



The Yield Curve: A Population Pyramid Scheme?

David Aksberg
Filip Angeria

Master Thesis in Finance
Stockholm School of Economics
Spring 2025

Abstract

This paper expands on previous research on the determinants of the yield curve by examining the relationship between the age structure of Sweden and the yield curve of Swedish government debt during 1998–2025. During this period, two shocks impacted Sweden’s demographics: the migration wave of the mid-2010s and the covid-19 pandemic of the early 2020s. The relationship is first examined using vector autoregression, controlling for macro variables, in an attempt to find correlation. It is then investigated further employing the two shocks as exogenous variation in an instrumental variable analysis. Neither analysis presents evidence for an effect of age structure on the yield curve.

Keywords: Macrofinance, Yield curves, Demographics, Migration, Covid-19

Authors: David Aksberg & Filip Angeria

Supervisors: Paolo Sodini, Professor, Department of Finance
Álvaro Jañez Garcia, Assistant Professor, Department of Economics

Examiner: Anders Anderson, Associate Professor, Department of Finance

Acknowledgements: We would like to thank our main supervisor Paolo Sodini for his continuous support and valuable guidance throughout the writing process. We would also like to thank Lars Strand at Sveriges Riksbank who helped us obtain the required data on Swedish bills and bonds. Without their respective contributions, this thesis would not have been possible.

Master Thesis in Finance
Master Programme in Finance & Master Programme in Economics
Stockholm School of Economics

© David Aksberg & Filip Angeria, 2025

1 Introduction

Ever since the advent of the industrial revolution, some two-and-a-half centuries ago, the world has undergone a rapid and radical transformation. At the turn of the 19th century, the population of the earth stood at one billion; at present, it exceeds eight billion (O'Neill, 2024). During this period, it is hard to doubt that humanity has indeed followed God's commandment to: *Be fruitful and multiply and fill the Earth* (Genesis 1:28). It seems, however, that humanity might have forgotten this divine edict, for with industrialisation and modernisation has also come a sharp drop in fertility rates around the globe (United Nations, 2025).

As the population of the developed world is rapidly ageing, a multitude of consequences are likely to follow, both large and small. A topic relating to this is that of pensions and how they ought to be paid for: With a population where the portion of working-age individuals falls while the number of those in need of economic support increases, how are societies supposed to manage the resulting budget crunch? There is a risk of tougher times and tighter margins for the state as the productive share of the population decreases, and, most importantly, for this paper, this may affect the ability of the state to finance itself at present.

In addition to taxes and other revenue sources, states finance themselves by issuing debt through bills and bonds of different maturities. The yield paid on these debts generally differs depending on the maturity. Together, the yields of various maturities create a yield curve. The shape of the yield curve varies over time and can be both upward and downward sloping depending on circumstances.

Understanding what underlies the yield curve is crucial for bond valuation, investment strategies, and policymaking. One way of explaining the yield curve is the expectations hypothesis, where changes in slope are assumed to be entirely driven by changes in market expectations about future rates. However, as Froot (1989) put it:

If the attractiveness of an economic hypothesis is measured by the number of papers that statistically reject it, the expectations theory of the term structure is a knockout.

As such, there is a need to better explain the dynamics of the yield curve and what may affect it. This paper aims to investigate if and how demographics, defined as the age structure of a country, can help explain the yield curve seen on the government debt issued by that country. Specifically, we build on the method of Ang & Piazzesi (2003), who model the yield curve of the United States using lagged values of the curve as well as different combinations of macroeconomic variables. We instead apply the model to the yield curve of Sweden and also add demographic variables to the specification. The paper continues as follows: *Section 2* introduces the topic and reviews the previous literature; *Section 3* presents a correlation analysis; *Section 4* follows up with a causality analysis; *Section 5* discusses the results and *Section 6* concludes.

2 Background

2.1 The Demographic Shift

The world is currently experiencing a profound demographic shift marked by falling birthrates and an aging population. Over the last half-century, the world has witnessed a significant decline in fertility rates, with the global fertility rate dropping precipitously from more than five children per woman in the 1970's to just above the so-called replacement level of 2.1 children per woman today. This trend has been seen across the world, but has been most pronounced in developed countries and is projected to continue in the decades to come (United Nations, 2025). Although it is unclear what exactly underlies this decline, some have linked it to socio-economic development, varying degrees of equality between the sexes, an increased level of education, social norms and postponement of parenthood (Bignami et al., 2024).

The fall in fertility rates has occurred concurrently with massive increases in life expectancy (United Nations, 2024a) which has been attributed to improvements in medicine leading to falling rates of child mortality and disease (Crimmins, 2015). As these trends have occurred in tandem with one another, the proportion of elderly in the world has risen and is projected to continue rising (United Nations, 2024b). Yet an ageing population presents both opportunities and challenges: On the one hand, longer lifespans reflect societal progress and improved quality of life; on the other hand, an aging population risks putting strain on public services, as fewer working-age individuals are left to support a larger retired population. Governments are left to manage a shrinking taxable population with an increased demand for costly services such as healthcare and elderly care.

2.2 Demographic Shocks

In addition to the gradual demographic shift, countries may experience drastic shocks to their demographic structure due to external factors such as migration, natural disasters, war and disease. Specifically, Sweden has experienced two major shocks to its demographic structure during the last decades. The first of these is the large influx of asylum seekers that came to Sweden during the mid-2010s and the second is the large number of deceased during the covid-19 pandemic in the early 2020s. These shocks affected the demographic structure of Sweden in different ways, with the first shock mainly adding younger people to the population, while the second mainly removed older people. This is shown in *Figure 4* and *Figure 5* for each shock respectively.

In contrast to the gradual demographic shift, which has been anticipated and is expected to continue, demographic shocks are sudden and unpredictable. As such, any economic effect of these shocks should not be reflected in markets until they occur and are thereby exogenous. This exogeneity makes them suitable as instrumental variables in an attempt to establish causality.

2.3 Literature Review

Ever since Macaulay (1938), the expectation hypothesis has been a frequent topic of research for many. The idea that the current long-term yield is given by the average of future expected short-term yields and that changes in the slope of the yield curve are entirely driven by changes in market expectations about future rates is both intuitive and intellectually appealing. There is evidence for the expectation hypothesis holding in certain geographies, mainly at the short-end of the yield curve (Piazzesi, 2010; Ilmanen, 2011). Overall, however, research suggests that expectations of short-term yields alone are not enough to explain the far-end of the yield curve. In other words, a large part of the variation seen in the far-end of the yield curve remains unexplained if assuming the expectation hypothesis to hold. Campbell & Shiller (1991) propose that a considerable part of the variation seen in the yield curve could instead stem from risk premia.

The liquidity theory builds on the ideas of Campbell & Shiller (1991) by contending that the price of long-term bond reflects not only market expectation of future yields but also time-varying compensation for duration risk, meaning the risk of being forced to sell a bond before maturity at a disadvantageous point in time. As such, risk premia compensate investors for various types of macro risk to the extent that they impact duration risk or market appetite for risk. Previous research has shown that bond risk premia are time-varying and are higher in tough times with high inflation, low productivity and recession (Ang & Piazzesi, 2003; Piazzesi & Schneider, 2006; Wachter 2006; Rudebusch & Swanson, 2012).

Ang & Piazzesi (2003) examine the interaction between bond yields and macroeconomic variables through a term structure model with time-varying risk premia, building on the findings of Campbell & Shiller (1991). They incorporate inflation and economic growth factors to analyse the influence of macroeconomics on bond pricing and the dynamics of the yield curve and find that macro explains a large part of the variation seen in bond yields.

In addition to the above, there are other approaches to explaining the yield curve. One of these is the market segmentation hypothesis, which proposes that the variation in yield across maturities instead stems from differences in preferences among investors. However, this is not compatible with a model in which yields are the result of duration risk premia and market expectations, as shown by Krishnamurthy (2002) and Vayanos & Vila (2021).

There exists a large theoretical foundation relating to the notion that demographics can affect many important factors in the economy. Theorising about such effects is nothing recent, as both Malthus (1798) and Smith (1776) discussed the subject in detail. In neoclassical models of growth, age structure and change in population size are assumed to directly impact many important parts of the economy, such as the rate of growth and savings as well as asset returns (McCandless & Wallace, 1991; Solow 1999; Abel, 2001). The main way demographics are believed to affect these factors is through its effect on the labour supply.

For investors, such an effect would be another factor to consider if it impacts their investments. At present, however, empirical studies looking into the question

have not found conclusive evidence. Poterba (2001) finds that most measures of demographic structure do not show a statistically significant correlation with asset returns, but later studies examining a broader set of countries over a longer period have instead found that demographics do exhibit predictability of risk premia (Ang & Maddaloni, 2003). Due to the inconclusive empirical evidence, further research on the topic is warranted.

The existing literature has not examined the effects on specifically the yield curve. As demographics may affect state finances, an effect on the yield curve could also exist. For instance, a channel through which this may occur is by impacting duration risk or market appetite for risk, hence giving rise to a demographic risk premium.

We extend the literature by examining whether demographics, as defined by the age structure, may help explain the yield curve through this channel. Contrary to previous research on related topics, which has mostly focused on the United States, we examine this in Sweden. The reason for this is that Sweden has experienced two shocks to its demographic structure over the last decades: the large influx of asylum seekers in the mid-2010s and the covid-19 pandemic of the early 2020s. These shocks present a unique opportunity to causally evaluate the impact of demographics on the yield curve given their exogenous nature. We use this opportunity to conduct our causality analysis in *Section 5* below.

3 Correlation Analysis

Our study begins by examining the association between demographics and the yield curve, and whether a significant relationship can be observed. This is done by first constructing a zero-coupon yield curve and then estimating a vector autoregression model using macroeconomic variables as controls.

3.1 Data

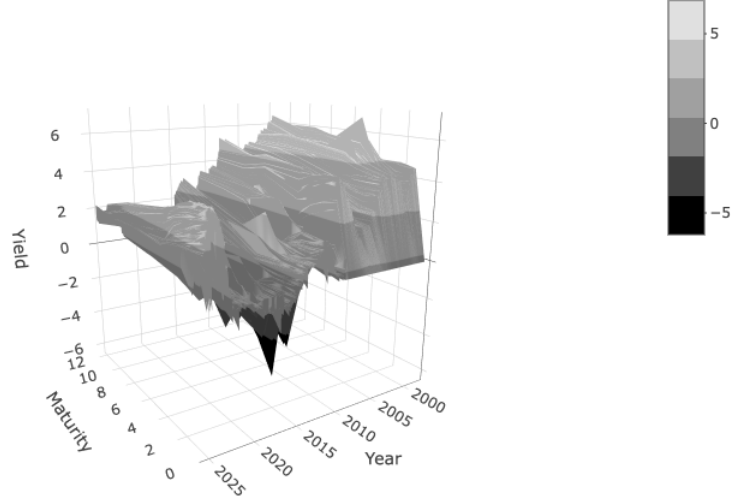
3.1.1 Bills & Bonds

Data on bills and bonds issued by the Kingdom of Sweden is provided by the Riksbank (2025). The yield data provided by the Riksbank includes data on prices, coupons and yields of debt instruments of various maturities. Zero-coupon yields are provided directly for bills with maturities less than one year. For bonds with longer maturities than this, zero-coupon yields are derived using bootstrapping by sequentially solving the following equation for each maturity:

$$P_T = \sum_{t=1}^T \frac{C_t}{(1 + y_t)^t} + \frac{FV_T}{(1 + y_T)^T} \quad (1)$$

where P_T is the current price of a bond with maturity T , C_T is the coupon payment and FV_T is the face value for that bond. y_t is then the zero-coupon

Figure 1: Zero-coupon yield curve for Swedish government debt instruments during the period 1998 to 2025 (Riksbank, 2025). Yield and Maturity are percentages.



yield for maturity t . For maturities where no debt instruments are provided, zero-coupon yields are interpolated linearly. *Figure 1* shows the resulting zero-coupon yield curve.

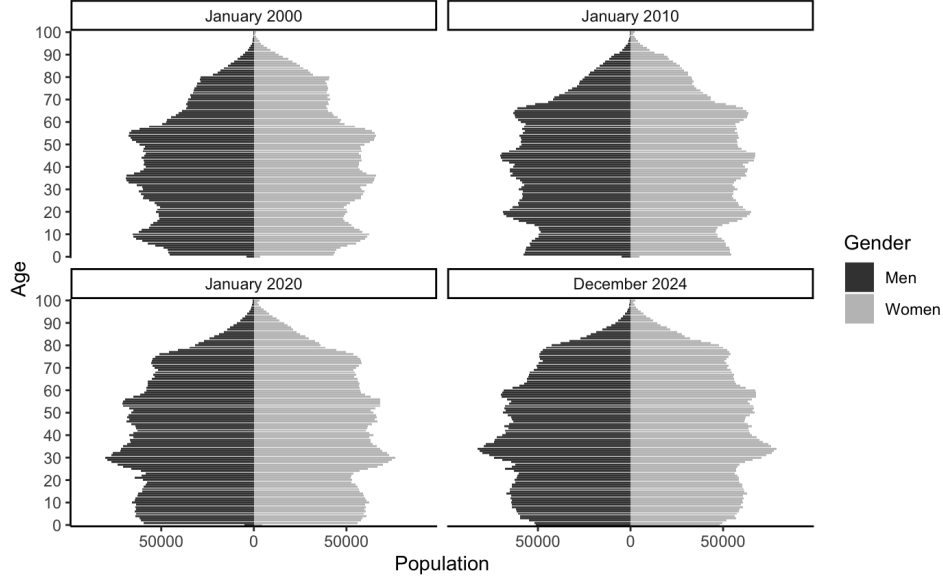
The yield curve shows considerable variation over time, but a generally decreasing trend since the start of the observed period can be seen, reaching negative territory in the mid-2010s. Since around 2020, however, a possible shift in the trend can be noted with increasing interest rates across maturities. Furthermore, the yield curve has been upward sloping for most of the period, as can be expected, but flattening or turning slightly inverted in times of distress. This can be observed somewhat during the 2008 financial crisis, but particularly clearly during the last half-decade.

3.1.2 Demographics

Age structure data is gathered from Statistics Sweden (2025a; 2025b), who provide monthly data on the Swedish population in one-year brackets for each month since January 2000. The so-called population pyramid, describing the population age structure, is shown for various points in time in *Figure 2*.

The most apparent development that can be observed over time is that the pyramid has become wider, indicating a growth in population across different ages. This is especially clear among those 60 years and older where the pyramid has

Figure 2: *Population pyramid of Sweden at particular times (Statistics Sweden, 2025a; 2025b).*



widened substantially over time. Furthermore, the number of newborns has varied, and is currently at a low. This is a result of a varying fertility rate among women in Sweden, which recently reached 1.43 children per woman, the lowest ever recorded (Statistics Sweden, 2025c). The number of people varies across generations, but the magnitudes of both highs and lows have decreased over time, especially since the turn of the millennium, when the last low in fertility rate was observed (Statistics Sweden, 2024).

3.1.3 Macroeconomics

Both the macroeconomic variables used and their labelling stem from the method employed by Ang & Piazzesi (2003), which serves as the basis for our method, and their dataset is replicated using equivalent Swedish metrics. We mainly gather this data from Statistics Sweden (2025d) who provide time series on the consumer price index (CPI), producer price index (PPI), unemployment rate (UE), the number of vacant positions (HELP), the number of employed persons (EMPLOY) and the industrial production (IP) during 2000-2025. Commodity prices (PCOM) are proxied using the S&P GSCI index for the same period, which includes 24 commodities from different sectors (Standard & Poor's, 2025).

3.2 Methodology

The study begins by estimating a term structure model of interest rates using vector autoregression (VAR). This is an established method used by several authors, including Campbell & Shiller (1987), Ang & Piazzesi (2003) and Evans & Marshall (2007). More specifically, we build on the method of Ang & Piazzesi (2003), who model the yield curve of government debt instruments issued by the United States using lagged values of the curve as well as different combinations of macroeconomic variables. We instead apply the model to the yield curve of government debt instruments issued by the Kingdom of Sweden and also add demographic variables to the specification.

The vector autoregression models estimated are generally specified as follows:

$$Z_t = \beta_0 + \beta_1 Z_{t-1} + \beta_2 Z_{t-2} + \cdots + \beta_n Z_{t-n} + \varepsilon_t \quad (2)$$

where Z_{t-n} is the n th lag of the vector of included variables, β_n is the vector of regression coefficients for the n th lag of the vector of included variables and ε_t is the error term.

Specifically, we estimate three models with different variables included in the vector. The first model includes twelve lags of the yield curve and macroeconomic variables. The second model includes twelve lags of the yield curve and demographic variables. The third model includes twelve lags of the yield curve and both macroeconomic and demographic variables.

The yield curve is a vector consisting of zero-coupon yields of debt instruments with maturities of 1 month, 3 month, 6 month as well as 1–10 years in one-year increments, or

$$y_t = [y_{1m}, y_{3m}, y_{6m}, y_{1y}, y_{2y}, \dots, y_{10y}] \quad (3)$$

The macroeconomic variables are divided into two broad categories: variables representing inflation and variables representing real economic activity.

Inflation is a vector consisting of the consumer price index (CPI), the producer price index (PPI) and the price of commodities (PCOM), or

$$I_t = [CPI_t, PPI_t, PCOM_t] \quad (4)$$

Real activity is a vector consisting of the unemployment rate (UE), the number of vacant positions on the job market (HELP), the number of employed persons (EMPLOY), and industrial production (IP), or

$$R_t = [UE_t, HELP_t, EMPLOY_t, IP_t] \quad (5)$$

Demographic variables is a vector consisting of the population (P) divided into brackets of people aged 0-19, 20-69 and 70+, or

$$\Delta = [P_t^{0-19}, P_t^{20-69}, P_t^{70+}] \quad (6)$$

The yield curve is represented using the first three principal components of the vector, which approximately correspond to its level, slope and curvature and explain almost all of its variation. The macroeconomic and demographic variables are represented using the first principal component of each vector respectively, which reduces dimensionality while still capturing the lion's share of the variation.

Formally, the models are specified as follows:

$$Z_{t,k} = \beta_0 + \beta_1 Z_{t-1,k} + \beta_2 Z_{t-2,k} + \dots + \beta_{12} Z_{t-12,k} + \theta_{t,k} \quad (7)$$

where k is the model estimated. 1 indicates the model including the yield curve and the macroeconomic variables, 2 indicates the model including the yield curve and the demographic variables and 3 indicates the model including the yield curve and both the macroeconomic and demographic variables. $\theta_{t,k}$ is the error term.

Formally, the vectors used in each model are defined as follows:

$$Z_{t,1} = [y_t^{PC1}, y_t^{PC2}, y_t^{PC3}, I_t^{PC1}, R_t^{PC1}] \quad (8)$$

$$Z_{t,2} = [y_t^{PC1}, y_t^{PC2}, y_t^{PC3}, \Delta_t^{PC1}] \quad (9)$$

$$Z_{t,3} = [y_t^{PC1}, y_t^{PC2}, y_t^{PC3}, I_t^{PC1}, R_t^{PC1}, \Delta_t^{PC1}] \quad (10)$$

3.3 Results

Table 1 shows the output of the vector autoregression of only inflation and real activity on the first three principal components of the yield curve using twelve lags. The results indicate a statistically significant effect of 0.100 of *Inflation* at time $t - 1$ on the first principal component of the yield curve, i.e. the level. In other words, the inflation in one month seems to have a positive effect on the level of the yield curve in the following month. This is in line with the general understanding of conventional monetary policy, that high inflation is followed by hikes in policy rates. Other lags of *Inflation* do not appear to have an effect on any of the first three principal components of the yield curve, nor do any lags of *Real Activity*.

Table 1: Vector autoregression of inflation and real activity on the first three principal components of the yield curve using twelve lags. Autoregressive components included for control purposes are omitted from the displayed output for clarity.

	Inflation			Real Activity		
	PC1	PC2	PC3	PC1	PC2	PC3
t - 1	0.100*** (0.032)	0.008 (0.012)	-0.001 (0.015)	-0.00002 (0.00002)	0.00000 (0.00001)	0.00000 (0.00001)
t - 2	-0.037 (0.047)	0.012 (0.018)	-0.021 (0.022)	0.00002 (0.00003)	-0.00001 (0.00001)	0.00000 (0.00001)
t - 3	-0.025 (0.047)	-0.017 (0.018)	0.004 (0.022)	-0.00002 (0.00003)	0.00000 (0.00001)	0.00001 (0.00001)
t - 4	-0.043 (0.047)	0.013 (0.017)	0.026 (0.021)	0.00000 (0.00003)	0.00001 (0.00001)	-0.00002 (0.00001)
t - 5	-0.002 (0.047)	-0.006 (0.018)	-0.007 (0.021)	0.00002 (0.00003)	-0.00001 (0.00001)	0.00001 (0.00001)
t - 6	0.044 (0.047)	-0.002 (0.017)	-0.010 (0.021)	-0.00001 (0.00003)	0.00000 (0.00001)	0.00000 (0.00001)
t - 7	-0.014 (0.046)	-0.011 (0.017)	0.005 (0.021)	-0.00003 (0.00003)	0.00001 (0.00001)	0.00000 (0.00001)
t - 8	0.021 (0.045)	0.016 (0.017)	0.006 (0.021)	0.00001 (0.00003)	-0.00000 (0.00001)	-0.00001 (0.00001)
t - 9	-0.030 (0.046)	-0.022 (0.017)	-0.024 (0.021)	0.00001 (0.00003)	0.00000 (0.00001)	0.00001 (0.00001)
t - 10	0.036 (0.046)	0.007 (0.017)	0.010 (0.021)	0.00002 (0.00002)	0.00001 (0.00001)	-0.00002 (0.00001)
t - 11	-0.079* (0.047)	0.001 (0.018)	0.024 (0.022)	0.00001 (0.00002)	-0.00000 (0.00001)	-0.00000 (0.00001)
t - 12	0.032 (0.034)	0.010 (0.013)	-0.007 (0.016)	-0.00002 (0.00002)	0.00000 (0.00001)	0.00000 (0.00001)
Intercept	-1.533 (2.361)	-3.042*** (0.887)	-0.708 (1.085)	-1.533 (2.361)	-3.042*** (0.887)	-0.708 (1.085)
Observations	160	160	160	160	160	160
R ²	0.962	0.955	0.768	0.962	0.955	0.768
Adjusted R ²	0.939	0.928	0.628	0.939	0.928	0.628
Residual Std. Error (df = 99)	1.272	0.478	0.585	1.272	0.478	0.585
F Statistic (df = 60; 99)	42.116***	35.008***	5.472***	42.116***	35.008***	5.472***

Note:

*p<0.1; **p<0.05; ***p<0.01

Table 2: Vector autoregression of demographics on the first three principal components of the yield curve using twelve lags. Autoregressive components included for control purposes are omitted from the displayed output for clarity.

	<i>Dependent variable:</i>		
	Demographics		
	PC1	PC2	PC3
t - 1	0.00000 (0.00002)	-0.00001 (0.00001)	-0.00001 (0.00001)
t - 2	-0.00002 (0.00003)	0.00001 (0.00001)	-0.00000 (0.00001)
t - 3	0.00002 (0.00003)	0.00000 (0.00001)	0.00001 (0.00001)
t - 4	-0.00001 (0.00003)	-0.00001 (0.00001)	-0.00000 (0.00001)
t - 5	-0.00000 (0.00003)	0.00000 (0.00001)	0.00001 (0.00001)
t - 6	0.00000 (0.00003)	-0.00000 (0.00001)	-0.00000 (0.00001)
t - 7	0.00002 (0.00003)	0.00001 (0.00001)	-0.00002 (0.00001)
t - 8	-0.00001 (0.00003)	0.00000 (0.00001)	0.00002** (0.00001)
t - 9	-0.0001* (0.00003)	-0.00002** (0.00001)	-0.00000 (0.00001)
t - 10	0.00003 (0.00003)	0.00001 (0.00001)	0.00000 (0.00001)
t - 11	0.00000 (0.00003)	0.00001 (0.00001)	-0.00001 (0.00001)
t - 12	0.00002 (0.00002)	-0.00001 (0.00001)	-0.00000 (0.00001)
Intercept	3.179 (10.488)	-12.139*** (3.534)	0.552 (4.689)
Observations	167	167	167
R ²	0.958	0.954	0.718
Adjusted R ²	0.940	0.936	0.604
Residual Std. Error (df = 118)	1.327	0.447	0.593
F Statistic (df = 48; 118)	55.415***	51.168***	6.265***

Note:

*p<0.1; **p<0.05; ***p<0.01

Table 3: Vector autoregression of demographics, inflation and real activity, on the first three principal components of the yield curve using twelve lags. Autoregressive components included for control purposes are omitted from the displayed output for clarity.

	Demographics			Inflation			Real Activity		
	PC1	PC2	PC3	PC1	PC2	PC3	PC1	PC2	PC3
t - 1	0.00002 (0.00003)	-0.00001 (0.00001)	-0.00001 (0.00001)	0.070** (0.035)	0.007 (0.013)	0.005 (0.017)	-0.00000 (0.00002)	-0.00001 (0.00001)	-0.00000 (0.00001)
t - 2	-0.00003 (0.00004)	0.00001 (0.00001)	0.00002 (0.00002)	-0.007 (0.051)	0.019 (0.019)	-0.031 (0.024)	0.00001 (0.00003)	-0.00001 (0.00001)	0.00001 (0.00001)
t - 3	0.00001 (0.00003)	0.00001 (0.00001)	0.00001 (0.00002)	-0.010 (0.049)	-0.023 (0.018)	0.004 (0.024)	-0.00002 (0.00003)	0.00001 (0.00001)	0.00001 (0.00001)
t - 4	0.00002 (0.00003)	-0.00001 (0.00001)	-0.00002 (0.00002)	-0.087* (0.049)	0.007 (0.018)	0.042* (0.023)	0.00002 (0.00003)	0.00000 (0.00001)	-0.00002* (0.00001)
t - 5	-0.00005 (0.00004)	-0.00000 (0.00001)	0.00003 (0.00002)	0.024 (0.049)	-0.001 (0.018)	-0.021 (0.024)	0.00002 (0.00003)	-0.00002 (0.00001)	0.00001 (0.00001)
t - 6	0.00002 (0.00003)	-0.00000 (0.00001)	-0.00001 (0.00002)	0.042 (0.048)	0.005 (0.018)	-0.015 (0.023)	-0.00001 (0.00003)	0.00000 (0.00001)	0.00001 (0.00001)
t - 7	-0.00001 (0.00003)	0.00002 (0.00001)	-0.00002 (0.00001)	-0.018 (0.047)	-0.017 (0.018)	0.021 (0.023)	-0.00003 (0.00003)	0.00002 (0.00001)	-0.00000 (0.00001)
t - 8	0.00001 (0.00003)	-0.00000 (0.00001)	0.00001 (0.00001)	0.021 (0.045)	0.011 (0.017)	0.002 (0.022)	0.00003 (0.00003)	-0.00001 (0.00001)	0.00002* (0.00001)
t - 9	-0.0001** (0.00003)	-0.00002* (0.00001)	0.00001 (0.00002)	-0.012 (0.046)	-0.014 (0.017)	-0.027 (0.022)	-0.00002 (0.00003)	-0.00001 (0.00001)	0.00002* (0.00001)
t - 10	0.00003 (0.00003)	0.00001 (0.00001)	-0.00001 (0.00002)	0.038 (0.047)	0.003 (0.017)	0.003 (0.022)	0.00002 (0.00003)	0.00001 (0.00001)	-0.00001 (0.00001)
t - 11	0.00005 (0.00003)	0.00001 (0.00001)	-0.00002 (0.00002)	-0.088* (0.048)	0.005 (0.018)	0.028 (0.023)	0.00003 (0.00003)	0.00000 (0.00001)	-0.00002 (0.00001)
t - 12	-0.00002 (0.00003)	-0.00000 (0.00001)	0.00002 (0.00001)	0.051 (0.036)	0.006 (0.013)	-0.005 (0.017)	-0.00002 (0.00002)	-0.00000 (0.00001)	0.00001 (0.00001)
Intercept	46.368** (22.198)	-18.934** (8.311)	-7.555 (10.584)	46.368** (22.198)	-18.934** (8.311)	-7.555 (10.584)	46.368** (22.198)	-18.934** (8.311)	-7.555 (10.584)
Observations	160	160	160						
R ²	0.969	0.963	0.794						
Adjusted R ²	0.943	0.932	0.623						
Residual Std. Error (df = 87)	1.235	0.462	0.589						
F Statistic (df = 72; 87)	37.466***	31.375***	4.643***						

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2 shows the output from the vector autoregression of only demographics on the first three principal components of the yield curve using twelve lags. The results indicate no clear effects of *Demographics* on any of the first three principal components of the yield curve. There are some statistically significant coefficients, but they are very small in magnitude and there is no clear underlying economic intuition for why specifically those lags should have an effect on the yield curve and no other. As such, they seem to be spurious and not easily interpretable.

Table 3 shows the output from the vector autoregression of both inflation, real activity and demographics on the first three principal components of the yield curve using twelve lags. The results indicate that the *Inflation* variable at the time $t - 1$ still has a positive and statistically significant effect on the first principal component of the yield curve when controlling for demographics, albeit slightly smaller in magnitude at 0.070. Other than this, no clear effects can be distinguished. The statistically significant effects of demographics seen in *Table 2* remain in part statistically significant when controlling for macroeconomic variables. Some new statistically significant coefficients do appear, but these are likewise small in magnitude and without economic intuition. As such, we leave them without further consideration.

4 Causality Analysis

Our study continues by investigating the causal relationship between demographics and the yield curve by examining two shocks to the population of Sweden during the 2000s. The first shock examined is the large spike in the number of asylum seekers in the mid-2010s. This influenced the age structure through adding mainly younger people to the population of Sweden. The second shock examined is the covid-19 pandemic in the early 2020s. This influenced the age structure through removing mainly older people from the population.

4.1 Data

Data on asylum seekers comes from Statistics Sweden (2025e; 2025f), who provide monthly data during 2000-2025 on the total number of asylum seekers to Sweden as well as the number of unaccompanied minors.

The evolution of the total number of asylum seekers over time is shown in *Figure 3*. The number of asylum seekers above 18 years old is then estimated as the difference between the total number of asylum seekers and the total number of unaccompanied minors between 0-17 years old and shown in *Figure 4*. Monthly data is unavailable for 2008. As such, a gap is observable in the plots.

Figure 3: *Total asylum seekers of all ages to Sweden during 2000-2025 (Statistics Sweden, 2025e).*

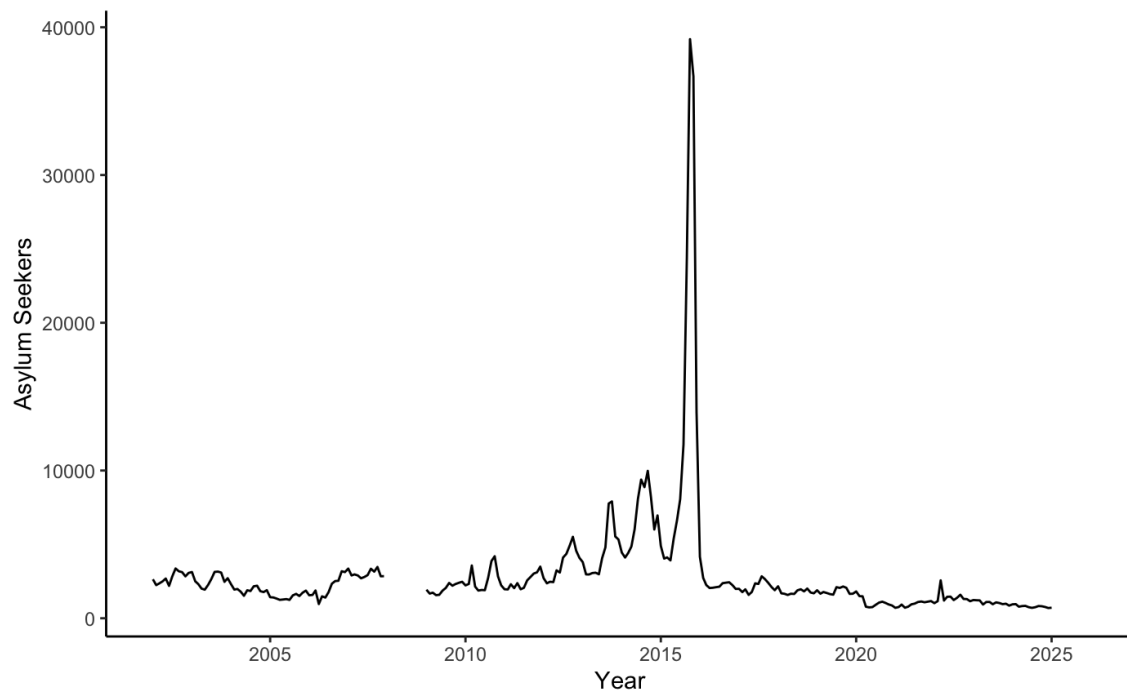
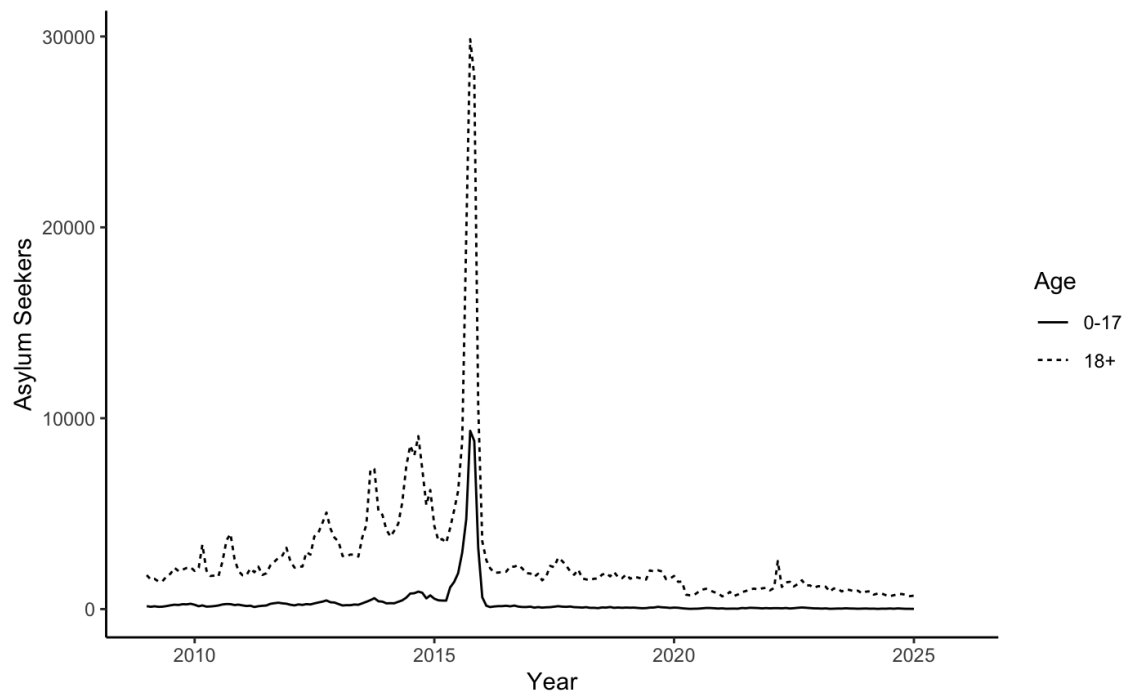


Figure 4: *Asylum seekers of different ages to Sweden during 2000-2025 (Statistics Sweden, 2025f).*



As can be seen in *Figure 3*, the number of asylum seekers remained relatively stable until 2010. Thereafter, a gradual upward trend can be observed with apparent seasonal variation. A clear break in the trend is seen in late 2015, with a spike of almost 40 000 asylum seekers in just one month in October 2015. Since then, the number of asylum seekers has been relatively constant with a slight downward trend until present.

The estimated number of asylum seekers older than 18 years shown in *Figure 4* closely follows the total number of asylum seekers shown in *Figure 3*. The number of unaccompanied minors aged 0-17 remains practically insignificant both before and after 2015. In 2015, however, the group made up a sizable share of the total number of asylum seekers, with a peak of just shy of 10 000 unaccompanied minors in just one month in October 2015.

The number of covid-19 deaths is sourced from the National Board of Health and Welfare (NBHW, 2025), who provide weekly data for different age brackets during the period March 2020 to March 2022. To conform with other data sets described above, the data is aggregated on a monthly level. The resulting time series are shown in *Figure 5*.

This plot clearly shows that almost all covid-19 deaths occurred among people aged 70 or older and almost none among people aged 0-19. Among people aged 20-69, some deaths can be observed, but they are marginal in comparison to the older age bracket. A clear seasonality can be seen, where the number of deaths spike during the winter months to then decline during the summer and early autumn.

4.2 Methodology

The potential of a causal relationship between demographics and the yield curve is examined using an instrumental variables (IV) model estimated using three-stage least-squares (3SLS) regression of the yield curve on the age structure of the population using the shocks as instruments.

The yield curve is a vector consisting of zero-coupon yields for maturities of 1 month, 3 month, 6 month as well as 1–10 years in one year increments, or

$$y_t = [y_{1m}, y_{3m}, y_{6m}, y_{1y}, y_{2y}, \dots, y_{10y}] \quad (11)$$

Demographic variables is a vector consisting of the number of people in different age brackets in the population (P). For the analysis of the covid-19 shock, the population is divided into brackets of people aged 0-19, 20-69 and 70+, or

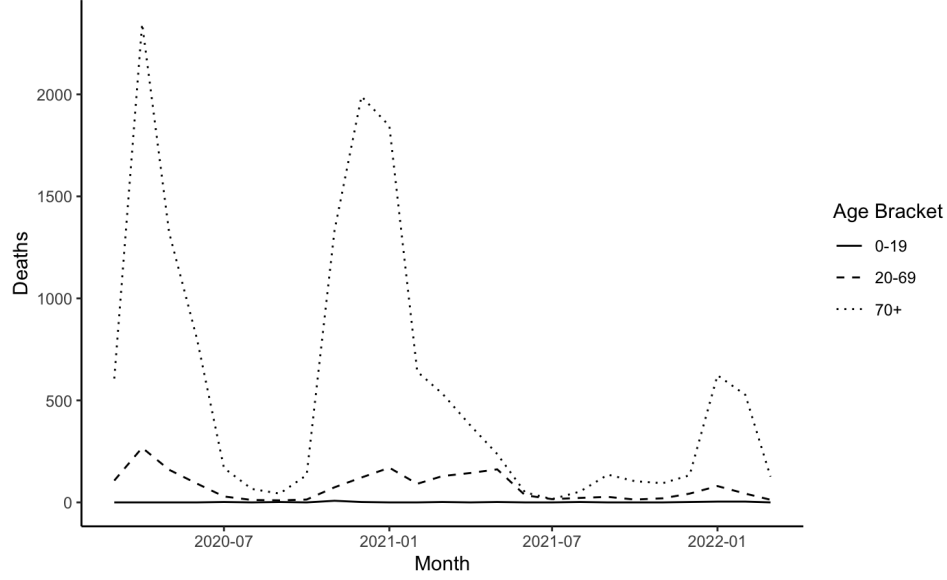
$$\Delta_1 = [P_t^{0-19}, P_t^{20-69}, P_t^{70+}] \quad (12)$$

For the analysis of the migration shock, the population is divided into brackets of people aged 0-17 and 18+, or

$$\Delta_2 = [P_t^{0-17}, P_t^{18+}] \quad (13)$$

The instrument is a vector consisting of the exogenous change in the population of

Figure 5: Covid-19 deaths in different age brackets during March 2020 to March 2022 (NBHW, 2025)



different ages. For the analysis of the covid-19 shock, the instrument is the number of people aged 0-20, 21-69 and 70+ who died with covid-19, or

$$z_t^1 = [D_t^{0-20}, D_t^{21-69}, D_t^{70+}] \quad (14)$$

For the analysis of the migration shock, the instrument is the number of asylum seekers to Sweden aged 0-17 and 18+, or

$$z_t^2 = [A_t^{0-17}, A_t^{18+}] \quad (15)$$

In addition, the same macroeconomic variables used in the correlation analysis are used as controls.

The IV models estimated are then formally specified as follows:

$$\Delta_t^m = \gamma_0 + \gamma_1 z_t^m + I_t^{PC1} + R_t^{PC1} + \gamma_t \quad (16)$$

$$[y_t^{PC1}, y_t^{PC2}, y_t^{PC3}] = \zeta + \zeta_1 \hat{\Delta}_t^m + I_t^{PC1} + R_t^{PC1} + \xi_t \quad (17)$$

where m is the shock used, 1 for the covid-19 shock and 2 for the migration shock.

λ_t and ξ_t are error terms.

4.3 Results

Table 4 shows the output from the three-stage least-squares (3SLS) regression of the first three principal components of the yield curve on the age structure of the population using covid-19 deaths as instruments. The results indicate that the demographic change caused by covid-19 deaths had no statistically significant impact on any of the first three principal components of the yield curve.

Table 4: *Three-stage least-squares (3SLS) regression of the first three principal components of the yield curve on the age structure of the population using covid-19 deaths as instruments.*

	<i>Dependent variable:</i>		
	PC1	PC2	PC3
0-19 years	−0.00026 (0.00059)	−0.00010 (0.00017)	0.00027 (0.00050)
20-69 years	0.00035 (0.00072)	0.00011 (0.00021)	−0.00033 (0.00061)
70+ years	−0.00033 (0.00070)	−0.00012 (0.00021)	0.00034 (0.00059)
Intercept	−1833.60434 (3715.91581)	−550.55547 (1097.04584)	1693.57747 (3145.87944)
Observations	75	75	75
R ²	−5.21033	−2.50909	−7.79947
Adjusted R ²	−6.09752	−3.01039	−9.05653
<i>Note:</i> *p<0.1; **p<0.05; ***p<0.01			

Table 5 shows the three-stage least-squares (3SLS) regression of the first three principal components of the yield curve on the age structure of the population using asylum seekers as instruments. The results indicate that the demographic change caused by asylum seekers also had no statistically significant impact on any of the first three principal components of the yield curve. As such, the results of these regressions do not support the notion that demographics have an effect on the yield curve.

Table 5: *Three-stage least-squares (3SLS) regression of the first three principal components of the yield curve on the age structure of the population using asylum seekers as instruments.*

	<i>Dependent variable:</i>		
	PC1	PC2	PC3
0-17 years	0.00016 (0.00013)	0.00004 (0.00003)	0.00000 (0.00001)
18+ years	−0.00005 (0.00003)	−0.00001 (0.00001)	−0.00000 (0.00000)
Intercept	77.79493** (33.74822)	−15.01202 (8.61603)	3.98179 (3.26373)
Observations	792	792	792
R ²	−3.19452	−1.91248	−0.23498
Adjusted R ²	−3.22666	−1.93480	−0.24444
<i>Note:</i> *p<0.1; **p<0.05; ***p<0.01			

5 Discussion

5.1 Findings

The overarching theme of the results suggests that demographics cannot explain the yield curve. This may be the result of a range of causes. The two demographic events examined are shocks in the sense that they represent large deviations from the long-term average trend in each variable, as seen in *Figure 3* and *Figure 5*. However, the effect on the overall population is comparatively modest, as seen in *Figure 2*. The population pyramids for January 2010 and January 2020 show the age structure before and after the mid-2010s migration shock. A clear trough can be seen for ages around 10 in January 2010. In January 2020, this trough, now around age 20, has been somewhat filled by a small peak for men, but the overall shape of the population pyramid remains the same. The population pyramids for January 2020 and December 2024 show the age structure before and after the covid-19 shock. When comparing the age structure, particularly among the elderly, no apparent difference can be seen. This may help explain the lack of significant effect, as the shocks observed may not have been large enough to have a meaningful impact.

Furthermore, the constructed yield curve only includes zero-coupon yields for maturities of up to ten years. This is a result of lack of data since yields for maturities longer than ten years have not been able to be obtained. Since the age structure of the population is slow-changing, as seen in *Figure 2*, any effects may

only show up at the far end of the yield curve. This may explain why no significant effect can be observed in the 10-year yield curve constructed.

Related to this, examining changes over a twelve month period, as is done in the method of Ang & Piazzesi (2003) that we employ, may not be enough to capture long-term effects. Alternative model specifications include using more lags or averaging variables over longer time periods. We have opted not to employ such methods to stay consistent with the existing literature on the subject, but invite future research to explore other options.

5.2 Robustness

The results of the correlation analysis show a statistically significant effect of inflation on the level of the yield curve, both with only macroeconomic factors and when adding demographic factors. In addition to the statistical significance, the direction of the estimates are also as anticipated. Positive estimates, as the ones observed, indicate that high inflation is followed by increases in the overall level of the yield curve. This is to be expected from conventional economic theory, which speaks for the ability of the model to capture effects that are present.

When estimating IV models, as done in the causality analysis, one must ensure that the relevance and exclusion restrictions hold. Firstly, the relevance criterion stipulates that the instrument, in our case the number of asylum seekers or the number of covid-19 deaths, must correlate with the endogenous variable, in our case the age structure of the population. This is likely to hold since both asylum seekers and covid-19 deaths directly affect the age structure. Secondly, the exclusion restriction stipulates that the instrument cannot affect the outcome variable in any other way than through the endogenous variable. This is also likely to hold since the mere action of handing in an asylum application is unlikely to affect the interest rates of government debt, and thereby also the yield curve, in any other way than through becoming part of the population and changing the demographic structure. We contend that the same holds for covid-19 deaths. While the change in the demographics may in turn affect the yield curve through different channels, this is not an issue since those effects are downstream of the instrument, and therefore do not violate the exclusion restriction.

5.3 Previous Research

In relation to previous research findings, the results show little significant effects and thus are not contradictory to the expectations hypothesis proposed by Macaulay (1938). This is in stark contrast to the findings of Ang & Piazzesi (2003), who find that macro factors explain a large part of the variation seen in bond yields, indicating that risk premia are an important part in explaining the yield curve. This could be due to several reasons, including the method and data used. For instance, they use data on the United States, which we have attempted to replicate as closely as possible using available Swedish data. However, specific definitions and measurement methods may differ between the two countries, which could affect

the results.

On a theoretical level, changes to the demographic structure of a population are thought to affect many important factors in the economy, including the yield curve. The main way this occurs is through changes in the labour supply. The two demographic shocks observed largely affected the population of the youth and elderly respectively, and may therefore not have had a meaningful immediate effect on the labour supply. Younger asylum seekers were still of school age and therefore unable to work. Even older asylum seekers may not have immediately been able to join the labour supply due to language and other labour market barriers. For the elderly who died during the covid-19 pandemic, most were above 70 years of age and thus likely had already left the workforce. This could help explain why the two demographic shocks observed do not seem to have affected the yield curve, even though it may have been expected. Our findings are more in line with Poterba (2001), who finds that most measures of demographic structure do not significantly correlate with asset returns.

An underlying assumption of our method has been that the effect of demographics on the yield curve occurs through impact on duration risk or market appetite for risk. An alternative channel for the effect could be through market segmentation, where investors of different ages demand yields of differing maturities. For instance, the older segment of the population is closer to retirement and may thus demand shorter yields, while the youth are far from retirement and may thus demand longer yields. This is something that our model would not be able to capture, but is an interesting theory to explore for future research.

6 Conclusion

This paper examines the relationship between demographics, more specifically the age structure, and the yield curve. This is done in a Swedish setting during the first two and a half decades of the 2000s. During this period, Sweden has experienced two exogenous shocks to its demographics, namely the large influx of asylum seekers during the mid-2010s and the covid-19 pandemic during the early 2020s. We begin by examining the relationship using vector autoregression, controlling for macro variables, in an attempt to find correlation. We then utilise the two shocks during the period as exogenous variation to perform an instrumental variable analysis in an attempt to establish causality.

Neither analysis presents evidence for an effect of demographics on the yield curve. Possible reasons for this include that the shocks may not be large enough to make a meaningful impact or that they do not immediately affect the labour supply, that the effects are long-term and cannot be captured using the available data or method employed. Another explanation is that the effect of demographics on the yield curve does not present itself as a risk premium, but rather as market segmentation. We invite future research to further explore these possibilities or other factors that may better explain the yield curve.

References

- Abel, A. B. (2001). Will Bequests Attenuate the Predicted Meltdown in Stock Prices When Baby Boomers Retire? *The Review of Economics and Statistics*, 83(4), 589-595. DOI 10.1162/003465301753237678
- Ang, A., & Maddaloni, A. (2003). Do Demographic Changes Affect Risk Premiums? Evidence from International Data. DOI 10.3386/w9677
- Ang, A., & Piazzesi, M. (2003). A no-arbitrage vector autoregression of term structure dynamics with macroeconomic and latent variables. *Journal of Monetary Economics*, 50(4), 745-787. DOI 10.1016/S0304-3932(03)00032-1
- Bignami, S., Endrich, M., Natale, F., & Ueffing, P. (2024). *Low Fertility in the EU: A Review of Trends and Drivers*. European Commission - JRC Publications Repository. <https://publications.jrc.ec.europa.eu/repository/handle/JRC137492>
- Campbell, J. Y. (1987). Cointegration and Tests of Present Value Models. *Journal of Political Economy*, 95(5), 1062-1088. DOI 10.1086/261502
- Campbell, J. Y., & Shiller, R. J. (1991). Yield Spreads and Interest Rate Movements: A Bird's Eye View. *The Review of Economic Studies*, 58(3), 495-514. DOI 10.2307/2298008
- Crimmins, E. M. (2015). Lifespan and Healthspan: Past, Present, and Promise. *The Gerontologist*, 55(6), 901-911. DOI 10.1093/geront/gnv130
- Evans, C. L., & Marshall, D. A. (2007). Economic determinants of the nominal treasury yield curve. *Journal of Monetary Economics*, 54(7), 1986-2003. DOI 10.1016/j.jmoneco.2006.12.015
- Froot, K. A. (1989). New Hope for the Expectations Hypothesis of the Term Structure of Interest Rates. *Journal of Finance*, 44(2), 283-305. DOI 10.1111/j.1540-6261.1989.tb05058.x
- Ilmanen, A. (2011). *Expected Returns: An Investor's Guide to Harvesting Market Rewards*. John Wiley & Sons, Incorporated.
- Krishnamurthy, A. (2002). The bond/old-bond spread. *Journal of Financial Economics*, 66(2-3), 463-506. DOI 10.1016/S0304-405X(02)00207-6
- Macaulay, F. (1938). *Some Theoretical Problems suggested by The Movement of Interest Rates, Bond Yields and Stock Prices in the United States since 1856* (General Series ed., Vol. 33). National Bureau of Economic Research.
- Malthus, T. (1798). *An Essay on the Principle of Population* (Electronic Scholarly Publishing Project ed.). J. Johnson, in St. Paul's Church-Yard. <http://www.esp.org/books/malthus/population/malthus.pdf>

- McCandless, G. T., & Wallace, N. (1991). *Introduction to Dynamic Macroeconomic Theory: An Overlapping Generations Approach*. Harvard University Press.
- National Board of Health and Welfare. (2024). *Statistik om döda i covid-19 och influensa*. <https://www.socialstyrelsen.se/statistik-och-data/statistik/alla-statistikamnen/lagesbild-covid-19-influensa-och-rs-statistik/statistik-om-doda-covid-19-influensa-och-rs-virus/>
- O'Neill, A. (2024). *Global population 10,000BCE-2100*. Statista. <https://www.statista.com/statistics/1006502/global-population-ten-thousand-bc-to-2050/>
- Piazzesi, M. (2010). CHAPTER 12 - Affine Term Structure Models. In *Handbook of Financial Econometrics: Tools and Techniques* (Vol. 1, pp. 691-766). Elsevier B.V. DOI 10.1016/B978-0-444-50897-3.50015-8
- Piazzesi, M., & Schneider, M. (2006). Equilibrium Yield Curves [with Comments and Discussion]. *NBER Macroeconomics Annual*, 21, 389-457, 459-472. DOI 10.1086/ma.21.25554958
- Poterba, J. M. (2001). Demographic Structure and Asset Returns. *The Review of Economics and Statistics*, 83(4), 565-584.
- Riksbank. (2025). *Swedish Benchmark Treasury Bills and Government Bonds* (L. Strand, Ed.).
- Rudebusch, G. D., & Swanson, E. T. (2012). The Bond Premium in a DSGE Model with Long-Run Real and Nominal Risks. *American Economic Journal: Macroeconomics*, 4(1), 105-143. DOI 10.1257/mac.4.1.105
- Smith, A. (1776). *The Wealth of Nations* (T. Darnell, Ed.).
- Solow, R. M. (1999). Chapter 9 Neoclassical growth theory. In *Handbook of Macroeconomics* (A ed., Vol. 1, pp. 637-667). Elsevier B.V. DOI 10.1016/S1574-0048(99)01012-5
- S&P GSCI Commodity Index* [January 2000 – January 2025.]. (2025). Standard & Poor's.
- Statistics Sweden. (2024). *Historiskt lågt barnafödande och lägsta folkökningen på 22 år*. Statistics Sweden. from <https://www.scb.se/pressmeddelande/antal-fodda-barn-per-kvinna-i-sverige-nar-ny-lagstaniva/>
- Statistics Sweden. (2025c). *Antal födda barn per kvinna i Sverige når ny lägstanivå*. Statistics Sweden. <https://www.scb.se/pressmeddelande/antal-fodda-barn-per-kvinna-i-sverige-nar-ny-lagstaniva/>
- Statistics Sweden. (2025e). *Asylum-seekers by country of citizenship and sex. Month, quarter, half year, whole year. Year 2002 - 2025*. Statistical database. https://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101P/AsylsokandeN/

- Statistics Sweden. (2025b). *Population per month by region, age and sex. Year 2000M01 - 2024M12*. Statistical Database. https://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101A/BefolkManad/
- Statistics Sweden. (2025a). *Population per month by region, age and sex. Year 2025M01 - 2025M02*. Statistical Database. https://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101A/BefolkManadCKM/
- Statistics Sweden. (2025d). *Statistical database*. Statistical database. <https://www.statistikdatabasen.scb.se/pxweb/en/ssd/>
- Statistics Sweden. (2025f). *Unaccompanied asylum-seeking minors by sex, age, citizenship. Month, quarter, half year, whole year. Year 2002 - 2025*. Statistics Database. https://www.statistikdatabasen.scb.se/pxweb/en/ssd/START_BE_BE0101_BE0101P/EnsamkommandeN/
- United Nations. (2024a). *Leaving No One Behind In An Ageing: World Social Report 2023*. United Nations. <https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2023/01/2023wsr-chapter2.pdf>
- United Nations. (2024b). *World Population Prospects 2024: Summary of Results — DESA Publications*. Publications — UN DESA Publications. <https://desapublications.un.org/publications/world-population-prospects-2024-summary-results>
- United Nations. (2025). *World Fertility Report 2024*. United Nations. https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/undesapd_2025_wfr-2024_advance-unedited.pdf
- Vila, J.-L., & Vayanos, D. (2021). A Preferred-Habitat Model of the Term Structure of Interest Rates. *Econometrica*, 89(1), 77-112. DOI 10.3982/ECTA17440
- Wachter, J. A. (2006). A consumption-based model of the term structure of interest rates. *Journal of Financial Economics*, 79(2), 365-399. DOI 10.1016/j.jfineco.2005.02.004