Macroeconomic Forecasts, 1Q2018

Capitalytics

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Introduction

Capitalytics performs a rigorous analysis of every variable that is included in our quarterly macroeconomic study. These variables include the following[1]:

1. Real GDP growth
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5. Unemployment rate
6. CPI inflation rate
7. 1-month Treasury yield
8. 3-month Treasury yield
9. 6-month Treasury yield
10. 1-year Treasury yield
11. 3-year Treasury yield
12. 5-year Treasury yield
13. 7-year Treasury yield
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15. 20-year Treasury yield
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18. Mortgage rate
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20. US Average Retail Gasoline Price ($/gal; all grades, all formulations)
21. S&P 500 Stock Price Index
22. Effective Federal Funds Rate
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24. Moody's BAA Rate
25. Dow Jones Total Stock Market Index
26. House Price Index
27. Commercial Real Estate Price Index
28. Market Volatility Index (VIX)

Our procedure is as follows:

1. Data is collected per the information in Appendix A, "Data sources".

2. Correlations between variables are identified to determine which variables are may be considered as "dependent" (upon other variables, i.e., highly correlated with other variables as part of their nature).

[1] This study is motivated by the Federal Reserve Board's Dodd-Frank Act, which includes requirements to consider various international factors; however, those factors will not be discussed extensively in this particular report based on the target use and audience of this report by Capitalytics' client.

3. Multiple analyses are performed per the procedure in Section I of Appendix B for all variables, with the results of corresponding forecasts aggregated.

4. The rationale for these analyses, modifications, and the conclusions thereto are documented the following section of this report, "Data Series Conclusions".

Data Series Conclusions

This report documents Capitalytics' forecasts and analyses for approximately 28 macro-economic variables. Most domestic variables are driven by T-bill yields and inflation. Most of these domestic variables are currently expected to move towards stronger positions, with (for example) the 10-year T-bill growing to 3% during 1Q2019 before retreating to 2% during mid-2022.

I. Overview

As part of the Dodd-Frank Act, larger banking institutions in the United States are required to use government specified variables, and approved proprietary processes, to determine if they are adequately prepared for unexpected "systemic failures". Some banking institutions are also incorporating portions or components of their forecasting processes to estimate future profitability; in order to do so, however, realistic forecasts (as opposed to extremes) are required.

While arguments could be made about the variables included in this study, as stated in Jiang, et al., "… a conclusion that can be made for … US data is that there is little to no improvement in forecast accuracy when the number of predictors is expanded beyond 20-40 variables."

This report documents Capitalytics' forecasts and analyses for the domestically focused macro-economic values specified. Most domestic variables are driven by T-bill yields, which drive mortgages & real estate, borrowing rates, and credit rates, and indirectly impacting GDP, inflation & unemployment. Most of these domestic variables are currently expected to move consistently towards stronger positions over the next 3-5 years.

II. Correlations

Part of Capitalytics' analysis of macro-economic variables entails computing the correlation between variables, in order to establish the existence and level of interdependence of variables.

In Appendix C of this document, we document the 164 pairs of variables that showed absolute correlation values greater than or equal to 0.6. As part of this portion of the study, Capitalytics identified the following sets of strong dependencies (correlations with magnitudes greater than 0.95) between variables that were subsequently validated as significant, long-term, recurring correlations as part of the nature of the variables; these pairings of variables are viewed as extremely significant based on the respective definitions of the variables and will be leveraged as discussed in Section II of Appendix B.

Regression (Dependent) Variable	… depends on …	Independent Variable[2]
6-month Treasury yield		1-year Treasury yield
3-month Treasury yield		6-month Treasury yield*
Prime rate		3-month Treasury yield*
1-month Treasury yield		3-month Treasury yield*
3-year Treasury yield		1-year Treasury yield
5-year Treasury yield		3-year Treasury yield*
7-year Treasury yield		5-year Treasury yield*
10-year Treasury yield		7-year Treasury yield*
Mortgage rate		10-year Treasury yield*
Moody's AAA Rate		Mortgage rate*
Moody's BAA Rate		Moody's AAA Rate*
BBB corporate yield		Moody's BAA Rate*
20-year Treasury yield		10-year Treasury yield*
30-year Treasury yield		20-year Treasury yield*
Commercial Real Estate Price Index		House Price Index

Using the correlations shown in Appendix C, it can be seen that the T-Bill yields are (unsurprisingly) tightly connectedGiven that they are so tightly coupled, the 1-year series will be treated independently of any regressors, with longer-term yield series being dependent on their immediately shorter-term companions, and shorter-term yield series being dependent on the immediately longer-term companions.

III. Analysis of Variables

Real & Nominal GDP Growth, Real & Nominal Disposable Income Growth, and CPI Inflation Rate

Analysis

Overall, Capitalytics' analysis points to GDP & disposable income growth rates that are between 2.25% and 2.5%[3]. Inflation, though, appears to be spiking in the near-term at over 3%, and then leveling out to 2.7%-2.8% over a five-year window.

The Federal Reserve has tended in past years to try to manage the economy towards a 2.0% inflation rate in order to manage unemployment and prices, but several forces are working against them at this time. Many companies have spent the past several years (of market instability) carefully managing their cashflow, and have built financial "war chests" that have not been deployed to date. While the White House has made very public efforts to

[2] It should be immediately apparent that several variables that are listed as "independent" are, in fact, dependent on other variables; these "independent" variables that actually have dependencies are noted by a trailing "*".

[3] Obviously, one should expect some volatility in most metrics to be observable on a quarter-to-quarter basis. However, the volatility is so pronounced and frequent in GDP analyses that its reoccurrence is actually part of the analysis in 4Q and 1Q; not only is this time of year a significant time of retail activity (for food/perishables, health care expenses, and non-durable goods) in the US, but it is also common to observe fluctuations in due to supply and transportation issues in some areas of the US.

(a) repatriate offshore monies held by private corporations;
(b) maintain and grow manufacturing operations in the United States; and
(c) actively manage trade relationships on a country-by-country basis,

it seems very likely that the segments that will benefit from these efforts will be low- to middle-end commodity skilled laborers, and segments requiring very highly skilled workers. As (successful and sought after) corporations become more comfortable with the current administration's positions and accomplishments, more of the monies that have yet to be deployed will be brought to bear on automation, re-education, and growth.

However, the losers in this scenario will be the rank-and-file of some service industries (who are already witnessing changes due to automation), some low skill jobs in many sectors (data processing within healthcare, insurance, etc.; face-to-face B2B & B2C sales organizations, etc.), and other non-specialty roles. Admittedly, a small portion of this segment will be willing to develop transferable skills and adapt to the changing landscape.

Other Commentary

- OECD speculates 2.5% growth for 2018, and 2.1% for 2019, and Kiplinger estimates 2.9% growth for 2018 (https://www.kiplinger.com/article/business/T019-C000-S010-gdp-growth-rate-and-forecast.html). OECD comparably estimates the nominal GDP at 4.1% growth for 2018 and 4.4% for 2019. (June 28, 2018)
- The US' real GDP growth is expected to be around 2.0% for 2018, and gradually slow to around 1.7% by 2022 per the extremely conservative IMF.
- Per the information at https://tradingeconomics.com/united-states/disposable-personal-income/forecast, real disposable income is expected to stagnate through 2020, indicating that nominal values will track with inflation rates.
- The US inflation rate is expected to grow steadily from 2.2% to 2.5% during 2018 per tradingeconomics.com and Knoema. Following this statement and the logic that drives the current administration's actions, per https://www.lombardiletter.com/u-s-inflation-rate-forecast-for-next-5-years-looks-ominous/8193/ , "Gains in wages should be sector-specific this time around. So, while automation of replaceable human labor will mean that the cost of a Happy Meal remains in check, goods made with highly skilled labor will probably rise asymmetrically. This doesn't bode well for inflationary trends for goods emanating from sectors like technology, health care, engineering and select manufacturing. … Trump has already cajoled several multinational companies to either keep manufacturing in the U.S., or build new factories within." (March 7, 2017)

Unemployment Rate

Analysis

Following up on our analysis on CPI, we see the White House's efforts to drive growth and investment by domestic corporations as playing favorably into lowering the national

unemployment rate. For almost a decade, the US labor force has eroded with otherwise capable workers exiting and not returning[4]. The President's push to return dollars that have left the US economy, and to offer a "pro-business" operating environment, is intended to generate the vacuum that will not only pull skilled labor back into the workforce, but also make it palatable to re-train personnel who may otherwise be phased out of their current position and end up unemployed.

While the Federal Reserve considers a ~5% unemployment rate as "full employment"[5], there is still significant debate about this figure, i.e., how low the unemployment rate could go within specific sectors while not imposing on the efficiencies of the current capital market. Capitalytics sees that it would be extremely reasonable for the published unemployment rate to drop to approximately 3.25% before the end of current 2020 based on the previously described forces, but additional decreases will be hampered by

(a) automation;
(b) an unwillingness to re-train by personnel; and
(c) other capital market influences (e.g., inflation, etc.).

Other Commentary

- A recent academic paper (https://www.ecb.europa.eu/pub/conferences/shared/pdf/20180618_ecb_forum_on_central_banking/Stock_James_Paper.pdf) authored by faculty from Harvard University and Princeton University suggests not only that unemployment is being mis-measured and/or understated nationally and globally "… because of special features of the financial crisis recession and the long recovery", but also that domestic (US) inflation is increasing in sectors that experience strongest *local* pricing pressures (e.g., food service, hospitality, etc.) and are "historically cyclically sensitive". (June 26, 2018)
- Based on BLS reports, US unemployment is expected to gradually bottom-out at about 3.75%-3.8%, with a focus on new jobs forming in the self-sustaining service's sector. Goods producing jobs will remain level, on the other hand, for next 2 years.
- This sentiment is echoed in tradingeconomics.com (https://tradingeconomics.com/forecast/unemployment-rate) and at the Kiplinger Report (https://www.kiplinger.com/article/business/T019-C000-S010-unemployment-rate-forecast.html). (June 28, 2018)
- Knoema has a slightly more conservative view (see https://knoema.com/ennihcf/us-unemployment-forecast-2015-2020-and-up-to-2060-data-and-charts).

[4] Notice that the unemployment rate exceeded 9% from Q2 of 2009 until Q4 of 2011, just following the "housing crisis" that peaked in 2008 & 2009.

[5] It should be noted that Capitalytics has not found a reference to any study that re-evaluates the validity of the 5% U3 rate since the passage of the ACA in 2014. The costs and regulatory requirements that the ACA imposes on individuals will have a non-negligible impact on their willingness to maintain employment where that is a consideration.

Treasury Yields (1, 3, & 6-month; 1, 3, 5, 7, 10, 20, & 30-year series)

Analysis

Treasury yields are a most interesting area for forecasting. Based on the Federal Reserve's published projection of raising rates several times over the next few years (as part of winding down the central bank's balance sheet), economic forecasts are generally positive; interest rates are expected to rise consistently over the next five years – with Capitalytics expecting an increase of as much as 125 bps depending on the term. (We see the 1Y yield at 2.55%, the 5Y yield at 2.7%, and the 10Y yield peaking between 2.8% & 3.0% in 2H of 2020.) However, the fact that the economy has not responded during 2017 as expected has led several experts to believe that it's a "matter of time" before the inflationary effects of raising rates will eventually trickle to treasury yields.

The issue is that the unwinding of the Central Bank's balance sheet, and the prevalence of "cheap money" over the past several years is coming to an end, and the change in economic policies will result in the way that banks, borrowers, and the economy as a whole will need to adjust their expectations as new rates ripple through the system. The Federal Reserve has already been found to adjust some of its announced decisions regarding the management of its MBS investments based on pressure from outside forces, in spite of their impartiality.

Finally, looking strictly at the math in the situation, we see that the change in policy is going to require periods of careful rate management in order to prevent periods of yield inversion in which a shorter-term bond generates a higher yield than a longer-term bond.

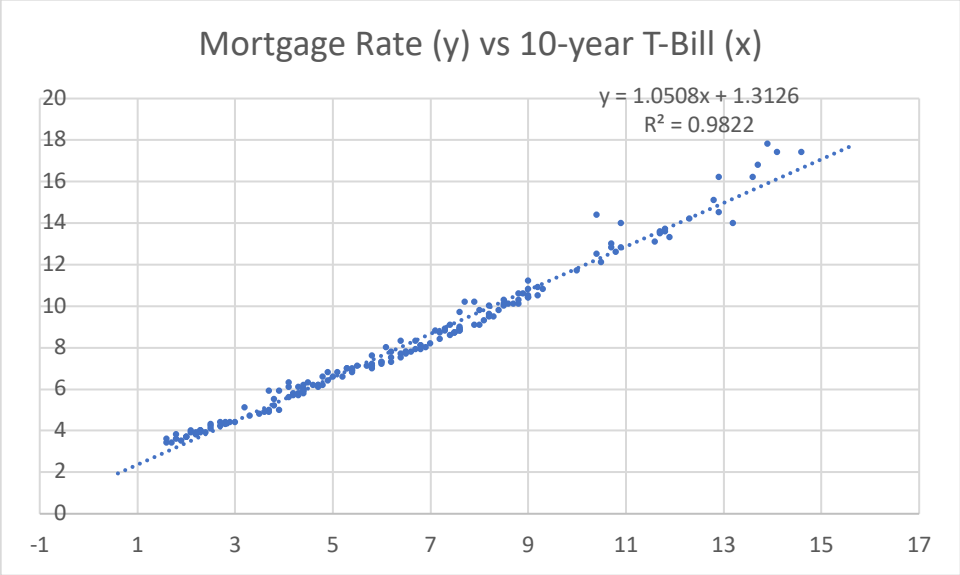
Other Commentary

- The Fed's returns on the MBS portfolio that it is attempting to unwind are running below its expected thresholds, resulting in the difference in monies not being re-invested as intended (see https://www.cnbc.com/2018/07/05/fed-balance-sheet-runoff-hits-another-snag.html). (July 5, 2018)
- The Fed' continues to assert that regular increases in interest rates are in the best interests of the economy (see https://www.cnbc.com/2018/07/05/fed-meeting-minutes-from-june.html). (July 5, 2018)
- Kiplinger asserts that 10Y T-bills will end 2018 at 3.3% (see https://www.kiplinger.com/article/business/T019-C000-S010-interest-rate-forecast.html). (May 29, 2018)
- Tradingeconomics.com asserts that 10Y yields will increase from a low of 2.38% to 2.75% from the end of 2018 to 2020. Others assert more aggressive stances of getting to 3.0% by the end of 2018.

30-year Mortgage Rate

Analysis

We expect the 30-year mortgage rate to inch up to just over 4.0% by the end of 2018. In October, the Federal Reserve began reducing the size of its $4.5 trillion asset portfolio that includes $1.7 trillion in mortgage securities. While mortgage rates are expected to gradually increase as a result of this portfolio reduction, and interest rates are targeted to increase over the next several years based on targets issued by the Federal Reserve, Capitalytics' analysis of the market does not currently indicate significant movement from 4.0-4.1% for the foreseeable period.



Other Commentary

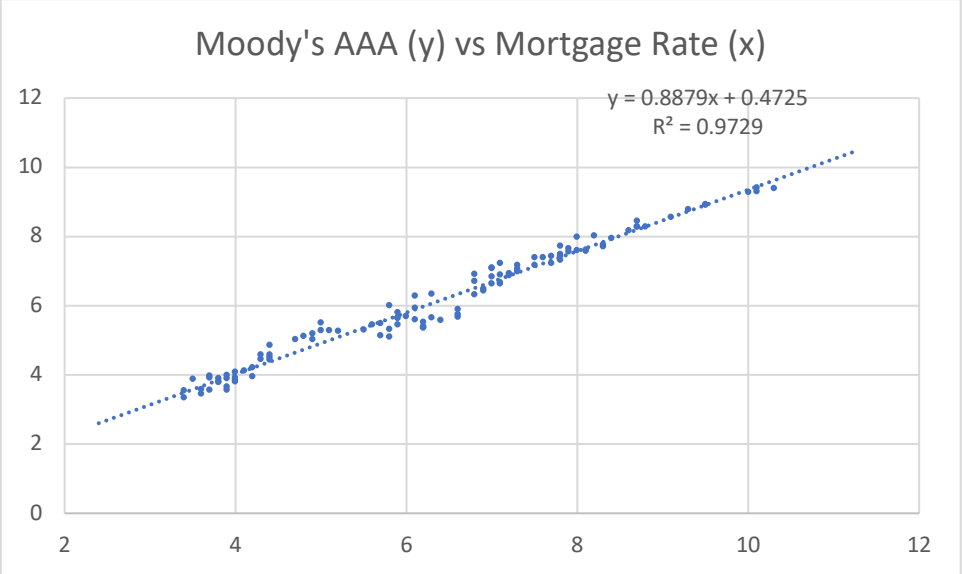
- Commentary has been volatile and reactive to events during 2018, with frequent pessimistic updates; see https://www.bankrate.com/finance/mortgages/mortgage-rates-forecast.aspx (Jan 2, 2018); https://www.nationalmortgagenews.com/news/mortgage-rates-will-spike-faster-higher-than-originally-projected (Feb 15, 2018); and https://www.bankrate.com/mortgages/analysis/ (July 3, 2018).

Moody's AAA & BAA Rates

Analysis

Moody's AAA bond rates tend to track in conjunction with 10Y T-bill yields. Given our analysis, we see AAA rates gradually rising from 3.6% to 3.75% by mid-2020 and then leveling out through the end of our analysis. Again, this rise goes hand-in-hand with the increased bond rates that are expected over the next few years, and there is a good possibility that the increase previously mentioned will require longer to accomplish than we are currently projecting due to caution that may be exhibited by the Federal Reserve.

Moody's BAA rates tend to be higher, and more volatile, than AAA rates. They are reported as 4.27% as of YE 2017, and are projected to be close to 4.4% by the end of 2019, and will increase by another 10bp around 2022.



Other Commentary

- From Seeking Alpha (https://seekingalpha.com/article/4164445-outlook-u-s-high-yield-corporate-bonds-gloomy), "Although Moody's forecasted that the default rate would decline from 3.92% in March to 1.71% over the next twelve months, … [the] default rate is a lagging indicator, and heavily indebted high-yield companies are vulnerable to political uncertainties, market volatility, a slowing economy, and shrinking liquidity." (April 20, 2018)
- https://www.forecasts.org/aaabonds.htm sees Moody's bonds remaining level through 2018.

BBB Corporate Yield

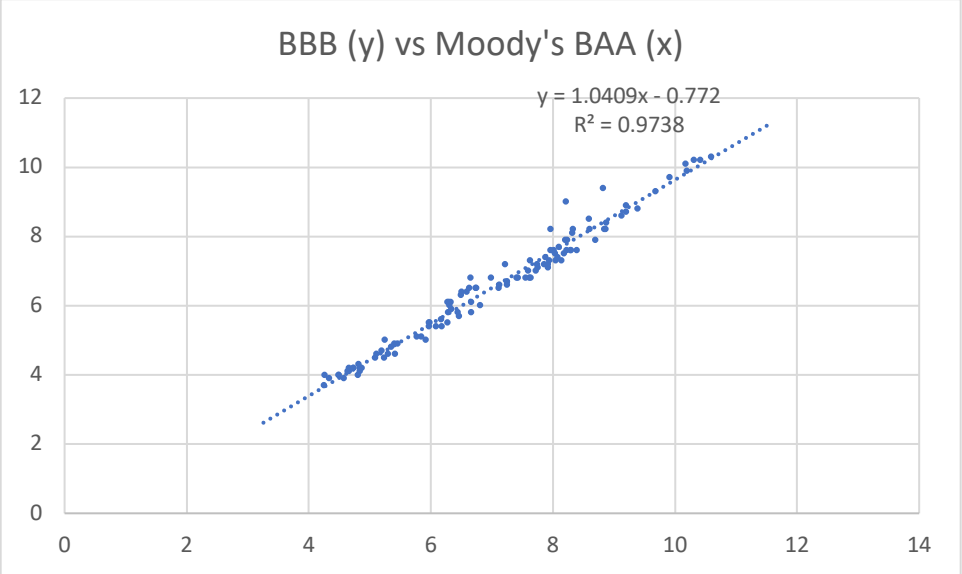
Analysis

The BBB Corporate Yield is tightly tied to Moody's indices, and the 30-year Mortgage Rate, even though these bonds are generally 10 years in duration. Capitalytics generally sees these instruments as stagnating at around 3.8-3.9% for the foreseeable future, balancing risk (and default) against potential return. The returns have been consistently coupled with Moody's BAA index, but not without some slight variations.

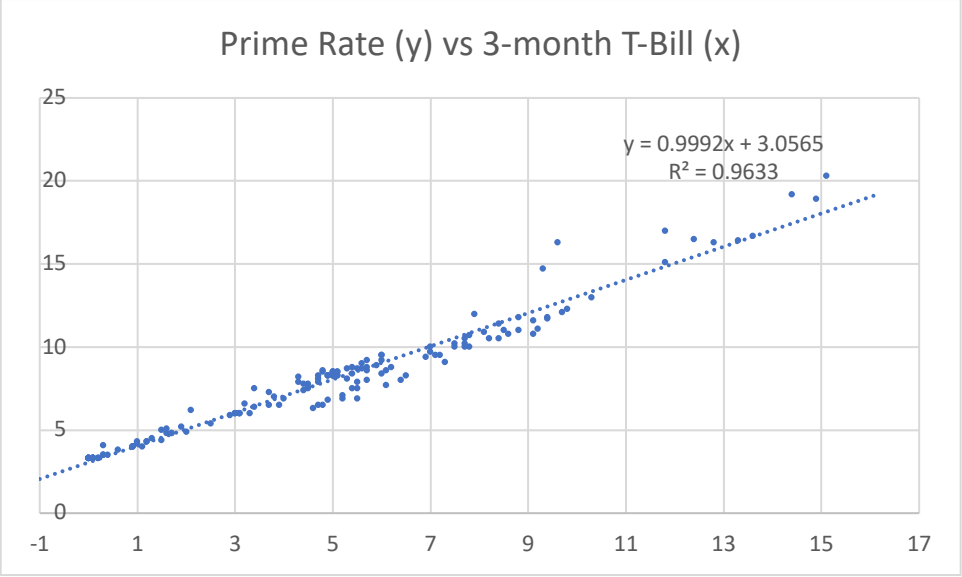
Other Commentary

- The NASDAQ and other brokers view the BBB yield as being bullish in the near term (per http://www.nasdaq.com/article/investors-like-outlook-for-investment-grade-us-corporate-bonds-and-funds-cm871285 and https://www.schwab.com/resource-

center/insights/content/corporate-bond-market-mid-year-outlook-further-price-gains-unlikely-this-year), though at least one fund believes that a turn for the worse is due (see https://seekingalpha.com/article/4104407-corporate-bonds-things-know-may).



Prime Rate



Analysis

Capitalytics' analysis shows that the Prime Rate appears to be very tightly coupled to very short-term Treasury Bills (specifically, 3-month yields), meaning that we see the Prime Rate consistently growing by 3-8 bp per quarter over the next several years. We don't anticipate any market forces preventing this from occurring, which would lead us to see the Prime Rate at 5%

in early 2020 and at 5.25% in 2022. In fact, knowing the current climate of near-quarterly 25 bp increases in the Prime Rate, with it having been set to 5% as of June 14, 2018, we anticipate the Prime Rate reaching 6% during 2020, but expect the current White House administration to use any leverage that it can gain during the remainder of its tenure to slow interest rates prior to the November 2019 election.

US Average Retail Gasoline Price

Analysis

While gasoline prices are generally at the discretion of OPEC, and subject to influences such as weather, Capitalytics is seeing a consistent increase in prices by about 5-8% Y/Y, with spikes during summer months causing increases of another 5-10% over same (following) YE prices. (In other words, June/July prices are expected to be 10%-15% over those of preceding January and 5-10% over those of the following December.) The summer increases (e.g., $2.85 for summer of 2018, $2.90+ for summer of 2019, approximately $3 during summer of 2020 as compared to $2.74 at YE 2018, $2.77 for YE 2019, and $2.80 for YE 2020) are due to increased demand as the US public typically drives several hundred additional miles during the summer months for vacations.

It should be noted that, if the current White House administration decides to impose tariffs on oil producing countries, or to take aim at ecological preserves (one of the points of President Trump's campaign from 2016), that could have a significant impact on oil prices, either directly or indirectly via retaliation from current oil producing countries.

Other Commentary

- Per Patrick DeHaan, head of petroleum analysis at GasBuddy, the retail price of gasoline is expected to rise by about 8% during 2018. Of course, while OPEC bears much of the responsibility for cutting oil production, and production is anticipated to be reduced in order to keep supply in line with demand, it should be noted that even one event can completely change trajectory of fuel prices for months thereafter (e.g., unexpected weather in the Gulf area, significant unexpected violence, etc.).

Effective Federal Funds Rate

Analysis

When a depository institution has a shortfall and need for liquidity, it may borrow funds on a short-term basis from the Federal Reserve; the Federal Funds Rate is the interest rate charged for these funds. However, when a depository institution has surplus balances in its reserve account, it may also directly lend to other banks in need of larger balances; the rate that the borrowing institution pays to the lending institution is determined between the two banks, and the weighted average rate for all of these types of negotiations is the Effective Federal Funds Rate. The Effective Federal Funds Rate is essentially determined by the market but is influenced by the Federal Reserve through open market operations to reach the Federal Funds Rate target. It influences other interest rates such as the Prime Rate, and it indirectly influences longer-term

interest rates such as mortgages, loans, and savings. The Federal Reserve affects liquidity by buying & selling government bonds, thereby impacting the Federal Funds Rate by changing the amount of liquidity that banks have to trade with other banks.

While our computational analysis dictates that the Effective Federal Funds Rate will only increase by 0.15% over the next 5 years, we are not prepared to provide such a tight bound on this figure's movements. Instead, Capitalytics anticipates the Effective Federal Funds Rate will gradually increase by between 0.25-0.5% (from 1.5% at YE2017) over the next several years.

Other Commentary

- The Fed' approves another 0.25% increase in the overnight borrowing rate despite concerns about the White House's "saber rattling" regarding tariffs (see https://www.cnbc.com/2018/07/05/fed-meeting-minutes-from-june.html). (July 5, 2018)

Dow Jones Total Stock Market Index (end-of-quarter) and S&P 500 (quarterly average)

Analysis

Given the business- and investor-friendly administration that is currently installed in the United States, we expect growth of the Dow-Jones and S&P500 indexes through 2018, with some slowing occurring in 2019 and 2020 as legislative elections are held and opposing members of Congress are elected. Obviously, the 2020 election will be a bell-weather referendum on the "nationalism versus progressive" movement, and will have strong ramifications on these metrics.

Assuming that the Republican party maintains its position within the US government, we see the Dow-Jones index growing (300-500 points per quarter, roughly linearly) to within reach of 37,000 (assuming that it is not reconstituted), and the S&P500 growing by 40-60 points per quarter to over 3,500 by YE2022. If the Republican party does not retain control of the White House, and even if they install a different specific leader, we expect that growth will be dampened to some degree[6].

House and Commercial Real Estate Price Indexes

Analysis

National home and commercial real estate price indexes are seen to be closely connected at this time, but the effects of the 2007-2009 housing crisis prevent us from statistically tying the two together. Over the past year, both residential and commercial real estate have seen dramatic increases in pricing across the US, with both indexes growing similarly (the residential home price index increasing by 5.6% during 2017, and the commercial real estate index increasing by 3.8% over the same period).

[6] Between 2009 and 2015, Q/Q growth of the Dow-Jones (quarter end) index ranged between -15% and 12%, with an average of 3% growth. For the same period, growth of the S&P500 was between -18% and 16%, with an average of 2.8% growth.

We expect both commercial and residential real estate prices (and these indexes) to increase consistently over the next several years. Our analyses show that the residential home price index will increase by approximately 0.5% per quarter, and the commercial real estate index will grow by 1% per quarter through mid-2019, and then slow to roughly 0.25% per quarter growth until mid-2022.

Commercial real estate needs will be driven by low unemployment, industry growth, real estate availability, and market strength. Unemployment and market strength are projected through at least mid-2019, after which point they will be subject to the impact of the US election cycle. Financial markets will be affected by the policies of the Federal Reserve and the FOMC, and whether they will be affected by the various political factions is an open question. New real estate development is concentrated in the current business centers around the US, with the five top cities taking about half of the development projects: New York, Washington, San Francisco, Dallas, and Seattle. As a result, while a national view is one of strong growth, that growth will be localized and focused around current population/talent centers.

Inkeeping with that conclusion, residential real estate is becoming an opportunistic game in which bi-modal distributions are painting a deceptive picture in many cities. While average housing prices and numbers of units on the market are approaching or surpassing pre-2007 levels in many areas, a disproportionate percentage of these (appreciation) dollars and homes are at overly affluent levels. The past several years of "home flipping" hobbyists have turned the population of "starter homes" in many cities into high-priced "retreats" or "villas" that can only be afforded by the most elite clients … and those homeowners, in turn, also want to resell their investments for a profit in a few years. Experts are generally stating that there are no market forces on the horizon to compel re-adjustment of prices in these localized areas, and it is unclear how the national effects of inflation will play out in these situations (or in areas where these phenomena are not playing out).

Other Commentary

- Business Insider reports that "Only 20% of the 1.2 million homes on the market are entry-level, … compared to 51% of for-sale homes priced in the most expensive tier … mini-housing bubbles are forming in cities all over the US" (see http://www.businessinsider.com/us-housing-markets-are-overvalued-2018-5). (May 9, 2018)
- National Real Estate Investor reports that "Momentum for the new year stems from … tax reform that is anticipated to leave many businesses and consumers with more money in their pockets. While there may be issues to keep an eye on—such as shifting consumer behavior and rising inflation and interest rates—the outlook remains positive for the short term" (see http://www.nreionline.com/finance-investment/six-economists-state-commercial-real-estate-2018). (Feb 7, 2018)

Market Volatility Index

Analysis

Our analysis shows that the Market Volatility Index will generally remain steady over the next five years between 10.9 and 12.4. However, given the recent past political landscape and its effect on the investment community, we find this fairly unlikely and would caution our clients in relying on this information. It should be noted that a value of 40.7 was recorded in Q3 of 2015 (immediately prior to the last US Presidential election), and a value of 22.5 was recorded in Q4 of 2016.

Appendix A: Data Sources

The following table lists the attributes provided by Capitalytics as part of its macro-economic forecast service. The sources for data that are defined by the document "2018 Supervisory Scenarios for Annual Stress Tests Required under the Dodd-Frank Act Stress Testing Rules and the Capital Plan Rule" (found at https://www.federalreserve.gov/supervisionreg/files/bcreg20180201a1.pdf) are listed. Please note that shaded attributes are not discussed within this report.

Attribute	Referenced Source[7]
Real GDP growth	Bureau of Economic Analysis (NIPA table 1.1.6, line 1)
Nominal GDP growth	Bureau of Economic Analysis (NIPA table 1.1.5, line 1)
Real disposable income growth	Bureau of Economic Analysis (NIPA table 2.1, line 27, and NIPA table 1.1.4, line 2)
Nominal disposable income growth	Bureau of Economic Analysis (NIPA table 2.1, line 27)
Unemployment rate	Bureau of Labor Statistics (series LNS14000000)
CPI inflation rate	Bureau of Labor Statistics (series CUSR0000SA0)
3-month Treasury yield	Quarterly average of 3-month Treasury bill secondary market rate on a discount basis, H.15 Release, Selected Interest Rates, Federal Reserve Board (series RIFSGFSM03_N.B)
5-year Treasury yield	Quarterly average of the yield on 5-year U.S. Treasury bonds, constructed for the FRB/U.S. model by Federal Reserve staff based on the Svensson smoothed term structure model; see Lars E. O. Svensson (1995), "Estimating Forward Interest Rates with the Extended Nelson-Siegel Method," Quarterly Review, no. 3, Sveriges Riksbank, pp. 13–26
10-year Treasury yield	Quarterly average of the yield on 10-year U.S. Treasury bonds, constructed for the FRB/U.S. model by Federal Reserve staff based on the Svensson smoothed term structure model; see Lars E. O. Svensson (1995), "Estimating Forward Interest Rates with the Extended Nelson-Siegel Method," Quarterly Review, no. 3, Sveriges Riksbank, pp. 13–26
BBB corporate yield	Merrill Lynch 10-year BBB corporate bond yield, Z.1 Release (Financial Accounts of the United States), Federal Reserve Board (series FL073163013.Q).

[7] Per https://www.federalreserve.gov/supervisionreg/files/bcreg20180201a1.pdf

Mortgage rate	Quarterly average of weekly series for the interest rate of a conventional, conforming, 30-year fixed-rate mortgage, obtained from the Primary Mortgage Market Survey of the Federal Home Loan Mortgage Corporation.
Prime rate	Quarterly average of monthly series, H.15 Release, Selected Interest Rates, Federal Reserve Board (series RIFSPBLP_N.M).
Dow Jones Total Stock Market Index (end-of-qtr value)	Dow-Jones
House Price Index	Price Index for OwnerOccupied Real Estate, CoreLogic National, Z.1 Release (Financial Accounts of the United States), Federal Reserve Board (series FL075035243.Q).
Commercial Real Estate Price Index	Commercial Real Estate Price Index, Z.1 Release (Financial Accounts of the United States), Federal Reserve Board (series FL075035503.Q divided by 1000).
Market Volatility Index (VIX)	VIX converted to quarterly frequency using the maximum close-of-day value in any quarter, Chicago Board Options Exchange.
Euro Area Real GDP Growth	Percent change in real gross domestic product at an annualized rate, staff calculations based on Statistical Office of the European Communities via Haver, extended back using ECB Area Wide Model dataset (ECB Working Paper series no. 42).
Euro Area Inflation	Percent change in the quarterly average of the harmonized index of consumer prices 16 Federal Reserve Supervisory Scenarios at an annualized rate, staff calculations based on Statistical Office of the European Communities via Haver.
Euro Area Bilateral Dollar Exchange Rate (USD/Euro)	End-of-quarter rates from the H.10 Release, Foreign Exchange Rates, Federal Reserve Board.
Developing Asia Real GDP Growth	Percent change in real gross domestic product at an annualized rate, staff calculations based on Bank of Korea via Haver; Chinese National Bureau of Statistics via CEIC; Indian Central Statistical Organization via CEIC; Census and Statistics Department of Hong Kong via CEIC; and Taiwan Directorate-General of Budget, Accounting, and Statistics via CEIC.
Developing Asia Inflation	Percent change in the quarterly average of the consumer price index, or local equivalent, at an annualized rate, staff calculations based on Chinese National Bureau of Statistics via CEIC; Indian Ministry of Statistics and Programme Implementation via Haver; Labour Bureau of India via CEIC; National Statistical

	Office of Korea via CEIC; Census and Statistic Department of Hong Kong via CEIC; and Taiwan Directorate General of Budget, Accounting, and Statistics via CEIC.
Developing Asia bilateral dollar exchange rate (F/USD, index)	End-of-quarter rates from the H.10 Release, Foreign Exchange Rates, Federal Reserve Board.
Japan Real GDP Growth	Percent change in gross domestic product at an annualized rate, Cabinet Office via Haver.
Japan Inflation	Percent change in the quarterly average of the consumer price index at an annualized rate, staff calculations based on Ministry of Internal Affairs and Communications via Haver.
Japan Bilateral Dollar Exchange Rate (Yen/USD)	End-of-quarter rates from the H.10 Release, Foreign Exchange Rates, Federal Reserve Board.
UK Real GDP Growth	Percent change in gross domestic product at an annualized rate, Office for National Statistics via Haver.
UK Inflation	Percent change in the quarterly average of the consumer price index at an annualized rate, staff calculations based on Office for National Statistics via Haver.
UK Bilateral Dollar Exchange Rate (USD/Pound)	End-of-quarter rates from the H.10 Release, Foreign Exchange Rates, Federal Reserve Board.

The above dataset from the Federal Reserve can be downloaded manually or automatically. Manual downloads are available at https://www.federalreserve.gov/supervisionreg/ccar-2018.htm (shown below, as of June 2018) by clicking the link marked "Historical data (ZIP)". Alternatively, downloading the file at https://www.federalreserve.gov/econres/files/2018-historical-data.zip using HTTP client software will also download the official dataset.

Decompressing the zip-file will provide two files in CVS format: one containing US domestic data elements on a quarterly basis, and the other containing international data elements on a quarterly basis[8].

[8] Again, due to the requirements of this client, international data elements are not being discussed in this document.

Since the CCAR dataset is only released annually (through Q4 2017 as of this writing), and Capitalytics provides quarterly updates to its forecasts (with data through Q1 2018, where possible), the CCAR dataset is supplemented by the data sources shown below on a quarterly basis.

Attribute	Supplementary Data Source
Real GDP growth	Bureau of Economic Analysis (NIPA table 1.1.6, line 1)
Nominal GDP growth	Bureau of Economic Analysis (NIPA table 1.1.5, line 1)
Real disposable income growth	Bureau of Economic Analysis (NIPA table 2.1, line 27, and NIPA table 1.1.4, line 2)
Nominal disposable income growth	Bureau of Economic Analysis (NIPA table 2.1, line 27)
Unemployment rate	Bureau of Labor Statistics (series LNS14000000)
CPI inflation rate	Bureau of Labor Statistics (series CUSR0000SA0)
3-month Treasury yield	Quarterly average of 3-month Treasury bill secondary market rate on a discount basis, H.15 Release
5-year Treasury yield	Federal Reserve Economic Research website (https://fred.stlouisfed.org/series/GS5), with “Quarterly” frequency and “Average” aggregation method
10-year Treasury yield	Federal Reserve Economic Research website (https://fred.stlouisfed.org/series/GS10), with “Quarterly” frequency and “Average” aggregation method
BBB corporate yield	Federal Reserve Economic Research website (https://fred.stlouisfed.org/series/BAMLC0A4CBBBEY),

	with "Quarterly" frequency and "Average" aggregation method
Mortgage rate	Federal Reserve Economic Research website (https://fred.stlouisfed.org/series/MORTGAGE30US), with "Quarterly" frequency and "Average" aggregation method
Prime rate	Federal Reserve Economic Research website (https://fred.stlouisfed.org/series/MPRIME), with "Quarterly" frequency and "Average" aggregation method
Dow Jones Total Stock Market Index (end-of-qtr value)	Dow-Jones as provided by the Wall Street Journal (https://quotes.wsj.com/index/DWCF/advanced-chart)
House Price Index	CoreLogic, index level (end-of-quarter)
Commercial Real Estate Price Index	From the Financial Accounts of the United States, Federal Reserve Board (Z.1 release); the series corresponds to the data for price indexes: Commercial Real Estate Price Index (series FL075035503.Q, divided by 1000). Series FL075035503.Q is also available at https://www.quandl.com/data/FED/FL075035503_Q-Interest-rates-and-price-indexes-commercial-real-estate-price-index-Quarterly-Levels-NSA
Market Volatility Index (VIX)	Federal Reserve Economic Research website (https://fred.stlouisfed.org/series/VIXCLS), with "Quarterly" frequency and "Average" aggregation method
Euro Area Real GDP Growth	Quarterly series for "European Union GDP Annual Growth Rate" per tradingeconomics.com
Euro Area Inflation	Quarterly average of monthly series for "European Union Inflation Rate" per tradingeconomics.com
Euro Area Bilateral Dollar Exchange Rate (USD/Euro)	End-of-quarter rates from the H.10 Release, Foreign Exchange Rates, Federal Reserve Board.
Developing Asia Real GDP Growth	The nominal GDP-weighted aggregate of the Real GDP growth for China, India, South Korea, Hong Kong Special Administrative Region, and Taiwan per OECD
Developing Asia Inflation	The nominal GDP-weighted aggregate of the inflation rate for China, India, South Korea, Hong Kong Special Administrative Region, and Taiwan per OECD
Developing Asia bilateral dollar exchange rate (F/USD, index)	End-of-quarter rates from the H.10 Release, Foreign Exchange Rates, Federal Reserve Board.
Japan Real GDP Growth	Quarterly average of monthly series for "Japan GDP Growth Rate" per tradingeconomics.com
Japan Inflation	Quarterly average of monthly series for "Japan Inflation Rate" per tradingeconomics.com
Japan Bilateral Dollar Exchange Rate (Yen/USD)	End-of-quarter rates from the H.10 Release, Foreign Exchange Rates, Federal Reserve Board.

UK Real GDP Growth	Quarterly average of monthly series for "United Kingdom GDP Growth Rate" per tradingeconomics.com
UK Inflation	Quarterly average of monthly series for "United Kingdom Inflation Rate" per tradingeconomics.com
UK Bilateral Dollar Exchange Rate (USD/Pound)	End-of-quarter rates from the H.10 Release, Foreign Exchange Rates, Federal Reserve Board.

While all data that is required for the Annual Stress Tests is available from https://www.federalreserve.gov/econres/files/2017-historical-data.zip, Capitalytics provides 13 additional values per the information in the following table.

Attribute	Capitalytics Source
1-month Treasury yield	https://fred.stlouisfed.org/series/dgs1mo
6-month Treasury yield	https://fred.stlouisfed.org/series/dgs6mo
1-year Treasury yield	https://fred.stlouisfed.org/series/dgs1
3-year Treasury yield	https://fred.stlouisfed.org/series/dgs3
7-year Treasury yield	https://fred.stlouisfed.org/series/dgs7
20-year Treasury yield	https://fred.stlouisfed.org/series/dgs20
30-year Treasury yield	https://fred.stlouisfed.org/series/dgs30
US Average Retail Gasoline Price ($/gal; all grades, all formulations)	https://fred.stlouisfed.org/series/gasallm
S&P 500 Stock Price Index	https://fred.stlouisfed.org/series/S&P 500 Stock Price Index
Effective Federal Funds Rate	https://fred.stlouisfed.org/series/FEDFUNDS
Moody's AAA Rate	https://fred.stlouisfed.org/series/aaa
Moody's BAA Rate	https://fred.stlouisfed.org/series/baa
Dow Jones Total Industrial Average	https://fred.stlouisfed.org/series/djia

Appendix B: Methodologies

Capitalytics uses non-structured macroeconomic forecasting techniques in order to prepare its clients for what trends and relationships drive certain metrics, and what values those metrics may take on in the coming months.

I. General Forecasting Methodology

Generally, the most effective overall forecasting techniques have been found to be a hybridization of multiple other techniques. Capitalytics uses several forecasting schemes, and aggregates the results, as part of its analysis methodology. This section describes the process that is executed for generating these results.

For each metric, four distinct forecasts are produced.

1. The first forecast uses the full quarterly history of the metric as an input to an additive exponential smoothing model. The model that is executed is that provided by R's[9] "forecast" package[10]; specifically, the "ets" function (see p.39 of https://cran.r-project.org/web/packages/forecast/forecast.pdf)[11] is designed to automatically determine the best fitting model out of the "Generic 'ETS' Methodology" (discussed later in this section), including optimal parameters thereto, given a sequence of values. In our work, we have restricted our study to only "additive" models (i.e., we set "`additive.only=TRUE`" in our calls), and our optimization criteria is set to the mean of absolute residuals (i.e., "`opt.crit=mae`"). Therefore, calls to generate our estimates through this procedure look something like the following command, where "`s`" is an appropriately populated array, vector, time series, or similar object.

```
> m<-ets(s, model='ZZZ', opt.crit=c('mae'), additive.only=TRUE)
```

   The results of this call are shown above each dataset, including the model type returned (as described later this section), the initial values that are used by the software, the optimal smoothing parameters estimated, and the $n+1^{st}$ forecasted value given the first n values of the metric's sequence (the "fitted" values)[12], and the determined parameters. While fitting forecasts to previous values,

[9] As of this writing, v.3.5.0 of the "R" language is available at https://cran.r-project.org/ .
[10] As of this writing, v.8.4 of the forecast package is available at https://CRAN.R-project.org/package=forecast .
[11] It should be noted that Microsoft's Excel software includes a FORECAST.ETS function which is documented as potentially producing comparable results; however, we have not been able to re-create its output independently, and, given the documentation, flexibility, and source availability of the R packages, Capitalytics has decided that it is a preferable option at this time.
[12] While this procedure does generate fitted values for intermediate samples within a sequence -- and allow for generating a forecasted set of samples to extend a sequence – according to the identified parameter set, it does not directly provide for determining the optimal parameter set of a sub-sequence. Capitalytics is currently codifying the process herein so that we may prescribe a "most likely" long term model for each forecast, and determine the likely effects of errors in the forecasts by estimating the "recent term" values of dy/dx_i (where y is the metric being estimated and x_i is each of the parameters within the model) and then compensating for recent quantified errors. We can also consider how "finite" a window to account for in building a set of parameters; these models are

- "forecast error" is defined as being actual values less forecasted values,
- "% error" is defined as forecast error divided by actual value, and
- "score" is defined as mean absolute forecast error over an appropriate range (generally the duration of the collected past values, less the first two to four years of collected values)[13].

2. The second forecast uses the differences between successive quarterly values in order to forecast the future quarterly differences. It should be noted that these sequences are (obviously) one data-point shorter than those in the preceding procedure. These values are forecasted using the same procedure as described in the first section, with forecasted values for the actual metric being built using the last known value for the metric and forecasts of incremental changes to the metric provided.

   An edited example for loading the SP500 end-of quarter values, and the differences between successive quarterly values, is shown below.

```
       > sp<-c(130.659129, 1250.520109, 998.4076848, 812.047, 799.5264066, 927.5045326,
       1041.372826, … )
       > sp_ts<-ts(sp,freq=4,end=c(2017,4))
       > sp_ts
          Qtr1      Qtr2      Qtr3      Qtr4
2008            130.6591 1250.5201  998.4077
2009  812.0470  799.5264  927.5045 1041.3728
       …

       > m<-ets(sp_ts,model='ZZZ',opt.crit=c('mae'),additive.only=TRUE)
       > dsp_ts<-diff(sp_ts)
       > dsp_ts
           Qtr1        Qtr2        Qtr3        Qtr4
2008                        1119.860980 -252.112424
2009 -186.360685  -12.520593  127.978126  113.868293
       …

       > m<-ets(dsp_ts,model='ZZZ',opt.crit=c('mae'),additive.only=TRUE
```

3. The third forecast uses the sequence of numbers from the second forecast, but partitions the dataset based on the quarter in which they are incurred. Assuming that the differences between quarters are associated with the ending points of each quarter (i.e., the difference between third and fourth quarter values are associated with a date of December 31st), four sequences of numbers are now created, with annual forecasts now being produced for each sequence using the same procedures as previously outlined. The final sequence appropriately interleaves the forecasted data-points.

4. The fourth forecast builds three sequences of values based the history of the metric to an observed point:

---

theoretically using all history in building a forecast, but the values for alpha, beta, etc. implicitly give an indication of how much history of a metric is truly impacting a specific value.

[13] At the risk of stating the obvious, it bears noting that a lower value for the "score" indicates better accuracy of an algorithm.

- the slope of the "best fitting" line (based on minimizing the total absolute error) using the immediately preceding 2 years of values[14];
- the same slope using the immediately preceding 4 years of values; and,
- the same slope using the immediately preceding 8 years of values.

While two years of data would provide for a relatively responsive change in aggregate values to be reflected given a change in the economic conditions, eight years of data (a not unreasonable estimate for an "economic cycle") would allow for a much more slowly moving change in average window for a counterbalance.

Using these datasets independently, we are able to use our previous procedure to generate forecasts for each slope, and then average the results on a quarterly basis. Multiplying the average slope by the duration of the following quarter (in days) provides an estimate for the change in the metric's value during that following quarter, just as in our second forecast.

Obviously, this technique requires at least eight years of data to pass before being able to produce any data. However, in order to err on the side of conservatism, we generally allow a sequence to "mature" for two to four years before believing that its initial transience has become less significant and its results are trustworthy.

5. In some cases, we may find variables with extremely tight cross-connections that can be justified as part of their nature (treasury bill yield rates, for example, with a magnitude or correlation greater than ~0.95). In these cases, we are able to additionally enhance our forecast by building a forecast that expresses one variable (the "dependent" variable, $y(t)$) in terms of another (the "independent" variable, $x(t)$) with a quantified "goodness of fit" coefficient (R^2), such that

$$y(t) = m(t) * x(t) + b(t) .$$

Notice that the "slope" and "intercept" terms in this expression are time varying expressions that are re-evaluated with each data-point, not simply constants.

By averaging the results of these distinct forecasts in order to provide an aggregate forecast, the error for which can be characterized and measured, Capitalytics aims to provide a robust dataset that can be used for future business decisions.

II. Exponentially Smoothed State Space Models & Generic "ETS" Methodology

Exponential smoothing was proposed in the late 1950s (Brown 1959, Holt 1957 and Winters 1960 are key pioneering works) and has motivated some of the most successful forecasting methods. Forecasts produced using exponential smoothing methods are weighted averages of past observations, with the weights decaying exponentially as the observations get older. In other

[14] The value for this slope is calculated using Microsoft Excel's SLOPE function, with the first argument being the appropriate number of preceding values for the metric, and the second argument being the same number of corresponding "end-of-quarter" dates.

words, the more recent the observation the higher the associated weight. (See the following equation for one example of this type of equation which requires $0 \leq \alpha \leq 1$, and estimates future values of $\hat{y}$ given a history of values denoted as y_t. The ε_{T+1} term denotes an error term, the *residual*, which determines the value of the forecasting function.) This framework generates reliable forecasts quickly and for a wide spectrum of time series.

$$\hat{y}_{T+1|T} = \alpha y_T + \alpha(1-\alpha)y_{T-1} + \alpha(1-\alpha)^2 y_{T-2} + \cdots + \varepsilon_{T+1}$$

In this study, the relevance of quarterly samples more than 3 years old is eliminated by setting the number of terms in this type of expression to no more than 13.

The challenge with these forecasting techniques is to estimate the value of α such that some criteria is optimized, e.g., minimizing the sum of squared errors (SSE), across all values of a set of historical values.

There are other forms of exponential smoothing methods that may account for any combination of forecasting *levels* (as in the Theta method), *trends* (for which a metric may, for instance, be growing or lessening according to a linear or higher order function), and *seasonality* (for which a metric may have engrained "cycles" on, e.g., a monthly, quarterly, or annual basis).

By considering variations in the combination of the trend and seasonal components, fifteen exponential smoothing methods are possible. Each method is labelled by a pair of letters (T,S) defining the type of 'Trend' and 'Seasonal' components. For example, (A,M) is the method with an additive trend and multiplicative seasonality; (M,N) is the method with multiplicative trend and no seasonality; and so on. Per Section 7.6 of Hyndman & Athanasopoulos, some of these methods are well known per the following table.

Trend & Seasonal Components	Method
(N,N)	simple exponential smoothing
(A,N)	Holts linear method
(M,N)	Exponential trend method
(A_d,N)	additive damped trend method
(M_d,N)	multiplicative damped trend method
(A,A)	additive Holt-Winters method
(A,M)	multiplicative Holt-Winters method
(A_d,M)	Holt-Winters damped method

Additionally, the following table (again from Section 7.6 of Hyndman & Athanasopoulos) gives the recursive formulae for applying all possible fifteen exponential smoothing methods. Each cell includes the forecast equation for generating *h*-step-ahead forecasts and the smoothing equations for applying the method. By recursively applying the appropriate expressions to generate consecutive forecasts, this framework can be an extremely powerful tool.

Trend	Seasonal		
	N	**A**	**M**
N	$\hat{y}_{t+h\|t} = \ell_t$ $\ell_t = \alpha y_t + (1-\alpha)\ell_{t-1}$	$\hat{y}_{t+h\|t} = \ell_t + s_{t-m+h_m^+}$ $\ell_t = \alpha(y_t - s_{t-m}) + (1-\alpha)\ell_{t-1}$ $s_t = \gamma(y_t - \ell_{t-1}) + (1-\gamma)s_{t-m}$	$\hat{y}_{t+h\|t} = \ell_t s_{t-m+h_m^+}$ $\ell_t = \alpha(y_t/s_{t-m}) + (1-\alpha)\ell_{t-1}$ $s_t = \gamma(y_t/\ell_{t-1}) + (1-\gamma)s_{t-m}$
A	$\hat{y}_{t+h\|t} = \ell_t + hb_t$ $\ell_t = \alpha y_t + (1-\alpha)(\ell_{t-1} + b_{t-1})$ $b_t = \beta^*(\ell_t - \ell_{t-1}) + (1-\beta^*)b_{t-1}$	$\hat{y}_{t+h\|t} = \ell_t + hb_t + s_{t-m+h_m^+}$ $\ell_t = \alpha(y_t - s_{t-m}) + (1-\alpha)(\ell_{t-1} + b_{t-1})$ $b_t = \beta^*(\ell_t - \ell_{t-1}) + (1-\beta^*)b_{t-1}$ $s_t = \gamma(y_t - \ell_{t-1} - b_{t-1}) + (1-\gamma)s_{t-m}$	$\hat{y}_{t+h\|t} = (\ell_t + hb_t)s_{t-m+h_m^+}$ $\ell_t = \alpha(y_t/s_{t-m}) + (1-\alpha)(\ell_{t-1} + b_{t-1})$ $b_t = \beta^*(\ell_t - \ell_{t-1}) + (1-\beta^*)b_{t-1}$ $s_t = \gamma(y_t/(\ell_{t-1} + b_{t-1})) + (1-\gamma)s_{t-m}$
$\mathbf{A_d}$	$\hat{y}_{t+h\|t} = \ell_t + \phi_h b_t$ $\ell_t = \alpha y_t + (1-\alpha)(\ell_{t-1} + \phi b_{t-1})$ $b_t = \beta^*(\ell_t - \ell_{t-1}) + (1-\beta^*)\phi b_{t-1}$	$\hat{y}_{t+h\|t} = \ell_t + \phi_h b_t + s_{t-m+h_m^+}$ $\ell_t = \alpha(y_t - s_{t-m}) + (1-\alpha)(\ell_{t-1} + \phi b_{t-1})$ $b_t = \beta^*(\ell_t - \ell_{t-1}) + (1-\beta^*)\phi b_{t-1}$ $s_t = \gamma(y_t - \ell_{t-1} - \phi b_{t-1}) + (1-\gamma)s_{t-m}$	$\hat{y}_{t+h\|t} = (\ell_t + \phi_h b_t)s_{t-m+h_m^+}$ $\ell_t = \alpha(y_t/s_{t-m}) + (1-\alpha)(\ell_{t-1} + \phi b_{t-1})$ $b_t = \beta^*(\ell_t - \ell_{t-1}) + (1-\beta^*)\phi b_{t-1}$ $s_t = \gamma(y_t/(\ell_{t-1} + \phi b_{t-1})) + (1-\gamma)s_{t-m}$
M	$\hat{y}_{t+h\|t} = \ell_t b_t^h$ $\ell_t = \alpha y_t + (1-\alpha)\ell_{t-1}b_{t-1}$ $b_t = \beta^*(\ell_t/\ell_{t-1}) + (1-\beta^*)b_{t-1}$	$\hat{y}_{t+h\|t} = \ell_t b_t^h + s_{t-m+h_m^+}$ $\ell_t = \alpha(y_t - s_{t-m}) + (1-\alpha)\ell_{t-1}b_{t-1}$ $b_t = \beta^*(\ell_t/\ell_{t-1}) + (1-\beta^*)b_{t-1}$ $s_t = \gamma(y_t - \ell_{t-1}b_{t-1}) + (1-\gamma)s_{t-m}$	$\hat{y}_{t+h\|t} = \ell_t b_t^h s_{t-m+h_m^+}$ $\ell_t = \alpha(y_t/s_{t-m}) + (1-\alpha)\ell_{t-1}b_{t-1}$ $b_t = \beta^*(\ell_t/\ell_{t-1}) + (1-\beta^*)b_{t-1}$ $s_t = \gamma(y_t/(\ell_{t-1}b_{t-1})) + (1-\gamma)s_{t-m}$
$\mathbf{M_d}$	$\hat{y}_{t+h\|t} = \ell_t b_t^{\phi_h}$ $\ell_t = \alpha y_t + (1-\alpha)\ell_{t-1}b_{t-1}^{\phi}$ $b_t = \beta^*(\ell_t/\ell_{t-1}) + (1-\beta^*)b_{t-1}^{\phi}$	$\hat{y}_{t+h\|t} = \ell_t b_t^{\phi_h} + s_{t-m+h_m^+}$ $\ell_t = \alpha(y_t - s_{t-m}) + (1-\alpha)\ell_{t-1}b_{t-1}^{\phi}$ $b_t = \beta^*(\ell_t/\ell_{t-1}) + (1-\beta^*)b_{t-1}^{\phi}$ $s_t = \gamma(y_t - \ell_{t-1}b_{t-1}^{\phi}) + (1-\gamma)s_{t-m}$	$\hat{y}_{t+h\|t} = \ell_t b_t^{\phi_h} s_{t-m+h_m^+}$ $\ell_t = \alpha(y_t/s_{t-m}) + (1-\alpha)\ell_{t-1}b_{t-1}^{\phi}$ $b_t = \beta^*(\ell_t/\ell_{t-1}) + (1-\beta^*)b_{t-1}^{\phi}$ $s_t = \gamma(y_t/(\ell_{t-1}b_{t-1}^{\phi})) + (1-\gamma)s_{t-m}$

Appendix C: Variable Correlations

The following table shows the correlation factors between all of the listed variables for which the absolute value of the correlation is greater than 0.6, indicating a noteworthy degree of correlation. These relationships are used as part of Capitalytics' manual analysis in order to determine the variables that should be used in determining the principle components of an auto-regressive model.

Additionally, as is discussed at other points in this report, correlations greater than 0.95 warrant further investigation as the relationship between variables may be able to be adequately modeled by a simple linear regression.

Variable 1	**Variable 2**	**Correlation**
BBB corporate yield	Commercial Real Estate Price Index	-0.709253
BBB corporate yield	Dow Total Stock Market Index	-0.820978
BBB corporate yield	6-month Treasury Yield	0.750539
BBB corporate yield	Moody's AAA Curve	0.932869
BBB corporate yield	Moody's BAA Curve	0.986727
BBB corporate yield	Residential Home Price Index	-0.732077
BBB corporate yield	Prime Rate	0.718044
BBB corporate yield	SP500 Stock Price Index	-0.710357
BBB corporate yield	1-year Treasury Yield	0.765162
BBB corporate yield	20-year Treasury Yield	0.845702
BBB corporate yield	30-year Mortgage Rate	0.922277
BBB corporate yield	30-year Treasury Yield	0.656844
BBB corporate yield	3-year Treasury Yield	0.821881
BBB corporate yield	7-year Treasury Yield	0.872865
Commercial Real Estate Price Index	6-month Treasury Yield	-0.602936
Commercial Real Estate Price Index	Moody's AAA Curve	-0.835991
Commercial Real Estate Price Index	Moody's BAA Curve	-0.784178
Commercial Real Estate Price Index	SP500 Stock Price Index	0.792276
Commercial Real Estate Price Index	1-year Treasury Yield	-0.624222
Commercial Real Estate Price Index	20-year Treasury Yield	-0.83768
Commercial Real Estate Price Index	3-year Treasury Yield	-0.702876
Commercial Real Estate Price Index	7-year Treasury Yield	-0.781001
Dow Total Stock Market Index	Commercial Real Estate Price Index	0.883253
Dow Total Stock Market Index	Moody's AAA Curve	-0.84319
Dow Total Stock Market Index	Moody's BAA Curve	-0.863421
Dow Total Stock Market Index	Residential Home Price Index	0.808695
Dow Total Stock Market Index	SP500 Stock Price Index	0.965708
Dow Total Stock Market Index	1-year Treasury Yield	-0.609985
Dow Total Stock Market Index	20-year Treasury Yield	-0.803549
Dow Total Stock Market Index	30-year Treasury Yield	-0.643649
Dow Total Stock Market Index	3-year Treasury Yield	-0.683513
Dow Total Stock Market Index	7-year Treasury Yield	-0.76962
1-month Treasury Yield	6-month Treasury Yield	0.995874
1-month Treasury Yield	1-year Treasury Yield	0.990438
1-month Treasury Yield	20-year Treasury Yield	0.625083
1-month Treasury Yield	30-year Treasury Yield	0.652022
1-month Treasury Yield	3-year Treasury Yield	0.942194
1-month Treasury Yield	7-year Treasury Yield	0.819615
3-month Treasury Yield	BBB corporate yield	0.744581

3-month Treasury Yield	Commercial Real Estate Price Index	-0.60494
3-month Treasury Yield	1-month Treasury Yield	0.998907
3-month Treasury Yield	6-month Treasury Yield	0.998924
3-month Treasury Yield	Moody's AAA Curve	0.838252
3-month Treasury Yield	Moody's BAA Curve	0.763835
3-month Treasury Yield	Prime Rate	0.991952
3-month Treasury Yield	10-year Treasury Yield	0.881909
3-month Treasury Yield	1-year Treasury Yield	0.995225
3-month Treasury Yield	20-year Treasury Yield	0.833334
3-month Treasury Yield	30-year Mortgage Rate	0.8923
3-month Treasury Yield	30-year Treasury Yield	0.65016
3-month Treasury Yield	3-year Treasury Yield	0.970436
3-month Treasury Yield	5-year Treasury Yield	0.940278
3-month Treasury Yield	7-year Treasury Yield	0.917322
6-month Treasury Yield	Moody's AAA Curve	0.841182
6-month Treasury Yield	Moody's BAA Curve	0.76833
6-month Treasury Yield	1-year Treasury Yield	0.998138
6-month Treasury Yield	20-year Treasury Yield	0.840693
6-month Treasury Yield	30-year Treasury Yield	0.650895
6-month Treasury Yield	3-year Treasury Yield	0.9752
6-month Treasury Yield	7-year Treasury Yield	0.921798
Moody's AAA Curve	Moody's BAA Curve	0.970128
Residential Home Price Index	Commercial Real Estate Price Index	0.93843
Residential Home Price Index	Moody's AAA Curve	-0.828248
Residential Home Price Index	Moody's BAA Curve	-0.796245
Residential Home Price Index	SP500 Stock Price Index	0.856357
Residential Home Price Index	1-year Treasury Yield	-0.606358
Residential Home Price Index	20-year Treasury Yield	-0.749778
Residential Home Price Index	3-year Treasury Yield	-0.681092
Residential Home Price Index	7-year Treasury Yield	-0.755706
Prime Rate	1-month Treasury Yield	0.990902
Prime Rate	6-month Treasury Yield	0.990054
Prime Rate	Moody's AAA Curve	0.805092
Prime Rate	Moody's BAA Curve	0.732338
Prime Rate	1-year Treasury Yield	0.983087
Prime Rate	20-year Treasury Yield	0.80988
Prime Rate	30-year Treasury Yield	0.660046
Prime Rate	3-year Treasury Yield	0.947179
Prime Rate	7-year Treasury Yield	0.885023
Real Disposable Income Growth	Nominal Disposable Income Growth	0.916051
Real GDP Growth Rate	Nominal GDP Growth Rate	0.934944
SP500 Stock Price Index	Moody's AAA Curve	-0.721813
SP500 Stock Price Index	Moody's BAA Curve	-0.752532
Unemployment Rate	SP500 Stock Price Index	-0.772319
10-year Treasury Yield	BBB corporate yield	0.90162
10-year Treasury Yield	Commercial Real Estate Price Index	-0.810643
10-year Treasury Yield	Dow Total Stock Market Index	-0.81883
10-year Treasury Yield	1-month Treasury Yield	0.728789
10-year Treasury Yield	6-month Treasury Yield	0.886325
10-year Treasury Yield	Moody's AAA Curve	0.985312
10-year Treasury Yield	Moody's BAA Curve	0.93741
10-year Treasury Yield	Residential Home Price Index	-0.783358
10-year Treasury Yield	Prime Rate	0.847411

10-year Treasury Yield	SP500 Stock Price Index	-0.60972
10-year Treasury Yield	1-year Treasury Yield	0.902852
10-year Treasury Yield	20-year Treasury Yield	0.992038
10-year Treasury Yield	30-year Mortgage Rate	0.993247
10-year Treasury Yield	30-year Treasury Yield	0.950008
10-year Treasury Yield	3-year Treasury Yield	0.957476
10-year Treasury Yield	7-year Treasury Yield	0.994294
1-year Treasury Yield	Moody's AAA Curve	0.8577
1-year Treasury Yield	Moody's BAA Curve	0.785318
1-year Treasury Yield	20-year Treasury Yield	0.862836
1-year Treasury Yield	30-year Treasury Yield	0.653323
1-year Treasury Yield	3-year Treasury Yield	0.984825
1-year Treasury Yield	7-year Treasury Yield	0.936572
20-year Treasury Yield	Moody's AAA Curve	0.979276
20-year Treasury Yield	Moody's BAA Curve	0.906386
20-year Treasury Yield	SP500 Stock Price Index	-0.718732
20-year Treasury Yield	30-year Treasury Yield	0.990227
30-year Mortgage Rate	Commercial Real Estate Price Index	-0.784346
30-year Mortgage Rate	Dow Total Stock Market Index	-0.808971
30-year Mortgage Rate	1-month Treasury Yield	0.735666
30-year Mortgage Rate	6-month Treasury Yield	0.896653
30-year Mortgage Rate	Moody's AAA Curve	0.986315
30-year Mortgage Rate	Moody's BAA Curve	0.949793
30-year Mortgage Rate	Residential Home Price Index	-0.768834
30-year Mortgage Rate	Prime Rate	0.862529
30-year Mortgage Rate	1-year Treasury Yield	0.91085
30-year Mortgage Rate	20-year Treasury Yield	0.979185
30-year Mortgage Rate	30-year Treasury Yield	0.900346
30-year Mortgage Rate	3-year Treasury Yield	0.958004
30-year Mortgage Rate	7-year Treasury Yield	0.987992
30-year Treasury Yield	Moody's AAA Curve	0.934303
30-year Treasury Yield	Moody's BAA Curve	0.700494
30-year Treasury Yield	SP500 Stock Price Index	-0.709433
3-year Treasury Yield	Moody's AAA Curve	0.919515
3-year Treasury Yield	Moody's BAA Curve	0.850186
3-year Treasury Yield	20-year Treasury Yield	0.919487
3-year Treasury Yield	30-year Treasury Yield	0.722602
3-year Treasury Yield	7-year Treasury Yield	0.980632
5-year Treasury Yield	BBB corporate yield	0.858127
5-year Treasury Yield	Commercial Real Estate Price Index	-0.750448
5-year Treasury Yield	Dow Total Stock Market Index	-0.737557
5-year Treasury Yield	1-month Treasury Yield	0.877939
5-year Treasury Yield	6-month Treasury Yield	0.944903
5-year Treasury Yield	Moody's AAA Curve	0.95518
5-year Treasury Yield	Moody's BAA Curve	0.891304
5-year Treasury Yield	Residential Home Price Index	-0.728088
5-year Treasury Yield	Prime Rate	0.911132
5-year Treasury Yield	10-year Treasury Yield	0.984368
5-year Treasury Yield	1-year Treasury Yield	0.957941
5-year Treasury Yield	20-year Treasury Yield	0.953698
5-year Treasury Yield	30-year Mortgage Rate	0.981223
5-year Treasury Yield	30-year Treasury Yield	0.808898
5-year Treasury Yield	3-year Treasury Yield	0.992195

5-year Treasury Yield	7-year Treasury Yield	0.996876
7-year Treasury Yield	Moody's AAA Curve	0.970147
7-year Treasury Yield	Moody's BAA Curve	0.908909
7-year Treasury Yield	20-year Treasury Yield	0.974229
7-year Treasury Yield	7-year Treasury Yield	0.886276

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