Econometric Methods for Finance and Macro

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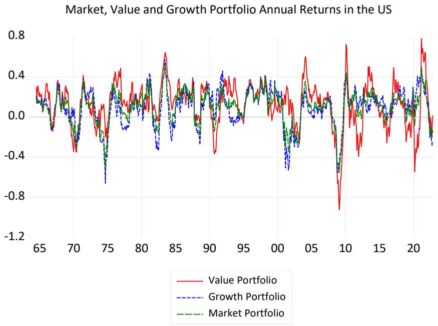
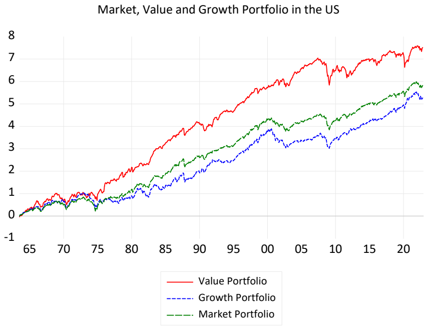
Time-Series Data in Macro and Finance

- The typical financial variables we shall consider are returns $r^i_{t,t+k}$
- Returns are related to prices $\ln P^i_t = \ln P^i_{t-1} + r^i_{t,t+1}$
- Modelling returns and prices requires modelling cycle and trends
- The relationship between macro trends and financial trends is different from the relationship between macro cycle and financial cycle
- main message of this course: modelling trends is relevant also for modelling cycle

Short-Horizon



Long-Horizon



Deterministic Trends

Trend stationary processes feature only a deterministic trend:

$$z_t = \alpha + \beta t + \epsilon_t.$$

The z_t process is non-stationary, but the non-stationarity is removed simply by regressing z_t on the deterministic trend.

Stochastic Trends

Consider, for example, the random walk process with a drift:

$$\begin{aligned} x_t &= a_0 + x_{t-1} + \epsilon_t, \\ \epsilon_t &\sim n.i.d.\left(0, \sigma_\epsilon^2\right). \end{aligned}$$

Recursive substitution yields

$$x_t = x_0 + a_0 t + \sum_{i=0}^{t-1} \epsilon_{t-i}, \tag{1}$$

which shows that the non-stationary series contains both a deterministic $(a_0 t)$ and a stochastic $\left(\sum_{i=0}^{t-1} \epsilon_{t-i}\right)$ trend.

Forecasting stochastic trends

An easy way to make a non-stationary series stationary is differencing:

$$\Delta x_t = x_t - x_{t-1} = (1 - L)\, x_t = a_0 + \epsilon_t.$$

However, note that when the equation above will be used to project x_{t+j} out-of-sample, only the deterministic trend will be forecasted and the variance of the forecasting error will explode as the forecasting horizon gets large.

Univariate de-trending

There are alternatives to differencing. The Hodrick–Prescott (HP) filter computes the permanent component TR_t of a series x_t by minimizing the variance of x_t around TR_t, subject to a penalty that constrains the second difference of TR_t. That is, the Hodrick–Prescott filter is derived by minimizing the following expression:

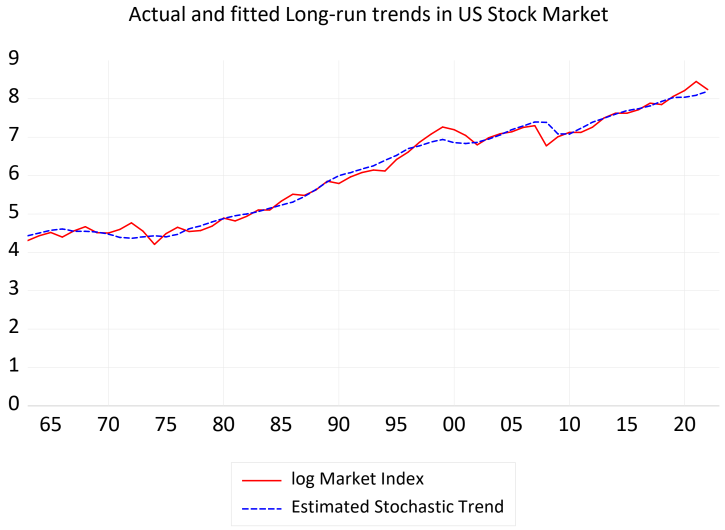
$$\sum_{t=1}^{T} (x_t - TR_t)^2 + \lambda \sum_{t=2}^{T-1} \left[(TR_{t+1} - TR_t)^2 - (TR_t - TR_{t-1})^2 \right].$$

The penalty parameter λ controls the smoothness of the series, by controlling the ratio of the variance of the cyclical component and the variance of the series. The larger the λ, the smoother the TR_t approaches a linear trend. In practical applications λ is set to 100 for annual data, 1600 for quarterly data and 14400 for monthly data.

Trends and Cycles

- Most trends in macro and finance are stochastic,
- many variables are co-trending
- when variables are co-trending deviations from the trend are natural predictors of cycle

Co-trending


Actual and fitted Long-run trends in US Stock Market
9
8
7
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3
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90
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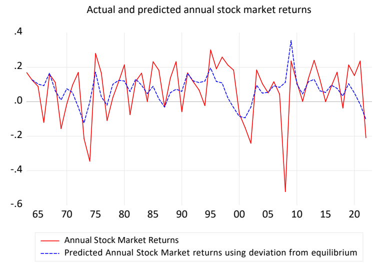
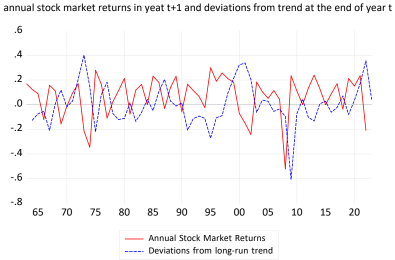
log Market Index
Estimated Stochastic Trend

Co-trending and Cycles





Cointegration and Predictability of Stock Returns

- Stock prices are drifting in the data
- The existence of common stochastic trends is at the core of the literature on predictability of returns.
  - the common stochastic trend in dividend and prices in the dynamic dividend growth model (Campbell-Shiller 1988),
  - the common stochastic trend between consumption, income and wealth in cay (Lettau-Ludvigson 2001) ,
  - the common stochastic trend between consumption, income and dividends in (Lettau-Ludvigson 2005),
  - and the common stochastic trend between dividends and consumption in (Bansal et al. 2007)

A permanent-transitory decomposition for stock prices

Fama and French(1988) argue that (the log of) stock prices, lnP_t are composed of two parts: a permanent non-stationary component q_t, modelled as a random walk with drift, and a temporary stationary component,u_t, modelled as a stationary AR(1) process.

$$\begin{aligned} \ln P_t &= q_t + u_t \qquad (2) \\ q_t &= q_{t-1} + \mu + \eta_t \\ u_t &= \rho u_{t-1} + v_t \end{aligned}$$

where η_t and v_t are independent processes with zero mean and constant variance and $\mid \rho_i \mid < 1$.

Stochastic Trends in prices and predictability of returns

Derive returns by differencing prices

$$r_t = \mu + \eta_t + (\rho - 1)u_{t-1} + v_t$$
$$u_{t-1} = lnP_{t-1} - q_{t-1}$$

returns are predictable from the deviations of prices from their trends

Modelling the Stochastic Trends in prices

The stochastic trend is not observed but suppose there is a set of variables candidate to explain it, $\ln \mathbf{F}_t$.

$$\ln P_t = \beta_i' \ln \mathbf{F}_t + u_t$$
$$u_t = \rho u_{t-1} + v_t$$

which implies:

$$r_{i,t+1} = \alpha_{1,i} + \beta_i' \Delta \mathbf{F}_{t+1} + \underbrace{(\rho_i - 1)}_{\delta_i} \underbrace{u_{i,t}}_{\equiv ECT_{i,t}} + v_{i,t+1}.$$

The Dynamic Dividend Growth Model

The dynamic dividend growth model posits that the stochastic trend in prices is driven by dividends:

$$\begin{aligned}
\ln P_{t+1} &= \ln D_{t+1} + u_{t+1} \\
\ln D_{t+1} &= \ln D_t + \mu + \eta_{t+1} \\
u_{t+1} &= \rho u_t + v_{t+1}
\end{aligned}$$

which implies:

$$r_{t+1} = \Delta \ln D_{t+1} + (\rho - 1) \underbrace{u_t}_{\equiv ECT_t} + v_{t+1}.$$

$$r_{t+1} = \mu + (\rho - 1)(\ln P_t - \ln D_t) + v_{t+1}$$

Forecasting with a co-integrated system

In case of cointegration between prices and dividends, the joint process for returns and dividends can be written as :

$$
\begin{aligned}
r_{t+1} &= \mu + (\rho - 1)(\ln P_t - \ln D_t) + v_{t+1} \\
\ln D_{t+1} &= \ln D_t + \mu + \eta_{t+1}
\end{aligned}
$$

this system works very well for 1-step ahead predictions, but for n-step ahead prediction it has the problem that dividends are predicted only with a deterministic trend and prices are forced to mantain their long run relations with dividends.

Univariate de-trending and look ahead bias

One should be aware of the look-ahead bias when using the HP filter. Deviations of Stock prices from their HP trend predict returns if the trend is computed using the full sample but they do not if the trend is computed using information available in real-time.