Return Predictability in International Bond and Stock Markets

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Master of Science in Business, Major in Finance

1. Research Topics

The expectations hypothesis (EH) of interest rates has been subject to curiosity and been under scrutiny empirically by researchers for several decades. The formulation of the hypothesis restricts the risk premium associated with holding government bonds to equal zero (Pure EH) or being constant over time. Assuming that investors are risk averse, asset pricing theory argues that time-varying risk premia of assets may arise either from time-varying macroeconomic risks or time-varying risk aversion (Campbell & Cochrane, 1999). Such theoretical arguments are confirmed empirically by Ilmanen (1995), who documents that a proxy for risk aversion varies inversely with wealth and that such variations do explain the observed pattern in expected asset returns. As such, if bond risk premia are time-varying, excess bond returns should be predictable, even if the market is efficient from an efficient market theory perspective. Further, Fama & French (1989) document that expected excess returns of bonds and stocks move together and ties this variation to the overall business cycle.

Recently, several well-known researchers have published articles in the field of bond return predictability, among the most acknowledged ones are Fama & Bliss (1987), Campbell & Shiller (1991) and Cochrane & Piazzesi (C&P) (2005). As a result of the publication of these articles, strong evidence has been documented empirically against the EH in the US market. As such, a consensus has recently emerged in the field of empirical asset pricing literature that excess bond returns show historically to be predictable. However, published research has been focused on the US market, so room for assessment of bond return predictability in other markets seems to be plenty. Motivated by the work of C&P (2005) and Dahlquist & Hasseltoft (2013) we intend to assess the predictability of excess bond returns in an international setting. Additionally, we aim to check if predictable variations in expected excess bond returns also can be used to predict excess stock market returns, motivated by Fama & French (1989) who document that the shape of the term structure of interest rates forecasts excess stock returns.

The first step in the assessment will be to replicate C&P's (2005) result in the US market and extend it with the most recent data. Then, with data from other bond markets (listed in section 5) we will assess the expected excess bond return predictability in these markets with the single-factor model of C&P (2005). More specifically, we want to assess whether the estimated coefficients in the single-factor model present a tent-shaped feature, like in the US, and if this feature is robust during subsamples.

In the second step, considering the integration of world-wide financial markets, we intend to assess if a global single-factor model, as formulated by Dahlquist and Hasseltoft (2013), has better predictive performance of expected excess bond returns than a local single-factor model.

Lastly, we intend to assess the predictability performance of the local CP-factors and Global CP-factor to predict expected excess stock market returns.

2. Literature Review

To our knowledge, Lutz (1940) sparked the research interest within this empirical asset pricing literature field by postulating that investors, under certain assumptions, are indifferent on how to structure a loan for a given time horizon (e.g. if the investment horizon is 1-year they are indifferent between buying a 1-year government bond and a 10-year government bond and selling it after 1 year). Thus, forming the Expectations hypothesis of interest rates which has three statements:

1. Long-term interest rate equals the average expected future short-term interest rates plus a risk premium.
2. Observed forward rate equal expected future interest rate plus a risk premium.
3. Expected one-period return on bonds equals the one-period interest rate plus a risk premium.

Extensive research has been conducted to document empirical aspects of the EH and whether risk premia is time-varying. In this section we conduct a literature review on references we find particularly relevant for our research topic and master thesis.

2.1 Fama & Bliss (1987)

Eugene F. Fama and Robert R. Bliss test the EH by running predictability regressions on US Treasuries, where the annual excess bond return of a bond with n-year maturity is regressed on the spread between the n-year forward rate and 1-year spot interest rate. With their model they forecast annual excess returns of n-year bonds with R^2 up to 0.18 and conclude that the expected 1-year excess bond returns for the US Treasuries (maturities up to 5 years) vary through time, hence documenting strong evidence against EH in the US in the sample period 1964-1985. Additionally, the authors document that forward rates are able to forecast changes in short-term interest rates for 2 to 5 years ahead and not in the near-term, concluding that interest rates inherit a tendency of slow mean-reverting.

2.2 Campbell & Shiller (1991)

Further testing the validity of the EH, John Y. Campbell and Robert J. Shiller ran regressions on pure discount government bonds with maturities from 1 month to 10 years. The general finding of their research is that for any combination of maturities, between 1-month and 10-years, a high yield spread results in a tendency of a falling yield on the longer-term bond over the life of the shorter-term bond, while the yield on shorter-term bonds tend to rise over the life of the longer-term bond. The first observation violates, while the latter is more in-line with the EH.

2.3 Fama & French (1989)

Eugene F. Fama and Kenneth R. French study expected excess returns on corporate bonds and stocks, whether these move together and if that is related to overall business conditions. They study factors common to risky securities: dividend yield (d/p), default premium (difference in yield between market portfolio of bonds and yields on highest rated securities) and term spread of interest rates.

They document that the dividend yield and default premium variables seem to be related to long-term business conditions and that the term spread of interest rate is more related to the variations in short-term business conditions. Also, Fama and French find that the term spread is low around business cycle peaks and high around troughs and that it contributes positively, and in a similar magnitude, to the expected excess returns for the stock and bond portfolios they examine. This suggests that the term spread of interest rates tracks a component of expected returns that is similar for all risky assets.

2.4 Ilmanen (1995)

Antti Ilmanen studies predictable variations in excess returns of government bonds in five major bond markets outside the US. Ilmanen confirms empirically the theoretical argument that the aggregate wealth level can explain variations in expected asset returns, and proposes that relative risk aversion varies inversely with relative wealth and consequentially that these variations can explain the pattern of expected asset returns.

In addition, the author finds that excess bond returns can be forecasted by common global instruments, and that they are better predictors than local instruments. Further, Ilmanen documents that expected excess returns are highly correlated across international bond markets but not as high across bond and stock returns.

2.5 Cochrane and Piazzesi (2005)

John H. Cochrane and Monika Piazzesi study time variation in expected excess returns in US government bonds. They contribute to the literature by documenting that a single linear combination, a single "return-forecasting factor" (CP-factor) (we use single factor and CP-factor interchangeably), of observed forward rates predicts annual excess returns on bonds with 1 to 5 years maturity with an R^2 of up to 0.44, hence, intensifying the evidence against the EH in the US market.

An important aspect of the CP-factor is that it seems to predict annual excess bond returns of not only a specific n-year maturity bond but different maturity bonds. This finding is complement to the factors that Fama & Bliss (1987) and Campbell & Shiller (1991) constructed which only predict annual excess return on a specific n-year bond. The single factor seems to capture information relevant to predict annual excess bond returns that is unrelated to the factors that capture virtually all of the variations in expected excess bond returns: level, slope and curvature of the yield curve (Litterman & Scheinkman, 1991). Additionally, the authors document that the CP-factor has forecasting power for expected excess stock returns. In their sample, they document an R^2 of 0.15 when regressing excess stock returns on moving average values of CP-factor realizations, term spread and dividend yield factors.

2.6 Dahlquist and Hasseltoft (2013)

Magnus Dahlquist and Henrik Hasseltoft find evidence for government bond predictability across international markets. They extend the work of C&P (2005) by using the CP-factor to construct local factors for Germany, UK, Switzerland and the US and further incorporate a weighted average of each country's GDP to create a global CP-factor (GCP) with which they assess time-varying bond risk premia in international markets. This global factor, they find, relates closely to US bond risk premia and international business cycles.

They document that a rise in global risk premia is associated with a contemporaneous drop in leading economic indicators across countries. Being jointly significant, these local factors and the global factor seem to have strong forecasting power for bond returns across countries and linked to overall business conditions.

3. Research Questions

With inspiration from the mentioned research, we want to explore and answer the following research questions in our master thesis:

Research Question 1

Are the results documented by Cochrane & Piazzesi (2005) in the US confirmed in country *i*?

Research Question 2

Considering the integration between international financial markets, does the Global CP-factor (as specified by Dahlquist & Hasseltoft, 2013) increase the forecasting power of excess bond returns in country *i*?

Research Question 3

Does the CP-factor forecast excess stock returns in country *i*? Does the Global CP-factor increase the forecasting power?

4. Research Methodology

As mentioned, to try and answer our research questions we will follow the work and methodological procedures by C&P (2005) and Dahlquist & Hasseltoft (2013). We briefly describe the research methodology we intend to follow in this section. The mentioned methodology and computations will be conducted in MATLAB.

4.1 Notations

We use notations as formulated by C&P (2005). The data we intend to use is monthly time-series of yields quoted in annual terms, hence smallest time increment is one month. For the sake of convenience, we use $n = 1, 2, 3, 4, 5$ instead of $\mathrm{n} = 12, 24, 36, 48, 60$. Countries are denoted by a subscript *i*.

Log price of n-year discount bond at time t	$p_{i,t}^{(n)}$
Log yield	$y_{i,t}^{(n)} \equiv -\frac{1}{n} p_{i,t}^{(n)}$
Log forward rate at time t	$f_{i,t}^{(n)} \equiv p_{i,t}^{(n-1)} - p_{i,t}^{(n)}$
Log holding period return	$r_{i,t}^{(n)} \equiv p_{i,t+1}^{(n-1)} - p_{t}^{(n)}$
Excess log returns on n-year bond	$rx_{i,t+1}^{(n)} \equiv r_{i,t+1}^{(n)} - y_{i,t}^{(1)}$
Average excess returns across maturity	$\overline{rx}_{i,t+1} \equiv \frac{1}{4} \sum_{n=2}^{5} rx_{i,t+1}^{(n)}$
Vector of excess returns across maturities	$\boldsymbol{rx}_{i,t+1} \equiv \left[rx_{i,t+1}^{(2)}, rx_{i,t+1}^{(3)}, rx_{i,t+1}^{(4)}, rx_{i,t+1}^{(5)}\right]^{\mathrm{T}}$
Vector of yields	$\boldsymbol{y}_t \equiv \left[1, y_{i,t}^{(1)}, y_{i,t}^{(2)}, y_{i,t}^{(3)}, y_{i,t}^{(4)}, y_{i,t}^{(5)}\right]^{\mathrm{T}}$
Vector of one-year forward rates	$\boldsymbol{f}_t \equiv \left[1, y_{i,t}^{(1)}, f_{i,t}^{(2)}, f_{i,t}^{(3)}, f_{i,t}^{(4)}, f_{i,t}^{(5)}\right]^{\mathrm{T}}$
Log value-weighted stock returns	$\overline{sr}_{i,t}$
Excess stock returns	$\overline{sx}_{i,t+1} = \overline{sr}_{i,t+1} - y_{i,t}^{(1)}$

4.2 Single factor model

4.2.1 Unrestricted regression

Firstly, we intend to run regressions of two to five year maturity bond excess returns at time t+1 (i.e. one-year return horizon) on forward rates at time t

$$rx_{i,t+1}^{(n)} = \beta_{i,0}^{(n)} + \beta_{i,1}^{(n)} y_{i,t}^{(1)} + \beta_{i,2}^{(n)} f_{i,t}^{(2)} + \beta_{i,3}^{(n)} f_{i,t}^{(3)} + \beta_{i,4}^{(n)} f_{i,t}^{(4)} + \beta_{i,5}^{(n)} f_{i,t}^{(5)} + \varepsilon_{i,t+1}^{(n)}$$

C&P (2005) find that when plotting the values of $\boldsymbol{\beta}_i^{(n)}$ for a specific n (maturity of bond), a "tent-shaped" graph appears (see figure 1). The tent-shaped graph is maintained in the US market for different n, suggesting that the same function of linear combination of forward rates forecasts holding period returns of two to five year *maturity bonds.*

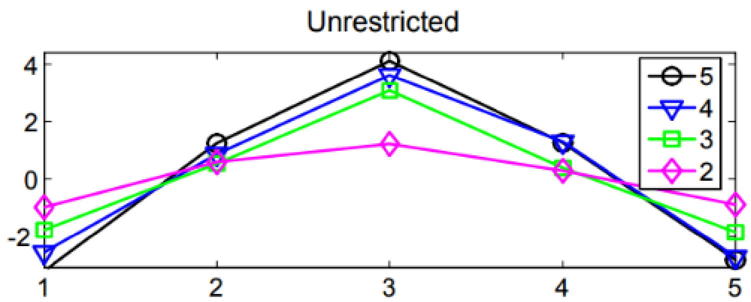

Figure 1: Tent-shape in coefficients from the unrestricted regression.
From Bond risk premia overheads, slide 4 - Cochrane & Piazzesi (2007)

4.2.2 Restricted regression

For each country i, we plot the estimated coefficients, $\boldsymbol{\beta}_i^{(n)}$, as a function of n and look for the tent-shape as described above. If present, we estimate the single factor model as formulated by C&P (2005):

$$rx_{i,t+1}^{(n)} = b_{i,n}(\gamma_{i,0} + \gamma_{i,1} y_{i,t}^{(1)} + \gamma_{i,2} f_{i,t}^{(2)} + \gamma_{i,3} f_{i,t}^{(3)} + \gamma_{i,4} f_{i,t}^{(4)} + \gamma_{i,5} f_{i,t}^{(5)}) + \varepsilon_{i,t+1}^{(n)}$$

$$: \frac{1}{4} \sum_{n=2}^{5} b_{i,n} = 1$$

This is done in two steps:

(1) Estimate $\boldsymbol{\gamma_i}$ by running the following regression:

$$\overline{rx}_{i,t+1} = \boldsymbol{\gamma}_i^T \boldsymbol{f}_{\boldsymbol{i,t}} + \bar{\boldsymbol{\varepsilon}}_{\boldsymbol{i,t+1}}$$

$$\text{Where } \boldsymbol{\gamma}_i \equiv [\gamma_{i,0}, \gamma_{i,1}, \gamma_{i,2}, \gamma_{i,3}, \gamma_{i,4}, \gamma_{i,5}]^{\mathrm{T}}$$

(2) Estimate $b_{i,n}$ by running four regressions in the form of:

$$rx_{i,t+1}^{(n)} = b_{i,n}(\boldsymbol{\gamma}_i^T \boldsymbol{f}_{\boldsymbol{i,t}}) + \varepsilon_{i,t+1}^{(n)} \quad , \quad n = 2, 3, 4, 5$$

According to C&P (2005), the restricted model has empirically only a minor impact on the forecasting ability of excess bond returns in the US market suggesting that the variable $\boldsymbol{\gamma}_i^T \boldsymbol{f}_{\boldsymbol{i,t}}$ (*CP*-factor) is a state variable for time-varying expected excess returns for two to five-year maturity bonds. We intend to check if this is also the case in country *i*.

In a similar fashion as C&P (2005), to check the model's validity and reach a conclusion to our research question we intend to perform several analyses such as checking whether the restricted model coefficients $\boldsymbol{b_i \gamma_i}$ match the unrestricted coefficients $\boldsymbol{\beta_i}$, statistical significance tests and subsample analyses to see if parameter estimates are robust and similar across countries.

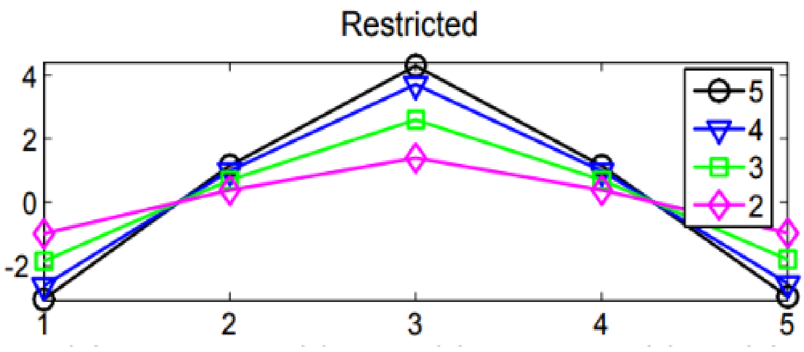

Figure 2: Tent-shape in coefficients from the restricted regression.
From Bond risk premia overheads, slide 4 - Cochrane & Piazzesi (2007)

4.2.3 Lagged single factor model

C&P (2005) observe that adding lags of forward rates as explanatory variables in the regression of excess annual bond returns increase the forecasting power on bonds of two to five year maturity (R^2 increase from 0.35 to 0.44). Hence, if we are able to estimate the restricted regression (as described above), we will subsequently add lags to see if these may increase the forecasting power:

$$rx_{i,t+1}^{(n)} = b_{i,n}\boldsymbol{\gamma}_i^T\left[\alpha_{i,0}\boldsymbol{f}_{i,t} + \alpha_{i,1}\boldsymbol{f}_{i,t-(\frac{1}{12})} + \cdots + \alpha_{i,k}\boldsymbol{f}_{i,t-(\frac{k}{12})}\right] + \varepsilon_{i,t+1}^{(n)}$$
$$: \sum_{j=0}^{k} \alpha_{i,j} = 1$$

Again, estimation is done in two steps:

(1) Estimate $\boldsymbol{\alpha}_i$ by running the following regression:

$$\overline{rx}_{i,t+1} = \alpha_{i,0}\left(\boldsymbol{\gamma}_i^T\boldsymbol{f}_{i,t}\right) + \alpha_{i,1}\left(\boldsymbol{\gamma}_i^T\boldsymbol{f}_{i,t-(\frac{1}{12})}\right) + \ldots + \alpha_{i,k}\left(\boldsymbol{\gamma}_i^T\boldsymbol{f}_{i,t-(\frac{k}{12})}\right) + \bar{\varepsilon}_{i,t+1}$$

(2) Estimate b_i by running the four following regressions:

$$rx_{i,t+1}^{(n)} = b_{i,n}\boldsymbol{\gamma}_i^T\left[\alpha_{i,0}\boldsymbol{f}_{\boldsymbol{i,t}} + \alpha_{i,1}\boldsymbol{f}_{i,t-(\frac{1}{12})} + \cdots + \alpha_{i,k}\boldsymbol{f}_{i,t-(\frac{k}{12})}\right] + \varepsilon_{i,t+1}^{(n)},$$
$$n = 2, 3, 4, 5$$

With observations documented by C&P (2005), lagged values up to k=4 have rising R^2 and $b_{i,n}$. We want to check if this is also the case in country *i*.

4.3 Global single factor model

In similar manner as Dahlquist & Hasseltoft (2013), we intend to check whether a GDP weighted average of countries' individual CP-factors is able to increase the forecasting power of the expected excess bond return in country *i*. We will use the following model:

$$rx_{i,t+1}^{(n)} = c_i^{(n)} + d_{i,GCP}^{(n)}GCP_t + \varepsilon_{i,t+1}^{(n)}$$
$$GCP_t = \sum_{i=1}^{I} w_{i,t}\,\boldsymbol{\gamma}_i^T\boldsymbol{f}_{\boldsymbol{i,t}} \qquad , \qquad \mathrm{w}_{i,t} = \frac{\mathrm{GDP}_{i,t}}{\sum_{\boldsymbol{i=1}}^{\boldsymbol{I}} GDP_{i,t}}$$

4.4 Forecasting excess stock returns

Fama & French (1989) document in their paper that the slope of the term structure of interest rates is positively related to excess stock returns. C&P (2005) confirm this and show that the CP-factor is able to forecast excess stock returns. While this factor alone forecast stock returns with an R^2 of 0.07, a moving average of the single factor in combination with the term spread and dividend yield forecasts stock returns with an R^2 of 0.15. We intend to check whether these two models are able to forecast excess stock returns with similar magnitude in country *i*.

First, with the single factor alone:

$$\overline{sx}_{i,t+1} = a_i + b_i \boldsymbol{\gamma}_i^T \boldsymbol{f}_{i,t} + \varepsilon_{i,t+1}$$

Then substituting the single factor with the moving average of the single factor, the term spread and the dividend yield:

$$\overline{sx}_{i,t+1} = a_i + b_{i,1} MA(\boldsymbol{\gamma}_i^T \boldsymbol{f}_{i,t}) + b_{i,2}\left(y_{i,t}^{(5)} - y_{i,t}^{(1)}\right) + b_{i,3}(\frac{D}{p})_{i,t} + \varepsilon_{i,t+1}$$

We also want to assess whether forecasting power increase when utilizing the Global CP-factor in these models:

$$\overline{sx}_{i,t+1} = c_i + d_i GCP_{i,t} + \varepsilon_{i,t+1}$$

and,

$$\overline{sx}_{i,t+1} = c_i + d_{i,1} MA(GCP_{i,t}) + d_{i,2}\left(y_{i,t}^{(5)} - y_{i,t}^{(1)}\right) + d_{i,3}(\frac{D}{p})_{i,t} + \varepsilon_{i,t+1}$$

5. Data

In the original work on “Bond risk premia”, C&P (2005) use monthly zero-coupon yields on bonds with maturity of 1-5 years, known as the Fama-Bliss Discount Rates. We have downloaded an updated version of this dataset from The Center of Research in Security Prices (CRSP), available through Wharton Research Data Services (WRDS). We will use this dataset to replicate and update the work by C&P (2005). The sample period in this dataset ranges from January 1953 to December 2016 (data for 2017 will be collected when it is available). Figure 3 shows an illustration of this data for 1990-2016.

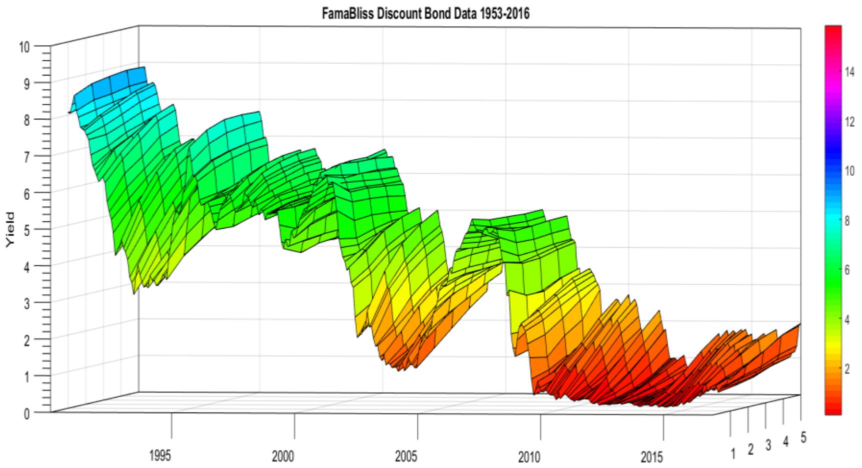

Figure 3: Fama-Bliss Discounted Bond Data 1990-2016.
The x-axis are monthly observations, y-axis yields in % and z-axis maturities from 1 to 5 years.

For the other countries we use a dataset constructed by Wright (2011). The sample periods for these countries vary but all end in May 2009, and the data has been smoothed with either the spline, Svensson (1994) or Nelson-Siegel (1987) interpolation method. For the data from June 2009 to today we will reach out to Wright and request an updated dataset, alternatively use the same methods to construct the dataset ourselves with data from the same sources as Wright (2011) used (various sources specified in his paper). Table 1 gives an overview of the zero coupon bond data.

Country	Sample period (Obs.)	Obs.	Smoothing method
Fama-Bliss data			
US	Jan. 1953 – Dec. 2016	780	Not smoothed
Wright data			
Australia	Feb. 1987 – May 2009	268	Nelson-Siegel
Canada	Jan. 1986 – May 2009	281	Spline
Japan	Jan. 1985 – May 2009	293	Svensson
Germany	Jan. 1973 – May 2009	437	Svensson
New Zealand	Jan. 1990 – May 2009	233	Nelson-Siegel
Norway	Jan. 1998 – May 2009	137	Svensson
Sweden	Jan. 1992 – May 2009	198	Svensson
Switzerland	Jan. 1988 – May 2009	257	Svensson
UK	Jan. 1979 – May 2009	365	Spline
US	Nov. 1971 – May 2009	451	Svensson

Table 1 – Monthly zero coupon bond data

Data on stock returns except US is collected from Kenneth R. French's (2017) website. US data is collected from CRSP. The data are local value-weighted country market returns including dividend yield (d/p). (Data for 2017 will be collected when it is available).

Country	Sample period	Obs.
Australia	Jan. 1975 – Dec. 2016	504
Canada	Jan. 1977 – Dec. 2016	480
Japan	Jan. 1975 – Dec. 2016	504
Germany	Jan. 1975 – Dec. 2016	504
New Zealand	Jan. 1988 – Dec. 2016	348
Norway	Jan. 1975 – Dec. 2016	504
Sweden	Jan. 1975 – Dec. 2016	504
Switzerland	Jan. 1975 – Dec. 2016	504
UK	Jan. 1975 – Dec. 2016	504
US	Jan. 1926 – Dec. 2016	1092

Table 2 – Overview of stock market data in the selected countries.

Each country's GDP has been gathered from OECD's Quarterly National Accounts Database. We use GDP data from each country measured in US dollars, which enable us to measure country's GDP as proportion of total GDP in the sample. See figure below for a quarterly time-series of GDP weights from 1980Q1 to 2017Q3.

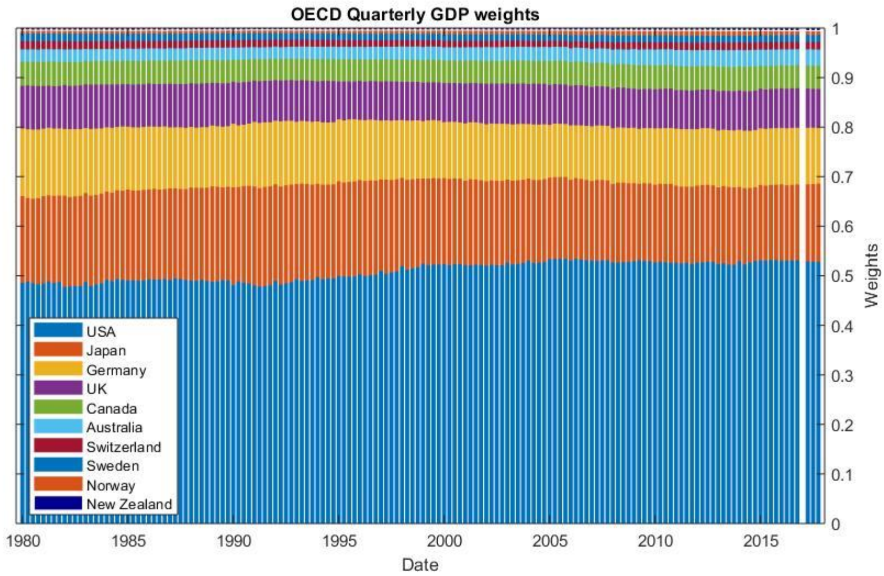

Figure 4: OECD quarterly GDP weights of our selected countries (OECD, 2018)

6. Progression Plan

January	Replication of main references Collect necessary data
February	Apply models to collected datasets
March	Finish analysis
April	Finalize first draft of thesis
May	Proof-reading, correct errors, improve writing and finalize thesis
June	End of project – deliver thesis

7. References

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