# Inexorable

## The drivers of long-term interest rates and the political solution for eliminating sovereign debt defaults

By

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## *Abstract*

The purpose of this thesis is to explore the drivers behind long-term interest rates. This thesis aims to explain the evolution of long-term interest rates, which – upon closer examination – exhibit multi-decade oscillations. The thesis makes use of various statistical methods, including correlations, linear regressions, and time series analysis. The major finding of this thesis is that there is a significant risk of long-term interest rates rising in the future, which would entail sovereign debt defaults. This is due to three primary factors: the velocity of money, the aging of the population, and rising oil prices. This thesis proposes a solution to mitigate that risk in the form of GDP shares, known as *trills*.

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## Introduction

The *puzzle* which this thesis seeks to address is the striking multi-decade cyclicality of nominal long-term interest rates. I address this puzzle theoretically with the concept of feedback loops. The *structure* of this thesis will be split into several main parts. A literature review chapter of the empirical and theoretical work which has been done on the drivers of long-term interest rates is provided. The second chapter is dedicated to describing how bond markets work. Moreover, the second chapter analyzes the historical oscillations in long-term interest rates. It further goes on analyze if and how the government can control or manipulate long-term interest rates. Lastly, the second chapter explains the historical oscillations in long-term interest rates using the concept of feedback loops.

The third chapter is dedicated to analyzing precipitating factors, or independent variables, which may influence long-term interest rates going forward. These are the velocity of money, the aging of the population, and dwindling oil reserves. Moreover, a significant portion of the third chapter is dedicated to statistical work done on the price of oil and the price of gold. This thesis hypothesizes that there is an institutional link between the two variables. The fourth chapter of this thesis deals with a potential solution that could mitigate the adverse consequences of potentially rising long-term interest rates. It stressed the fact that the alternative, namely fiscal consolidation, has a poor track record in preventing sovereign debt defaults. The concluding chapter provides an overview of the thesis and discusses its various limitations.

# Chapter 1: Literature Review

## *1.1 Empirical*

The most comprehensive work on the history of interest rates has been done by Sidney Homer and Richard Sylla in *A History of Interest Rates* (Homer and Sylla 2005). The book chronicles interest rates from their first known records in ancient times (Sumer, Babylonia, Assyria, Egypt, Greece, and Rome). It further goes on to chronicle interest rates over the Dark Ages, the medieval period, and the Renaissance. Due to a relative abundance of data throughout the 20th century, the last part of the book is by far the richest in detail and data. It discusses interest rates throughout Switzerland, France, England, Netherlands, Scandinavia, Ireland, Turkey, Iberia, Austria, Italy, Japan, Russia, China, Latin America, and the Old Sterling Area throughout the course of the 20th century. While this thesis relies on numerous sources, the richest work with regards to the history of interest rates is certainly the aforementioned one by Sidney Homer and Richard Sylla.

### 1. 1. 1 Ancient Times

Ancient history is littered with examples of political leaders imposing wage and price controls (Schuettinger 1979). This holds just as well for interest rates, if one were to think of interest rates as prices. In fact, it is in large part thanks to political leaders in the past having set arbitrary maximum limits on interest rates that we have any records of interest rates from the ancient world (Homer and Sylla 2005, 3). Despite having only records of price controls in the form of limits on interest rates throughout much of history, those price ceilings are still quite telling of what the situation was like at any given time and place. The reason for this is that the limits on interest rates had to resemble some sort of reality of what was an acceptable amount of interest to charge. As an analogy, if the minimum wage were to be set significantly above the market equilibrium, it would simply lead to mass unemployment. Likewise, but in reverse, if the maximum rate of interest were

to be set significantly below the market equilibrium, it would likely lead to a drying up of credit or to a thriving black market.

In roughly 1800 B.C., the Code of Hammurabi set a maximum rate of interest of 20% per annum for loans of silver and 33⅓% per annum for loans of grain (Viel 2011). This can be contrasted to the Law of the Twelve Tables, which served as the foundation of Roman law and which set a maximum rate of interest at 8⅓% per annum in roughly 450 B.C. (Constitution n.d.). Undoubtedly, the Romans were wealthier than the ancient Babylonians and therefore it is unsurprising that the maximum rates were much higher under Hammurabi. The reasoning behind this is that relatively wealthy countries tend to have relatively lower interest rates, a phenomenon that will be elaborated on in the theoretical literature review on interest rates within this thesis.

The first known productive assets were cattle and grain. Therefore, it is no coincidence that Sumerians used the word *mas* for both interest and calves (Homer and Sylla 2005, 20). As cattle and grain became available to some beyond subsistence, they also provided a form of primitive money which in turn allowed them to be loaned out at interest and to serve as a prerequisite for economic calculation[1]. This phenomenon could be observed as late as the 20th century in Northern Siberia, where domesticated reindeer served as money and loans were granted in reindeer (Einzig 1948, 117). The caveat, however, is that all civilizations capable of recording and preserving their own history were already highly advanced. It is important to keep in mind that the 5,000 years or



[1] During the Paleolithic Age (~10,000 B.C.) European and Asiatic tribes bartered, possibly using some commodities like sea shells as a medium of exchange; the discoveries of shell hoards ranging from Switzerland to the Red Sea suggest this could have been the case (Heichelheim 1958, 21).

so of written history which is available to us represents less than 10% of actual human history (Graeber 2011).

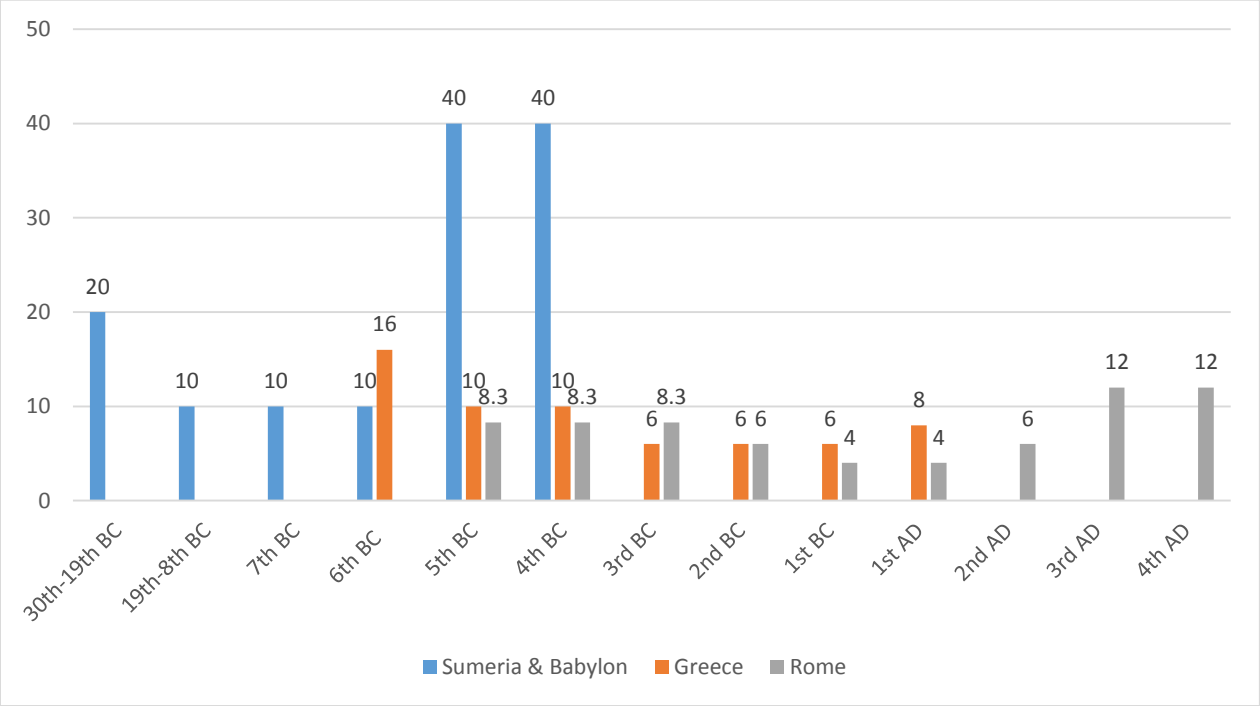
As far as the broad historical record of interest rates goes, the overall findings are quite striking. Minimum interest rates[2] were relatively stable in Babylonia from 3000 B.C. until 1900 B.C. at 20%, then proceeded to decline to 10% over the course of a century where they would stay until roughly 550 B.C. After this point, minimum interest rates started rising, which coincides with the decline and disintegration of Babylonia. Interestingly, the rise of ancient Greece and Rome coincides with falling interest rates, which went from as high as 16% in 550 B.C. to as low as 4% in 50 B.C., where they stayed until roughly 50 A.D., after which they started rising. This would mark the end of declining and relatively low interest rates for Western Europe for more than a thousand years.

The chart below (Chart 1) shows the aggregated data extracted from Homer and Sylla's book. It displays the average minimum recorded interest rates on various types of loans that were obtainable via historical records for Mesopotamia, Ancient Greece, and Rome. What is evident from the chart is that as the given civilizations progressed, interest rates tended to fall over time. On the other hand, as those civilizations matured, and ultimately declined, interest rates started to rise over time. The levels of interest rates are probably not that relevant. However, their direction over time seems to indicate a parabola shape in interest rates as the given civilization spawns, matures, and ultimately declines. As put by Homer and Sylla,

[2] What is meant by minimum interest rates is the lowest rate reported during a given time and within a given place, typically associated with short-term loans. These rates were compounded to provide annual averages. The minimum interest rates in Greece were comprised almost solely of Athenian data.

"*For each of these three great peoples the suprasecular patterns of minimum interest rates provided by this method of analysis had a good deal of similarity. In all three cases interest rates seemed to decline from earliest history until a period of late commercial development, and later to advance during the final centuries of political breakdown.*" (Homer and Sylla 2005, 64)

**Chart 1.** ***Ancient Times – Minimum Interest Rates***




(Homer and Sylla 2005)

### 1.1.2 Dark Ages and the Renaissance

It was during the late second and third centuries A.D. that Roman interest rates started to rise sharply. The period of relatively low interest rates ended for Western Europe for the next thousand years (Homer and Sylla 2005, 62). It was not until the 12$^{th}$ century that interest rates throughout Europe, or more specifically the Netherlands, Italy, England, Spain, and Germany, started to once again decline. Moreover, throughout most of this period there was in effect one main money market throughout Europe, spearheaded and dominated by the Italians.

In 1171, the republic of Venice issued a mandatory bond yielding 5% to all citizens in order to finance the construction of a fleet to fight Byzantium (Pezzolo 2005). Subsequently, loans called *prestiti* were frequently issued in Venice by the mid-13th century. Moreover, the consolidation of Venetian debt *by decree* in 1262 institutionalized and gave birth to the practice of governments financing themselves via debt obligations (Pezzolo 2005, 148).

### 1.1.3 Enlightenment

It was not until the 17th century that interest rates started to become fragmented along national borders and the Italians started losing their dominant position in finance (Homer and Sylla 2005, 137). What eventually brought an end to the Italian hegemony of the credit markets were the repeated defaults of the Spanish Crown. The decline of Antwerp as a financial center coincided with the rise of Holland and England. Worth noting is that interest rates started to become geographically correlated, i.e., they started moving in the same direction over time as is the case in modern times. This was most likely due to increased travel and financial sophistication amongst market participants engaging in *arbitrage*[3]. Financial development via money markets started to encourage a flow of funds; encouraging flows into places that had relatively tight money (*strettezza*) and out of places that had relatively easy money (*larghezza*).

### 1.1.4 Industrial Age

The 19th century was one of falling interest rates for Western Europe and the US. For both England and the US, long-term interest rates fell continuously from 1816 until 1896 (Homer and Sylla 2005, 287). Eventually, and ironically near a turning point, the Austrian economist Eugen von Böhm-

[3] Arbitrage refers to taking advantage of price discrepancies between two or more markets. For example, if apples were selling for $2 on one corner of the market but $1 on another, then sellers (or re-sellers) would gravitate towards the former, assuming there are no barriers. The result of this arbitrage would lead the prices to converge.

Bawerk declared in the late 19th century that the higher is a people's intelligence and morality, the lower the rate of interest (Schumpeter 1951, 182).

### 1.1.5 Modern Era

On average, the 20th century saw interest rates rising from 1900-1920, falling from 1921-1944, rising from 1945-1980, and falling from 1981-present. The chart below (Chart 2) shows various overlapping interest rates stretching from 1857 until present. The oldest running set of interest rates in the chart is American rail road bond yields (red), which stretches from 1857 until 1937. The second oldest running set of interest rates in the chart is Moody's seasoned AAA corporate bond yields (blue), stretching from 1919 until present. The third oldest running set of interest rates in the chart is long-term US government securities (green), stretching from 1925 until 2000. The fourth oldest running set of interest rates in the chart is the 10-year US Treasury maturity rate (black), stretching from 1952 until present. Finally, the most recent running set of interest rates in the chart is the 10-year Euro Area bond market rate (yellow), stretching from 1970 until present[4]. There are predominantly two phenomena which the chart reveals: (1) different countries' *interest rates* as well as different types of interest rates tend to *move in the same direction over time*[5], and (2) interest rates tend to *rise or fall for decades* at a time[6].

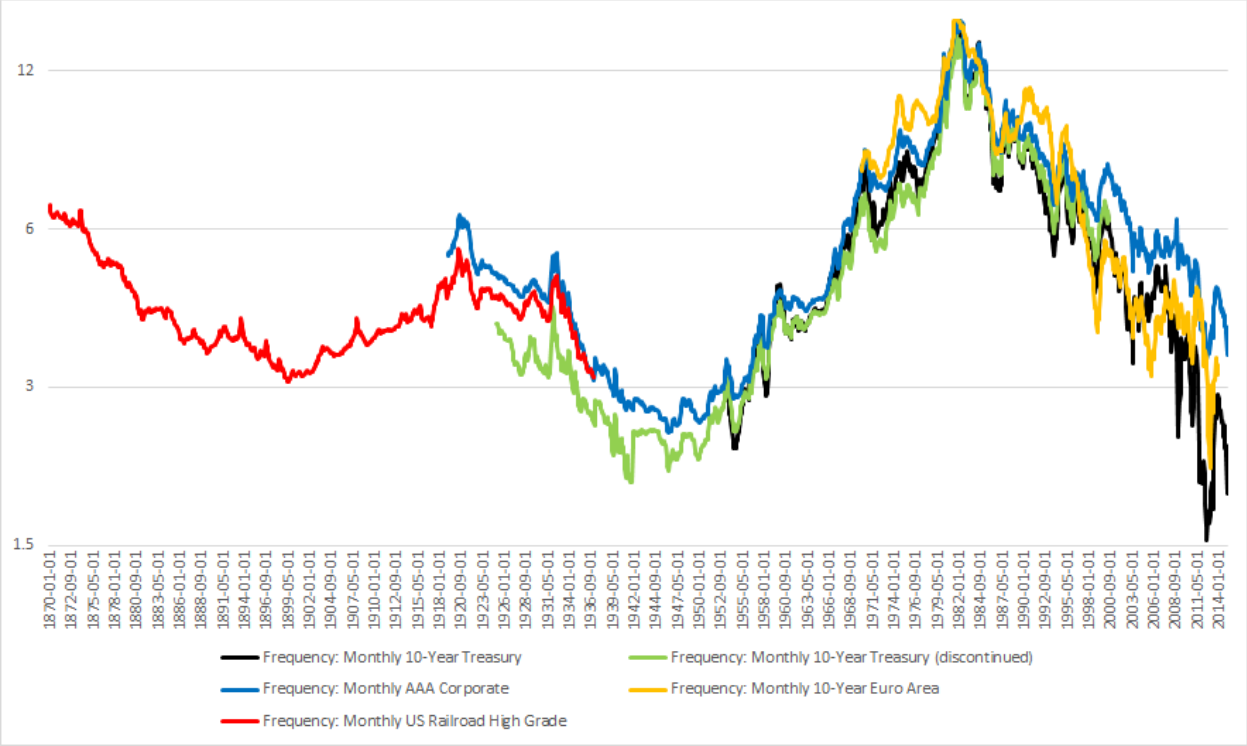


[4] The Euro Area 10-year bond market rate represents the average 10-year bond market rate of the 18 European countries which officially use the Euro currency.

[5] Consider that interest rates moved in the same direction (fell) throughout the 1930s in virtually all countries despite creditor or debtor status, or whether gold was pouring into the country or being drained out of the country (Homer and Sylla 2005, 12).

[6] Another point worth mentioning is that interest rates have become more volatile (higher multi-decade peaks and troughs) over the past two centuries, i.e., the *amplitude* has increased. Indeed, British Consol yields over the past 250 years have shown increasing amplitude (Shiller and Siegel 1977).

**Chart 2.** ***Long-Term Interest Rates (1870-2015)***




(FRED 2015)

### 1.1.6 Turn of the Millennium

Economists David Laibson and Johanna Mollerstrom (2010) found that there were five main factors which contributed to falling interest rates throughout the world from 2000 until 2010. First, the shift away from equities and to fixed income instruments (such as government bonds) following the crash of the NASDAQ in the late 1990s pushed up bond prices, and therefore pushed down interest rates. Second, the Federal Reserve embarked on an expansionary monetary policy following the NASDAQ crash in order to stimulate the economy. Third, capital flows started to shift from Asia over to the developed world. Fourth, there was a misperception which developed about the world economy being less risky, i.e., the "great moderation" since the 1980s (Bernanke 2004), which implied stable and low consumer price inflation along with recessions that were historically mild and scarce. Lastly, there was a misperception of non-government debt being

assumed to be as safe as government debt (Laibson and Mollerstrom 2010, 18). The implication was that organizations such as Fannie Mae and Freddie Mac[7], which were private entities, would end up being bailed out if anything went wrong. Therefore, *moral hazard*[8] accumulated in the market place (Shiller and Weiss 1998).

### 1.1.7 Summary

The primary insight of the empirical work done by Sidney Homer and Richard Sylla is that interest rates provide a sort of "fever chart" of the economic and political health of the given nation at a given time. One can instantly detect wars or natural disasters just by looking at a chart of the long-term interest rates of a nation. Relatively low interest rates indicate a healthy and prospering state of affairs, while relatively high interest rates indicate turmoil of one sort of another. Another major insight is that credit (and therefore interest rates) predate industry, banking, coinage, and even money, a commonly used medium of exchange. The use of loans is likely to have been deployed as early as the Neolithic era, with seed being loaned out in expectation of a premium come harvest time (Homer and Sylla 2005, 25). A third major insight is that interest rates do not move in isolation from market to market or even country to country. For example, it is widely held that interest rates fell in the US during the 1930s because of gold inflows from England and Europe (Bernanke and James 1991). However, interest rates were declining in most countries throughout the 1930s, including in England (Homer and Sylla 2005, 12).



[7] Freddie Mac (Federal Home Loan Mortgage Corporation) and Fannie Mae (Federal National Mortgage Association) are government-sponsored enterprises (GSEs) designed to expand the mortgage market via securitizing mortgages.
[8] Moral hazard refers to a situation in which two or more parties get involved in a risky endeavor knowing that they are protected against the risk and that some other parties will incur the costs.

## *1.2 Theoretical*

### 1.2.1 Supply and Demand

The forces of supply and demand apply to long-term interest rates as well. If one were to think of interest rates as the price for acquiring capital, which is a scarce resource, then the rate of interest serves to compress demand to the point where it meets supply (Cassel 1928, 513). This logic of supply and demand revolving around interest rates has been noticed as far back as the 17th century. For example, Sir Dudley North wrote that, "*As more Buyers than Sellers raiseth the price of a Commodity, so more Borrowers than Lenders, will raise Interest.*" (North 1691). In other words, the supply of capital must be encouraged by a corresponding rise in interest rates. However, it was not until John Locke rearticulated the supply and demand argument behind interest rates that it gained force (Locke 1691). Since then, all serious investigations into monetary theory and interest rates started with the assumption of a market in which supply and demand determined the rate of interest.

Once it was recognized that interest was a price, determined by supply and demand, the confusion between money and capital still remained. Since loans are generally made in money, it was natural to think of interest rates as the price of acquiring money. David Hume was perhaps the first person to have pointed out that this was not really the case. For him, the rate of interest is the price for borrowing land, labor, and commodities. As he put it, interest rates are fundamentally the price for capital "*since we really and in effect borrow these, when we take money upon interest*" (Hume 1742).

### 1.2.2 Equilibrium

Richard Cantillon[9] believed that interest rates were not determined by the supply of and demand for money per se, but rather *the supply of and demand for loanable funds*. He believed that an increase in savings would decrease interest rates over time while lavish spending would increase interest rates over time (Cantillon 2001, 176). Moreover, he maintained that war has a tendency to destroy capital goods and thus will, over time, raise interest rates while peace has a tendency to create the environment for capital accumulation, investment, and the production of capital goods and thus will, over time, decrease interest rates (Cantillon 2001, 177). One of his primary insights was that an increase in the supply of money could increase or decrease the interest rate, depending on how the money entered the economy. This insight is very important in large part because it has not yet been fully absorbed. There are some who claim that monetary inflation leads to rising interest rates (Lindsey, Orphanides and Wieland 1997) while there are also others who claim that monetary inflation leads to falling interest rates (Krishnamurthy and Vissing-Jorgensen 2011). It turns out that both views can be correct and wrong, depending on how the monetary inflation enters the economy. As wrote Cantillon,

> "*If the abundance of money in the state comes from the hands of moneylenders, the increase in the number of lenders will probably lower the rate of interest. However, if the abundance comes from the hands of people who will spend it, this will have just the opposite effect and will raise the rate of interest by increasing the number of entrepreneurs who go into business as a result of this increased spending, and will need to supply their businesses by borrowing at all types of interest*" (Cantillon 2001, 178)



[9] Richard Cantillon (1680s – 1734) was an Irish economist mostly known for having predicted and profited from both the Mississippi bubble in France and the South Sea bubble in England, both of which occurred in 1720. His insights were based on looking at how movements in interest rates and changes in monetary policy affect the relative prices of assets.

One of the first theoretical treatises solely focused on interest rates was written by the Swedish economist Knut Wicksell[10], who in 1898 published *Interest and Prices* (Wicksell 1936). Wicksell held that there were essentially two different interest rates which prevailed on the market, the so-called "natural rate" of interest and the so-called "money rate" of interest. The natural rate of interest refers to the interest rate which would have prevailed without the use of a medium of exchange, i.e., in a pure barter economy not subjected to the *double coincidence of wants*[11]. This natural rate is akin to the real rate of interest that was in accordance with the capital structure of the economy. While the money rate and the natural rate tend to converge and sometimes coincide over time, Wicksell held that they may also differ and diverge at times. In a nutshell, if the money rate is kept below the natural rate, then the price level would rise and, vice-versa, if the money rate is kept above the natural rate, then the price level would fall. In accordance with Richard Cantillon, Knut Wicksell held that, "*A reduction of the real rate requires, other things being equal, new real capital, i.e., increased savings*" (Wicksell 1936, 202).

### 1.2.3 Period of Investment

Another important contribution made by Knut Wicksell was how interest rates influence the period of investment[12]. In essence, there are relatively lower-order goods and relatively higher-order goods in any economy. The higher-order goods are those which take a relatively longer time and require relatively more resources to bring to fruition, such as skyscrapers or railroads. As an example, suppose a company wanted to borrow $1 billion for 15 years, presumably on a capital

[10] Knut Wicksell (1851 – 1926) would later go on to have a significant impact on some of the leading economists throughout the 20th century cutting across the ideological spectrum, including John Maynard Keynes, Ludwig von Mises, Joseph Alois Schumpeter, and Hyman Minsky.

[11] Barter transactions have numerous limitations such as timing constraints. If one wanted to trade apples for oranges, this can only be achieved when the apples and oranges are both available at the same location and time. More importantly, the apple trader looking for oranges would have to find an orange trader looking for apples, i.e., there would have to be a double coincidence of wants.

[12] The period of investment would later be called by some as the *period of provision* or the *structure of production*.

intensive project such as a skyscraper. The difference between an annual compound interest rate of 3.5% and an annual compound interest rate of 1.25% on this loan would be more than $470 million in interest payments[13]. Therefore, long-term interest rates have an enormous impact on the ability of governments, institutions, and individuals to sustainably finance their long-term expenditures via loans.

#### 1.2.3.1 Correlation

The economist Joseph A. Schumpeter considered the phenomenon of interest to be the price paid for a "social permit" to acquire commodities or services without having previously contributed to society (Schumpeter 2005, 123). An even more significant insight brought forth by Schumpeter was that interest rates, although subject to variation depending on risk, tend to move in a uniform matter over time. As put by Schumpeter,

> "*A premium on present dollars in any sector is sufficient to enforce a general premium in all. Thus interest intrudes into every transaction, calculation, and valuation, turns time into a cost factor, and becomes that subtle and omnipotent entity that acts on and reacts to everything and is so difficult to trace in all its protean forms*" (Schumpeter 2005, 607)

### 1.2.4 Time Preference

The phenomenon of interest naturally gives rise to some very basic questions. For example, why do interest rates tend to be positive, i.e., why do people demand a premium in the future in exchange for resources in the present? Moreover, why is it the case that in modern societies interest rates tend to be a few percentage points per annum and not much higher? Why is it not the case or could it not be the case that interest rates be negative for an extended period of time? In his magnum opus *Capital and Interest*, originally published in 1884, the economist Eugen von Böhm-Bawerk stipulated that there were three primary reasons behind the phenomenon of interest rates (Böhm-

[13] The cost of debt servicing would be $675,348,831 in interest payments on the 3.5% loan versus $204,829,183 in interest payments on the 1.25% loan.

Bawerk 1890). The first reason was that the level of interest tends to reflect the rate at which technology is improving. The second reason was that interest could be caused by advantages from the length of the production process, with a more lengthy structure of production (period of investment) tending to be more costly in terms of resources and time, but also being more efficient and productive *ad hoc*. The third and primary reason was that the level of interest rates tends to reflect the aggregate *time preference* of society[14]. This thesis explains the reason for interest rates by drawing upon the concept of time preference as a major theoretical building block.

The relevance of looking at the broad historical record of interest rates is that it gives credence to the idea that interest rates are underpinned by time preference. As put by Alan Greenspan, "*Interest rates, after all, in the fifth century B.C. were similar to those of modern times. I know of no other "time series" that has exhibited such stability.*" (Greenspan 2014, 384). What this means is that *real* interest rates[15] (adjusted for inflation) reflect an underlying human faculty: time preference, which has stayed relatively stable (despite fluctuations) over millennia.

The underlying idea behind the concept of time preference is that people value present goods over future goods (Jevons 2013). As put by Alan Greenspan, "*Time preference is the self-evident propensity to value more highly a claim to an asset today than a claim to that same asset at some fixed time in the future.*" (Greenspan 2014, 20). In other words, time preference is the degree to which people value present goods over future goods. The phenomenon of time preference was observed as early as the 14th century. For example, Giovanni Boccaccio described the impact of

[14] The concept of time preference is also known as *temporal discounting*, *delay discounting*, or *time discounting*.
[15] [15] The term "real interest rate" was first used by Columbia University Economist John Bates Clark in 1895 (Clark 1895). The real rate is the nominal rate minus the inflation rate. Formally, it looks like this: (i-p)/(1+p) where *i* is the interest rate and *p* is the expected one-year inflation rate.

the Black Death on the people of Florence in 1360 (Boccaccio 2003). Since they did not expect to live much longer, the aggregate time preference went up dramatically. Instead of working to preserve and cultivate the land and livestock, the people of Florence devoted all of their attention to present consumption. As their life expectancy shrunk, interest rates on loans were extremely high since most people lived in the moment. For those lending money, the Black Death meant very high risks of default. Those taking on loans tolerated high interest rates because they expected to live little and, even if expecting to repay the debt before their death, they had very strong incentives to consume in the present. While the Black Death is certainly an extreme example, it is meant to illustrate that the aggregate time preference can rise dramatically in stressful times. As put by Gustav Cassel[16],

> "*There is, in fact, an intimate connection between the average length of human life and the rate of interest. In a state of war, of internal disorders or general insecurity in regard to life, or in bad climates, the probable length of life is short, and the rate of interest has always, under such circumstances, been high.*" (Cassel 1903, 152)

One of the earliest writers to have defended the charging of interest on the grounds that it was an inevitable phenomena that had to do with discounting the future was Jeremy Bentham (Bentham 1787). To illustrate this mathematically, 0.95 raised to the hundredth power comes out to less than 0.006. This means that, assuming someone is discounting the future by five percent per annum in a linear fashion, she really does not care much about what happens in 100 years. On the other hand, if we were to raise 0.98 to the twentieth power, we would end up 0.66. This means that, assuming someone is discounting the future by two percent per annum, the future 20 years from now is still

[16] Karl Gustav Cassel (1866 – 1945) was a Swedish economist mostly known for creating the concept of purchasing power parity (PPP). With regards to this thesis, his insights are extremely relevant. Consider that in his 1903 book, *The Nature and Necessity of Interest*, he argued that interest rates were bound to rise again (they were steadily falling for the past century). His timing could not have been better, as interest rates started to rise until 1920. Moreover, he is purported to have been the only economist to have systematically predicted the Great Depression (Shiller 2015). As an example, in 1928 Cassel wrote that "*an increasing scarcity of gold will make itself felt, with the result that the general level of prices in every gold standard will be subject to a continual and unlimited fall.*" (Cassel 1928, 521).

quite important[17]. In general, the higher the interest rate and the longer the duration in question, the less one cares about the future. This is part of the reason why a company (and its shareholders) could be completely aware that the depletion of cheap oil reserves is well in sight and yet have little incentive to alter its behavior towards conservation.

Although it may be said that some people have relatively low time preferences (i.e., they are relatively more patient) while others have relatively high time preferences (i.e., they are relatively impatient), all people must have a *positive* time preference due to being subject to the need to avoid starvation and death. In other words, time preferences are limited, and therefore cannot be negative, by the physiological reality that people must consume in the present in order to sustain themselves. From the point of view of an individual, time is a scarce resource that needs to be economized. It was this insight that led the economist Gustav Cassel to write that there are "*strong reasons for believing that the* [long-term] *rate of interest will never, for any length of time, sink below 1½ or even 2 percent*" (Cassel 1903, 94).

Another way of explaining time preference would be to state that goods or services of equal quality, quantity, or form are valued less in the future than they are in the present[18]. The catalyst

[17] These examples assume that there is *time-consistency* in discounting, i.e., that people discount the future in an exponential way. However, the assumption of a constant discount rate is frequently violated (Strotz 1955). Indeed, studies have found that inter-temporal choices are better described by hyperbolic discount functions (Kalenscher and Pennartz 2008). In other words, one may prefer a larger but more delayed reward when both rewards have a given delay. However, this preference may change when the delays are reduced by the same percentage. This may be the case because primates (including humans) perceive time in a logarithmic way (Takahashi 2005).

[18] There are some apparent exceptions to this rule. For example, a typical person would presumably prefer a cube of ice more in the summer as opposed to the winter. Thus, it may be said that during January the typical person would prefer a cube of ice more in 6 months as opposed to the present. However, the principle would still stand as she would still prefer a cube of ice in 6 months as opposed to 10 years and 6 months. This logic was reinforced by Gustav Cassel, in having written, "*Present needs are necessarily more urgent than future ones. This should not be understood as meaning that every present need is more urgent than any future one. But if we compare two needs, each of which has the same importance in its own time, that one which is present is generally more urgent than that which belongs to the future*" (Cassel 1903, 140).

for deferring consumption in the present is the perception that by doing so, one will be able to consume more in the future. Since goods are valued more in the present, goods in the future are discounted. From this it follows that since goods in the future are discounted, one must offer more goods in the future in exchange for goods in the present. In a post-barter economy, this phenomenon is expressed in terms of money via interest rates. As put by Alan Greenspan, "*We experience this phenomenon mainly through its most visible counterpart: interest rates and savings rates*" (Greenspan 2014, 21).

In essence, the more patient a society tends to be, the lower is the aggregate time preference. Consequently, interest rates also tend to be lower. The idea that the driving force behind interest rates is the inherent tendency for human beings to prefer things in the present versus the future, i.e., time preference, is established (Frederick, Loewenstein and O'Donoghue 2002). Another way of formulating of what constitutes interest is the margin by which the value of capital goods falls short relative to their expected products (Mises 2009, 339). As written by Charles Koch, "*When property rights are clearly defined and respected, time preference decreases, individuals are more willing to save and businesses are more willing to invest long term*" (Koch 2007, 146).

#### 1.2.4.1 Experimental Evidence for Time Preference

There is also some experimental evidence for the phenomenon of time preference. Abnormally high time preferences are associated with psychiatric disorders such as substance abuse or pathological gambling (Reynolds 2006). Moreover, children and adolescents tend to have higher time preferences than adults (Olson, et al. 2007). Some have suggested that the discrepancy in time preferences between adults and children may be mediated in part by the gradual maturation of the prefrontal cortex (Kim, Hwang and Lee 2008). There has also been a study which found that rats,

using food and water as reinforcers, also discount the future, i.e., they prefer present consumption to future consumption unless the future reward is substantially higher (Richards, et al. 1997). A similar study using pigeons found the same result, except that pigeons tend to discount the future 3-4 times faster than rats (Mazur 2000). A more recent study analyzed the discounting rates in rhesus monkeys using cocaine injections as reinforcers (Woolverton, Myerson and Green 2007). As expected, preference for immediate doses increased as the delay (of larger but more distant doses) increased[19].

### 1.2.5 Synthesis

In *The Theory of Interest*, originally published in 1930, the economist Irving Fisher wrote that the interest rate is the intersection of the supply and demand for savings (Fisher 1930). Thus, higher interest rates encourage a larger supply of savings. On the other hand, the lower the interest rate, the more demand for investment there will be. This theoretical framework is tautological in nature and flows from standard micro economic supply and demand dynamics (Hirshleifer, Glazer and Hirshleifer 2005). Yet, within his framework, Fisher seemed to have allowed for the explanations of interest originally stipulated by Böhm-Bawerk. Even in an economy with one person, say a Robinson Crusoe economy, the phenomenon of interest would still exist according to Fisher. The reason behind this is that Robinson Crusoe would still have to make decisions regarding time. For example, he would decide how much grain he would consume in a given year versus how much grain he would plant for the following years. Potentially, he could decide to eat all of the available grain, but then he would have nothing in the future. Today, this sort of tug of war between present consumption and the prospects of future consumption is known as the *intertemporal production-*

[19] The $R^2$ values ($\geq 0.70$) were comparable in all of the studies, suggesting that time preference explains a substantial amount of variance when it comes to delayed gratification.

*possibility frontier*. Rather than contradicting each other, the underlying reasons forinterest rates stipulated by Böhm-Bawerk and Fisher may be said to build upon each other; incorporating supply, demand, capital, and time preference.

### 1.2.6 Term Structure of Interest Rates

Another primary contribution to the work on interest rates was done by Sir John Hicks in his 1939 book *Value and Capital* regarding the *term structure* of interest rates (Hicks 1975). The term structure of interest rates refers to the various different rates of interest quoted throughout different points in time. For example, interest rates on 1 year bonds are virtually always lower than interest rates on 10 year bonds. In general, the longer the duration until maturity, the higher the interest rate tends to be which is due to both more risk and time preference (i.e., people discount the distant future more than a relatively immediate future). More risk because the future is uncertain, especially the distant future, and higher discounting because people prefer consumption in the present versus consumption in the future, especially the distant future. The implication of the term structure of interest rates are *forward rates*, or the implied interest rates between two or more future dates. Nevertheless, despite the element of risk and the presence of inflation, the underlying factor behind interest rates seems to be time preference. As put by Alan Greenspan, "*The real (inflation-adjusted) interest rate is anchored by time preference, and it fluctuates according to the balance of saving and investment in an economy and the degree of financial intermediation*" (Greenspan 2014, 27).



### 1.2.7 Central Banks

Central banks can and actively do influence short-term interest rates by shaping the yield curve of short-term government bonds. In practice, this is typically done via the central bank buying

government bonds, which has the effect of pushing up bond prices and thus pushing down the interest rate which they yield over their duration. However, central banks are not some omnipotent entities that can simply dictate what the interest rate should be at any given point in time. As put by Robert Shiller,

> "*long-term interest rates are not really exogenous factors. They are market phenomena determined by many of the same supply and demand factors that determine the level of prices in the stock and housing markets, and their behavior is part of the same market psychology that drives these markets*" (Shiller 2005, 32)

Studies have found that the Federal Reserve does have an influence on short-term interest rates (Shiller 1980). However, over time the effect diminishes towards zero and the more monetary actions are anticipated, the smaller is the effect. Regarding long-term interest rates, there is very little support in the idea that central banks are in control. With that said, it would be a grave mistake to conclude that central bank policy is sterile, in the short-run, on interest rates. As is the case with price-controls in general, continuous and aggressive meddling in the bond markets can cause some serious distortions. For example, Shiller would later go on to write that,

> "*on February 14, 1929, the Federal Reserve raised the rediscount rate from 5% to 6% for the ostensible purpose of checking speculation. In the early 1930s, the Fed continued the tight monetary policy and saw the initial stock market downturn evolve into the deepest stock market decline ever, and a recession into the most serious U.S. depression ever*" (Shiller 2005, 224)

### 1.2.8 Summary

In summary, there are a few key points to take away from this theoretical literature review on the drivers of long-term interest rates. One key point is that interest rates are not determined by the supply and demand of money, but rather the supply and demand for loanable funds. This is a key point because it shows that interest rates can actually increase during monetary expansion, depending on how that money is injected into the economy. Another key point is that falling interest rates stimulate long-term and capital intensive projects. Furthermore, one key theoretical

insight, and one that this thesis heavily relies on, is that interest rates reflect the *aggregate* time preference. Moreover, while time preferences may fluctuate over time, they are always positive, i.e., people prefer present consumption to future consumption because they discount the future. Lastly, relatively wealthy countries tend to have relatively low time preferences due to an abundance of physical, human, and social capital; which means they also have relatively low interest rates. The table below (Table 1) articulates the main findings regarding long-term interest rates.

**Table 1.** ***Primary Insights Regarding Interest Rates***

| ***Empirical*** | ***Theoretical*** |
|---|---|
| The birth of the sovereign debt market can be traced to Venice (1171 A.D.) (Pezzolo 2005, 148) | Interest rates are determined by the supply and demand for loanable funds (Cassel 1928, 513) |
| Interest rates became geographically correlated in the 17th century, i.e., various interest rates move in the same direction over time (Homer and Sylla 2005, 137) | Underlying factor behind interest rates is time preference<br>• Innate propensity to discount the future (Böhm-Bawerk 1890) |
| Long-term interest rates display significant oscillations<br>• The amplitude of the oscillations has increased over the past century (Shiller and Siegel 1977) | Falling interest rates disproportionately stimulate long-term and capital intensive projects (Wicksell 1936, 133) |
| Interest rates provide a "fever chart" of economic and political health (Homer and Sylla 2005)<br>• Rising interest rates imply political turmoil (e.g., wars or debt defaults) | Central banks cannot control long-term interest rates (Shiller 1980) |

# Chapter 2: The US Bond Market as the Conductor of the International Orchestra

> "*The federal government, the only issuer of sovereign credit, is the "eight-hundred-pound gorilla" in the marketplace, and every other claimant for private savings is forced to stand in line behind the U.S. Treasury.*"
> – Alan Greenspan (2014)

## 2.1 Inverse Relationship

Rising bond prices are the equivalent of saying that interest rates are falling, it is another way of stating the same thing. On the other hand, falling bond prices are the equivalent of saying that interest rates are rising. Thus, it is not the level of interest rates which is crucial to keep in mind, but rather the *direction* of where interest rates are heading. If, for a prolonged time, interest rates are falling, it means that the value of government bonds has been rising over that specified period of time and vice-versa. As put by Jason Zweig,

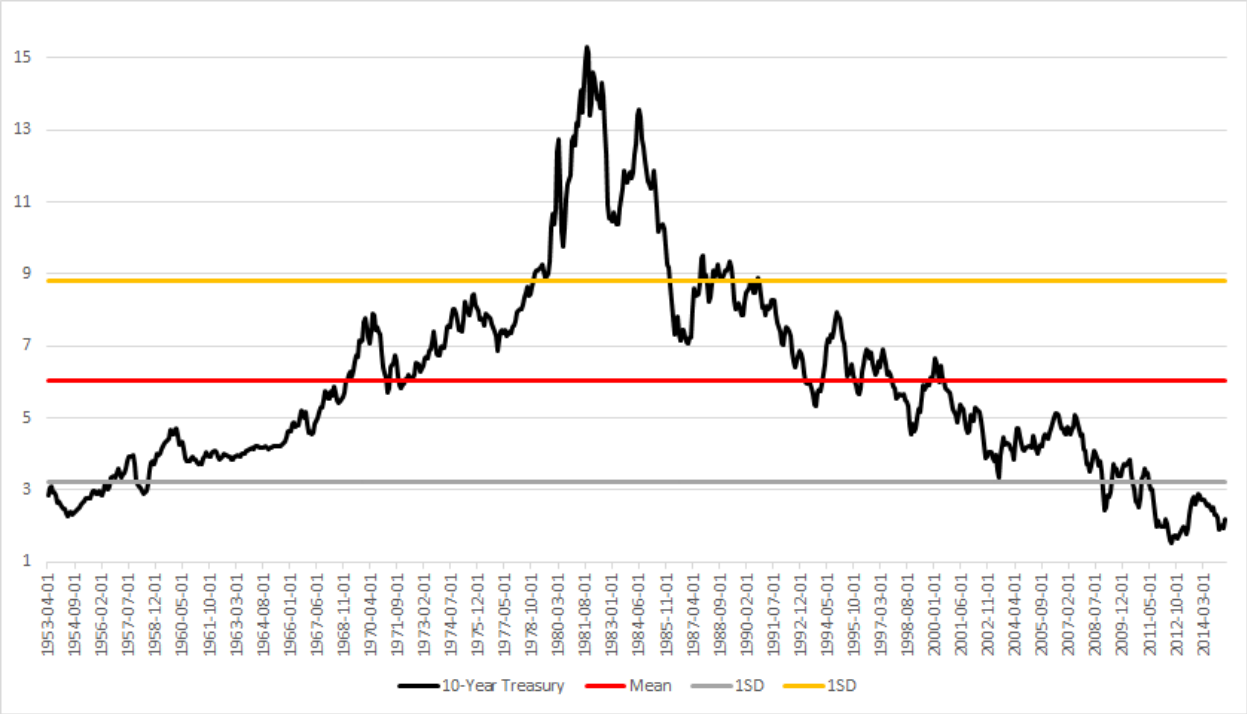
> "*Bonds and interest rates teeter on opposite ends of a seesaw: If interest rates rise, bond prices fall – although a short-term bond falls far less than a long-term bond. On the other hand, if interest rates fall, bond prices rise – and a long-term bond will outperform shorter ones*" (Graham and Zweig 2006, 106)

The reason why interest rates and bond prices are inversely related may seem a bit counterintuitive. Part of the reason why this is so is because bonds may be bought and sold in the bond market prior to maturity. Assume that an investor purchases a 10-year Treasury bond with a 3% coupon at a time when interest rates are 3%. In effect, the investor would be paying 100% of the face value of the bond. Subsequently, interest rates rise to 4%. If the investor who bought at 3% wanted to sell her bond with the 3% coupon, she would be unlikely to find buyers since the bonds are now quoted at 4%. Therefore, she would have to sell the bond *below* par value. This logic also works in reverse. Suppose that, instead of rising, interest rates subsequently fell to 2%. The investor could now sell the bond at a premium since it offers a higher interest rate.

### *2.2 Oscillations*

Long-term interest rates tend to oscillate around an equilibrium value, rising or falling decades at a time. The chart below (Chart 3) shows the interest rates on the 10-year Treasury bond from 1953 until 2015[20]. The red line represents the mean value throughout that duration (6.02%), the yellow line represents one standard deviation (1SD = 2.79%) away from the mean on the upside throughout that duration (8.81%), and the gray line represents one standard deviation away from the mean on the downside throughout that duration (3.23%).

**Chart 3.** ***10-Year Treasury Bonds (1953-2015)***

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[20] The reasoning for analyzing the 10-year Treasury bond is primarily twofold: (1) the US bond market is by far the largest in the world and (2) the 10-year Treasury bond is the most liquid of all the Treasury securities. In this sense, the US bond market is the "*conductor of the international orchestra*" (Keynes 1930, 274).

### 2.2.1 Regression to the Mean

As can be seen on the chart above (Chart 3), interest rates are virtually at all-time lows. Thus, the fundamental argument for why interest rates are likely to rise (and hence bond prices are likely to fall) is due to a *regression to the mean*[21]. Historically, long-term interest rates have always regressed to the mean (albeit the mean has changed over time), and there is no particular reason why they should stay at all-time lows indefinitely. Moreover, we know that long-term interest rates cannot continue to fall since this would entail negative long-term interest rates, a violation of time preference.

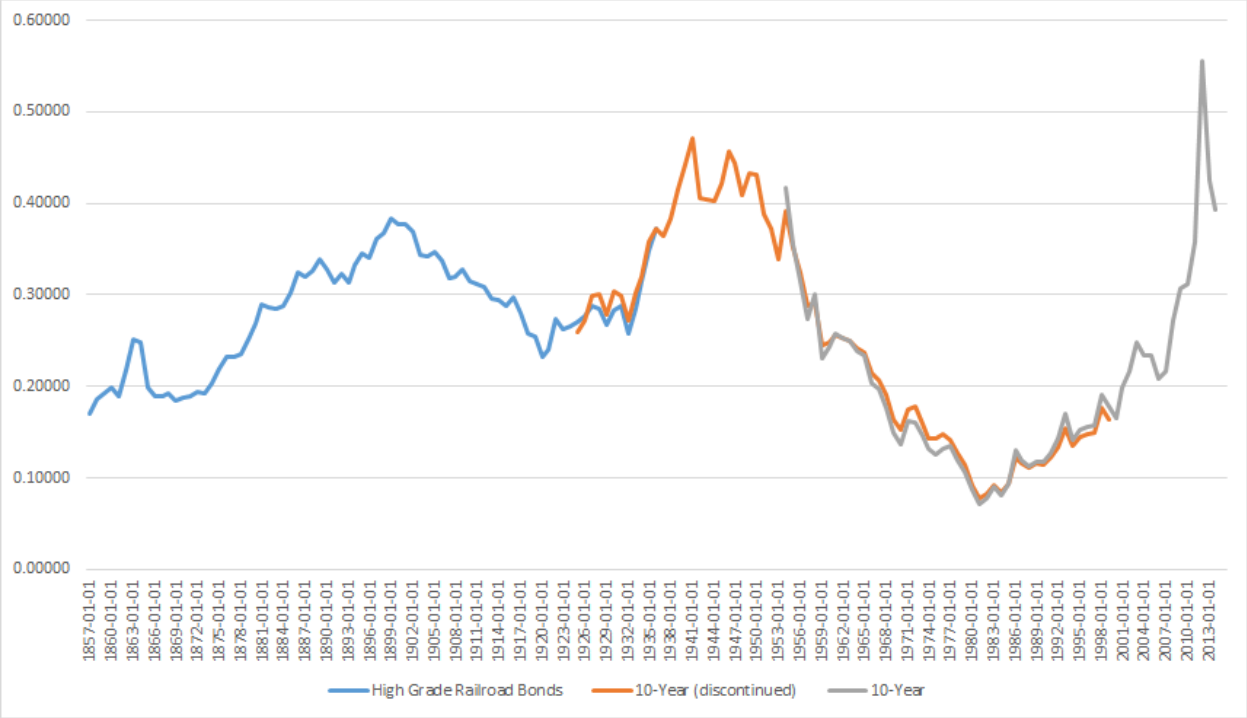
### 2.2.2 Decreasing Returns

The Pulitzer Prize-winning author and economic researcher Daniel Yergin documented that some oil industry observers used a decreasing-return framework in the late 1970s in order to predict lower oil prices (Yergin 1991). The sharp rises in the oil price throughout the 1970s stimulated conservation, exploration, and exploitation of alternative energy sources. This decreasing-return framework seems appropriate with regards to long-term interest rates today, since each step away from equilibrium is harder than the last in the sense that it depresses the incentive to save and stimulates consumption. Each basis point lower is offset by counter-reactions. The following chart (Chart 4) shows the *inverted* average annualized interest rates on long-term bonds[22]. Since bond prices and interest rates are inversely related, the chart shows that the bond market today is at all-time highs.



[21] The term "regression" is derived from its early 19th century application with the observation that the height of descendants of unusually tall or short ancestors tended to "regress" towards the mean of their distribution.
[22] The chart displays high-grade US railroad bonds from 1857-1936 and long-term Treasury bonds from 1925 until present.

**Chart 4.** ***Annualized Long-Term Bond Levels (1857-2015)***

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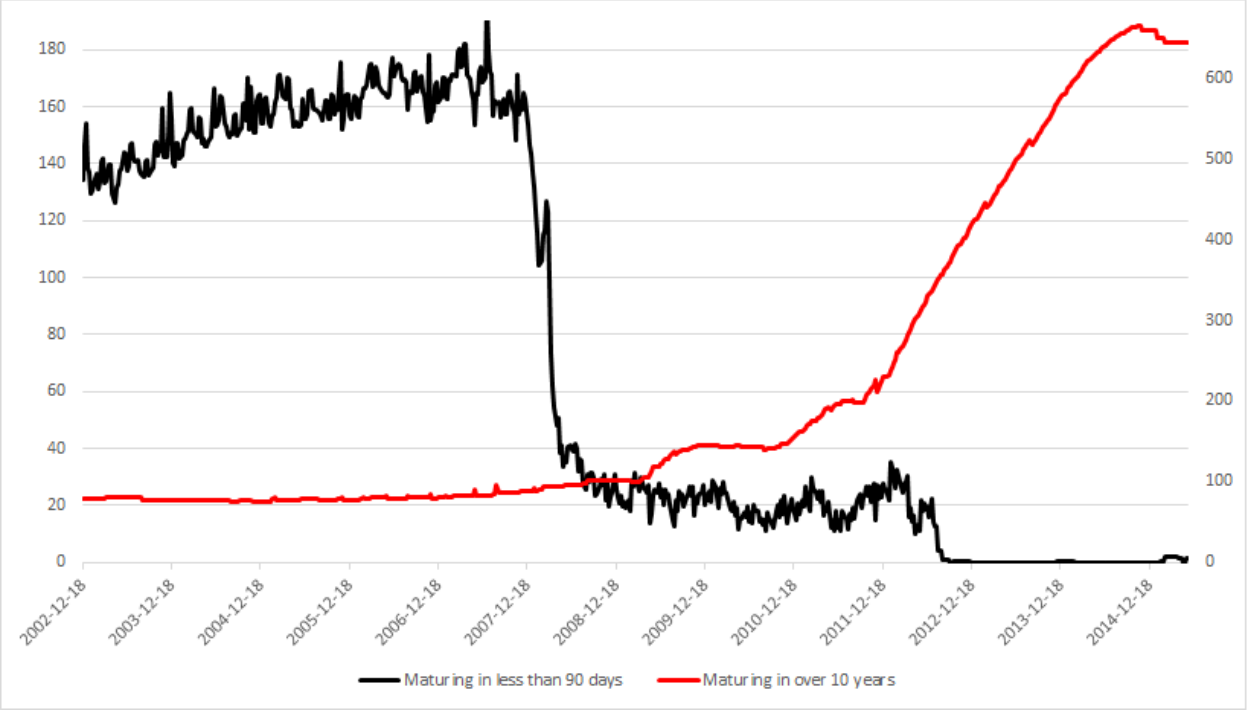
### *2.3 Government Intervention*

One reason why interest may rise in the future relates to government intervention in the bond markets. As the chart below (Chart 5) shows, the Federal Reserve currently holds virtually no short-term government bonds (left-hand scale, black), most of which were sold off in late 2007. On the other hand, the Federal Reserve currently holds an unprecedented amount of long-term government bonds (right-hand scale, red), currently amounting to roughly $640 billion. The bulk of these long-term government bond purchases by the Federal Reserve were initiated in September of 2011, during the so-called "Operation Twist"[23] (Investopedia n.d.).

[23] Operation Twist refers to the actions taken by the Federal Reserve in September 2011 whereby it sold short-term Treasury bonds (bonds maturing in less than 2 years) and simultaneously bought long-term Treasury bonds (bonds maturing in more than 5 years).

**Chart 5.** ***Composition of Federal Reserve Treasury Holdings (2003-2015)***

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While the consequences of these actions remain unclear, it is safe to say that interest rates on long-term government bonds are lower than they would otherwise have been absent this intervention. As put by Robert Shiller,

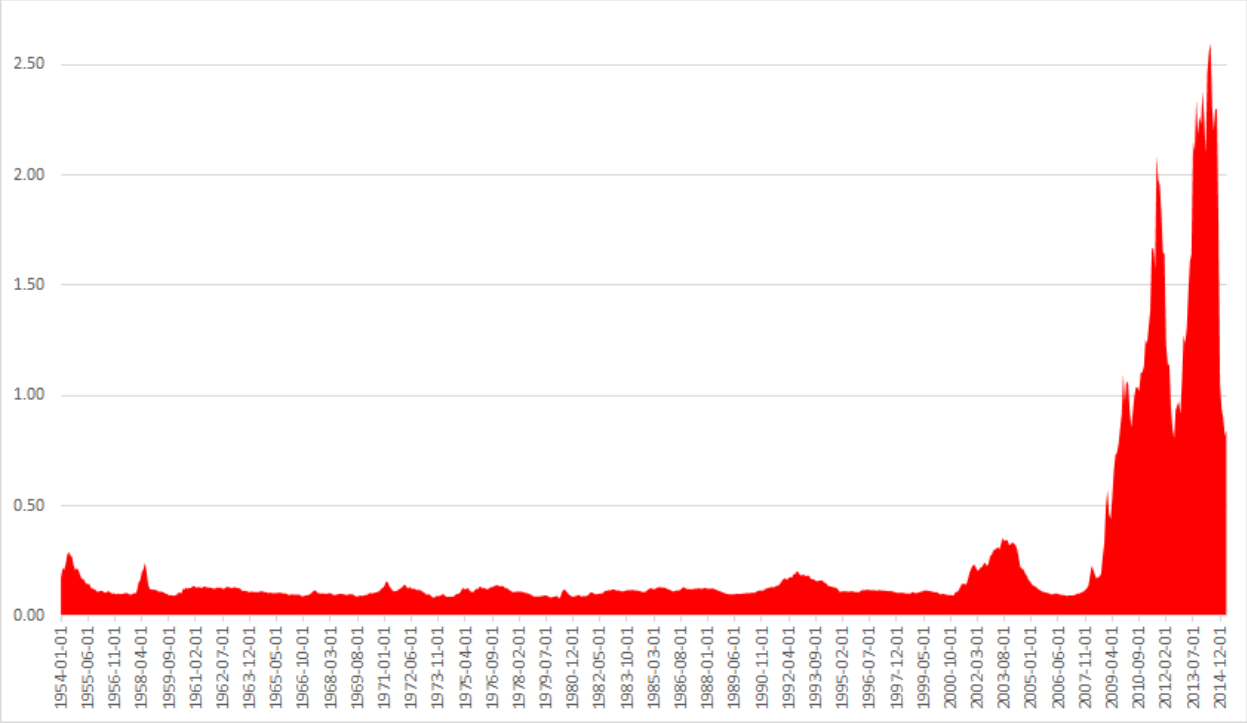
> "*the U.S. bond market, showing such low yields, looks as if it may have been going through something of a bubble, too, and may collapse further eventually, especially given the imminent withdrawal of the support of quantitative easing from the Federal Reserve and a likely increase in inflation.*" (Shiller 2015, 13)

## 2.4 The Current Spread

Nevertheless and somewhat paradoxically, the spread between short-term interest rates and long-term interest rates has never been higher. As can be seen in the chart below (Chart 6), the spread between the 10-year Treasury bond and the 1-year Treasury bond (called a note) is historically

abnormal. It indicates that, despite historically low interest rates, investors are heavily discounting the future. The historical average of the spread is 0.25%. That is, the interest rate on the 10-year Treasury has been 0.25% higher on average from 1954 to 2015. The spread reached a record high of 2.6% in June 2015. Although it has declined somewhat since, it is still at a very elevated level compared to its historical average (0.84% as of May 2015). The spread between the 30-year Treasury bond and the 5-year Treasury bond is even greater (Greenspan 2014, 137).

**Chart 6.** ***Interest Rate Spread (1954-2015)***

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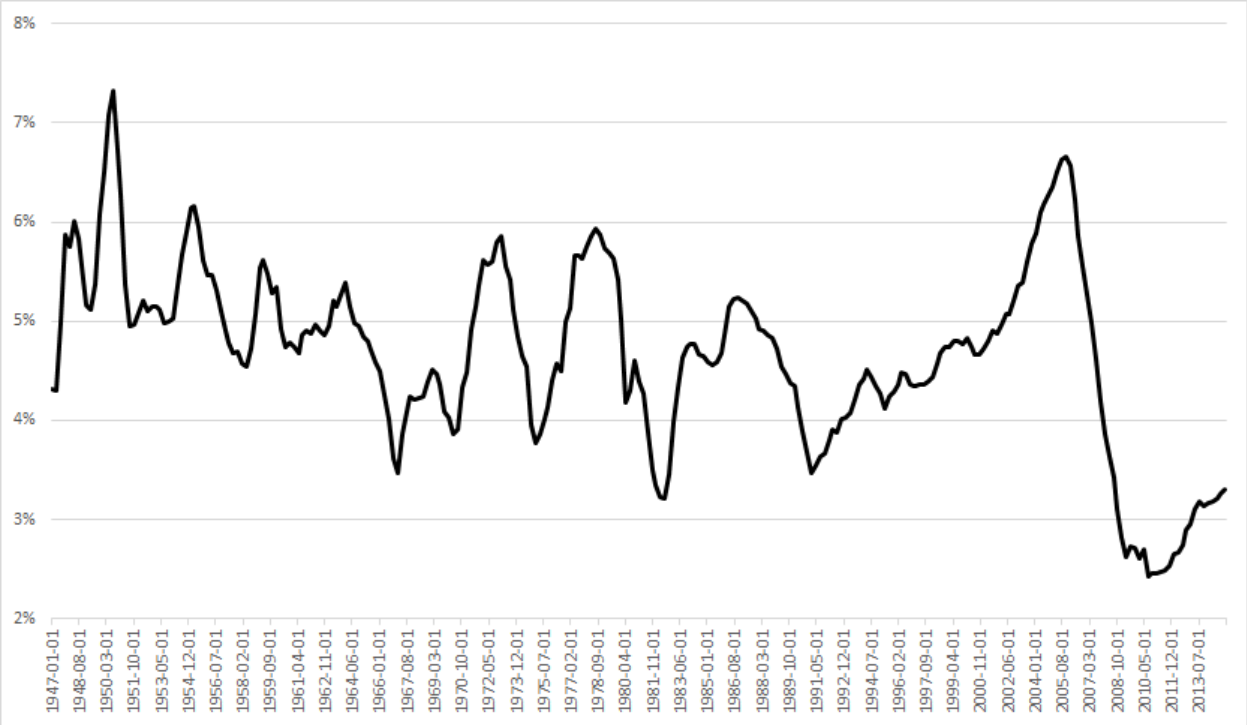
### 2.4.1 Two-Tier Economy

Alan Greenspan has been arguing that, since the recent financial crisis, there has developed a two-tier economy. On the one hand, we have the production of goods and services which take less than 20 years to come into fruition (this represents ~95% of GDP for most economies) running more or

less at potential. On the other hand, we have the production of goods which takes more than 20 years running at half of potential (Greenspan 2014, 141). Indeed, as the chart below (Chart 7) shows, private residential fixed investment (typically long-term and capital-intensive projects) as a percentage of GDP is unusually low by historical standards. The historical average comes out to 4.6% of GDP, currently it is running at 3.3% of GDP.

**Chart 7.** ***Private Residential Fixed Investment as a percentage of GDP (1947-2015)***

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### *2.5 Bond Market Bubble*

A recent study on long-term interest rates has found that negative real interest rates have formed in developed countries since 2010 which in turn have pushed international investors back into the bond markets of emerging markets in search for yield (Turner 2014). Furthermore, the paper

argued that movements in US long-term interest rates, considered to be a global benchmark, can have major implications for the financial stability of emerging markets (Turner 2014, 16). Essentially, the idea is that interest rates throughout the world follow the direction of the US bond market. Based on the idea that bond markets throughout the world seem to be fully saturated, the study seems to suggest that the "*long period of declining long-term interest rates at the global level is over*" (Turner 2014, 16). The assumption is that long-term interest rates cannot fall much further than zero, because that would violate the concept of time preference.

With long-term interest rates at all-time lows, the upside risk is tremendous. Numerous economists have recently expressed their concerns about this development. For example, Robert Shiller writes that, "*There is indeed reason to be concerned about the possible widespread economic effects of an end to this decades-long downtrend in real long-term interest rates, and of a corresponding drop in long-term bond prices*" (Shiller 2015, 17). Others have warned of an outright bubble in the long-term bond market. For example, Jeremy Stein, Professor of economics at Harvard University and former governor of the Federal Reserve System expressed his concerns during his last speech as a governor; he warned that "*upward spikes, when they do occur, are associated with significant adverse economic effects*" (Stein 2014). There is indeed force behind these concerns for two primary reasons: (1) debt-to-GDP ratios of virtually all countries are historically high and (2) a to-be-expected process of *regression to the mean* will inevitably force interest rates higher.



### *2.6 Feedback Loop*

> "*Where there are no fundamentals to claim attention, and an alleged bubble appears to be the result of herd behavior, positive feedback or bandwagon effects—credulous suckers following smart insiders—econometricians who believe in the efficient market hypothesis tend to suggest that the model is "misspecified," i.e. that something was going on not taken into account by the theory, and that more research is called for.*"
> – Charles P. Kindleberger (2000)

A possible explanation behind the oscillations in long-term interest rates is that the bond market is susceptible to feedback loops, in which (1) initial price increases lead to more price increases, (2) price increases feed back into yet higher prices, (3) and the initial impact of precipitating factors is amplified (Shiller 2015, 84). An example of a feedback loop would be bringing a microphone close to a loudspeaker, which would in turn amplify the sound leading to an eerie whistle. Of course, with the bond market, these feedback loops are a lot less dramatic and take a long time to play out. This was also mentioned by Homer and Sylla, who wrote, "*A tendency to go to extremes is often observed at the highs or the lows of a protracted market trend. At such times, precedent and overwhelming psychological expectations reinforce prevailing economic factors*" (Homer and Sylla 2005, 211).

When it comes to the social sciences, feedback loops may be said to be *self-fulfilling prophecies*[24]. The essential idea behind feedback loops with respect to interest rate changes is that increases (or decreases) feed back into further increases (or decreases), i.e., the initial impact is amplified. The assumption is that people have *adaptive expectations*, meaning that feedback takes place because past increases (or decreases) generate expectations of further increases (or decreases) (Barberis, Shleifer and Vishny 1998). Typically, these feedbacks are not the result of sudden price changes but rather a pattern of consistently rising (or falling) prices (Shiller 2015, 85). This phenomenon is known as the price-to-price feedback. With regards to interest rates, the theory may apply as follows: interest rates fall (i.e., bond prices rise), which leads to the emergence of success stories,

[24] The term *self-fulfilling prophecy* was popularized in 1948 by the sociologist Robert K. Merton. His prime example of a self-fulfilling prophecy was the Great Depression, where gloomy expectations led to gloomy outcomes (Merton 1948).

which in turn draws in new investors (and money) who imagine they will have a similar amount of success[25]. Interestingly, feedback loops need not have high serial correlation in the short-term. Feedback loops may operate over long time intervals (i.e., with a distributed lag).

### 2.6.1 Explaining the Oscillations

There are two types of feedback loops: (1) *positive* (i.e., self-reinforcing) feedback loops and (2) *negative* (i.e., self-correcting) feedback loops (Sterman 2000, 12). Positive feedback loops amplify whatever is happening in the system while negative feedback loops counteract changes in the system[26]. For example, rising widget prices would eventually lower the demand for widgets and stimulate the production of more widgets, acting as a negative feedback loop. However, adding time delays to negative feedback loops creates the tendency for the system to oscillate (Sterman 2000, 23). Moreover, the longer the time delay tends to be, the more pronounced the oscillations tend to become. Negative feedback loops with no time delays are first-order loops, making oscillation impossible, whereas negative feedback loops with time delays are *second-order loops*[27]. The diagram below (Diagram 1) shows the basic process of the two types of feedback loops.

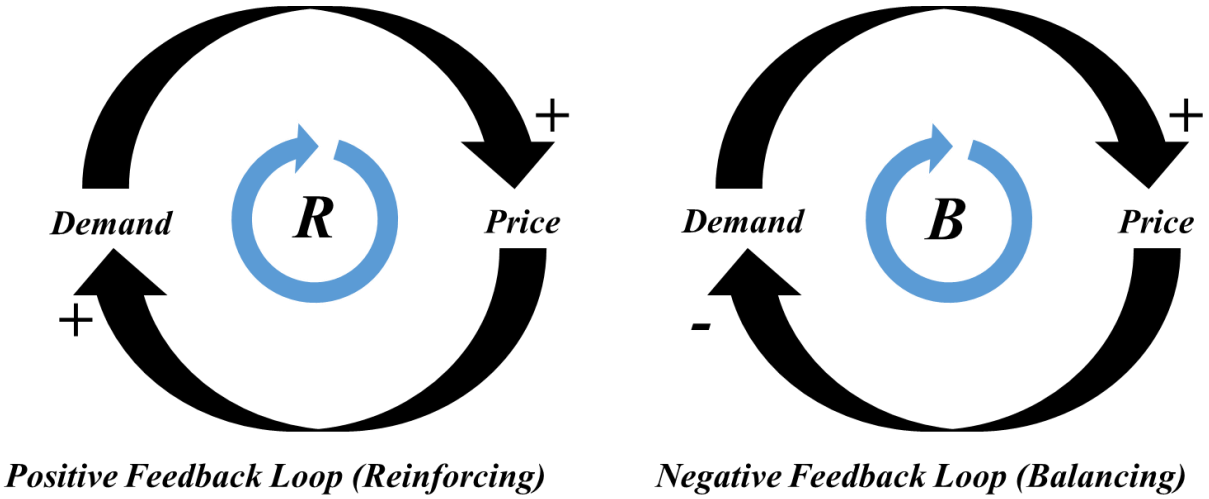


[25] The adherents of rational choice would argue that smart money will take advantage of novice investors, eventually driving them out of the marketplace and bringing prices back into equilibrium. However, the presence of smart money may not offset the effects of feedback loops. Indeed, smart money may choose to ride along with the novice investors, since increased volatility on the upside (as well as the downside) provides more profit opportunities which would otherwise have been absent (De Long, Shleifer, et al. 1990).

[26] The concept of a positive feedback loop was also articulated by George Soros with the idea of reflexivity[26] (Soros 2007). What is meant by reflexivity is that inputs may function as outputs and vice-versa.

[27] As an example of a *second-order negative feedback loop*, imagine rotating a shower handle in order to increase the temperature of the water. However, the water does not actually begin to warm until a certain amount of time lag. This may induce the person to rotate the handle too much, forcing her to later rotate the handle yet again in order to decrease the temperature of the water. In effect, the temperature of the water will oscillate around what the user initially wanted precisely due to the time lag.

**Diagram 1.** ***Feedback Loops***



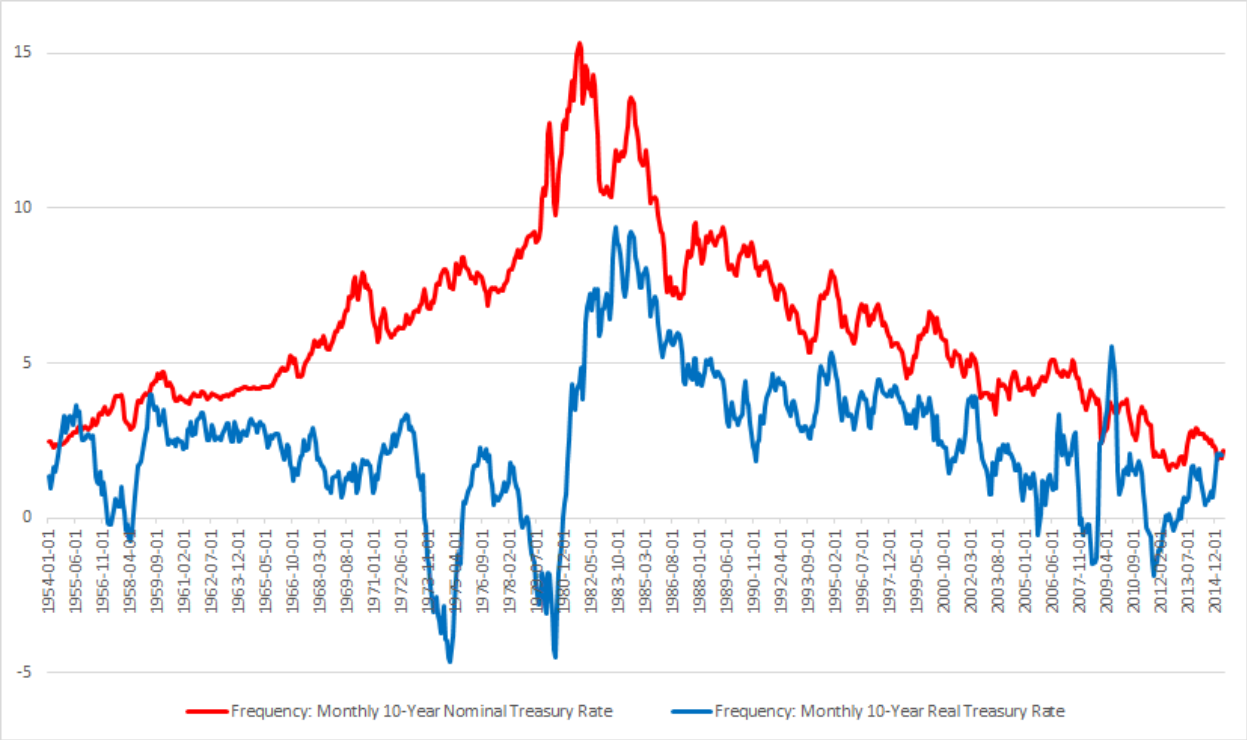

***Positive Feedback Loop (Reinforcing)*** ***Negative Feedback Loop (Balancing)***

Positive feedback loops tend to amplify deviations and reinforce change whereas negative feedback loops act to bring the state of the system into equilibrium (Sterman 2000, 111). Oscillations can occur if there are delays in at least one of the links in a negative feedback loop (Sterman 2000, 114). As put by John D. Sterman, in an "*oscillatory system, the state of the system constantly overshoots its goal or equilibrium state, reverses, then undershoots, and so on*" (Sterman 2000, 114). Every type of oscillation has at its core a second-order negative feedback loop.

With regards to long-term interest rates, the oscillations are due to the bond market being incapable of accounting for inflation in real-time. In other words, there is a contemporaneous association between interest rates and *preceding* inflation rates. Thus, the bond market consistently fails at pricing in future inflation rates (Shiller 2015, 14). The following chart (Chart 8) shows the nominal interest rate on the 10-year Treasury bond (red) and the real interest rate on the 10-year Treasury bond (blue) from 1954-2015. Interestingly, the average real interest rate over that duration is

2.41%, which is in the range that the theoretical portion of the literature review in this thesis has stipulated. On the other hand, the bond market was very slow to react to the inflation of the 1970s, with real interest rates falling all the way to -4.6% in December 1974. Moreover, the bond market was also very slow to react to the falling rate of inflation during the 1980s, with real interest rates going as high as 9.39% in August 1983.

**Chart 8.** ***Real and Nominal 10-Year Treasury Bonds (1954-2015)***

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## Chapter 3: Precipitating Factors

Thus, the next step is to find out what are the precipitating factors which could push long-term interest rates up going forward. I believe that there are three fundamental factors which can push them back up to the mean, and perhaps even higher. The first potential factor would be an increase in the velocity of money[28], the second potential factor would be the aging of the population, and the third potential factor would be an increase in the price of oil (a finite non-renewable resource).

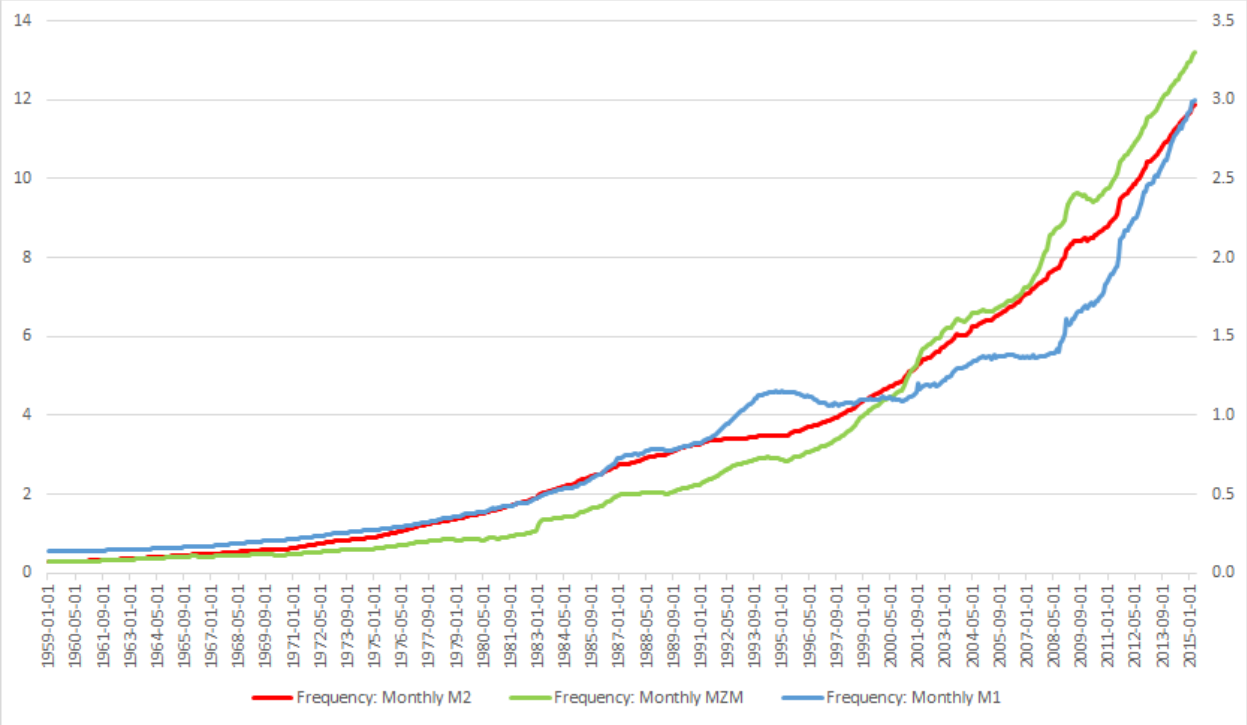
### *3.1 Animal Spirits: The Velocity of Money*

There are various money supply aggregates that are *currently* tracked by central banks. One broad money aggregate is called M1, which includes physical money in circulation (i.e., notes and coins), traveler's checks of non-bank issuers, demand deposits, and other checkable deposits (OCDs). The broadest measure currently tracked by central banks is called M2, which is M1 plus time deposits and money-market deposit accounts of less than $100,000. These two aggregates build on each other. However, the most liquid money aggregate is known as Money of Zero Maturity (MZM), which is made up of M2 except that it removes time deposits and adds money market funds of all sizes. The chart below (Chart 9) shows how the three aggregates have evolved since 1959. As can be seen, M1 (blue, right-hand scale) is currently at $3 trillion, M2 (red, left-hand scale) is currently at $12 trillion, and MZM (green, left-hand scale) is currently at $13.2 trillion.



[28] The velocity of money is the frequency at which one unit of money (in this case dollars) is used to purchase goods or services per unit of time (in this case 3 months). The velocity of money, or the rate at which money is exchanging hands, is frequently thought to measure the demand for money. A rising rate of velocity implies that the demand for money is falling while a falling rate of velocity implies that the demand for money is increasing (Tatom 1983, 12).

**Chart 9.** ***Money Supply Aggregates (1959-2015)***

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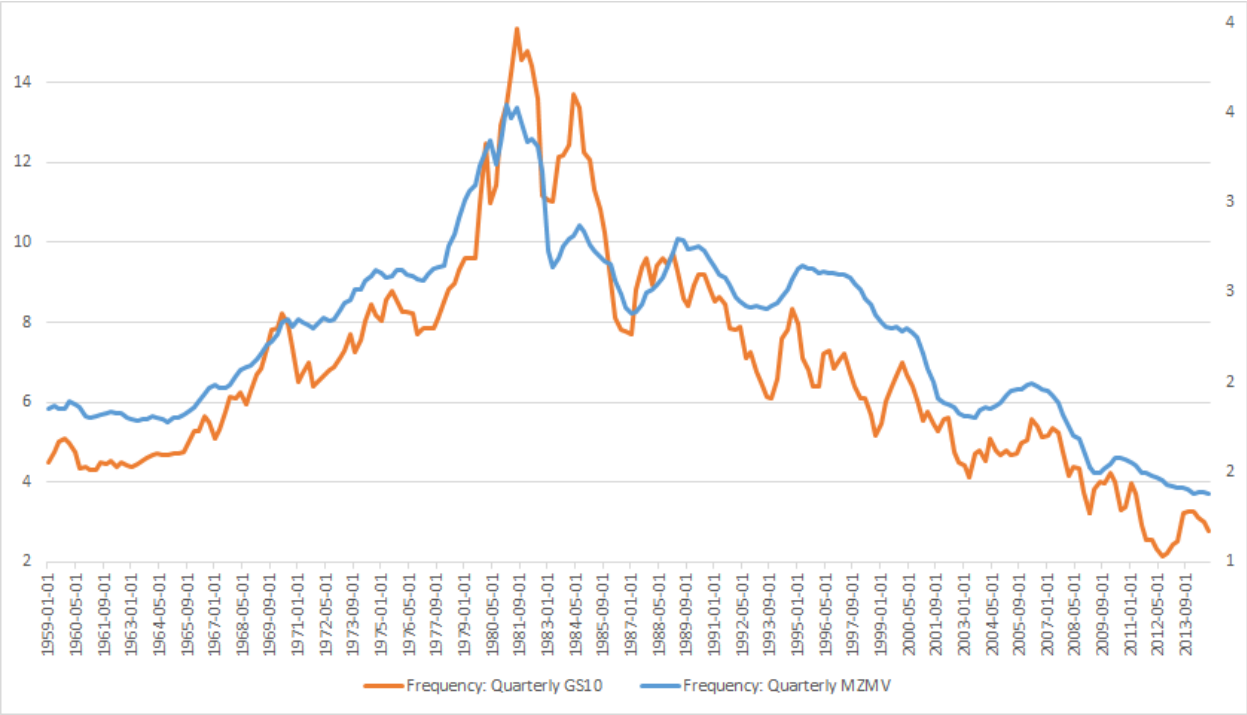
In order to gauge money velocity, it is probably best to look at the broadest yet most liquid measure of money supply, which would be MZM. The reasoning for this is that MZM measures that portion of the money supply that is instantly available. Thus, if aggregate velocity were to pick up, it would by definition first appear in the MZM. The chart below (Chart 10) shows the velocity of MZM (right) and the interest rates on 10-year treasury bonds (left) from 1959 until 2015. The correlation between the two variables is strong (0.93). Moreover, as can be seen, MZM velocity declined *before* interest rates did in 1980. The theoretical reason for this is that price inflation is a function of money velocity. The most alarming aspect of the chart is that MZM velocity is currently at an all-time low (1.38), quite a bit lower than its historical average (2.26). Thus, it is reasonable to

assume that once velocity picks up, so will inflation, and therefore interest rates.

**Chart 10.** ***MZM Velocity & 10-Year Treasury Bonds (1959-2015)***




(FRED 2015)

### *3.2 The Aging Process*

Yet another precipitating factor which may lead to rising interest rates revolves around demographics. According to the United Nations, the global median age, which is currently at 29, is projected to be 36 by 2050 (United Nations 2013). Countries like Japan, Spain, Italy, and Germany are projected to have a median age above 50 by 2050. This relates to interest rates because the most future-oriented members of society are those in their middle ages. In general, children and the elderly do not save and invest as much as do people in their middle ages. As put by Charles P. Kindleberger, middle age is "*future-oriented, which supports the propensity to save, lowers the rate of interest, spurs investment, stimulates growth… age resembles extreme youth,*

*with the addition that it is interested in the past (as well as the present) more than the future*" (Kindleberger 2000, 180).

### 3.2.1 Baby Boomers

The baby boom generation was born between 1946 and 1964. Within the next two decades, the vast majority of the so-called baby boomers will be heading into retirement. The theoretical portion of this thesis has maintained that the underlying force behind interest rates is time preference. Moreover, it has demonstrated that people in their middle-ages tend to save and invest more than adolescents and the elderly, partly because they have the largest incomes (people in retirement typically have lower incomes)[29]. As such, it should be expected that, in order to finance retirement, many of the baby boomers will sell off some of their liquid assets, including government bonds.

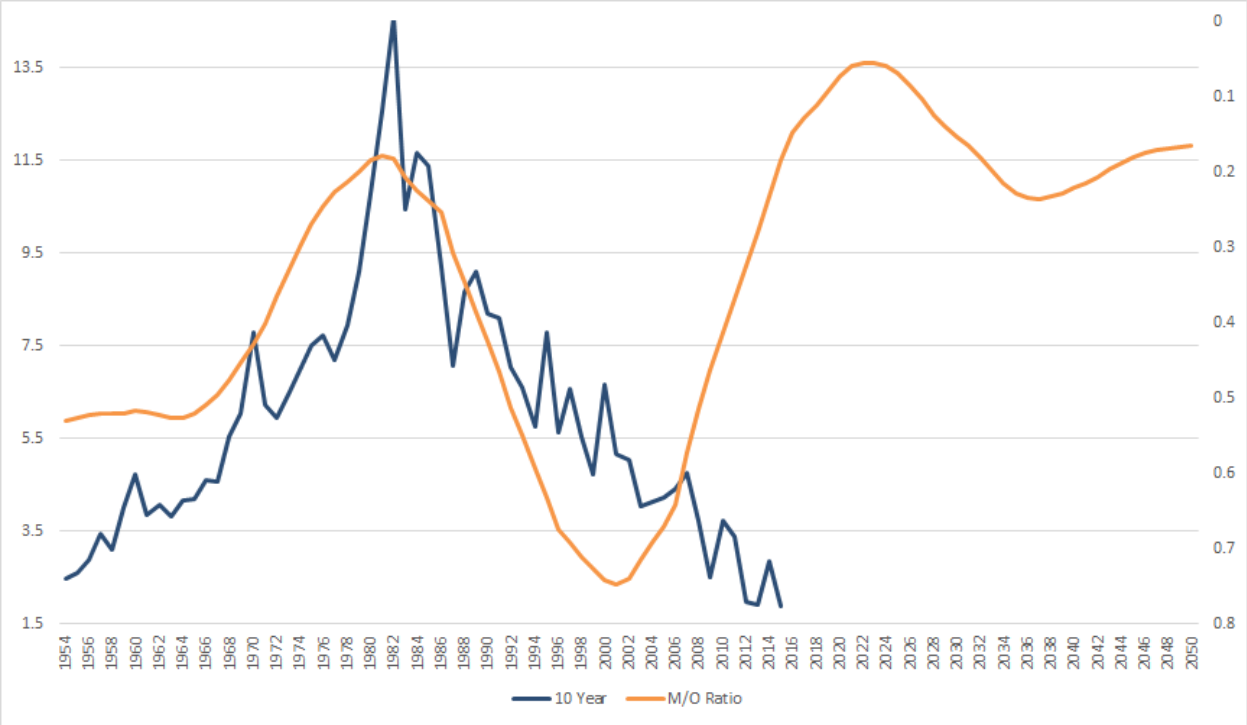
### 3.2.2 M/O Ratio

In order to see if there is indeed a relationship between aging and interest rates, the so-called "M/O ratio" will be analyzed (Liu and Spiegel 2011). The ratio looks at the number of people in the middle-age cohort (40-49) versus the number of people in the old-age cohort (60-69). To put things into perspective, if there are 1000 people in the middle-age cohort and 2000 in the old-age cohort, the M/O ratio would be 0.5. A rising ratio implies that there are more people in the middle-age cohort while a declining ratio implies that the population is aging. Between 1981 and 2000, the ratio went from a low of 0.18 to a high of 0.74. Interestingly, interest rates also declined substantially throughout that period of time. The chart below (Chart 11) shows the annualized interest rate on 10-year Treasury bonds (blue, left-hand scale) and the M/O ratio (orange, inversed,

[29] It has been argued that the asset market booms in the 1980s and 1990s were partly attributable to the fact that the baby boomers were entering their middle ages, considered to be the period of life during which people accumulate financial assets for retirement the most (Bakshi and Chen 1994).

right-hand scale) from 1954 until 2050. The correlation between the two variables is moderate (-.47). If the M/O ratio is any indication, then the projected aging of the US population (and many developed countries) should push long-term interest rates up[30].

**Chart 11.** ***Inversed M/O Ratio and 10-Year Treasury Bonds (1954-2050)***




(FRBSF 2015)

### 3.2.3 Life-Expectancy

As the empirical portion of the literature review has demonstrated, long-term interest rates show no discernable trend over time. In other words, there is no inherent tendency for them to rise or fall over very long periods of time. One of the reasons why this is the case, as the theoretical portion of the literature review has demonstrated, is that there is something inherent in a long-term

[30] Worth nothing is that many other developed countries have populations that are aging even more rapidly than the US population (Krueger and Ludwig 2007).

real rate of interest between 2-3%. The table below (Table 2) shows the number of years that it would take for a savings account to double in value at a given interest rate. The reason why 2% is such an important threshold is because, below that rate, it takes over 35 years for an asset to double. People are usually unwilling to wait longer than that due to life-expectancy. As put by Gustav Cassel,

> "*It is perhaps not apparent to everyone that there is something natural in a rate of interest of 3 or 4 per cent. But it is quite obvious that the number of years' purchase for which the same nominal rental will sell in the market must tend to be something between 25 and 33⅓ years, and is not likely to surpass the latter limit, for the simple reason that human life is short."* (Cassel 1903, 151)

**Table 2.** ***Doubling at Given Interest Rate***

| ***Interest Rate*** | 6 | 5 | 4 | 3 | 2 | 1 ½ | 1 | ¾ | ½ |
|---|---|---|---|---|---|---|---|---|---|
| ***Years until Doubling*** | 11.9 | 14.21 | 17.67 | 23.45 | 35 | 46.56 | 69.66 | 92.77 | 138.98 |

### *3.3 Oil: The Cup is Half Empty*

Studies have shown that liberals are less accurate than conservatives when it comes to judging the consequences of rising oil prices. More precisely, experts foresee considerable future risks to human wellbeing arising from more expensive oil prices, which are projected to rise (Schwartz, et al. 2011). Moreover, surveys have shown that liberals are less likely than conservatives to recognize and appreciate the magnitude of these risks (Nisbet, Maibach and Leiserowitz 2011). Conversely, conservatives are less likely than moderates, independents, or liberals to recognize the issues associated with global warming (Gallup 2015). Further studies have shown that people who deny global warming for ideological reasons may be persuaded if global warming is presented as a business opportunity for the nuclear industry (Feygina, Jost and Goldsmith 2010). On the one hand, people (conservatives) who recognize the magnitude of higher oil prices are reluctant to

switch to alternatives. On the other hand, people (liberals) who recognize the ramifications of global warming fail to see the economic and health implications of rising oil prices.

### 3.3.1 The Relationship between Energy and Growth

While this thesis is not about the link between energy consumption and economic growth, it is worth pointing out that numerous studies have pointed out the strong correlation between the two variables[31]. Moreover, there have also been numerous studies which have attempted to uncover which of the two variables (energy consumption or GDP growth) acts as the underlying independent variable. The table below shows the results of several previous studies. While the results are mixed, with some studies showing energy consumption while others showing GDP growth as the independent variable, the essential point to keep in mind is that energy is an essential component of economic growth[32]. Thus, rising oil prices entail a drag on GDP, which would presumably place upward pressure on interest rates due to the theoretical reasons discussed below. In a nutshell, the broad historical record of interest rates shows that countries tend to have relatively low interest rates during their prime years of economic growth and political stability. On the other hand, as economic growth slows down and there is political turmoil, interest rates tend to rise.



[31] Since 1850, there has been a strong correlation between total primary energy requirements (TPER) and GDP adjusted for purchasing power parity (WEC 2003).

[32] The fact that the results are mixed should not come as a surprise. On the one hand, economies need at least some energy in order to function and grow, in this sense energy consumption being an independent variable. On the other hand, a higher level of economic wellbeing enables people to demand more energy, in this sense GDP being an independent variable. However, if one were to start from first principles, it should be obvious that one must consume before growing, and not the other way around.

**Table 3.** ***Causality Tests between Energy Consumption and GDP***

| ***Authors*** | ***Method*** | ***Period*** | ***Subject*** | ***Results*** |
|---|---|---|---|---|
| (Kraft and Kraft 1978) | Granger[33] | 1947-1974 | USA | GDP → Energy |
| (Yu and Hwang 1984) | Granger | 1947-1979 | USA | No causality |
| (Yu and Choi 1985) | Granger | 1954-1976<br><br><br><br>1963-1993 | Korea<br>Philippines, US, UK, Poland<br>Brazil | GDP → Energy<br>No causality<br><br>Energy → GDP |
| (Yu and Jin 1992) | Error-correction model[34] | 1974-1990 | USA | Non-cointegrated[35] |
| (Masih and Masih 1996) | Error-correction model | 1955-1990 | Malaysia, Singapore,<br>Philippines<br>India<br>Indonesia<br>Pakistan | Non-cointegrated<br><br>Energy → GDP<br>GDP → Energy<br>Bi-directional |
| (Cheng 1997) | Granger | 1963-1993 | Brazil, Mexico, Venezuela | Energy → GDP |
| (Masih 1997) | Error-correction model | 1955-1991<br>1952-1992 | Korea<br>Taiwan | Energy → GDP<br>Bi-directional |
| (Asafu-Adjaye 2000) | Error-correction model | 1973-1995 | India, Indonesia, Turkey<br>Thailand, Philippines | Energy → GDP<br><br>Bi-directional[36] |
| (Glasure 2002) | Error-correction model | 1961-1990 | Korea | Bi-directional |
| (Hondroyiannis, Lolos and Papapetrou 2002) | Error-correction model | 1960-1996 | Greece | Bi-directional |
| (Soytas and Sari 2003) | Error-correction model | 1950-1992 | Argentina<br>Korea<br>Turkey<br>Indonesia, Poland | Bi-directional<br>GDP → Energy<br>Energy → GDP<br>Non-cointegrated |
| (Wolde-Rufael 2004) | Granger | 1952-1999 | Shanghai | Energy → GDP |
| (Oh and Lee 2004) | Error-correction model | 1970-1999 | Korea | Bi-directional |
| (Lee 2005) | Vector Error-correction model | 1975-2001 | 18 developing countries | Energy → GDP |
| (Lee 2006) | Granger noncausality | 1960-2001 | 11 developed countries | Mixed |

[33] The Granger causality test detects the causal direction between two times series variables, i.e., it detects a correlation between the current value of one variable and the past values of another variable (Granger 1969). In theory, the test would allow for the establishment of "predictive causality" (Diebold, et al. 2000).

[34] An error-correction model analyzes present deviations of two time series relative to their long-run relationships.

[35] Non-cointegrated means that there was no significant covariance found.

[36] Bi-directional causality means that the two variables have a joint impact on each other, i.e., they have a cross-lagged impact on each other.

| | | | | |
|---|---|---|---|---|
| (Chiou-Wei, Ching-Fu and Zhu 2008) | Granger, BDS, Nonlinear Granger | 1971-2003 | Hong Kong, Indonesia Singapore, Philippines | Energy → GDP<br><br>GDP → Energy |

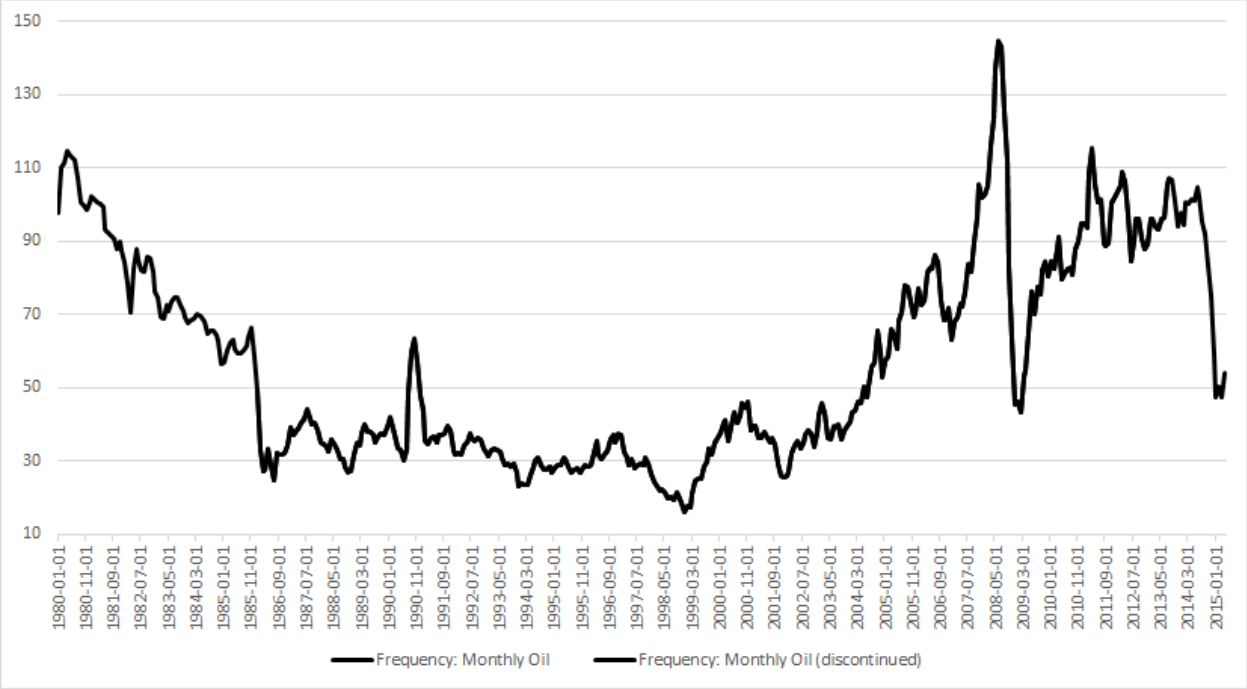
### 3.3.2 Peak Cheap Oil

Peak cheap oil (PCO) is a term coined in 2006 by economist Eric Janszen (Janszen 2006). It refers to a particular and distinct variation of peak oil theory. Instead of running out of oil, the idea behind PCO is that the world will gradually run out of profitable oil, i.e., at a certain point it costs more energy to extract a barrel of oil from the depths of the ocean than that extracted oil can generate. According to Eric Janszen, it is not a hypothetical theory but instead an incontrovertible empirical observation that has been in place since 1998 when oil prices bottomed out. As shown in in the chart below (Chart 12), which shows the USD price of West Texas Intermediate (WTI) oil divided by the consumer price index (2015 dollars), the data does seem to bear this out. Until present, roughly 1 trillion barrels of oil have been consumed. There are still roughly 1 trillion± worth of proven reserves that can potentially be extracted. The top three holders of oil are Venezuela (298 billion barrels), Saudi Arabia (268 billion barrels), and Canada (173 billion barrels) (U.S. Energy Information Administration 2015). Yet, this second trillion barrels of oil is typically heavier oil that is harder to reach and more expensive to extract and to refine[37].



[37] The easily accessible and high quality oil is typically referred to as "sweet" oil, while the harder to reach and lower quality oil which requires expensive refinement is typically referred to as "sour"oil.

**Chart 12.** ***West Texas Intermediate Oil Prices in 2015 Dollars (1980-2015)***




(FRED 2015)

In an extremely well timed article titled "*The End of Cheap Oil*", Colin J. Campbell and Jean H. Laherrère argued that the era of falling oil prices (as was the case since 1980) was coming to an end (Campbell and Laherrère 1998). Their logic was straightforward: we have consumed roughly half of the economic oil that exists underground and the second half is more expensive to extract (Campbell and Laherrère 1998, 78)[38]. The prevalence of and reliance on oil in the modern world is truly staggering. As put by Eric Janszen,

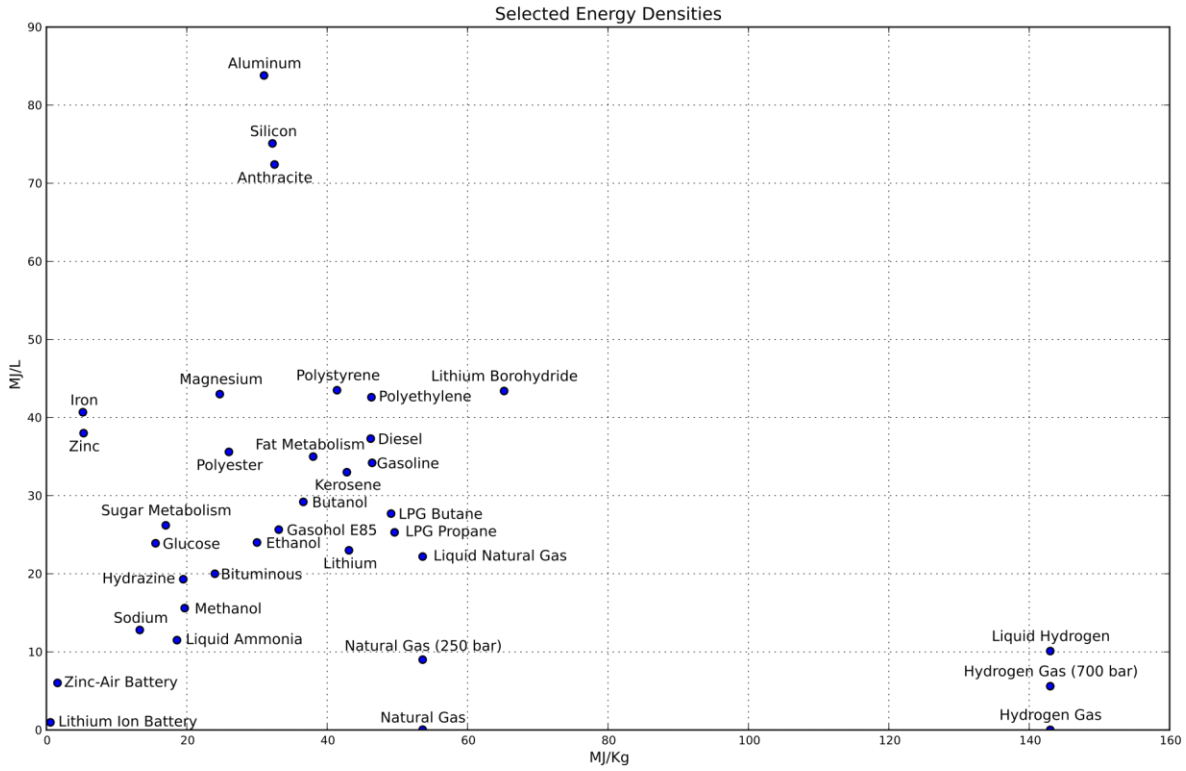
> "*Food is, for all practical purposes, made out of oil. Oil is a key component of fertilizer, and food doesn't walk to your local grocery store; it's carried there on trains and in trucks that burn fossil fuels. In fact, it's hard to think of a single good or service that does not directly or indirectly depend on oil to exist, and if supply depends on oil, you can bet prices do too.*"
> (Janszen 2010, 111)

[38] It should be pointed out that their logic was not original. In 1956, Marion King Hubbert correctly predicted that oil production from the lower 48 US states would peak around 1969, which was very close to the mark (it peaked in 1970) based on knowing that once half the oil is extracted, innovation improvements do not keep up with rising costs (Hubbert 1956).

### 3.3.3 Energy Density

Energy density is the amount of energy contained within a unit of mass or unit of volume. Hydrogen has the highest energy density on a per unit of mass basis. However, hydrogen has a very low energy density on a per unit of volume basis. On the other hand, anthracite (thermal coal) has a very high energy density on a per unit of volume basis yet a low energy density on a per unit of mass basis. What makes oil so unique is that it has a fairly high energy density on a per unit of mass *and* per unit of volume basis. The plot below (Plot 1) shows the energy density of various commodities on a per unit of mass (MJ/Kg) and per unit of volume basis (MJ/L). As can be seen, oil (diesel, gasoline, and kerosene) sits on the sweet spot between the two types of energy density.

**Plot 1.** ***Energy Density (MJ/L and MJ/Kg)***




(Wikimedia 2015)

### 3.3.4 No Moore's Law in Thermodynamics

Alternatives to oil such as Lithium-ion batteries will not increase substantially in energy density over time primarily because there is no Moore's law in thermodynamics. Moore's law is the idea that the processing power of computers will double roughly every two years. Intel co-founder Gordon E. Moore (whom the law is named after) himself acknowledged that the law does not apply to thermodynamics, in having written, "*No barrier exists comparable to the thermodynamic equilibrium considerations that often limit yields in chemical reactions*" (Moore 1965, 83). Thus, while the processing power of smartphones tends to double roughly every two years, the battery life of those smartphones hardly tends to improve over time.

### 3.3.5 EROEI

The implication of this is that PCO will not be offset via innovations in the energy sector. In fact, the energy return on energy invested (EROEI)[39] has been declining for nearly a century. Consider that in the 1930s, the ratio was well above 100, i.e., more than 100 barrels could be extracted for every barrel of oil (or energy equivalent) used in the extraction process. By 1980, EROEI declined to 30, which is substantially lower but still economical. Currently, the ratio is around 20. More alarmingly, the ratio is well below 10 when it comes to oil extracted from tar sands and deep-ocean drilling (Hall and Day 2009). While oil will remain theoretically economical as long as the ratio stays above 1, a shrinking EROEI implies rising oil prices. In a working paper by the International Monetary Fund based on EROEI projections incorporating technology improvements and



[39] EROEI is a ratio between the average number of barrels of oil obtained and the average number of barrels of oil (or equivalent) needed to obtain those barrels. In essence, it takes a certain amount of energy in order to extract further energy. As the oil industry is forced to extract in harder (and more expensive) to reach places, the ratio tends to shrink. Economically, it would not make sense to extract oil from the ground if the EROEI was below 1, since it would cost more energy to extract than could be obtained.

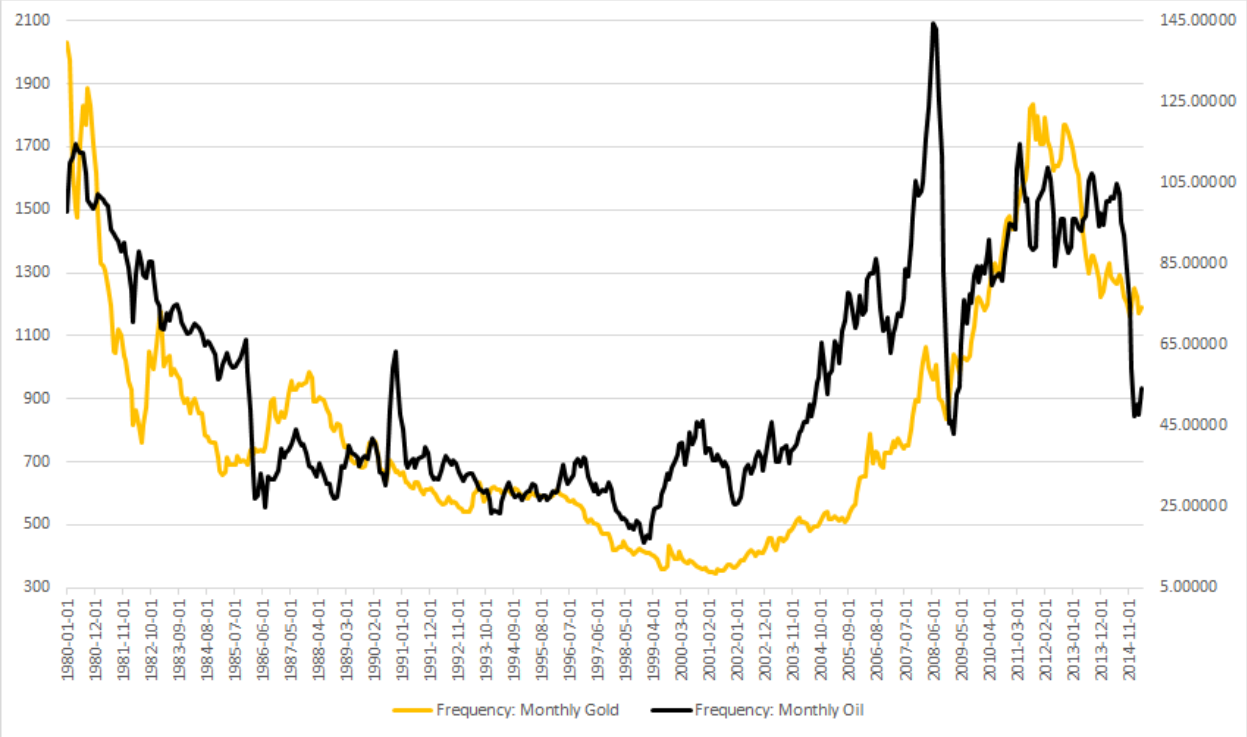
depletion rates, oil prices are projected to be around $180 per barrel by 2020, with a 90% probability of being within the $122-$240 range (Benes, et al. 2012). Consider that this entails a 100% increase from current prices ($60/bbl as of June 2015) in the best case scenario and a 300% increase from current prices in the worst case scenario, assuming the price stays within the 90% probability range.

### *3.4 Gold: The Barbarous Relic*

> "*If the dollar or any other fiat currency were universally acceptable at all times, central banks would see no need to hold any gold. The fact that they do indicates that such currencies are not a universal substitute. Of the 30 advanced countries that report to the International Monetary Fund, only four hold no gold as part of their reserve balances.*"
> – Alan Greenspan (2014)

Central banks are the largest institutional holders of gold. Worth noting is that central banks do not hold any other commodities in reserve (e.g., copper, wheat, natural gas, etc.). The six countries with the largest gold reserves are the US, Germany, Italy, France, Russia, and China (Aizenman and Inoue 2012). While China does not officially disclose its gold reserves, there is considerable evidence that it is one of the largest holders of gold (Salidjanova 2014). Together, these six countries make up over 45% of World GDP adjusted for purchasing power parity (CIA 2014). The purpose of this section is to see if there is a meaningful relationship between the price of gold bullion and the price of crude oil. While it is widely held that gold is a hedge against inflation (Worthington and Pahlavani 2006), the data seems to show otherwise. Consider that the consumer price index (Bureau of Labor Statistics 2015) has been steadily climbing from 1980 until 2001, yet the price of gold fell by more than 50% during that period of time, from $800/oz to less than $300/oz. On the other hand, the data does seem to bear out a meaningful and long-term relationship between the real price of gold and the real price of oil, as the chart below (Chart 13) shows.

**Chart 13.** ***Oil and Gold Prices, 2015 Dollars (1980-2015)***




(FRED 2015)

The theoretical reasoning for this relationship, and the most original contribution of this thesis, is that oil prices affect gold prices via central bank accumulation of gold. Contrary to the widespread notion that gold reserves are a hedge against inflation, this thesis asserts that *gold reserves act as an institutional proxy for oil prices*. The idea is that when oil prices are rising, central banks of oil exporting countries react by buying gold, which in turn pushes up gold prices[40]. By increasing the size of their gold reserves, central banks put a floor on their foreign exchange value, which in turn



[40] This process was already described in 1974 by Dr. Ibrahim M. Oweiss, who coined the term *petrodollar* (Oweiss 1974). The term petrodollar refers to oil revenues denominated in US dollars. Petrodollar surpluses are defined as net US dollars earned from the sale of oil that are in excess of internal development needs. These petrodollar surpluses were used to buy gold in the 1970s, Treasury bonds in the early 1980s, and since oil prices started rising in 1998, oil exporters have been increasingly purchasing gold.

guarantees purchasing power against oil. This relationship is tested statistically below via time series analysis.

### 3.4.1 Description and Data Analysis

Gold was measured by looking at the weekly closing USD price of gold per troy ounce (31.103 grams). Oil was measured by looking at weekly closing USD price of West Texas Intermediate (WTI) crude oil per barrel (42 US gallons). Both variables start from Friday, January 3rd of 1986 and conclude on Friday, May 22nd of 2015. The reason for starting in 1986 is because that is the first year from which *weekly* prices for crude oil are available.

Gold prices were gathered from the World Gold Council (WGC 2015) and oil prices were gathered from the U.S. Energy Information Administration (EIA 2015). The dependent variable is the price of gold and the independent variable is the price of oil. I believe this is appropriate because gold consistently seems to lag behind the price of oil. My theoretical reasoning for why this is the case is that central banks, amongst the largest holders and buyers of gold, seem to buy gold as a reserve asset for oil. Thus, when the price of oil is falling, central banks become net sellers of gold; and when the price of oil is rising, then central banks become net buyers of gold (WGC 2015). The hypothesis is that there is a relationship between the price of gold bullion (DV) and the price of crude oil (IV) over time. The null hypothesis would suggest that there is no relationship between the price of gold and the price of oil. The variables were coded as date, gold, and oil.

Both the dependent and the independent variables were handled as continuous. There were 1,534 cases for both gold and oil, with zero cases missing from the specified period of observation. There

were various types of analysis conducted on the data. These analyses included descriptives, correlations, running a linear regression, and checking the time series data using the Durbin–Watson statistic. More importantly, all of the major assumptions were checked so as to not present inappropriate results.

### 3.4.2 The Results

When it comes to oil prices, there are three cases that are three or more standard deviations away from the mean (≥$135.53). All three of these cases appeared in June or July of 2008, shortly preceding the financial crisis. When it comes to gold prices, there are no cases that are three or more standard deviations away from the mean (≥$1,875.37). The minimum price for oil appears in 1998, while the minimum price for gold appears in 2001. None of the cases reached a Cook's distance above 0.08, which is very far from the conventionally conservative score of ≥0.5 that would warrant the possible removal of an outlier.

The Pearson's correlation between the two variables comes out to .87, which is a very strong positive relationship[41]. What makes this even more important is that this is not merely the illusory effect of inflation. Consider that both oil and gold prices fell from 1986 until 1998, despite the consumer price index relentlessly rising throughout that period of time. Moreover, the gains that both oil and gold have seen since 2001 have greatly outpaced the rate of inflation.

The result from running the linear regression came out as follows:

[41] Relative to other commodities, this correlation is indeed surprisingly high. A Yale ICF Working Paper from 2005 studied the correlations of more than thirty commodities from 1959-2004 and found that the typical correlation between commodities is quite mild, usually less than .15 (Gorton and Rouwenhorst 2005, 37).

$$\hat{Y} = 106.08 + 11.60 * X$$

The β defines the slope and suggests that on average an increase of one unit (one dollar) in the price of oil is accompanied by an $11.60 increase in price of gold. Based on the t-test ($t(1,534) = 63.32$, $p<0.05$) we can reject the null hypothesis of no association on the 95% level.

The Durbin–Watson statistic tests for first-order serial correlation in the disturbance when all of the regressors are exogenous, i.e., the extent to which sequential residuals are serially correlated (the statistic ranges from 0.0 – 4.0)[42]. The Durbin–Watson test's d turned out to be 1.949 (d=(2, 1534)=1.949) which is between the acceptable thresholds of 1.4 – 2.6. This indicates that first-order serial correlation has a negligible effect on the linear regression analysis.

The distribution of the residuals was normally distributed based on face value by looking at the histogram provided by the deducer diagnostics. Moreover, the studentized residuals of the deducer diagnostics were exported to the data file. The correlational analysis of the residuals and the independent variable (oil) revealed no association on any conventional level of significance. Based on the diagnostics of the linear regression analysis, the scatterplot is fairly horizontal. Any funnel shaped distribution which would have indicated the violation of homoscedasticity was not detected. The F-test ($F(1,1532)=4,009$, $p<0.05$) indicated that there is no autocorrelation among the errors. The scatterplots reveal that the relationship between the independent variable and the dependent variable fit the criterion of linearity. Considering this is a simple linear regression, collinearity does not pose any threat, therefore the VIF test is out of the question. Thus, it would

[42] A Durbin-Watson statistic which is greater than 2.0 would imply that the residuals are uncorrelated while a Durbin-Watson statistic that is below 2.0 implies positive serial correlation, i.e., it overestimates the significance of the independent variable(s). In general, time series analysis is usually plagued by the latter.

be safe to assert that all of the major assumptions have been met with this analysis.

### 3.4.3 Discussion

These results confirm the findings of previous studies, which have shown that the price of oil statistically causes the price of gold to move in the same direction, i.e., the price of oil moves first and the price of gold follows (Le and Chang 2011; Malliaris and Malliaris 2013; Sari, Hammoudeh and Soytas 2010; Zhang and Wei 2010). Their reasoning for why this is the case seems to be similar to the one posited in this thesis: governments treat gold as a financial asset. The idea is that dominant oil exporting countries make use of their oil profits (when oil prices are high) by increasing their holdings of gold, thus pushing up the price of gold[43]. However, the fact that these two variables are highly correlated and that oil prices tend to Granger cause gold prices does not in and of itself prove causation. As put by William C. Brainard and James Tobin, "*In a highly interdependent dynamic system, the chronological order in which variables reach cyclical peaks and troughs proves nothing whatever about directions of causation*" (Brainard and Tobin 1968, 120).

While the results attained by this time series analysis are quite promising, the central point to keep in mind is that correlation does not mean causation. More in-depth analysis would have to be conducted to see whether oil prices do in fact have a meaningful relationship with the price of gold. While the idea that gold prices follow oil prices due to institutional pressures via central bank



[43] To be fair, gold is not the only asset that non-US governments buy. Perhaps the prominent asset held by non-US governments are US Treasury bonds. Gold is, as a matter of statistical fact, a diversification tool and represents a small percentage of official holdings. As put by Jörg Bibow, "*Beyond the nonnegligible contribution of non-interest bearing greenbacks (used in financing the international cocaine trade), Treasury debt securities feature prominently in US foreign liabilities.*" (Bibow 2012, 337).

purchases and sales is not contradicted by this analysis, it is in no way proven. While this thesis is primarily concerned with what factors make oil prices move in the first place, being able to establish a statistically significant relationship with one of the most important central bank assets, namely gold, has important ramifications for bond markets and therefore long-term interest rates.

**Table 4.** ***Descriptives of Oil and Gold Prices (1986 – 2015)***

| **(n=1,534)** | | | | | |
|---|---|---|---|---|---|
| | *Mean* | *SD* | *Median* | *Minimum* | *Maximum* |
| *Oil* | $42.80 | $30.91 | $26.86 | $11 | $142.52 |
| *Gold* | $611.64 | $421.24 | $391.90 | $253.82 | $1,861.20 |

**Table 5.** ***Linear regression coefficients of Gold Prices on Oil (1986 – 2015)***

| | **(n=1,534, $R^2$=0.75, $R^2_{adj}$=0.74)** | | |
|---|---|---|---|
| | *B* | *SE* | *t* |
| *Gold* | 106.08 | 9.26 | 11.46*** |
| *Oil* | 11.60 | 0.18 | 63.32*** |

***p<0.001

### 3.4.4 Diminishing Marginal Utility

The law of diminishing marginal utility states that as the consumption of a good or service increases, the utility derived from that good or services decreases. This ostensible law in economics was formally introduced by Hermann Heinrich Gossen in 1854, originally known as "Gossen's First Law" (Gossen 1983). The concept was later spontaneously reintroduced by William Stanley Jevons in England, and Léon Walras in France, and Carl Menger in Austria during the so-called "Marginal Revolution". The essential idea behind the DMU may be illuminated as follows: the first unit of consumption or production of a good or service yields more utility than

the second and subsequent units. Therefore, 1,000 widgets are worth more in a society which possesses only 1,000 widgets versus a society which has 1,000,000 widgets at its disposal. As is the case with time preference, the DMU applies to individuals and society as a whole.

This thesis will make use of the theory of diminishing marginal utility (DMU). More specifically, it will consider the DMU applied to PCO. In other words, as the supply of economic oil decreases, the utility derived from the remaining oil increases. The argument which flows from the theoretical buildings blocks may be summarized in the following way: (1) PCO will shrink *discretionary incomes*[44]; (2) aggregate time preferences will tend to increase due to DMU; which will, ceteris paribus, place upward pressure on interest rates going forward. Incidentally, this insight has been entertained by previous scholars looking at the relationship between oil and gold (Malliaris and Malliaris 2013)[45]. The political implication is that governments will have a tougher time financing themselves during a process of rising interest rates. The diagram below (Diagram 2) depicts this process at its most elementary level.

**Diagram 2.** ***The Impact of Peak Cheap Oil on Interest Rates***



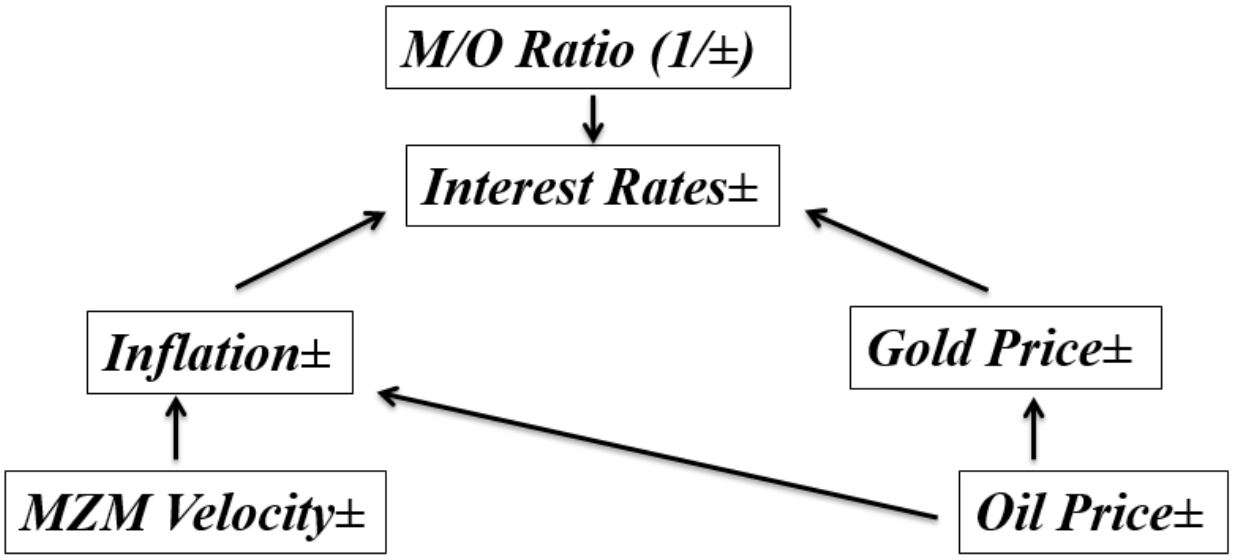

[44] Discretionary income is the amount of an individual's income that remains after taxes and necessities have been paid.

[45] They wrote, "*If oil prices increase and gold prices also increase, economic analysis suggests that interest rates will also increase*" (Malliaris and Malliaris 2013, 2).

### 3.4.5 Overall Framework

A recent study has found that there is a statistically strong relationship between oil prices and long-term interest rates (Reicher and Utlaut 2010). The study estimated a seven-variable-VAR for the US economy during the post-WWII era and found a strong connection between oil prices and long-term interest rates. Not only was the relationship between interest rates and oil prices found to be significant at conventional levels, but the authors conclude that it is nearly impossible to statistically distinguish oil shocks from shocks to long-term interest rates (Reicher and Utlaut 2010, 7). This suggests that there is a meaningful relationship between interest rates and oil prices. The diagram below (Diagram 3) shows the overall framework of the precipitating factors that have an influence on long-term interest rates.

**Diagram 3.** ***Overall Framework***



# Chapter 4: The Political Solution

## *4.1 Fiscal Consolidation as a Self-Defeating Process*

Fiscal consolidation, commonly referred to as austerity, implies public revenues increases, public expenditure cuts, or a combination of the two. The aim of fiscal consolidation is to bring down the debt-to-GDP ratio in order to boost investor confidence and make public finance more sustainable. However, the track record of fiscal consolidation is rather dismal. For example, a paper published by the IMF which analyzed 15 developed countries from 1980-2009 found no support for the *expansionary fiscal contraction* (EFC)[46] hypothesis (Leigh, et al. 2010, 113). More interestingly, the paper found that interest rate cuts will have little to no effect on stimulating the economy if interest rates are very low to begin with (they currently are). Yet another paper published by the IMF found that fiscal consolidations are self-defeating, i.e., the debt-to-GDP ratio actually increases, either because fiscal consolidations fail to reduce the deficit or because they shrink GDP more than the deficit (Cherif and Hasanov 2012). More recently, a paper published by the Federal Reserve Bank of San Francisco conducted time series analysis on data from the IMF and OECD between 1970 and 2007. Their results suggest that the output losses due to fiscal consolidation are even larger than previous studies have found (Jordà and Taylor 2013, 30).

### 4.1.1 Micro versus Macro Logic

When individuals, households, and firms alike are faced with financial difficulties, it is rational for them to cut expenditures and attempt to increase their revenues. However, this logic does not hold at the macro level. In other words, the modern credit machine is not designed to deleverage

[46] The expansionary fiscal contraction hypothesis assumes that fiscal retrenchment stimulates growth. The term was introduced by economists Francesco Giavazzi and Marco Pagano who analyzed the restructurings of Denmark and Ireland in the 1980s (Giavazzi and Pagano 1990).

at once. When individuals take out loans, money is generated into existence *ex nihilo*. Moreover, when individuals pay down their loans, money is extinguished, i.e., the supply of money shrinks[47]. The first person to succinctly describe this process was John Kenneth Galbraith (Galbraith 2001; Galbraith 2009). The idea is that when too many people are paying down debts which are not offset by other people taking out loans, the deleveraging becomes self-defeating because the value of the currency tends to increase, making the remaining debts harder to pay off. This process is known as *debt deflation*[48].

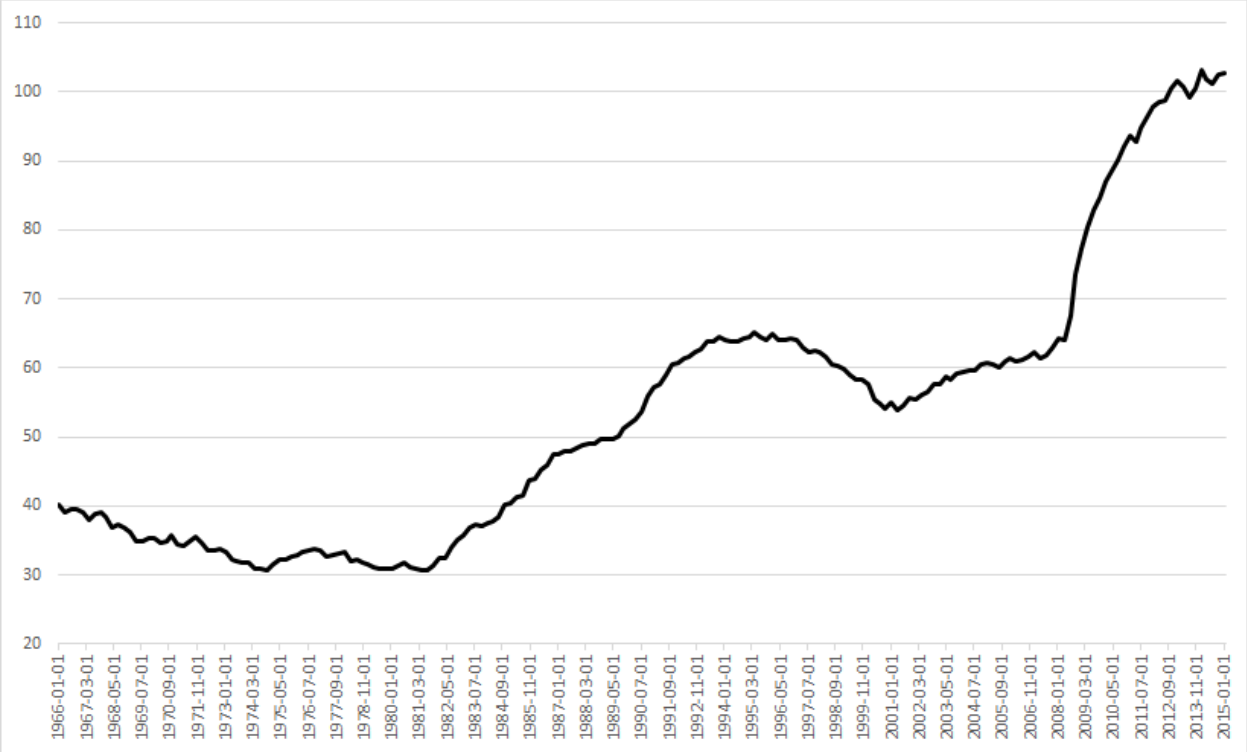
### 4.1.2 Fiscal Solvency

At present, public debt-to-GDP ratios of many countries are at all-time highs. The chart below (Chart 14) shows the debt-to-GDP ratio for the US. As can be seen, the ratio started rising in the 1980s as interest rates started to fall. The ratio has ballooned from 30% to over 100% at present. A high debt-to-GDP ratio is not a problem per se. In an environment of falling interest rates, the ratio can climb indefinitely since the sovereign can roll over old debts by issuing new debts at lower interest rates[49]. However, if and when interest rates start to rise, managing the debt becomes an increasingly unstable situation.



[47] This insight has recently been acknowledged by the Bank of England. In a quarterly bulletin whose purpose was to describe money creation in the modern economy, it states that "*taking out a new loan creates money, the repayment of bank loans destroys money*" (McLeay, Radia and Thomas 2014).
[48] Debt deflation is a term coined by economist Irving Fisher. It refers to the shrinkage of the overall stock of debt which dries up liquidity and makes balance sheets progressively unrepairable (Fisher 1933).
[49] This has indeed been the case in Japan for the past 35 years, which had a debt-to-GDP ratio of 50% in 1980 and currently has a debt-to-GDP ratio of 227% (Trading Economics n.d.).

**Chart 14.** ***US Federal Debt-to-GDP Ratio (1966-2015)***




(FRED 2015)

One way to gauge whether or not a country is solvent is by looking at its primary surplus relative to its short-term nominal interest rate and annualized nominal GDP growth. This approach has been used by Recovery Partners, an advisory company that has been involved in a number of successful sovereign debt restructurings (Recovery Partners 2015). The primary surplus should be equal to or greater than the nominal interest rate on short-term government bonds and the annualized nominal GDP growth rate multiplied by the debt-to-GDP ratio. Thus, the calculus is defined as follows[50]:

$$\text{Primary Surplus} \geq (r_{nom} - g_{nom}) * (\text{debt-to-GDP})$$

[50] In this calculus, *r* denotes the short-term interest rate and *g* denotes GDP growth rate for the past year.

Plugging in the numbers for the current state of affairs in the US, we end up with the following[51]:

$$-2.8 > -220.32$$

Thus, while the US currently has a historically high debt-to-GDP ratio, it is not insolvent by any means according to this ratio. However, if we run the same calculation with a historically average 1-year interest rate, we end up with the following[52]:

$$-2.8 < 305.6$$

As can be seen, with a historically average 1-year interest rate, the US would effectively be insolvent. Even if we were to double the growth rate, the equation would still place the US into insolvency. Thus, rising interest rates have the potential to do a lot of damage to public finance management going forward.

### *4.2 Trills: A Viable Alternative*

> "*When people are actually able to see the price in macro markets for GDP, they will be able to see an indicator of the long-run situation, diverting the framing from the small short-run ups and downs of the economy that so captures our attention today. They will be seeing much more dramatic movements up and down in the long-run value of the economy, reflecting the future as well as the present, and it is this long-run value that really matters to economic welfare. This reframing will create important new reference points, important new focuses of attention, just as the creation of stock markets centuries ago did for our appreciation of the long-run value of corporate earnings.*"
> – Robert Shiller (2003)

At the heart of this thesis lies a proposal for another such financial innovation in the form of GDP-linked bonds (so-called "trills"), which would supplant government bonds. This proposal is timely because (1) interest rates on long-term government bonds are at all-time historic lows and (2) the risk of sovereign debt defaults should interest rates regress to the historic mean is significant, as this thesis has hopefully demonstrated. The concept of GDP-linked bonds was first proposed by

[51] -2.8 > (0.25 – 2.42) * 101.53
[52] -2.8 < (5.43 – 2.42) * 101.53

Robert J. Shiller in 1993 (Shiller 1993). Since then, there have been a handful of articles analyzing and arguing for GDP-linked bonds. Borensztein and Mauro (2004) argued that GDP-indexed bonds would drastically reduce the likelihood of sovereign debt defaults and would mitigate pro-cyclical fiscal policies. Kruse, Meitner, and Schroder (2005) analyzed how to price bonds that would have their coupons tied to GDP. In a paper published by the United Nations, Griffith-Jones and Sharma (2006) outlined the benefits and concerns of introducing GDP-indexed bonds and documented various countries' efforts to establish such instruments.

### 4.2.1 Previous Experiments

Although there has never been a full-fledged GDP bond issued by a sovereign state to date, there have been a few historical examples of countries issuing something akin to trills. For example, in the mid-1990s as part of the Brady Plan restructurings, Bosnia and Herzegovina, Bulgaria, and Costa Rica issued bonds with warrants that promised to increase their payments if GDP reached a certain level (Council of Economic Advisers 2004, 5). However, these were not really trills, since the warrants were designed to increase payments at predetermined GDP thresholds rather than lockstep with GDP. Another related example happened in 2001, when Singapore issued the so-called "New Singapore Shares". These shares paid 3% interest plus the GDP growth rate, if positive (MOF 2001). Yet, these shares were missing an essential component of the trill with regards to public finances: the ability for the value of the bond to fall during a recession, thus shifting the risk onto investors and away from the sovereign. The most recent example of something akin to a trill happened in Argentina in 2005, which issued bonds with warrants linked to GDP growth. However, these payments were conditional on (1) real GDP being higher than a predetermined baseline, (2) real GDP growth being higher than baseline growth, and (3) the total payment cap not being exceeded. Thus, not only were these bonds exceedingly complicated to

scale, but the probability of investors benefitting from the warrants should GDP grow was predicated on better than expected growth.

### 4.2.2 The Structure and Benefits of Trills

More recently, Mark Kamstra and Robert Shiller have been proponents of "trills", which are essentially shares of the GDP of a given country. In essence, a trill would be a new security with a coupon tied to the nominal GDP of the country issuing the trill. The coupon would fall during recessions along with declining tax revenues and declining GDP. Rather than issuing government bonds, a sovereign would be issuing shares representing, say, a trillionth of the country's GDP[53]. This would mean that sovereigns would have an incentive to boost future growth, and if GDP declined the holders would bear the cost rather than the government having to implement austerity measures or face default. Needless to say, the government would no longer have to worry about insolvency, and "trill" holders would not have to worry about inflation, haircuts, nor defaults (Kamstra and Shiller 2009).

Trills have the potential to solve a moral hazard problem associated with government finance, namely inflation. With Trills, countries could no longer reduce their real obligations by creating massive inflation as is the case today with conventional government debt. This is because nominal GDP tends to increase with inflation. Therefore, Trills would maintain their value despite inflation. The relevance of inflation in eroding the real value of assets cannot be overstressed. A recent study has estimated that a quarter of all public debt reduction in the US during the post-WWII period was due to inflation (Hall and Sargent 2011).

[53] Technically, a trill would be 1/trillionth of a GDP, or $17.71 in the US at current levels. The asset would continue to track the nominal level of GDP over time. Thus, if and when the US GDP reached $20 trillion, a trill would be issued at $20.

US Treasury bonds and notes represent a loan to the US government, In effect, bond holders are creditors, versus being shareholders (Labuszewski, Kamradt and Gibbs 2013). Stock markets represent the corporate sector, which is typically a small portion of the economy in any given country, including the US. In fact, corporate profits in the US represent less than 10% of US GDP (Kamstra and Shiller 2009, 6). With the introduction of "trills", the amount of people involved in allocating public funds via debts dwindles down. The state could then only finance itself via taxes, which do not entail default risk, or via making a credible case to potential trill holders that GDP will grow versus making a credible case that government revenues in the future will increase. The incentive is switched from promising to expropriate society more in the future to promising to grow the economy more in the future. Trills are essentially an equity stake in the economy. As put by Shiller and Kamstra, "*In the language of financial economists, the Trill exposes domestic investors to systematic risk and insures the government against it*" (Kamstra and Shiller 2009, 9).

Unlike government bonds, trills are not a zero-sum game. Bonds are a zero-sum game because the owners of government bonds may benefit in a deflationary environment, since the real value of the bonds would increase. On the other hand, owners of government bonds may lose in an inflationary environment, since the real value of the bonds would decrease. This is a dysfunctional arrangement since deflationary environments are typically associated with slowdowns in the economy when the government can least afford to meet its obligations. Contrary to government bonds, trills would provide a mutual win-win or lose-lose situation for the state and investors alike, since the value of trills would fall during recessions and rise during booms. Thus, a government concerned with financing its obligations in a recession (typically associated with declining revenues and increasing

expenditures as more people claim unemployment benefits) would regard should regard the trill as a natural hedge against sovereign default.

Currently, there are a wide variety of assets available to investors, including but not limited to bonds (municipal, state, federal), equities (stocks), derivatives (e.g., futures, swaps, exchange traded notes), commercial paper, mortgages, and real estate investment trusts. The issue with all of these assets, even if combined, is that they represent a small fraction of GDP. The bulk of GDP (≥⅔ of GDP) is comprised of wages, salaries, and other income streams, but investing in these claims is currently closed off, which prevents financial diversification (Kamstra and Shiller 2009, 5).

Kamstra and Shiller used a mean-variance optimization retrodiction in order to estimate the potential performance of a trill. According to their analysis, which started from 1966 to 2006 (normalized for 1966, so that each investment was worth $1 in 1966), a trill would have increased from $1 in 1966 to $29 in 2006, whereas the S&P 500 would have increased from $1 in 1966 to $14 in 2006 (Kamstra and Shiller 2009, 13)[54]. Interestingly, the trill managed to perform this well with half the volatility of the S&P 500. The *beta* for a trill was only 0.25, meaning that it is only mildly correlated with the stock market[55]. More importantly, the analysis found that trills are negatively correlated with long-term government bonds (Kamstra and Shiller 2009, 29). This suggests that, apart from performing well, the trill would serve as a great diversification tool.

[54] One may wonder why the trill performed so well in the retrodiction. After all, GDP has not increased 29-fold from 1966 to 2006. The main reason why this was the case is because financial assets often sell at multiples. For example, the stock market often sells at several times its aggregate yearly earnings, i.e., the price-to-earnings ratio is always well above 1 and typically above 15. Assuming trills would trade at similar multiples, a current trill could easily end up selling for $265 in the market (17.71 * 15 = 265.65).

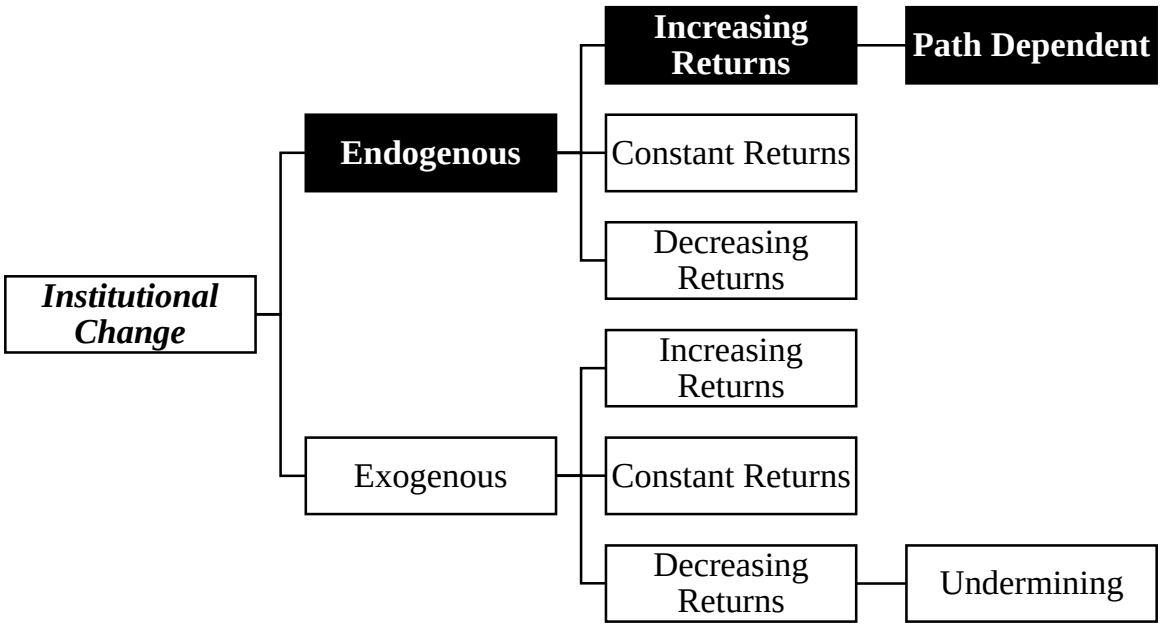
[55] The beta refers to the degree of correlation between the return on an asset, such as a particular stock, and the overall market return (typically proxied by the S&P 500).

One reason that trills can potentially supplant government bonds is that they have the potential to be path dependent. Narrowly understood, path dependence is an institutional "lock-in" where change becomes highly unlikely (Pierson 2004). In essence, path dependence is caused by self-reinforcement for two reasons: (1) *increasing returns* and (2) *endogeneity*. Increasing returns implies a sort of snowball effect, where "*the more a choice is made or an action is taken, the greater its benefit*" (Page 2006, 88). Endogeneity, on the other hand, implies a process in which there is a cause-effect circuit, i.e., a positive feedback loop. This is in contrast to processes in which exogenous factors are the result of change. Exogenous variables would be those which are not controlled or determined by an institution, but which may nevertheless affect the development of the given institution (Rixen and Viola 2014, 9).

As can be seen on the organization chart below, institutional change can come about through either endogenous or exogenous factors. These factors can provide either increasing, constant, or decreasing returns. Rixen and Viola argue that in order for a process to be truly path dependent, the factor responsible for institutional change must be endogenous in nature and must provide increasing returns (Rixen and Viola 2014, 11). I believe that trills are both endogenous and provide increasing returns. This is because it is ultimately up to the government to issue them, and historically GDP growth has vastly outperformed returns on bonds. On the other hand, I also argue that long-term government bonds are increasingly starting to look like they are controlled via exogenous factors that are providing decreasing returns. This is because governments cannot control long-term interest rates. While it is certainly true that Trills would entail high fixed costs

and learning effects, this is actually part of the path dependent taxonomy. In fact, part of the reason why a factor is path dependent is because, once in place, it is very expensive to undue.

**Chart 15.** ***Institutional Change via Path Dependence***




### *4.3 Limited Liability: Parallels to Trills*

In 1811, the state of New York passed a corporate law granting *general* limited liability for manufacturing companies (Davis and North 1971). Prior to general limited liability, shareholders were personally liable if the company they invested in were to go bankrupt. In other words, investing in a company prior to general limited liability meant that one was risking all of his or her assets when investing in a company, including potentially going to debtors' prison (Shiller 2003, 235). Needless to say, this greatly disincentivized capital formation; especially in commercial endeavors that were long-term oriented, required large sums of capital, and were by their nature relatively risky. As put by Robert Shiller, the "*proliferation of stock markets could not exist until*

*the corporate law was created that defined the rights of shareholders and provided for limited liability of shareholders*" (Shiller 1993, 11).

After general limited liability was established in New York, investors risked only the money they invested into a company[56] (Howard 1938). This incentive structure enabled the capital formation necessary for railways, factories, and other higher-order capital goods as money poured into New York. Moreover, it freed the companies now under limited liability from the burden of fixed-interest debt. In other words, companies no longer financed themselves *primarily* through issuing debt but instead through issuing equity. As put by Robert Shiller, "*An essential factor that has promoted the development of modern stock markets is the guarantee, in law, of limited liability for investors in stock*" (Shiller 2003, 234). At the time, many legislators were against limited liability due to their concern about the *moral hazard*.

What made general limited liability a true political financial innovation was that it was *not* a zero-sum game, i.e., it did not make equity less risky by making debt more risky (Moss 2004). Rather, the benefits of putting a ceiling on potential losses (the capital the investor put in) greatly outweighed the cost of potentially higher debt default risk. Not only did limited liability help make New York, which was previously relatively undeveloped compared to Boston, the financial capital of the US, but it was a big reason why New York eventually overtook London as the financial capital of the world. Moreover, limited liability came with an *unintended consequence*, albeit a positive one. It now made sense to diversify, which is considered today to be the hallmark of sound investment practices (Fabozzi and Drake 2009). Prior to limited liability, diversification was

[56] In theory, the stockholder cannot lose more than the purchase price of the stock. The caveat, however, is that even under limited liability one can lose more than they invested if the use of margin debt is involved.

counter-productive, since any one investment held an investor liable for the bankruptcy of a given company that they happened to invest in. As put by Robert Shiller,

> "*By clearly forbidding suits against shareholders for a company's sins, it limited the downside risk of investing to psychologically manageable proportions (no more worries that any one of your investments could explode and land you in debtors' prison), and it permitted portfolio diversification to proceed without exhaustive investigation of each company's management.*" (Shiller 2015, 266)

Once it became clear that limited liability was a superior form of capital formation, the other states started playing catch-up, with New Hampshire following suit in 1816, Connecticut in 1818, and Massachusetts in 1830 (Forbes 1986, 172). Eventually all US states followed New York in the implementing general limited liability, with California being the last in 1931. Furthermore, even Great Britain eventually recognized limited liability was a superior form of capital formation. Consider that in 1860, government bonds represented roughly half of the total market capitalization of Britain's securities whereas by 1914 government bonds represented less than 5 percent (The Economist 1999). Great Britain adopted general limited liability on the national scale in 1855, France in 1867, and Germany in 1870 (Orhnial 1982). Today, virtually every single country in the world has limited liability, truly a financial innovation brought about by the political sphere.

The early 19th century is also characterized by a *tipping point* in economic growth. Prior to the 19th century, estimated *world* per capita GDP growth was virtually flat, growing at less than 1 percent on average over the past millennia (De Long 1998). Indeed, Western Europe's population grew at only 0.2 percent annually between the years 1000 to 1820 A.D. (Maddison 2001, 28). While there are certainly a myriad of reasons for why economic growth picked up in the early 19th century, the establishment of general limited liability, which was essentially a *political decision*, certainly played an important role. The purpose of this thesis is not to establish how important limited

liability was in fostering unprecedented growth. Rather, the historical example of limited liability serves as an analogy and a reminder that *financial innovation* can have a tremendous and lasting impact on the world.

# Chapter 5: Conclusion

The goal of this final chapter is to discuss the implications of the main findings and to briefly summarize the main contributions of the thesis. Furthermore, this chapter outlines the various limitations of the analyses which were conducted.

One of the primary aims of this thesis was to address the historical oscillations in long-term interest rates. This thesis explained the oscillations using the concept of feedback loops. More specifically, it would appear that long-term interest rates are susceptible to second-order negative feedback loops. Assuming the concept of feedback loops appropriately explains the historical oscillations in long-term interest rates, a subsequent research question naturally presented itself. Since long-term interest rates tend to regress to the mean it was worthwhile to try and find out which factors could potentially push long-term interest rates towards the historical mean once again.

## *5.1 Main findings*

This thesis has uncovered some primary empirical findings that were already in the literature. First, the birth of the sovereign debt market can be traced to 12$^{th}$ century Venice. Second, long-term interest rates started to become geographically correlated throughout Europe in the 17$^{th}$ century. Third, long-term interest rates have displayed significant oscillations over the past two centuries, and the amplitude of these oscillations has increased over the past century. The last primary empirical finding regarding long-term interest rates was that they provide a short of "fever chart" of economic and political health; rising rates implying turmoil such as sovereign debt defaults, natural disasters, or wars.

This thesis has also uncovered some primary theoretical findings that were already in the literature. Firstly, long-term interest rates are determined by the supply and demand for loanable funds. Second, the underlying factor behind interest rates appears to be a latent variable known as time preference, i.e., the innate propensity for people to discount the future. Perhaps the most important finding, which is based on both theory and evidence, is that central banks cannot control long-term interest rates in the long run.

In the second chapter of this thesis, the historical oscillations in long-term interest rates are addressed. In order to narrow down the analysis, this thesis focused on US 10-year Treasury bond yields from 1953 until 2015. The primary finding was that interest rates are currently at all-time lows, more than one standard deviation from the mean throughout that duration. While one standard deviation may not appear to be alarming, it should be noted that government bonds are typically considered low risk and low volatility assets. Moreover, only part of the currently record low rates can be explained by central bank intervention in the form of Treasury purchases.

In addition, there were a number of interesting findings that came about from analyzing the data. Perhaps the most interesting is that, despite record low interest rates, the spread between long-term and short-term rates is at a record high. This means that people are heavily discounting the future, something that is not readily apparent if one were to simply look at interest rates. Lastly, the second chapter of this thesis explains the historical oscillations in long-term interest rates using the concept of feedback loops. More specifically, it appears that long-term interest rates are susceptible to second-order negative feedback loops. The reason why this is the case is because the bond

market has consistently been slow to react to inflation, i.e., there is a significant lag between inflation and the corresponding adjustment in the rate of interest.

In the third chapter of this thesis, three primary factors which could push long-term interest rates towards their historic mean are elaborated on. These factors are (1) an increase in the velocity of money, (2) the aging of the population, and (3) increasing real oil prices. First, the factors are justified on theoretical grounds. For example, the aging of the population would likely lead people that are heading into retirement to sell off some of their assets (including bonds) in order to finance a certain standard of living. However, all of these factors were put under empirical scrutiny. The relationship between the velocity of money (operationalized using the MZM money aggregate) is virtually as high as in can get, i.e., long-term interest rates are strongly correlated with the velocity of money. While the aging of the population (operationalized using the M/O ratio) only displays a moderate correlation with long-term interest rates, it nevertheless appears to be an important contributor historically. Projections of the aging of the US population into 2050 suggest much higher interest rates should the relationship continue to hold.

A significant portion of the third chapter is dedicated to the relationship between oil, gold, and interest rates. Theoretically, rising oil prices should (ceteris paribus) push up other prices, leading to less discretionary income, and therefore rising interest rates as time preferences rise. While there are certainly a number of channels through which rising oil prices can push up the general level of prices, and therefore interest rates, this thesis focuses on an institutional link between oil and gold. Namely, part of the reason why there is a very strong correlation between oil prices and gold prices, at least throughout the duration that this thesis analyzes the two prices (1986-2015), is because

central banks buy, sell, and hold a tremendous amount of gold. Noteworthy is that central banks do not hold any other commodity, which suggests that gold is still a monetary asset. The strong relationship between the two variables is explained via oil exporting countries using excess revenues increasing their stock of gold ex post oil prices rises.

The fourth chapter of this thesis outlines why the prospect of rising long-term interest rates significantly raises the risks of sovereign debt defaults. The primary reason for this is that debt-to-GDP ratios are at record highs throughout much of the developed world. Second, the chapter argues that the probability of fiscal consolidation (austerity) being successful in an environment of rising interest rates is dismal based on historical evidence. The rest of the chapter is dedicated to making the case for so-called "trills", which are essentially shares in GDP. Assuming that the state would start issuing these instruments, it could altogether mitigate the possibility of a sovereign debt default. Lastly, the chapter draws parallels between general limited liability (a type of financial innovation) and trills. Namely, many of the fears appear to be the same (e.g., moral hazard) and many of the benefits also appear to be the same (e.g., providing a win-win or lose-lose environment versus the status-quo, which amount to a zero-sum game).

### *5.2 Limitations*

The primary limitations of this thesis lie in the third chapter. While all of the proposed factors have an independently significant relationship to long-term interest rates, this thesis has not explored how much of the variance can be explained by the three factors combined. Moreover, it remains unknown how related the factors to one another. In other words, this thesis did not provide a fully specified model. Furthermore, the causal relationships between the three factors and long-term interest rates were not absolutely determined. For example, while the velocity of money is strongly

correlated to long-term interest rates, it could be the case that the latter drives the former or that they are really unrelated and the correlation in spurious. Unfortunately, I could not conduct time series analysis nor causality tests between the velocity of money (nor the aging of the population) and long-term interest rates because the number of observations were simply too low (quarterly data).

Furthermore, the unit of analysis of this thesis was the US. The results from the analyses in this thesis may not apply to other countries. While it is known that interest rates are geographically correlated, it has not yet been established that the three factors considered in this thesis (velocity of money, aging of the population, and rising oil prices) are correlated to interest rates in other countries. Another inherent limitation is the speculative nature of trills. While a number of studies are cited which suggest that trills would be a net benefit for investors and governments alike, this is ultimately unknowable until the assets actually exist. Lastly, simply because debt-to-GDP ratios throughout the developed world are currently at all-time highs, it does not mean that they will continue to rise. It may be the case that the level of debt will shrink and the level of growth will increase going forward, thus mitigating the negative consequences of rising long-term interest rates going forward.

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