfect substitutes, therefore the evaluation of the performance of $MY_t$ in forecasting yields to maturity of long-term bonds seems a natural extension. In fact, the debate on the so-called FED model (Lander et al., 1997) of the stock market, based on a long-run relation between the price-earning ratio and the long-term bond yield, brings some interesting evidence on this issue. The FED model is based on the equalization, up to a constant, between long-run stock and bond market returns. This feature is shared by the GMQ framework, and it requires a constant relation between the risk premium on long-term bonds and the risk premium on stocks. It has been shown that, although the FED model performs well in period where the stock and bond market risk premia are strongly correlated, some measure of the fluctuations in their relative premium is necessary to model periods in which volatilities in the two markets have been different (see, for example, Asness (2003)). As a consequence, to put $MY_t$ at work to explain the bond yields, some modelling of the relative bond/stock risk premia is also in order.
3 Resources

The development of the research programme requires access to long-run data. Such data are made available in an international database called Global Financial Data (www.globalfinancialdata.com).

In particular the relevant database is called The Global Financial Database. The GFDatabase is an unparalleled collection of financial and economic data covering more than 200 countries extending back to 1265. The GFDatabase has been compiled from original data sources such as historical archives, academic journals and news periodicals. The data have been verified and cross-referenced prior to being included in the database. GFD continues to investigate new sources and extend existing series whenever possible creating chain-linked data series that no other data vendor can offer.

Annual subscriptions to the entire GFDatabase are the most efficient and economical method of accessing our data. Four databases are interlinked and reinforce each other: Economic Database, Fixed Income Database, Equity Database, Total Return Database.

The cost of the database is ten thousand dollars. We ask for financial support for the acquisition of this data. Of course once acquired data will be available to all IGIER researchers.