What's a Recession? Who Should Worry About a Recession? Is There a Recession Coming Soon?

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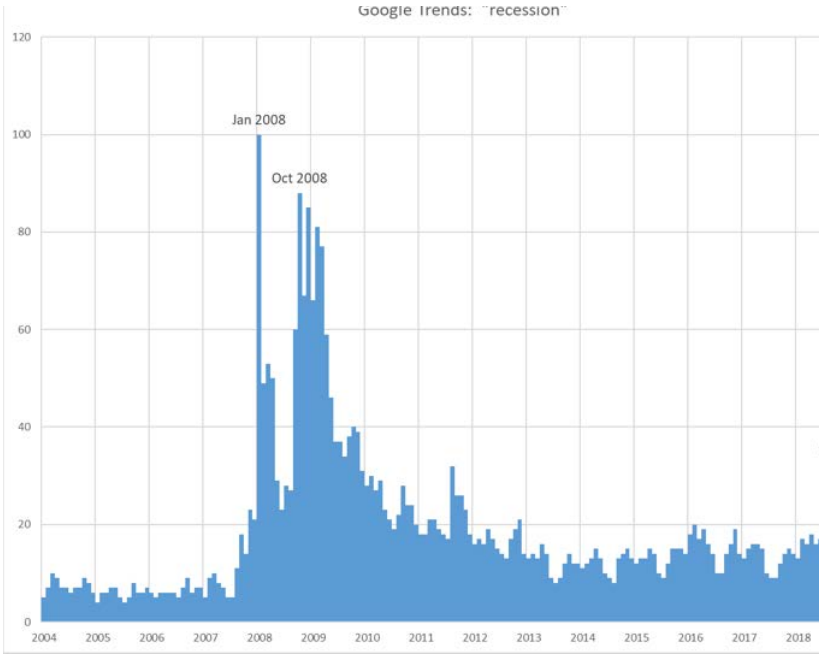
December 2019

As the current expansion sets new records as the oldest ever, there is increasing interest in what comes next: a recession. Google Trends records a spike up in "recession" searches in December 2018 and a much higher spike in August 2019, at a level comparable to spikes that occurred during the last recession: January and October 2008. In this document, I offer a response to these Google inquiries with answers to the three critical questions:

- What is a recession?
- Who should worry about a recession?
- Is there a recession coming soon?

What is a recession? The Wikipedia definition of a recession offered by Google is "In economics, a recession is a business cycle contraction when there is a general decline in economic activity." The popular identifier of a "general decline in economic activity" is two consecutive quarters of negative GDP growth. I prefer to define a recession as a period of time in which markets fail and allow sharp increases in idleness of labor, capital and land.

Who should worry about a recession? Everyone should. Some of your family members may lose their jobs; debt service may be difficult; you might lose your home. Even if



your revenue flows are not threatened, the value of all your assets is. A recession is a time that is hard on leverage but great for those with cash to acquire new assets.

Is there a recession coming soon? This is a hard question that cannot be answered with complete confidence. There are some reliable precursors that together raise concerns: an inverted yield curve, a decline in weekly hours in manufacturing and a bottoming out of the unemployment rate at low levels. These precursors currently by themselves support the conclusion that there is a 17% chance that the recession will commence sometime between 2019q4 and 2020q3.

As for the aging effect, one hypothesis is that the probability of death is the same in every quarter, and does not elevate with age. However, there is a suggestion in the distribution of lifetimes in the eleven expansions since World War II that the death rate for young expansions is too low and the death rate of older expansions is too high to be consistent with this random model. On the other hand, the precursors are like a cancer diagnosis and they may override the aging effect, meaning the life prognosis after cancer diagnosis may be little affected by the age of the patient.

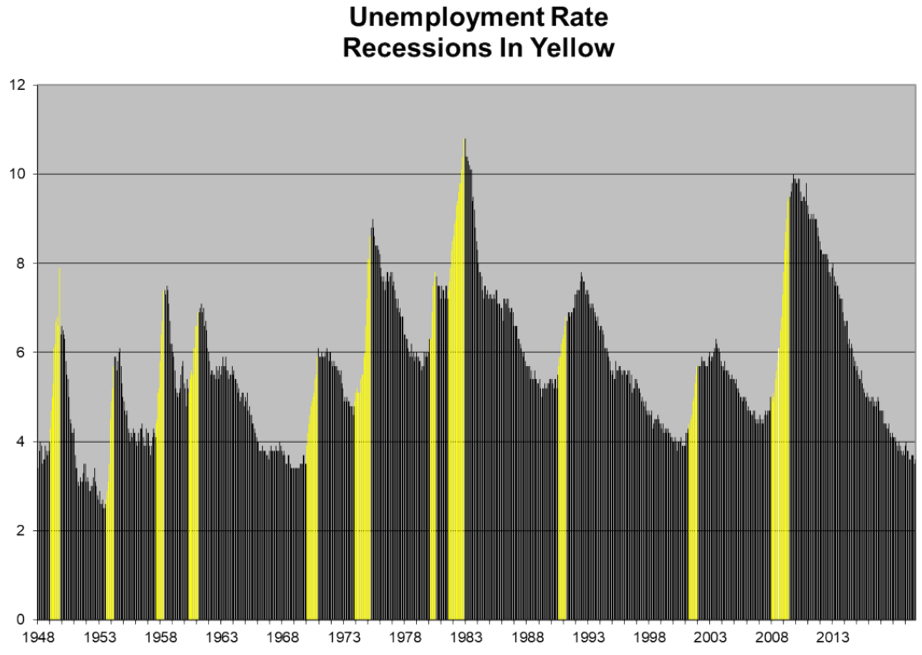
I do present one model with precursors which allows an old-age effect and which produces an estimated recession probability of 0% and another model also with aging effects that produces an estimated probability of 100%. That highlights the extreme impact that modelling aging can have. The statistical fits of the pure precursor model and the two models that include aging suggests putting weights of 31%, 35% and 34% on the three prediction which combine into the single forecast 39%.

You choose: 17% if you think aging doesn't matter and 39% if you want to allow aging to have an effect.

What is a recession? Unwanted idleness is the answer.

Newspapers often report that a recession is two negative quarters of GDP growth, but actually the "official" recessions are determined by a committee of economists at the NBER and are based on their perusal of a wide variety of data, and they sometimes violate the two negative GDP rule. Especially in the period of very low normal GDP growth, it would be better to describe a recession as a period of elevated and unwanted idleness of labor, land and capital, which may or may not be related to GDP growth below some threshold. The idleness of labor as measured by the unemployment rate is illustrated in Figure 1 which has the official NBER recessions in yellow. If instead of the Ph.D. economists at the NBER, you had your five-year old child color the mountain slopes facing west, she or he would almost exactly replicate the NBER decisions.

Figure 1 Unemployment Rate



You all should all care about recessions.

Recessions are periods of weak sales, weak cash flows, and weak job markets. The worst way to enter a recession is with a heavy debt load premised on overly optimistic ideas about future growth of sales and earnings and future appreciation of asset values. It is doubly bad if the debt is collateralized with assets and inventories, whose prices tend to be very soft in recessions. In a recession, you cannot get out of debt service problems by growing your income and you cannot get out of debt by selling off assets. Delinquency, default and bankruptcy are your only options.

With the recession risks elevating, now is the time for a personal stress test: Is your family/business relying on income from jobs or sales that are threatened? Do you have debt service obligations that depend on those earnings or do you have other threatened earnings? If yes, sell off some assets to retire some of that debt. In other words: deleverage. Leverage is a great idea early in an expansion, but a bad choice when the expansion ends. Cash is what you want in a recession when asset prices are plummeting. There are a lot of great deals, but the risk is you might miss the next big surge in asset prices between now and the next recession.
Next we can look at some images that reveal the problems that arise in recessions: falling revenues, falling asset prices and rising defaults and delinquencies.

Main Street Impacts of Recessions

The declines in revenues in aggregate are depicted in Figure 2 which illustrates the behavior of real GDP during twelve expansions and eleven recessions (the twelfth expansion has not yet ended). The heavy vertical line is the cycle peak. To the left of that vertical line are the data during expansions and to the right the subsequent recessions. Each expansion is a different line. The legend labels refer to the year and quarter of each cycle peak, except the most recent data are displayed as if 2019Q3 were the last quarter of the current expansion, which it still could be.

These real GDP data are measured as the percent difference from the cycle peak. Thus at the peak all the expansions have a zero value. The vertical axis at the left displays the percent difference.

Left of the peak vertical line, you can see the steady growth of total revenues during the expansions. Right of the vertical line has the declines in revenues in recessions. The most recent recession lasted 6 quarters, longer than any other, and it was accompanied by a 4% decline in real GDP, the largest decline. Generally, the decline in real GDP has been in the 2% to 4% range. That is the average decline in labor and capital earnings. Your situation could be worse or better depending on the sector from which your revenues flow and depending on whether or not you get laid off.

The last year before the recession is shaded to attract your attention. That is where we will look for signs of the coming recession. For example, some analysts talk about "stall speed" as if weak growth is an indicator of a recession soon to come. It is pretty had to see any stall speed effect in this image. As we peruse other figures like this, try looking for symptoms of the recession to come.

Figure 3 illustrates the unemployment rate using the same figure format. Here we see unemployment generally declining in expansions and shooting up in recessions. The rising unemployment rates in recessions means that not all American workers are affected the same – a small fraction of the employed (e.g. 5%) become unemployed but the rest continue to work, though possibly with reduced hours and reduced hourly wage rates. Here you can see a symptom of the last year of a recession: low unemployment that has bottomed out, ready to take off in the recession.

A lot of the impact of recessions on Main Street has historically been felt in manufacturing and construction. Figure 4 illustrates the decline in weekly hours in manufacturing during recessions, and Figure 5 illustrates the decline in housing starts. We will return to manufacturing and construction below when we examine employment data.

Figure 2 Real GDP at the Ends of Expansions

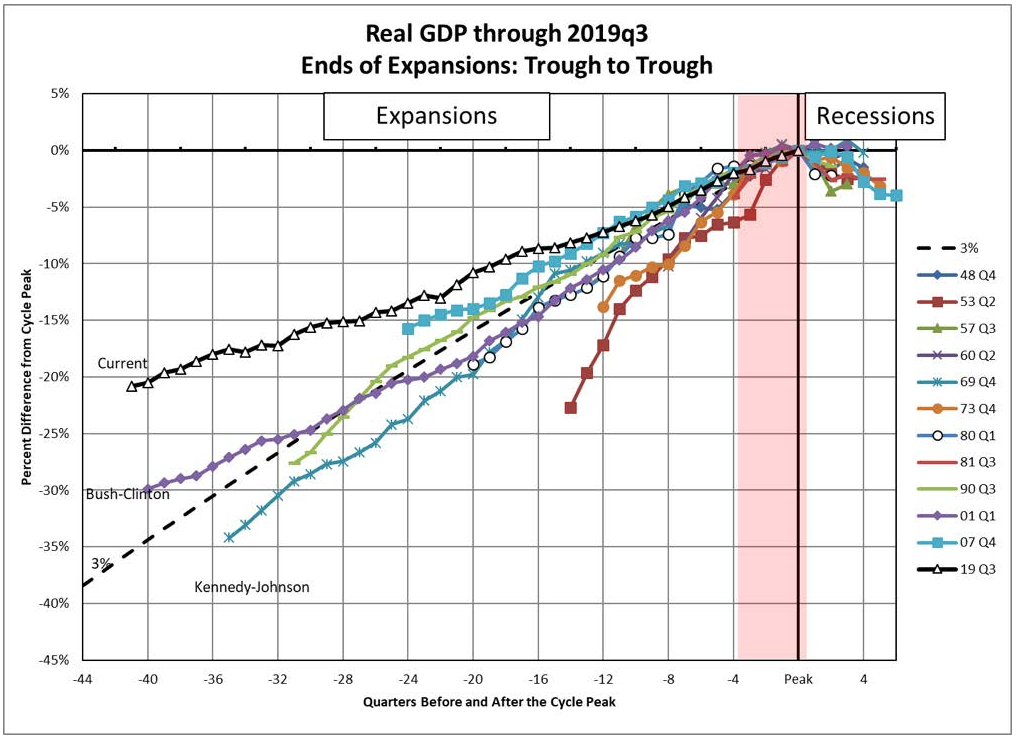


Figure 3 Job Losses for Some Workers

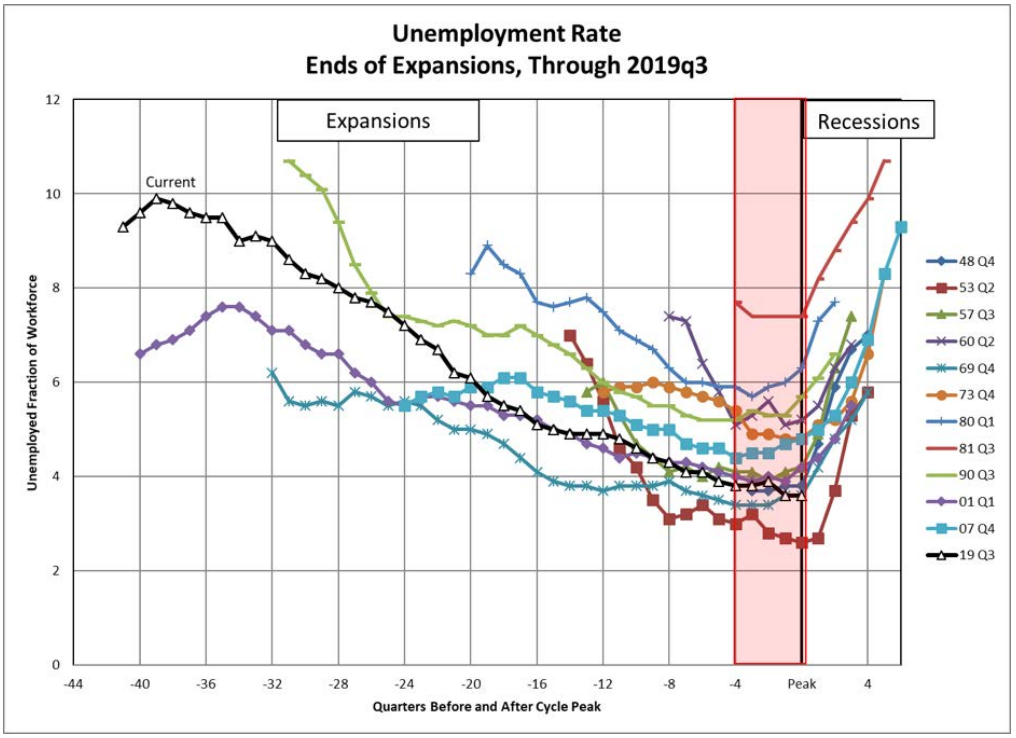


Figure 4 Loss in Hours Worked for Workers in Manufacturing

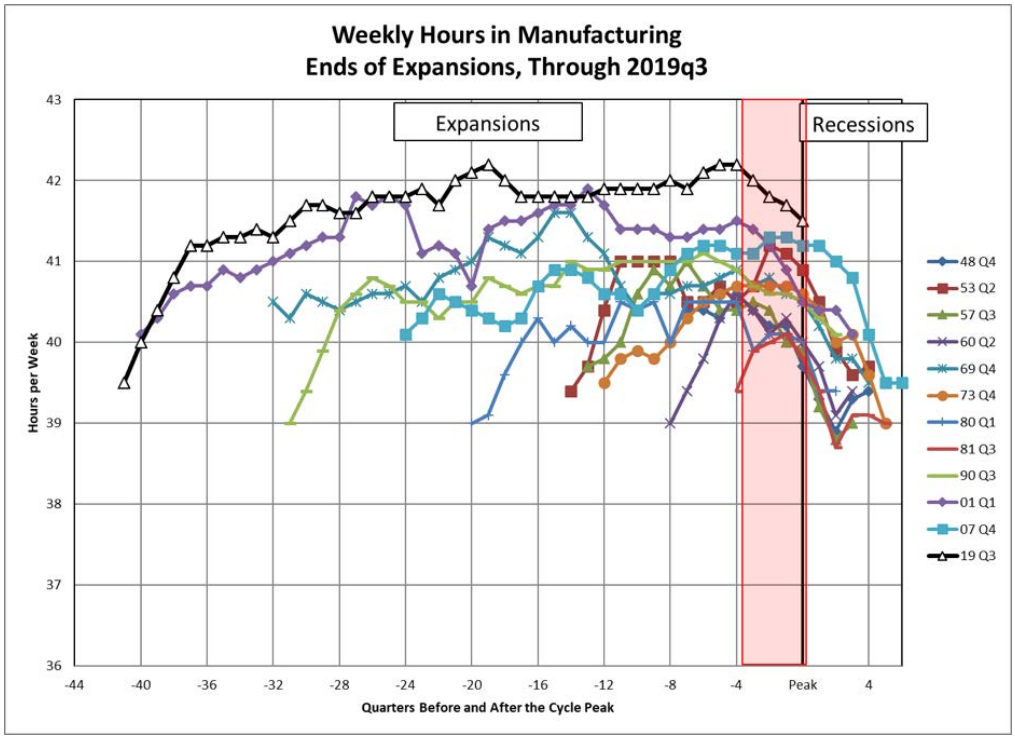
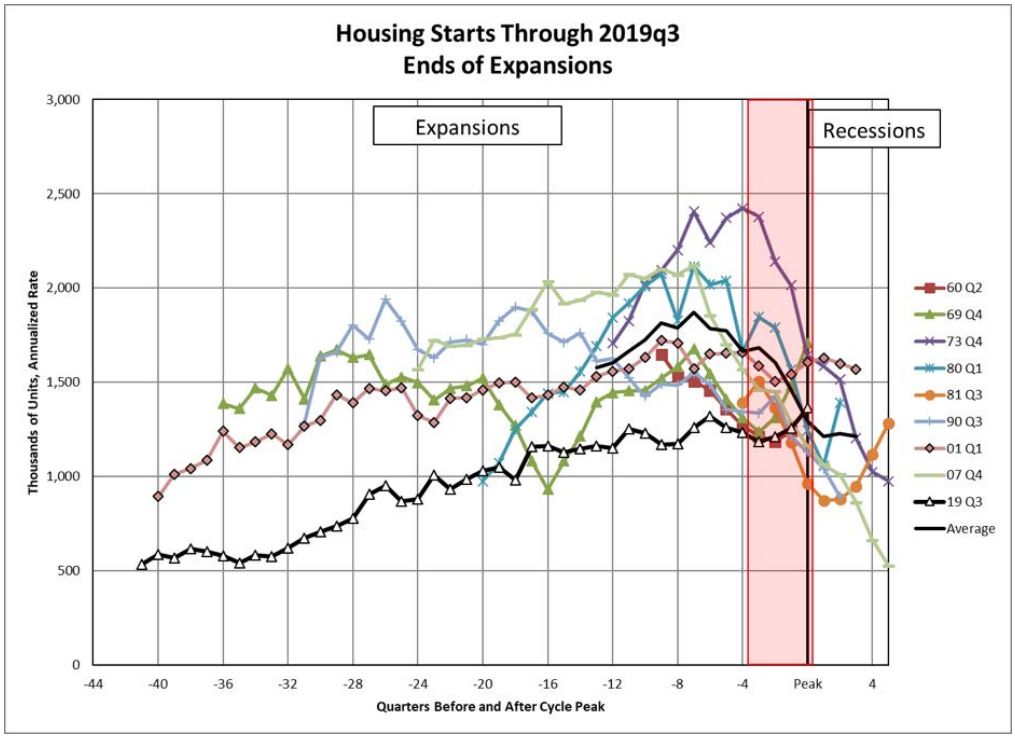


Figure 5 Construction: A Hard Hit Sector



Wall street Impacts of Recessions

Wall Street impacts are illustrated in Figure 6 and Figure 7 and Figure 8. Figure 6 depicts the level of the S&P 500 Index, which rises nicely during the expansions by amounts that vary typically between 30% and 70% but the index declines in recessions by amounts as high as 48%, in the most recent recession. Some of these asset price declines were small and short-lived and some more severe. This is symptomatic of the decline in asset prices more generally. Don't plan on selling your used car in a recession. You will not get the full value.

Figure 7 illustrates the credit spread between the yield on Moody's Baa bonds and the yield on the "risk-free" 10-year Treasury. Baa is the lowest of the "investment grade" bonds, one step above the high risk "junk" category. This credit spread is fairly high when the expansion begins and investors are still wary about defaults and delinquencies; it declines during the expansions when investors do not experience the defaults and delinquencies that worried them; and it jumps up dramatically during recessions when defaults and delinquencies elevate again.

Figure 8 illustrates the slope of the yield curve: the difference between the yield on a 10-year Treasury and the yield on a 3-month Treasury. The yield curve is steeply sloped early in an expansion, courtesy of the Fed's choice for a very low yield on the 3-month Treasury based on the hope that this would stimulate the economy and help support the recovery. That slope of the yield curve dips low and becomes negative in the year before recessions. That is the bond market prediction that the short-term yield will be falling soon. Think about it. Why would you buy a 10-year Treasury yielding less than a 3-month Treasury? If you think that high short-term yield will be falling soon, it is better to lock in the 10-year yield than the expose yourself to declining short-term yields. If you doubt the accuracy of that forecast, take a look at Figure 9 which depicts the yield on the 3-month Treasury, which is usually elevating in the year or two before recessions and then reverses with decline during the recessions. The Fed Funds rate controlled by the Federal Reserve is almost exactly the same as the 3-month Treasury yield and what you see here is evidence of rather poor performance by the Fed which near the ends of the expansions is trying to slow growth with increases in interest rates but then says it is really sorry for that when the recession begins and the

Figure 6 Decline in Asset Value

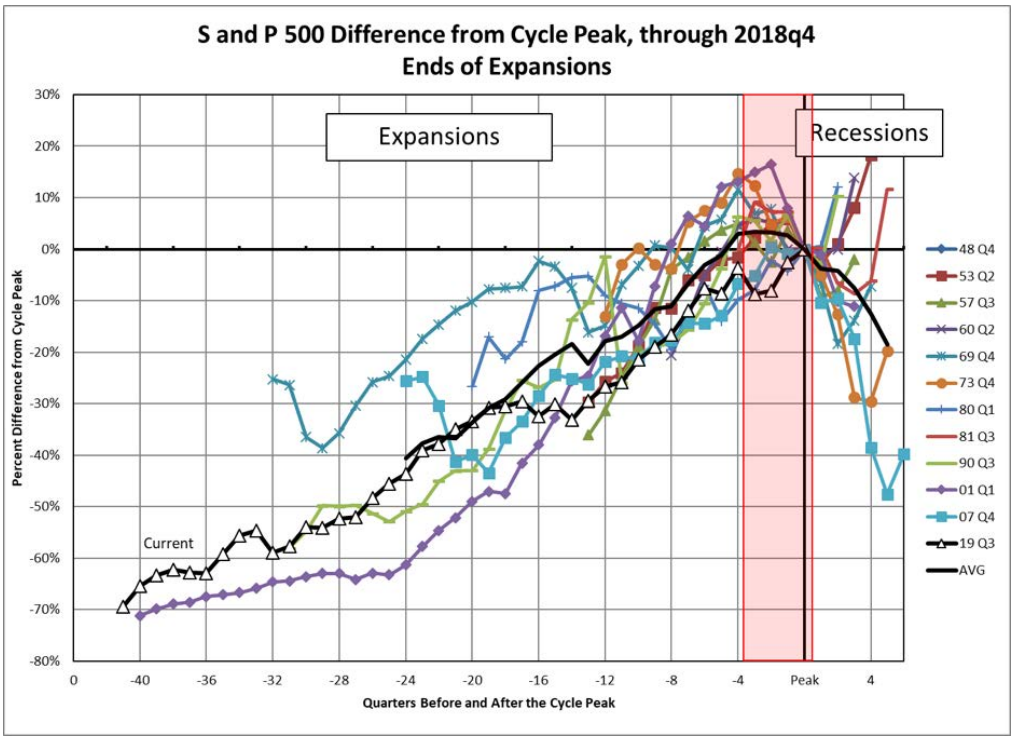


Figure 7 Rising Loan Delinquencies and Default

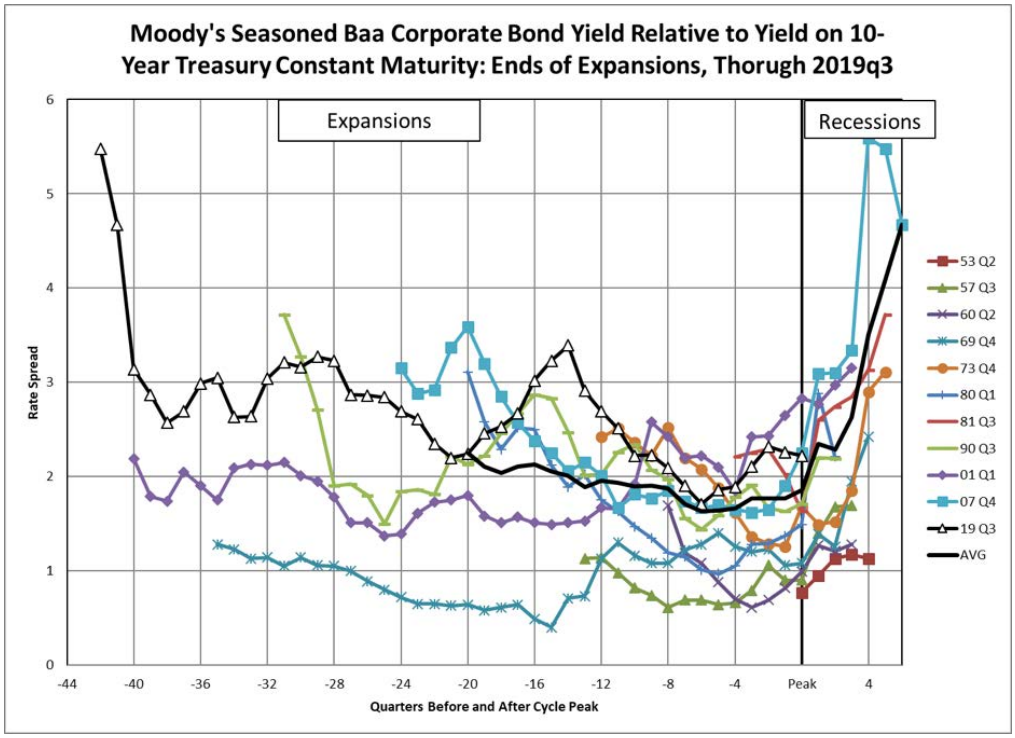


Figure 8 Slope of the Yield Curve

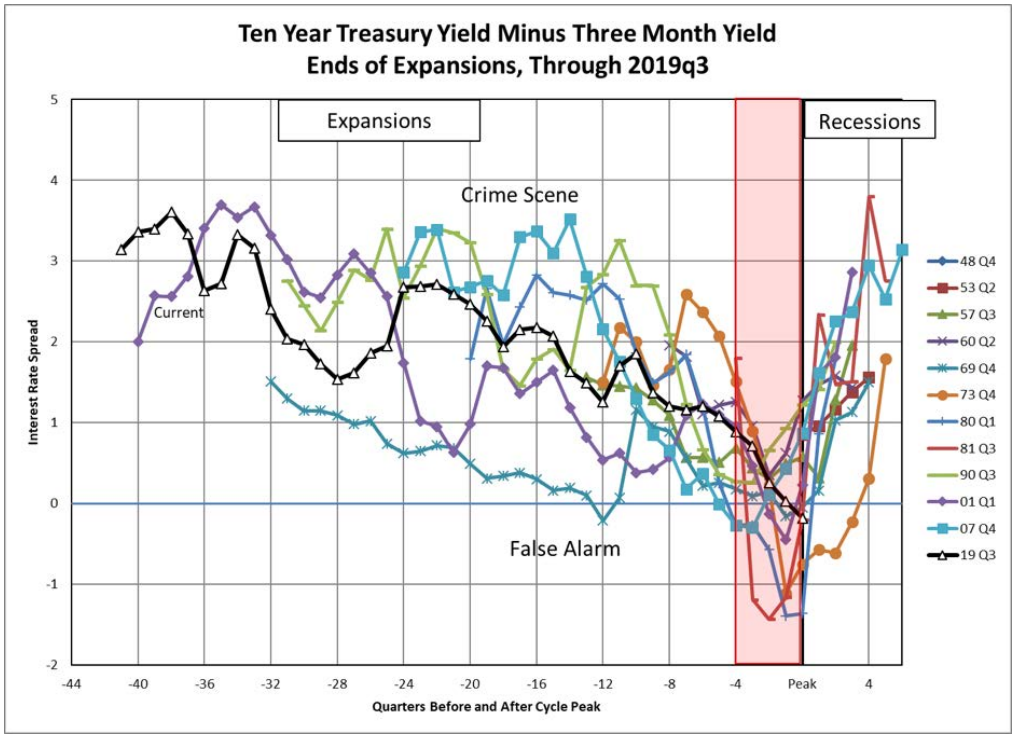
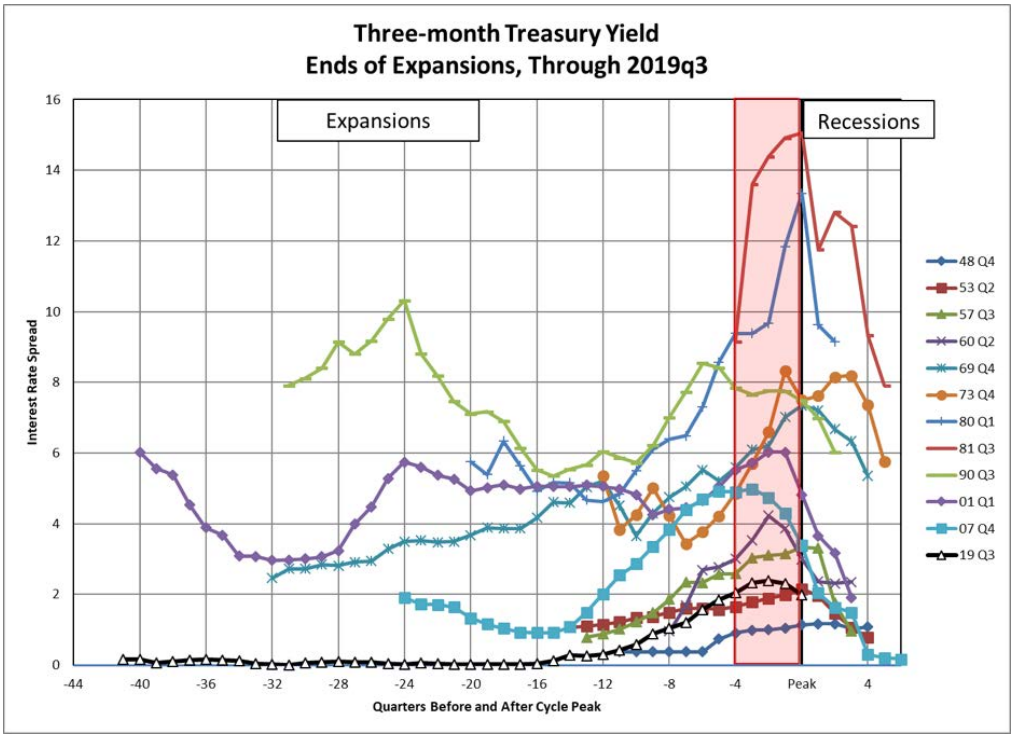


Figure 9 3-Month Treasury Yield



Fed is forced to lower the rate in the hope that it can reverse the damage that has occurred. It conveniently blames each recession on a "shock." That's a shocking excuse.

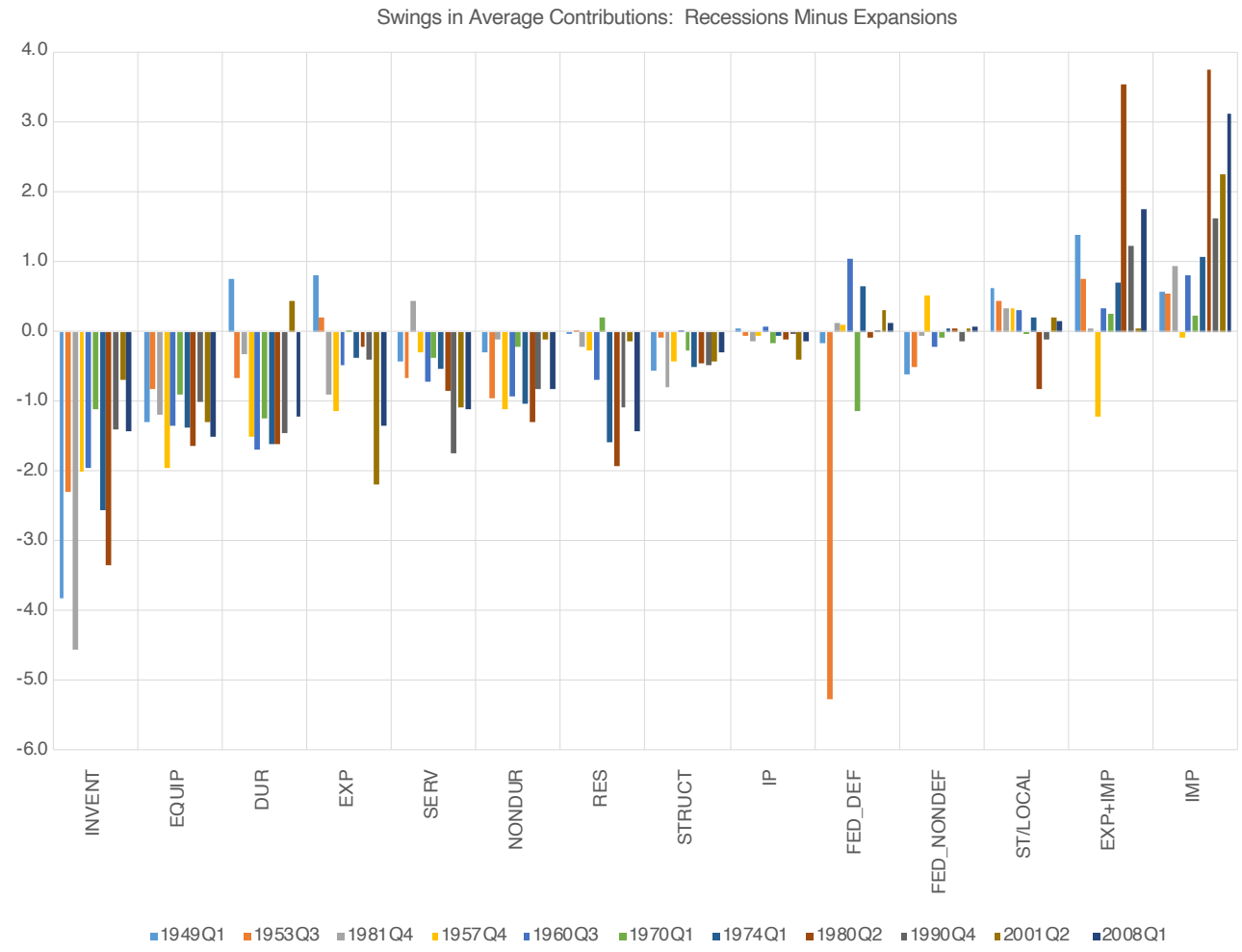
Disaggregated Contributions to GDP growth in Expansions and Recessions

GDP is disaggregated into consumer (durables, nondurables and services), investment (equipment, structures, intellectual property, residences), exports, imports and government (Fed nondefense, Fed defense and state/local). We can determine more closely who loses in recessions by studying the eleven contributions to GDP Growth which sum to quarterly GDP growth. Tables in an appendix report the average of the contributions to GDP for the twelve expansions since WWII and the eleven expansions. Three of the expansions have unusual structures of the contributions to GDP. There is also a table that records the "swings" from expansion to recession. This is the total impact of the recession on growth.

Figure 10 illustrates these swings sorted by average from smallest to largest based on the numbers in the last row of Table 3. Keep in mind that the first three of the bars in each group refer to the "unusual" expansions and the other eight to the usual ones. The huge negative swing in Federal Defense in recession 2 really stands out. The large swings in the contributions of inventories for recession 1 and 3 stand out but not so much.

Generally the sectors at the left are hardest hit in recession and the sectors at the right not so much. Inventories contribute during the recessions following the usual expansions -1.8 to the -5.7 swing in GDP growth. After that come equipment (-1.29), consumer durables (-0.87), consumer services (-0.69) and consumer services (-0.69). The contributions to expansions of the three consumer spending items make up 62% of GDP growth during the usual expansions, but the swings make up only 38% of the swings. Although I am fond of reporting that "Housing IS the Business Cycle" the

Figure 10 Swings in Average Contributions



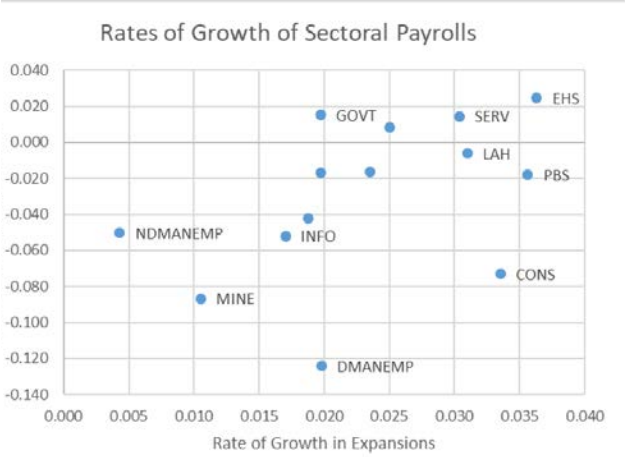
contributions of housing to the decline in GDP in recessions is not one of the greatest problems.

Disaggregated Payroll growth in Expansions and Recessions

It may be difficult for readers to map these GDP contributions into estimates of their own recession risks, but it is much easier to do that with disaggregated payroll data. Appendix Table 4 reports annualized rates of growth of payrolls overall and 14 components during the twelve expansions and Table 5 reports the same information for recessions. The columns are sorted by the rates of growth over all recessions in the last row of Table 5 from -12.4% for durable manufacturing to +2.5% for Education and Health Services. Numbers in this table are colored if the rates of growth are below the 45th percentile in each recession. You want to avoid this shaded jobs. Numbers in Table 4 are colored if they exceed the 55th percentile in each expansion. You want those colored jobs.

The scatter diagram in Figure 11 compares the rates of growth in expansions with the rates of growth in recessions and is designed to make your choice easy – go the northeast with high growth in both expansions and contractions. Education and Health Services is the clear winner. Government is good too with jobs that grow even in recessions though not growing so fast during recessions. This image should make you wary of manufacturing, mining and information too. That includes the movie business and well as software.

Figure 11 Rates of Growth of Payrolls in Expansions and Recessions



If you choose to work in one of those three sectors, try to find a spouse in EHS.

More detail is offered in Figure 12 which displays all the data since 1947. After noticing in these images slower growth late in some of the sectors, take another look at Table 4 and notice that Government, Consumer Services, Finance Insurance Real Estate, and Retail Trade have recently lost their shading because other sectors are doing better. Better do some more exploring before you choose one of those jobs.

Recession Forecasts Based on Quarterly Data Through 2019q3

Next is the third topic: assessing the risk of a recession in the near future. This is not so easy.

Measuring The Age of an Expansion

Calendar Age

The current expansion through 2019Q3 is 41 quarters old, exceeding the previous maximum of 40 during the 1990s expansion. Rather than celebrating this record-breaking achievement, many are predicting a recession soon merely because age.

Calendar age alone might signal the coming end of an expansion and nothing else matters. Many economists think a recession is like an earthquake, infrequent, hard to predict, and not man-made. They talk about "shocks." Figure 13 helps us explore this idea by contrasting the actual cumulative death risk with the cumulative death risk based on the assumption that there is a 96% chance of living another quarter, and death is a risk that is the same at every age: 4%. The death curve for this random process in this figure starts with the end of life in the first quarter which has probability 4%. Death in the nth quarter has probability (1-0.96)*0.96n-1 , which is the probability of living through n-1 quarters and then perishing in the nth. The random curve is the accumulation of these death probabilities, ending at 83% at quarter 43. The actual curve is built on the assumption that 2020q1 is the last quarter of the current expansion, quarter 43. That random curve does a pretty good job of approximating the actual cumulative between 15 and 35 quarters, but it overestimates the death risks early in the life of an expansion and underestimates the death risks late in the expansion. I will be excluding the first eight quarters of each expansion because a recovery from a recession is likely to have features unlike the rest of the expansion. A side benefit of that exclusion is the low death rates during the excluded period to not affect the analysis. With those early observations excluded, it may be important to allow for elevated death risks for expansions older than 30 quarters.

Figure 13 Death Rates of U.S. Expansions versus a Random Model

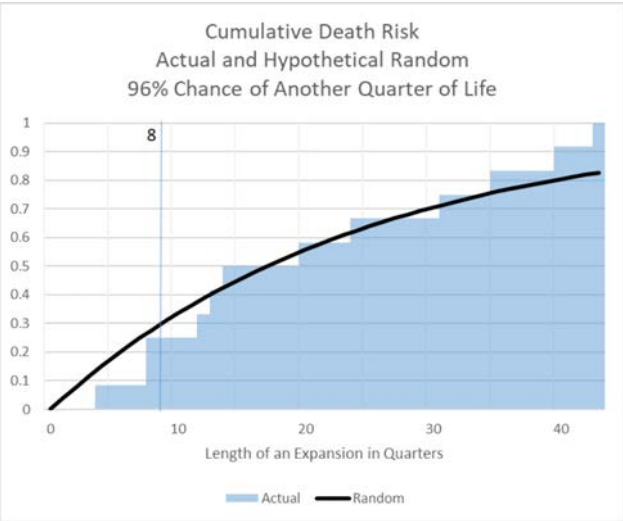
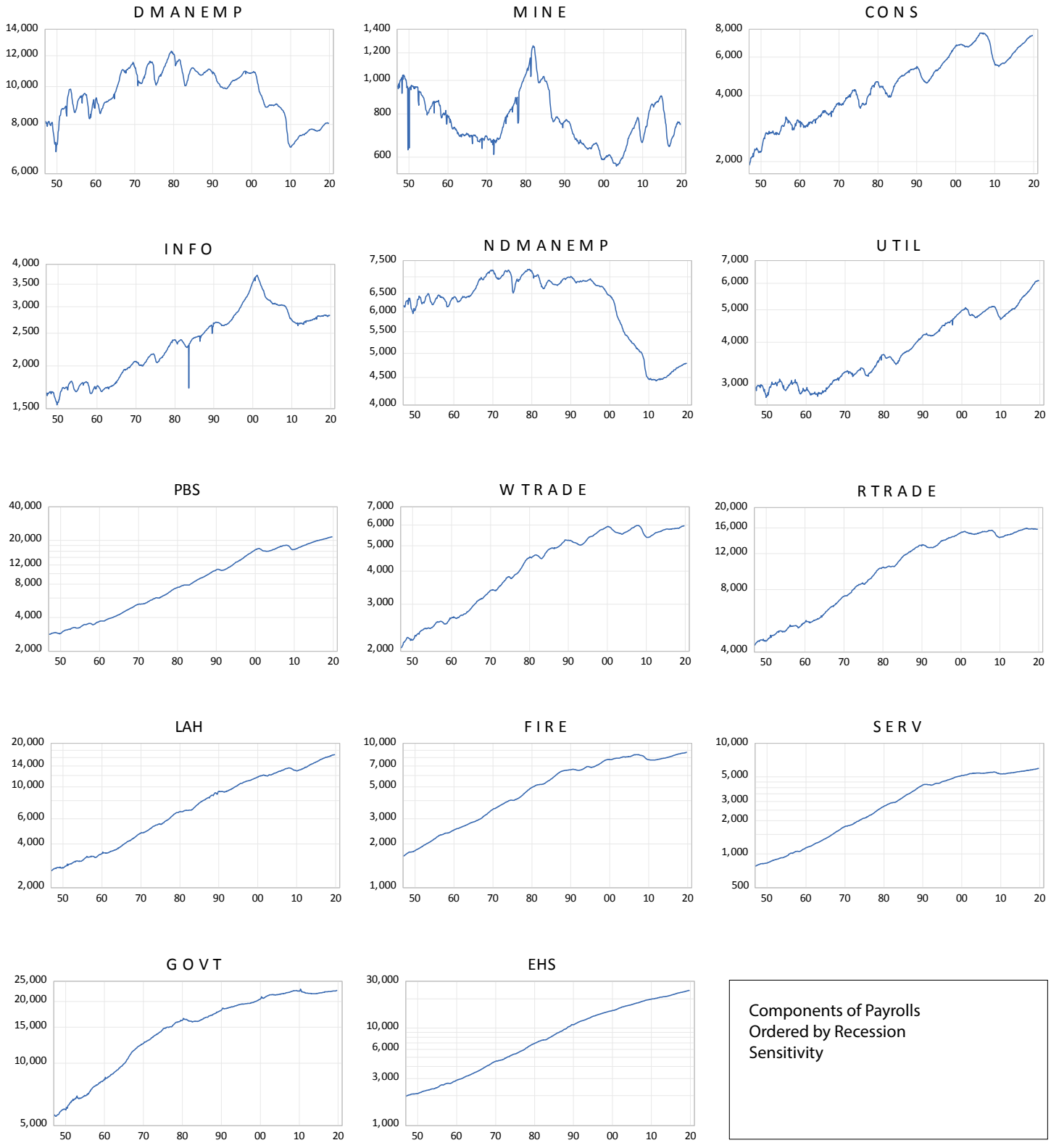


Figure 12 Log of Payroll Components Since 1947



Overbuilding and Overharvesting May Create a Fragile Economy, Ready to tip into Recession

Another view of the lifetimes of expansions is that unwise choices during expansions create a fragile economy that can be tipped into recessions when the economy "runs out of gas" or "hits a bump in the road." Think of obese and drug-dependent humans.

The running-out-of-gas story is that a new technology supports high economic growth early in an expansion when new ideas are easy to pick from the low-hanging branches, but when these are gone it gets harder and harder to harvest new ideas, and a time-out is needed for the tree of ideas to replenish itself. That's a high-growth expansion driven by the harvesting of new ideas and a recession when the all the best and most accessible ideas have already been harvested. The bump-in-road story is that the Federal reserve uses low interest rates to support what turns out to be an unsustainable level of investment in housing and late in an expansion a time-out is needed for the economy to catch up with the housing investments already made. That's a recession brought on by an increase in interest rates by the Federal Reserve when housing is overbuilt and banks have already dipped deep into the barrel of potential borrowers.

One place to look for excessive growth is the GDP cumulative growth during the expansions depicted in Figure 14. This makes an important point: while we are living in the oldest expansion, 4 of the previous 10 expansions had greater accumulated GDP growth than our current one. Maybe we are not so old.

Figure 14 Accumulated GDP Growth During Expansions

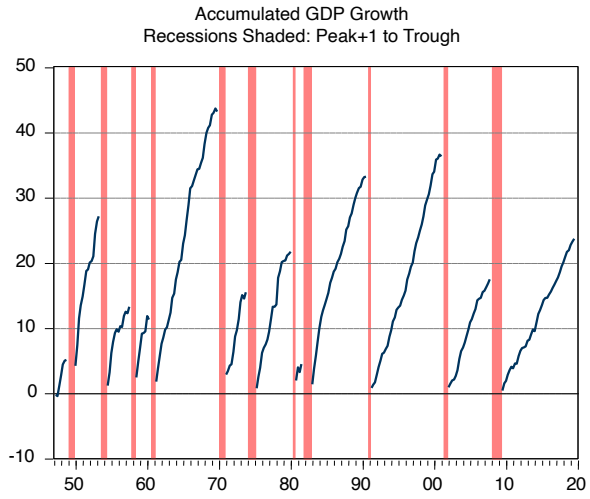


Figure 15 illustrates the cumulative contribution of residential investment which is a very different image than the GDP cumulative. Here we see the residential investment cumulative usually peaking before the expansion ends and then tumbling downward. This is the economy growing obese because of the low-interest rate candy bars provided by the Federal Reserve and then desperately trying to cope when the candy bars are taken away.

In search of evidence of overharvesting of good ideas, Figure 16 illustrates the accumulated contributions of business investment in equipment during the expansions. Here

Figure 15 Overbuilding of Homes

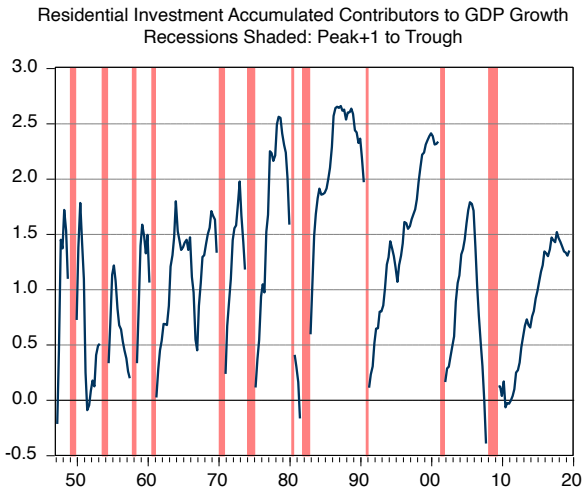
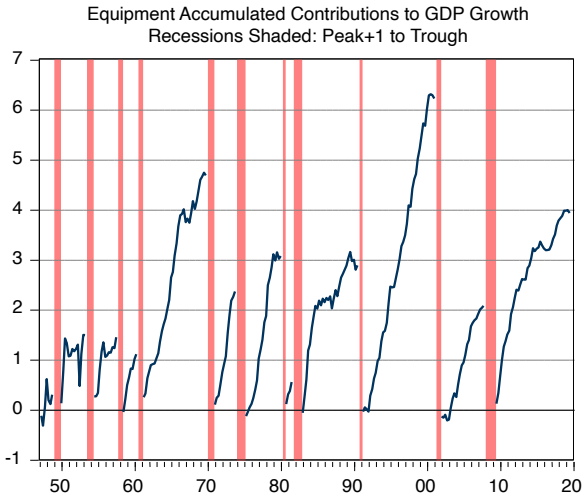


Figure 16 Overharvesting of Ideas



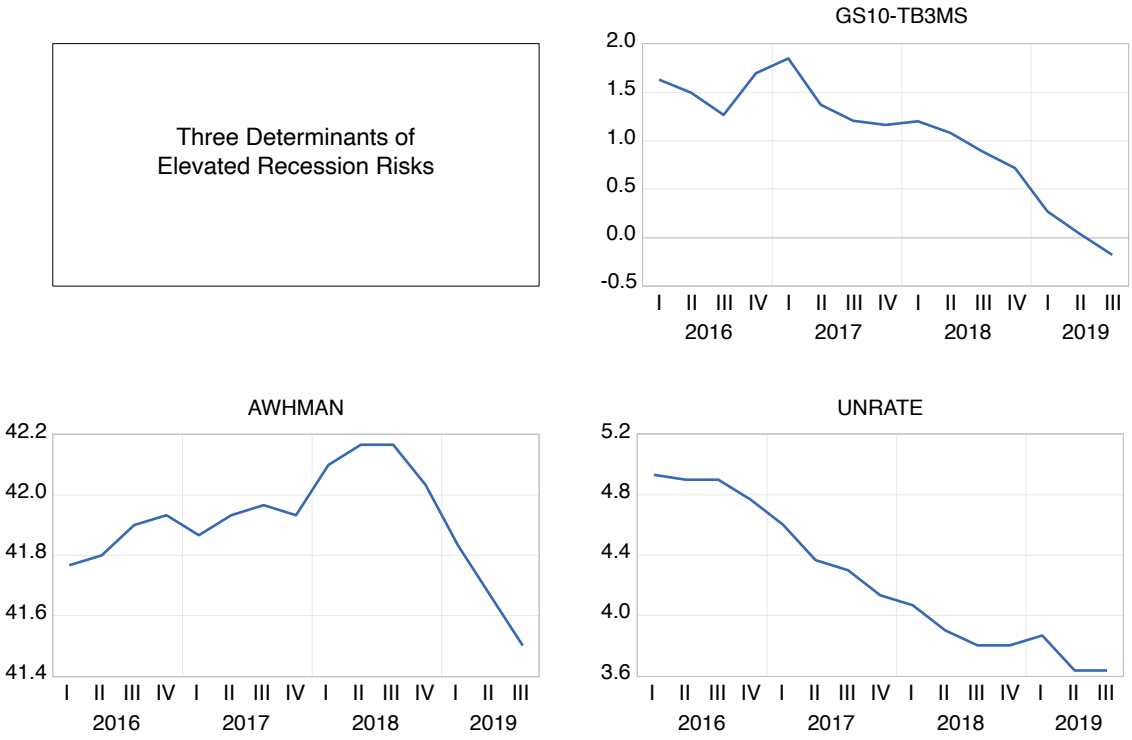
we are looking for some ups and downs like we saw in the residential investment image, perhaps especially noticeable in the 1990s when the Internet Boom was occurring. The ups are there but the downs at the very end of the expansions are just barely noticeable. Not much evidence of overharvesting of ideas here.

Four Probit Models

We now discuss four probit models that identify differences between the final years of the expansions and the earlier expansion data. Recessions are excluded as are the first two years of each expansion because these quarters include the distinctive recovery periods after recessions when GDP growth tends to be high because unemployed workers find jobs again. Late in our expansion, the difference between the current data and what was happening in the recession recovery periods should not influence the recession prediction. In addition, we exclude expansions that have distinctly different structures than the current one. These are the first expansion after WWI, the second expansion that began in 1950q1, the fourth expansion that began in 1958q3. The brief seventh expansion from 1980q4 to 1981q3 is also excluded because it did no last beyond eight quarters.

The dependent variable in these models is a binary indicator identifying the final year of each expansion. If the next recession commences next quarter in 2019q4, then the quarters from 2018q4 to 2019q3 would be part of the final year of the expansion. We do not have that data yet, and thus the last four quarters are excluded from the estimated model, though we use the estimated model to predict the recession probabilities in these four quarters.

When reviewing the recession forecasts based on these models, it is appropriate to keep in mind the "background" recession risk which is the ratio of the number of quarters that were in the last year of an expansion divided by the total number of quarters in the sample: 28/148 = 0.19. If all the coefficients in these probit models were zero except for the constant, the recession forecast would equal the background risk of 19%. To offer a different forecast, one needs non-zero coefficients with values that can confidently be determined. That is a lead in to an important warning: the Eviews estimated probabilities from the probit model do not account for statistical uncertainty in the coefficients. You need informally to shrink these probabilities toward 19% to account for the uncertainty in the coefficients. When you see a 100% chance of a recession, think of it as high but not that high.



The first probit model is designed to capture the ideas about aging in the previous section, including calendar age and also over-building of homes as recession predictors. The second model has only "precursors", variables that might behave very differently shortly before a recession arrives. The first model is like studying the effect of climate change on weather and the second is like using changes in barometric pressure. The third model includes both the aging variables and the precursors. The fourth model is a "trimmed" version of the third model, with the least reliable variables omitted. The recession risks are 7% for the first model with aging alone considered, and 17% for the precursor model. and 0% for the combined model and 100% for the trimmed combined model.

The first two models are steps toward understanding but the models that we should be relying on are the two that include both aging effects and precursors. That is the third model with a 0% recession risk and the fourth model with a 100% recession risk.

While I am inclined to favor the fourth model which allows all effects to play a role, and which eliminates the effects that are statistically unreliable, I report the other three to reveal the sensitivity of the results to change in the model and also to help reveal what leads to these different conclusions. The images below identify the three important drivers of elevated recession risk: the inverted yield curve, the decline in weekly hours in manufacturing and the bottoming out of the unemployment rate. If only these variables were used, the final expansion year risk would elevate to 41% in 2019q3. When the state of the housing market is also considered per the second model, the risks drop to 17%: the cumulated residential investment is small compared with the earlier episodes and rate of decline is also small. The extremes are determined by how age affects the outcomes. The combined model with the 0% estimated risk has age variables with estimated coefficients which allow the expansion to grow younger over time. The trimmed final model has a positive age effect that kicked in when this expansion hit 31 quarters. That is how you get to 100%.

Aging Only Model

Table 6 reports an estimated probit regression explaining the last year of an expansion binary variable with the expansion age and the cumulated GDP during the expansions and with two variables that reflect the overbuilding of homes: the 8 quarter moving maximum of the cumulative residential investment and the 4-quarter change in the cumulative residential investment. The two aging variables EXPANSION AGE and GDP CUMULATIVE are both allowed special impacts when they exceed 30. This is suggested by the extra aging that Figure 13 has suggested takes place for the older expansions. According to the signs of the estimated coefficients, both variables make the expansion more youthful (less likely to end) until the positive aging effects kick in a 30 quarter and 30 cumulated GDP.

The two variables involving the cumulative residential investment are meant to capture what Figure 15 suggests: the period preceding recessions have high but declining cumulative residential investment, high captured by the moving maximum @MOVMAX(I_RES_CUM_EXP,8) and declining captured by the four-quarter difference I_RES_CUM_EXP-I_RES_CUM_EXP(-4). The signs on these coefficients conform with that feature.

The change in the cumulative residential investment is the most statistically significant. This is picking up the fact that during the last year of the expansions residential investment is contributing negatively to GDP growth and signaling the recession soon to arrive. After that in terms of statistical significance comes the cumulated GDP variable, but only when it exceeds 30, which means that it kicks in only for two of the expansions. Next in terms of statistical significance is the max of the cumulated residential investment. Last is the calendar age of the expansion, but only in excess of 35 quarters.

The estimated/predicted recession probabilities implied by this model are illustrated in Figure 17. This image has the recessions shaded in red, and a perfect predictor would have the black bars at 1.0 in the four quarters before these

Figure 17 Recession Risks Implied by Aging Model, Table 1

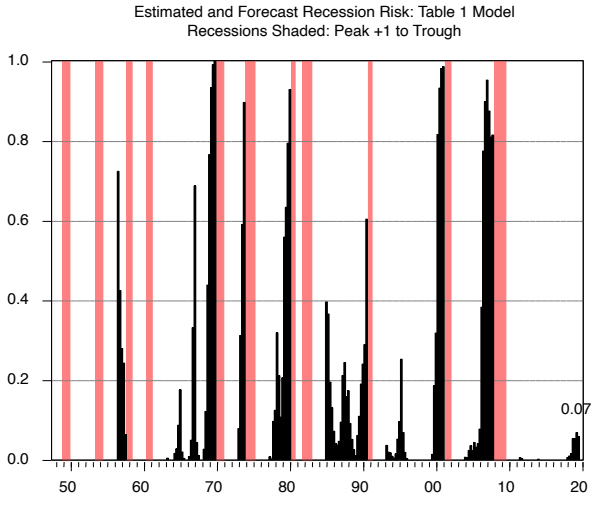
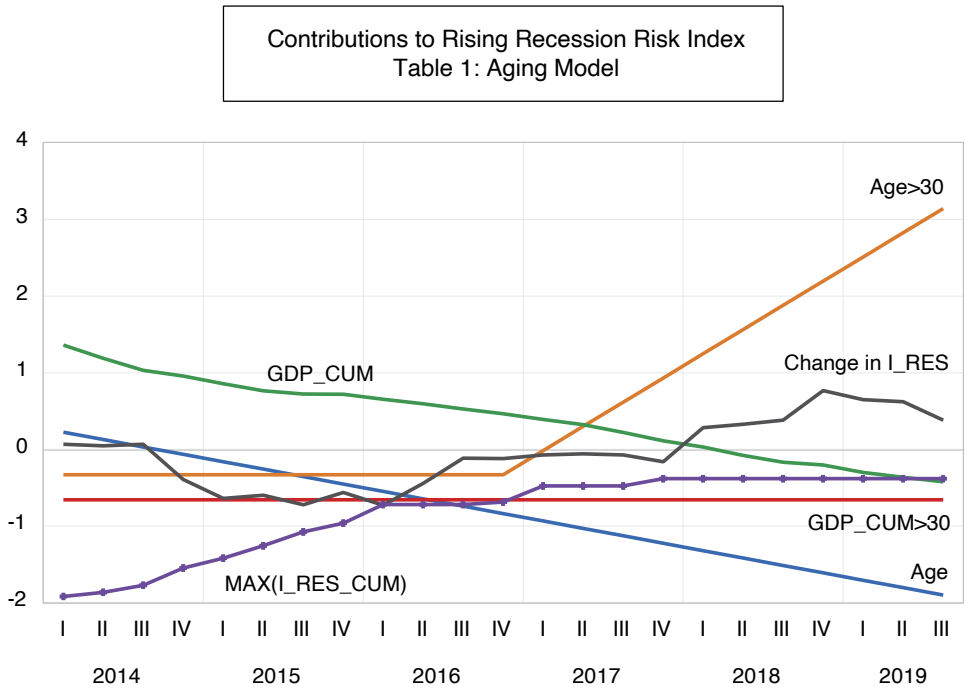


Figure 18 Contributions to the Rising Recession Risk



recessions and zero otherwise. This model provides an estimated probability that 2019q2 is in the year before recession equal to only 0.68%, which falls to 0.58% in 2019q3. This is telling us that growing old is not a big problem for our current expansion.

Figure 18 illustrates the contributions to the recession risk index implied by the estimated coefficients in the model multiplying the values of the variables with their means removed. Here we discover what is happening. The estimated 0.316 positive effect of AGE in excess of 30 is partly offset by the negative effect -0.97 of AGE itself, and partly offset by the negative on GDP_CUM_EXP , while the other positive aging effect for GDP_CUM_EXP in excess of 30 has not kicked in since in 2019q3 the cumulative GDP growth in the current expansion is only 24. When that cumulative GDP increases by 6 which will take two or three years, that's when aging will kick in per this model. Until then, we remain youthful.

Usual Precursors

The first model just discussed has four variables that increment slowly over time and two "precursors" which behave differently in the year before recession: the change in the residential investment cumulative and the maximum residential cumulative. Table 7 is an estimated probit model that associates the last year of expansions with the two residential investment precursors and four additional potential precursors of recession:

- GS10-TB3MS: The slope of the yield curve equal to the yield on ten-year Treasuries (GS10) minus the yield on three-month Treasuries (TB3MS). This is expected to have a negative coefficient since a steeply sloped yield curve is typically absent the last year of an expansion. Actually, the slope typically becomes negative, something described as an inverted yield curve.
- UNRATE-UNRATE(-8): The two-year change in the unemployment rate. This is expected to have a positive coefficient, meaning ring an alarm when unemployment is increasing.
- AWHMAN: Average weekly hours in manufacturing. Expect a negative coefficient on this variable because overtime is often eliminated before layoffs commence.
- BAA10YR: Moody's Seasoned Baa Corporate Bond Yield Relative to Yield on 10-Year Treasury Constant Maturity. Worries about distressed debt in the coming recession may be evident in this risk premium before the recession officially begins in which case the coefficient will be positive.
- I_RES_CUM_EXP-I_RES_CUM_EXP(-4). This is most statistically significant variable in the aging study above. If the coefficient is negative again, that means the year before recessions typically has a declining cumulative of residential investment.
- @MOVMAX(I_RES_CUM_EXP,8). This variable and the previous one are intended to capture the overbuilding of homes in Figure 15

All six of the precursor coefficients in Table 7 have the "right" signs. The most statistically significant variable is the slope of the yield curve, which is turned on only when it is below 2, a feature suggested by some graphs and some numerical exploration. The other coefficients have the expected signs: Recession risks rise when unemployment is increasing, when average weekly hours in manufacturing are low, when the risk spread for corporate bonds is high when the cumulative investment in residences is high and falling. Notice also that the fit of this model is superior to the one in Table 6.

Figure 19 illustrates the predicted recession probabilities based on this six-precursor model. There are no false negatives, recessions that were not preceded with alarms. (That 1981Q4 recession start is excluded from the estimated model because the expansion that precedes it did not exceed 8 quarters in length, but the absence of any black bars in this region does indicate that the circumstances that preceded the other recessions were not present in 1981 – call that a false negative, if you like.) There were brief false alarms rung in 1964q1 and 1986Q2. Now in 2019q3 there is a soft alarm sounding with a recession probability of 17%!

Figure 19 Forecasts Based on Five Precursors

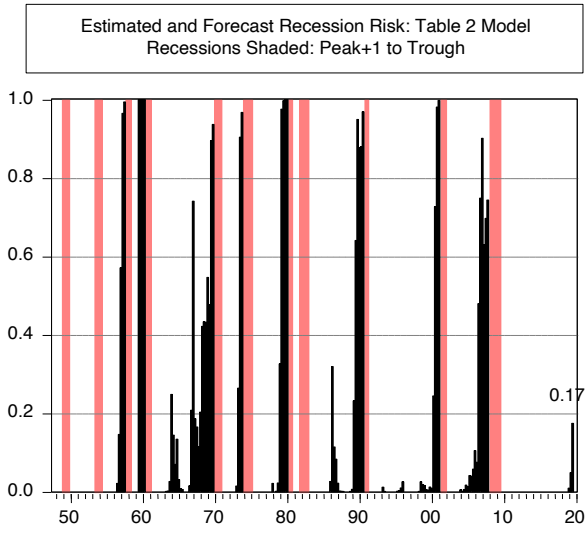


Figure 20 Contributions to the Rising Recession Risk, Table 2 Model

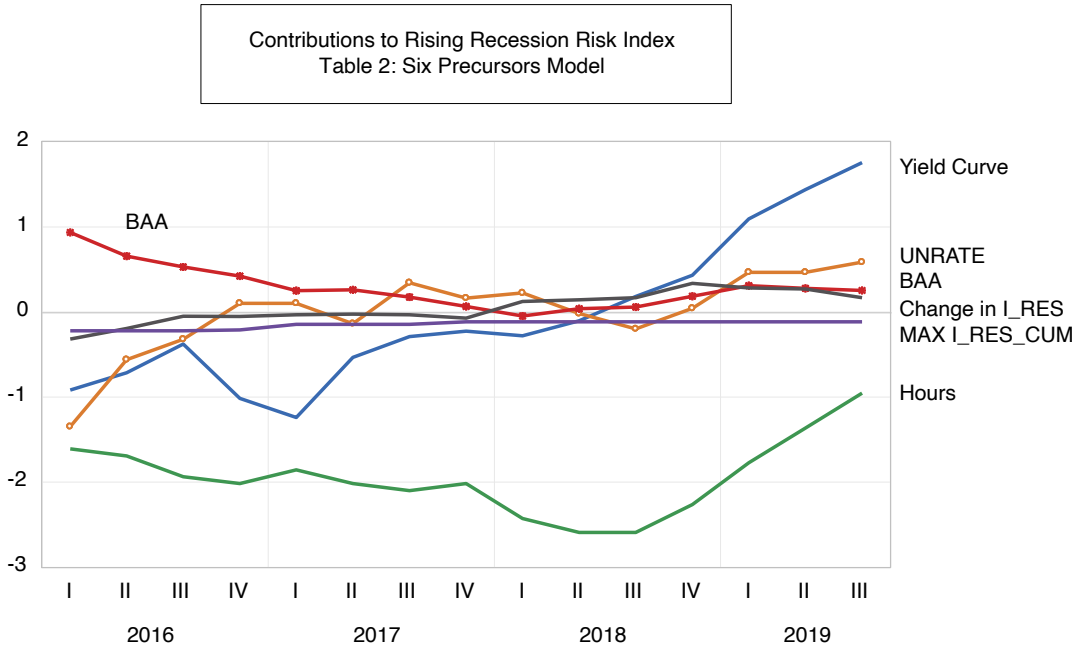


Figure 20 illustrates the contribution of each of the five precursors to the index that is used to form the recession probability. Here we see that the increased recession risk comes mostly from the flattening of the yield curve and the decline in weekly hours in manufacturing.

Combined Age and Precursors

Table 8 is a probit model that includes all the age effects and precursors with predictions in Figure 21. Per this model there is a 0% chance that 2019q3 is in the last year of the expansion. Table 9 is the same model but with a statistically insignificant variable excluded and with predictions in Figure 23. Per this model there is a 100% chance that 2019q3 is in the last year of the expansion. That is the greatest amount of confusion possible, but the statistical fit of these two models and the pure precursor model in Table 7 as measured by the Akaike Information Criterion can be used to compute model probabilities (0.313, 0.348 and 0.338) which can multiple the three predicted recession probabilities (0.17, 0 ,1) to get a combined probability of 39% that 2019q3 is in the last year of recession, a number which is much influenced by the implicit belief that aging matters. Otherwise go with the pure precursor prediction on 17%.

While not taking it all literally, we have learned some important things:

- If calendar age is included in the model, the recession risk is very high
- Three items contribute to rising recession risk: the inverted yield curve, the falling hours in manufacturing and the flattening of the unemployment decline.

Figure 21 Estimated Recession Probabilities, Table 3 Combined Model

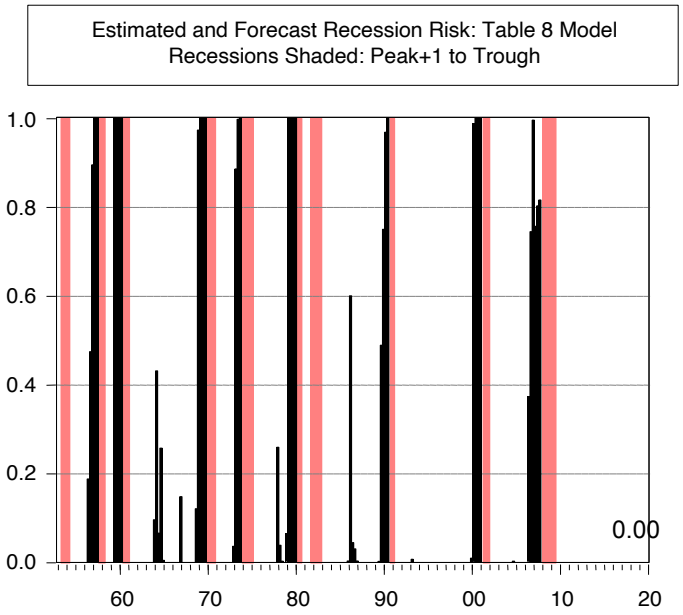


Figure 22 Contributions to the Rising Recession Risk, Table 8 Combined Model

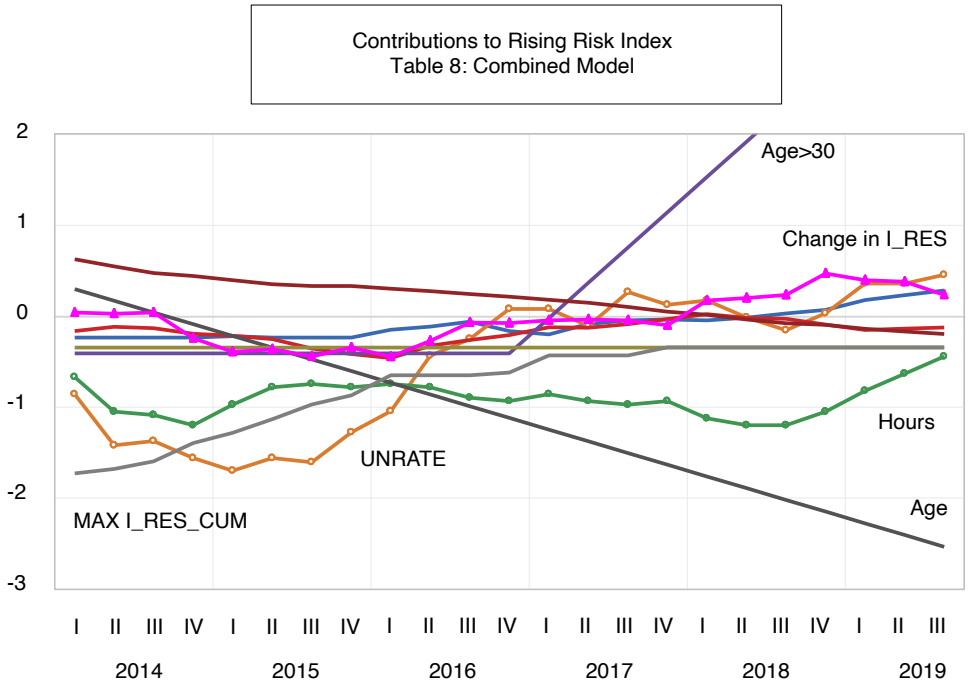


Figure 23 Estimated Recession Probabilities, Table 9 Trimmed Combined Model

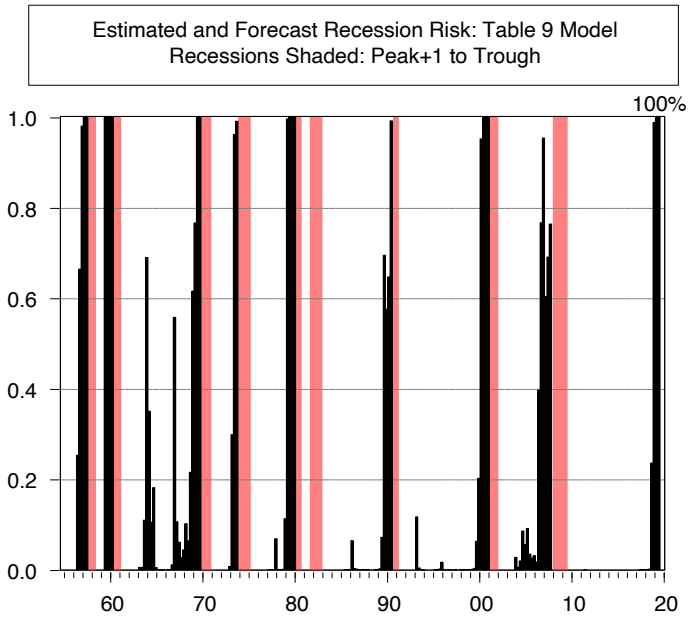
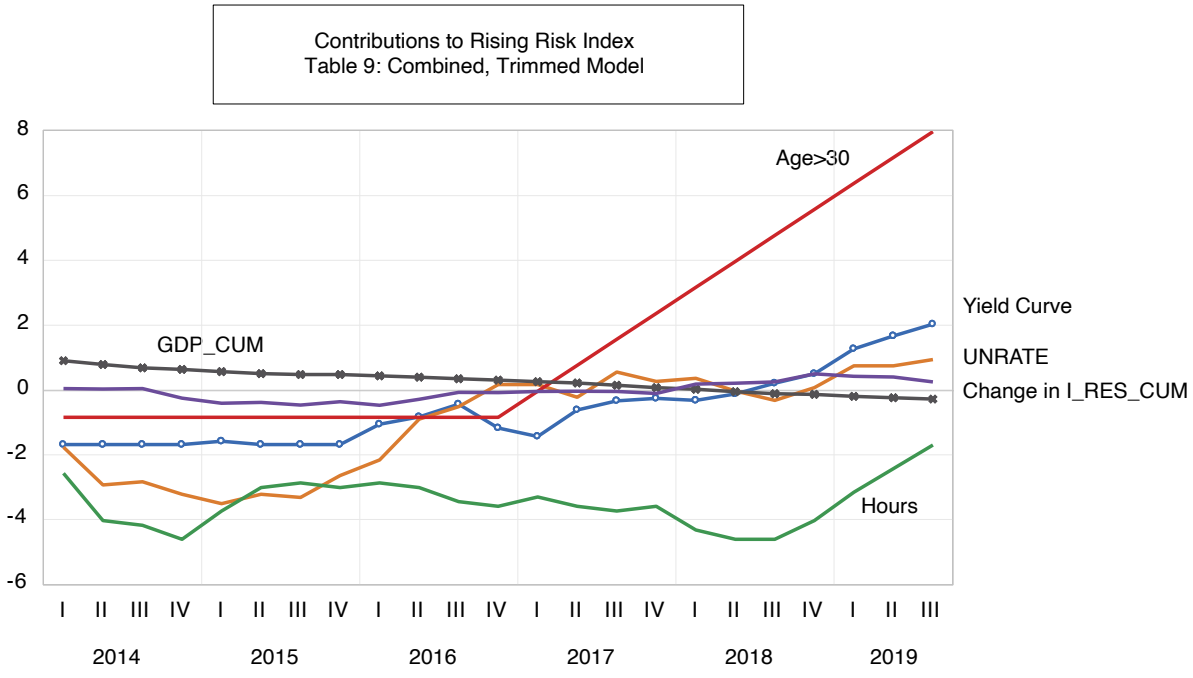


Figure 24 Contributions to the Rising Recession Risk, Table 9 Trimmed Combined Model



Caution

We are currently in the 12th expansion. The post-war data includes 11 expansions that have ended, but we will use only 7 of them. That means we are studying dozens of potential variables but with only seven experiments. This is called an "undersized" sample which offers a "perfect fit" of the data if the number of variables exceeds the number of experiments 7 with infinite standard errors of the coefficients and zero t-values. We offer a "pretend" solution which involves more data and fewer variables. The appearance of more experiments than seven is made possible with the probit model that treats each of the 120 quarters of data as an independent experiment of which 28 (4 times 7) were in the last year of the expansion. The appearance of fewer variables than dozens is made possible with an exploratory approach, always keeping the number of variables conveniently few. An honest and valid way to reduce the number of variables would to begin with a fully-disclosed nearly-complete list and a fully-disclosed prior assessment of the likely importance of each, followed by a data analysis that highly favors the more important variables. A dishonest and invalid approach would be to limit the number of variables arbitrarily to assure that the final reported model "looks good."

Appendix: Tables

Contributions to GDP growth

Table 1 contains the average contributions to GDP growth during the twelve US expansions with the two largest values shaded green and the two smallest shaded red. The first column counts the expansions during calendar time from 1 to 12. The first three rows refer to what are taken to be unusual expansions. Expansion 2 that commenced in 1950q1 has a huge 3.33 average contribution of Federal Defense spending. Expansions 1 and 8 had unusually large contributions from inventory investment.

Table 2 reports the average contributions to GDP in the subsequent recessions number like 2.1 meaning the recession that followed expansion 2. This 2.1 recession had a large negative from defense, a response to the very large positive in expansion 2. The recessions 1.1 and 8.1 experiences big negatives from inventory offsetting the big positives in expansions 1 and 8.

Table 3 reports the swings in contributions: the recession contribution minus the expansion contribution. This swing is the full damage done to economic growth: e.g. the swing from an average expansion GDP growth rate of 3.85 to a recession value of -1.9, reduced GDP growth by 5.7.

Table 1 Average Contributions to GDP Growth, Expansions

Expansions

			Consumption			Investment					Exports and Imports			Government			
		GDP	DUR	NONDUR	SERV	STRUCT	EQUIP	IP	RES	INVENT	EXP	IMP	EXP+IMP	FED_DEF	FED_NONDEF	ST/LOCAL	Obs
1	1947Q1	2.9	0.58	0.53	0.64	0.23	0.17	-0.02	0.62	0.80	-1.37	-0.34	-1.71	-0.08	0.71	0.41	7
2	1950Q1	7.7	0.39	0.89	1.30	0.29	0.43	0.11	0.14	0.91	0.17	-0.49	-0.32	3.33	0.11	0.18	14
8	1980Q4	4.5	0.40	0.40	0.58	0.46	0.55	0.23	-0.17	2.56	0.02	-0.85	-0.83	0.43	0.02	-0.20	4
3	1954Q3	4.1	0.47	0.96	1.15	0.15	0.44	0.10	0.06	0.44	0.38	-0.27	0.12	-0.20	-0.05	0.43	13
4	1958Q3	5.6	0.71	0.95	1.43	0.16	0.55	0.09	0.53	0.73	0.60	-0.34	0.26	-0.35	0.20	0.39	8
5	1961Q2	4.9	0.67	0.80	1.39	0.17	0.54	0.12	0.15	0.23	0.30	-0.38	-0.08	0.26	0.20	0.48	35
6	1971Q1	5.2	1.01	0.50	1.38	0.15	0.79	0.08	0.39	0.78	0.60	-0.32	0.29	-0.63	0.13	0.30	12
7	1975Q2	4.3	0.50	0.64	1.20	0.29	0.61	0.14	0.32	0.30	0.56	-0.62	-0.06	0.10	0.11	0.19	20
9	1983Q1	4.3	0.56	0.48	1.49	0.02	0.37	0.21	0.25	0.28	0.69	-0.83	-0.15	0.27	0.09	0.40	31
10	1991Q2	3.6	0.63	0.46	1.46	0.06	0.62	0.27	0.23	0.07	0.70	-1.10	-0.40	-0.14	0.05	0.32	40
11	2002Q1	3.2	0.45	0.46	1.20	-0.09	0.35	0.16	0.44	0.39	0.59	-1.10	-0.51	0.23	0.09	0.03	16
11.01	2006Q1	2.3	0.47	0.27	0.88	0.41	0.34	0.24	-1.08	-0.23	1.03	-0.44	0.59	0.16	0.06	0.19	8
12	2009Q3	2.3	0.44	0.33	0.89	0.00	0.38	0.23	0.13	0.20	0.48	-0.73	-0.26	-0.04	0.03	-0.01	41
	USUAL	3.85	0.58	0.55	1.26	0.10	0.50	0.18	0.19	0.26	0.56	-0.70	-0.14	0.02	0.09	0.27	224

Table 2 Average Contributions to GDP Growth, Recessions

Recessions

			Consumption			Investment					Exports and Imports			Government			
		GDP	DUR	NONDUR	SERV	STRUCT	EQUIP	IP	RES	INVENT	EXP	IMP	EXP+IMP	FED_DEF	FED_NONDEF	ST/LOCAL	Obs
1.1	1949Q1	-1.5	1.34	0.23	0.23	-0.32	-1.13	0.02	0.62	-3.02	-0.56	0.24	-0.33	-0.25	0.10	1.04	4
2.1	1953Q3	-2.4	-0.28	-0.07	0.62	0.20	-0.40	0.05	0.16	-1.39	0.38	0.05	0.43	-1.95	-0.41	0.63	4
8.1	1981Q4	-2.0	0.08	0.28	1.01	-0.34	-0.64	0.10	-0.37	-1.99	-0.87	0.09	-0.78	0.56	-0.03	0.14	5
3.1	1957Q4	-3.8	-1.04	-0.16	0.86	-0.28	-1.50	0.04	-0.22	-1.55	-0.75	-0.34	-1.10	-0.09	0.47	0.77	3
4.1	1960Q3	-0.1	-0.97	0.04	0.71	0.17	-0.79	0.17	-0.17	-1.23	0.13	0.47	0.60	0.69	-0.02	0.70	3
5.1	1970Q1	-0.1	-0.56	0.58	1.01	-0.10	-0.37	-0.06	0.37	-0.88	0.32	-0.15	0.17	-0.87	0.11	0.47	4
6.1	1974Q1	-2.5	-0.60	-0.55	0.84	-0.36	-0.58	0.01	-1.19	-1.77	0.23	0.75	0.98	0.03	0.19	0.51	5
7.1	1980Q2	-4.3	-1.12	-0.64	0.35	-0.17	-1.02	0.03	-1.60	-3.06	0.33	3.14	3.47	0.00	0.16	-0.65	2
9.1	1990Q4	-2.8	-0.89	-0.33	-0.26	-0.45	-0.64	0.19	-0.84	-1.12	0.29	0.80	1.08	0.29	-0.05	0.29	2
10.1	2001Q2	0.6	1.08	0.35	0.38	-0.35	-0.66	-0.12	0.09	-0.62	-1.49	1.15	-0.34	0.17	0.10	0.53	3
11.1	2008Q1	-2.6	-0.76	-0.37	0.10	-0.38	-1.15	0.02	-0.99	-1.04	-0.77	2.03	1.26	0.35	0.16	0.19	6
	USUAL	-1.9	-0.29	-0.04	0.57	-0.23	-0.80	0.03	-0.37	-1.58	-0.30	0.70	0.39	-0.10	0.07	0.44	41

Table 3 Average Contributions to GDP Growth, Swings from Expansions into Recessions

Swings: Recessions minus Expansions

			Consumption			Investment					Exports and Imports			Government			
		GDP	DUR	NONDUR	SERV	STRUCT	EQUIP	IP	RES	INVENT	EXP	IMP	EXP+IMP	FED_DEF	FED_NONDEF	ST/LOCAL	Obs
1.1	1949Q1	-4.4	0.75	-0.30	-0.42	-0.55	-1.29	0.04	-0.01	-3.81	0.81	0.57	1.38	-0.17	-0.61	0.63	4
2.1	1953Q3	-10.1	-0.67	-0.95	-0.67	-0.09	-0.82	-0.06	0.01	-2.30	0.20	0.55	0.75	-5.27	-0.52	0.44	4
3.1	1981Q4	-6.4	-0.31	-0.11	0.43	-0.80	-1.19	-0.13	-0.20	-4.55	-0.89	0.94	0.04	0.13	-0.05	0.34	5
4.1	1957Q4	-7.9	-1.51	-1.12	-0.29	-0.44	-1.94	-0.06	-0.28	-2.00	-1.14	-0.08	-1.22	0.11	0.52	0.33	3
5.1	1960Q3	-5.7	-1.68	-0.91	-0.72	0.00	-1.34	0.08	-0.70	-1.95	-0.47	0.81	0.34	1.04	-0.22	0.32	3
6.1	1970Q1	-5.1	-1.23	-0.23	-0.38	-0.27	-0.91	-0.18	0.22	-1.12	0.01	0.23	0.25	-1.12	-0.09	0.00	4
7.1	1974Q1	-7.6	-1.61	-1.04	-0.54	-0.51	-1.37	-0.07	-1.58	-2.54	-0.37	1.06	0.69	0.66	0.06	0.21	5
8.1	1980Q2	-8.6	-1.62	-1.28	-0.85	-0.45	-1.63	-0.11	-1.92	-3.36	-0.23	3.76	3.53	-0.10	0.05	-0.83	2
9.1	1990Q4	-7.0	-1.45	-0.81	-1.74	-0.47	-1.01	-0.02	-1.09	-1.40	-0.40	1.63	1.23	0.02	-0.14	-0.11	2
10.1	2001Q2	-3.0	0.45	-0.11	-1.07	-0.42	-1.28	-0.39	-0.14	-0.69	-2.19	2.25	0.05	0.31	0.06	0.20	3
11.1	2008Q1	-5.8	-1.21	-0.83	-1.11	-0.29	-1.49	-0.14	-1.43	-1.43	-1.36	3.13	1.77	0.12	0.06	0.16	6
		-5.7	-0.87	-0.59	-0.69	-0.32	-1.29	-0.15	-0.55	-1.84	-0.86	1.40	0.53	-0.12	-0.02	0.18	41

Rates of Growth of Monthly Payrolls

Table 4 Annualized Rates of Growth of Monthly Payroll Data During Expansions

Expansions: Average Rates of Growth Above the 55%tile Shaded

#	Months	PAYEMS2	DMANEMP	MINE	CONS	INFO	NDMANEMP	UTIL	PBS	WTRADE	RTRADE	LAH	FIRE	SERV	GOVT	EHS
1	23	0.021	-0.010	0.051	0.087	0.005	0.013	0.013	0.025	0.047	0.033	0.034	0.026	0.034	0.022	0.034
2	45	0.043	0.099	0.095	0.048	0.043	0.017	0.030	0.036	0.026	0.030	0.029	0.037	0.029	0.032	0.028
3	39	0.025	0.026	0.019	0.033	0.017	0.006	0.014	0.030	0.017	0.021	0.024	0.034	0.038	0.039	0.038
4	24	0.036	0.050	-0.002	0.031	0.024	0.022	0.009	0.038	0.029	0.043	0.043	0.029	0.043	0.041	0.043
5	106	0.032	0.032	-0.006	0.028	0.023	0.016	0.017	0.039	0.027	0.033	0.036	0.034	0.047	0.042	0.047
6	36	0.034	0.047	0.017	0.050	0.024	0.010	0.005	0.036	0.030	0.042	0.040	0.035	0.039	0.030	0.039
7	58	0.035	0.033	0.056	0.050	0.031	0.020	0.027	0.046	0.038	0.039	0.042	0.043	0.051	0.019	0.051
8	12	0.019	0.035	0.129	-0.012	0.022	0.015	0.009	0.036	0.025	0.020	0.024	0.029	0.040	-0.015	0.041
9	92	0.028	0.009	-0.043	0.038	0.022	0.006	0.026	0.043	0.020	0.032	0.039	0.031	0.049	0.020	0.049
10	120	0.020	0.004	-0.022	0.034	0.032	-0.009	0.018	0.045	0.011	0.017	0.026	0.018	0.020	0.012	0.031
11	73	0.009	-0.021	0.034	0.016	-0.026	-0.027	0.008	0.019	0.009	0.005	0.020	0.007	0.006	0.008	0.027
12	124	0.014	0.011	0.008	0.022	0.001	0.005	0.024	0.026	0.008	0.008	0.025	0.011	0.010	0.000	0.021
Total	752	0.025	0.020	0.011	0.034	0.017	0.004	0.019	0.036	0.020	0.024	0.031	0.025	0.030	0.020	0.036

Table 5 Annualized Rates of Growth of Monthly Payroll Data During Recessions

Contractions: Average Rates of Growth Below the 45%tile Shaded

Contractions

#	Months	PAYEMS2	DMANEMP	MINE	CONS	INFO	NDMANEMP	UTIL	PBS	WTRADE	RTRADE	LAH	FIRE	SERV	GOVT	EHS
1	11	-0.056	-0.183	-0.533	-0.030	-0.090	-0.028	-0.086	-0.032	-0.019	-0.012	-0.007	0.016	0.011	0.019	0.009
2	10	-0.038	-0.142	-0.109	0.010	-0.075	-0.052	-0.066	-0.016	0.001	-0.008	-0.004	0.038	0.018	0.019	0.017
3	8	-0.061	-0.196	-0.151	-0.084	-0.105	-0.046	-0.080	-0.040	-0.027	-0.040	-0.027	0.015	-0.006	0.021	-0.005
4	10	-0.028	-0.096	-0.093	-0.047	-0.045	-0.027	-0.054	0.000	-0.011	-0.029	-0.023	0.022	0.026	0.007	0.027
5	11	-0.013	-0.128	-0.022	-0.019	-0.027	-0.033	0.006	0.008	0.005	0.006	0.013	0.030	0.024	0.030	0.024
6	16	-0.012	-0.085	0.079	-0.115	-0.036	-0.074	-0.024	0.013	0.010	0.004	0.009	0.011	0.033	0.037	0.034
7	6	-0.021	-0.134	0.055	-0.122	-0.044	-0.062	-0.045	0.016	-0.007	-0.015	-0.006	0.028	0.037	0.027	0.039
8	16	-0.023	-0.114	-0.099	-0.064	-0.036	-0.045	-0.033	0.004	-0.021	-0.003	0.003	0.007	0.018	-0.009	0.019
9	8	-0.017	-0.067	-0.020	-0.116	-0.005	-0.020	-0.004	-0.028	-0.021	-0.026	-0.004	-0.006	-0.001	-0.006	0.050
10	8	-0.018	-0.116	-0.022	-0.017	-0.075	-0.078	-0.057	-0.061	-0.030	-0.019	-0.002	0.010	0.032	0.027	0.039
11	18	-0.037	-0.128	-0.051	-0.147	-0.052	-0.069	-0.042	-0.062	-0.053	-0.046	-0.024	-0.038	-0.018	0.006	0.024
Total	122	-0.029	-0.124	-0.087	-0.073	-0.052	-0.050	-0.042	-0.018	-0.017	-0.017	-0.006	0.009	0.014	0.015	0.025

Regression Models that Explain the Last Year of the Expansions

Table 6 Looking for Age Effects

Dependent Variable: EXPANSION_LAST_YEAR

Method: ML - Binary Probit (Newton-Raphson / Marquardt steps)

Date: 11/13/19 Time: 05:58

Sample: 1947Q1 2020Q1 IF EXPANSION_USUAL=1 AND EXPANSION_AGE>8

Included observations: 148

Convergence achieved after 7 iterations

Coefficient covariance computed using observed Hessian

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-1.153	0.73	-1.58	0.114
EXPANSION_AGE	-0.097	0.062	-1.564	0.118
(EXPANSION_AGE-30)*(EXPANSION_AGE>30)	0.316	0.163	1.94	0.052
GDP_CUM_EXP	-0.126	0.063	-1.988	0.047
(GDP_CUM_EXP-30)*(GDP_CUM_EXP>30)	0.593	0.159	3.726	0
I_RES_CUM_EXP-I_RES_CUM_EXP(-4)	-2.8	0.531	-5.277	0
@MOVMAX(I_RES_CUM_EXP,8)	1.948	0.546	3.57	0

McFadden R-squared	0.554	Mean dependent var	0.189
S.D. dependent var	0.393	S.E. of regression	0.269
Akaike info criterion	0.528	Sum squared resid	10.184
Schwarz criterion	0.669	Log likelihood	-32.048
Hannan-Quinn criter.	0.585	Deviance	64.097
Restr. deviance	143.573	Restr. log likelihood	-71.787
LR statistic	79.477	Avg. log likelihood	-0.217
Prob(LR statistic)	0		

Obs with Dep=0	120	Total obs	148
Obs with Dep=1	28		

Table 7 Typical Precursors

Dependent Variable: EXPANSION_LAST_YEAR

Method: ML - Binary Probit (Newton-Raphson / Marquardt steps)

Date: 11/13/19 Time: 15:14

Sample: 1947Q1 2020Q1 IF EXPANSION_USUAL=1 AND EXPANSION_AGE>8

Included observations: 148

Convergence achieved after 8 iterations

Coefficient covariance computed using observed Hessian

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	96.679	34.342	2.815	0.005
(GS10-TB3MS<2)*(GS10-TB3MS-2)	-1.472	0.466	-3.158	0.002
UNRATE-UNRATE(-8)	1.812	0.586	3.093	0.002
AWHMAN	-2.455	0.852	-2.881	0.004
BAA10YM	0.586	0.579	1.012	0.311
I_RES_CUM_EXP-I_RES_CUM_EXP(-4)	-1.224	0.453	-2.701	0.007
@MOVMAX(I_RES_CUM_EXP,8)	0.596	0.597	0.997	0.319

McFadden R-squared	0.683	Mean dependent var	0.189
S.D. dependent var	0.393	S.E. of regression	0.22
Akaike info criterion	0.403	Sum squared resid	6.795
Schwarz criterion	0.544	Log likelihood	-22.788
Hannan-Quinn criter.	0.46	Deviance	45.576
Restr. deviance	143.573	Restr. log likelihood	-71.787
LR statistic	97.997	Avg. log likelihood	-0.154
Prob(LR statistic)	0		

Obs with Dep=0	120	Total obs	148
Obs with Dep=1	28		

Table 8 Precursors and Aging Effects Combined

Dependent Variable: EXPANSION_LAST_YEAR
Method: ML - Binary Probit (Newton-Raphson / Marquardt steps)
Date: 11/13/19 Time: 05:58
Sample: 1947Q1 2020Q1 IF EXPANSION_USUAL=1 AND
EXPANSION_AGE>8
Included observations: 148
Convergence achieved after 11 iterations
Coefficient covariance computed using observed Hessian

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	187.189	77.252	2.423	0.015
(GS10-TB3MS<2)*(GS10-TB3MS-2)	-0.95	0.87	-1.092	0.275
UNRATE-UNRATE(-8)	5.621	2.009	2.798	0.005
AWHMAN	-4.546	1.881	-2.417	0.016
BAA10YM	-1.156	1.046	-1.106	0.269
EXPANSION_AGE	-0.516	0.294	-1.753	0.08
(EXPANSION_AGE-30)*(EXPANSION_AGE>30)	1.553	0.744	2.089	0.037
GDP_CUM_EXP	-0.233	0.141	-1.647	0.1
(GDP_CUM_EXP-30)*(GDP_CUM_EXP>30)	1.238	0.6	2.063	0.039
I_RES_CUM_EXP-I_RES_CUM_EXP(-4)	-6.845	2.874	-2.382	0.017
@MOVMAX(I_RES_CUM_EXP,8)	7.018	3.258	2.154	0.031

McFadden R-squared	0.848	Mean dependent var	0.189
S.D. dependent var	0.393	S.E. of regression	0.152
Akaike info criterion	0.296	Sum squared resid	3.153
Schwarz criterion	0.519	Log likelihood	-10.885
Hannan-Quinn criter.	0.386	Deviance	21.77
Restr. deviance	143.573	Restr. log likelihood	-71.787
LR statistic	121.803	Avg. log likelihood	-0.074
Prob(LR statistic)	0		

Obs with Dep=0	120	Total obs	148
Obs with Dep=1	28		

Table 9 Trimmed Combined Model

Dependent Variable: EXPANSION_LAST_YEAR

Method: ML - Binary Probit (Newton-Raphson / Marquardt steps)

Date: 11/13/19 Time: 06:03

Sample: 1947Q1 2020Q1 IF EXPANSION_USUAL=1 AND EXPANSION_AGE>8

Included observations: 148

Convergence achieved after 9 iterations

Coefficient covariance computed using observed Hessian

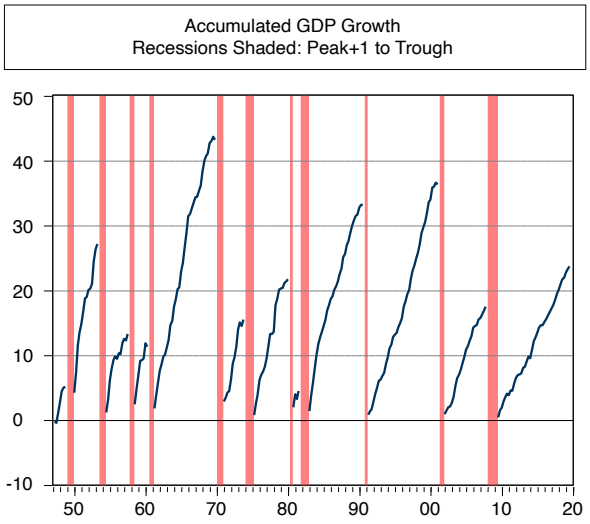
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	178.698	56.564	3.159	0.002
(GS10-TB3MS<2)*(GS10-TB3MS-2)	-1.704	0.573	-2.976	0.003
UNRATE-UNRATE(-8)	2.903	0.862	3.368	0.001
AWHMAN	-4.37	1.376	-3.175	0.001
(EXPANSION_AGE-30)*(EXPANSION_AGE>30)	0.802	0.281	2.85	0.004
GDP_CUM_EXP	-0.084	0.036	-2.351	0.019
I_RES_CUM_EXP-I_RES_CUM_EXP(-4)	-1.809	0.561	-3.222	0.001

McFadden R-squared	0.763	Mean dependent var	0.189
S.D. dependent var	0.393	S.E. of regression	0.178
Akaike info criterion	0.325	Sum squared resid	4.468
Schwarz criterion	0.466	Log likelihood	-17.026
Hannan-Quinn criter.	0.382	Deviance	34.051
Restr. deviance	143.573	Restr. log likelihood	-71.787
LR statistic	109.522	Avg. log likelihood	-0.115
Prob(LR statistic)	0		

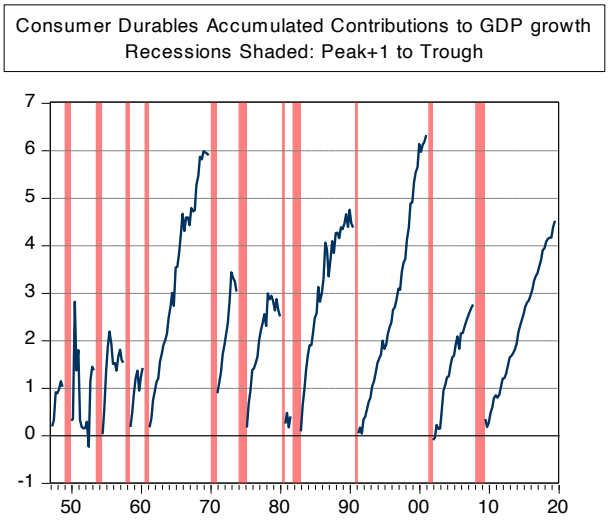
Obs with Dep=0	120	Total obs	148
Obs with Dep=1	28		

Appendix: Accumulated Contributions to GDP During Expansions

GDP



Consumer Spending



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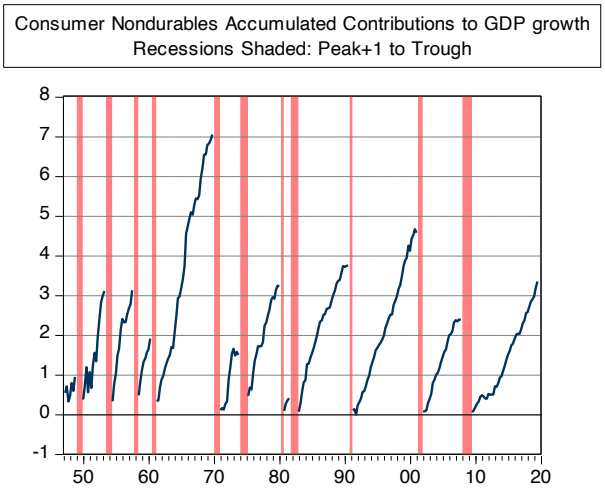

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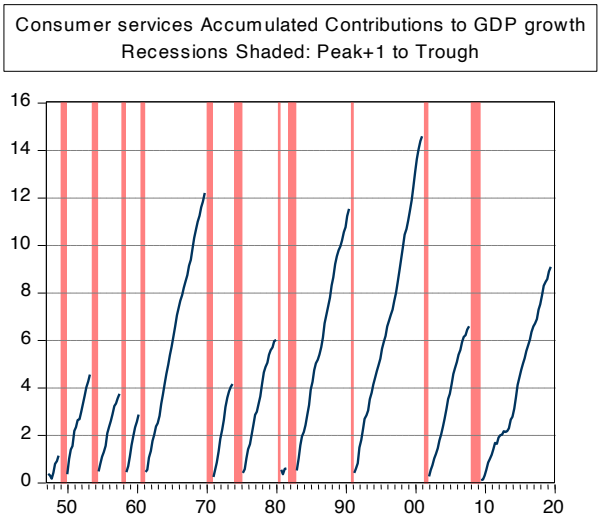
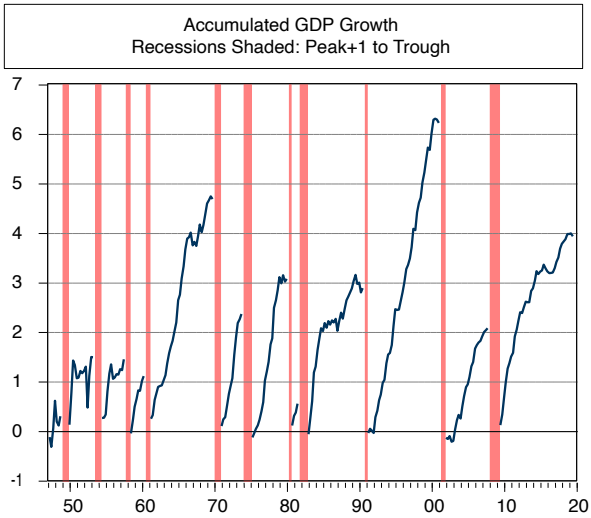


Investment



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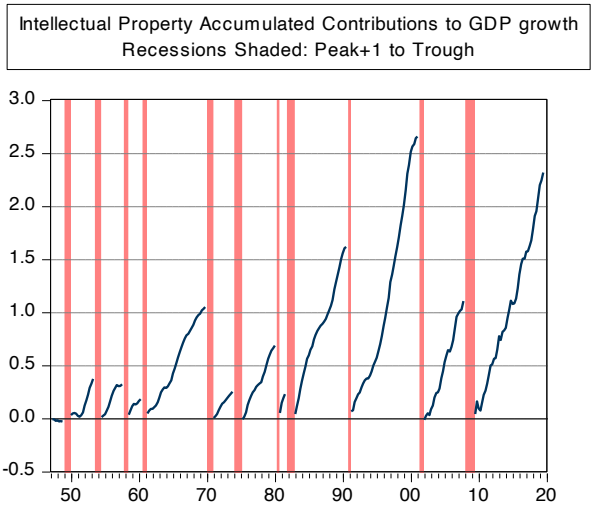

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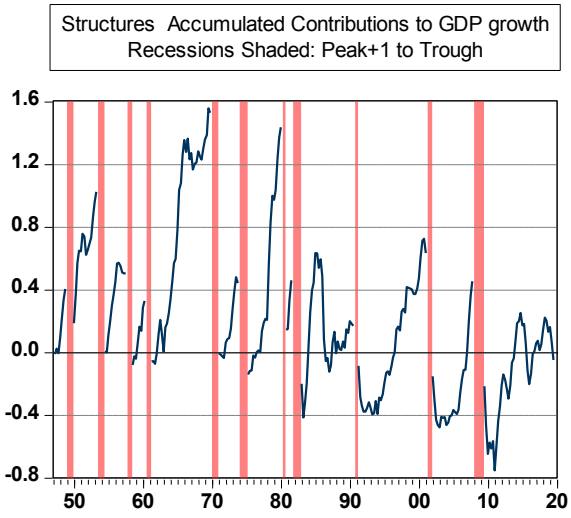

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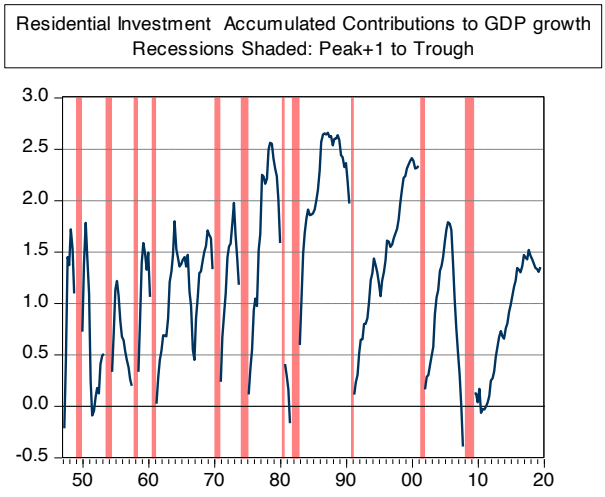

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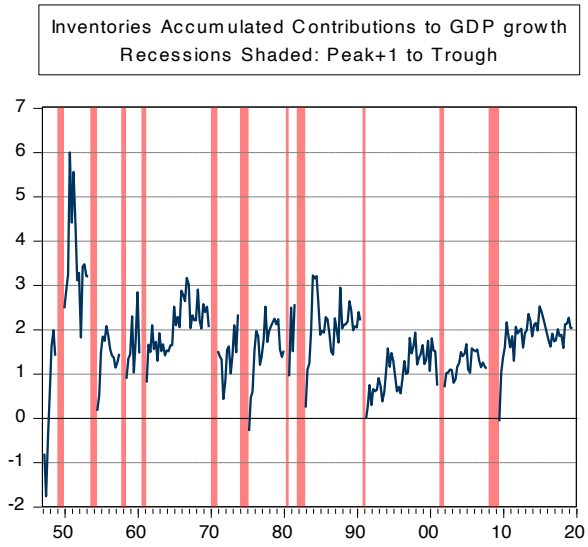
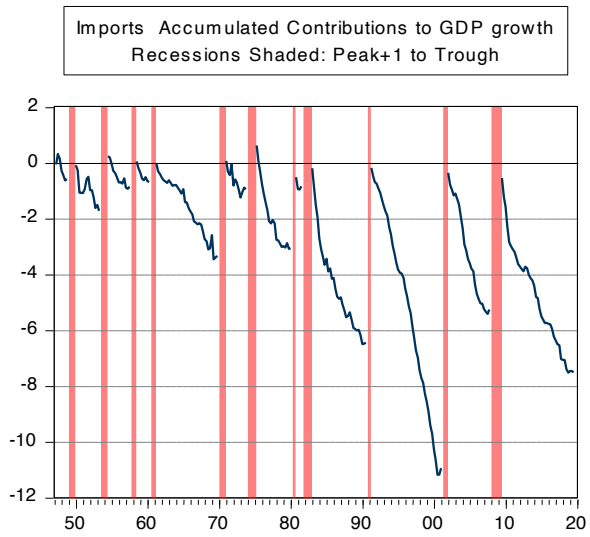


Exports and Imports



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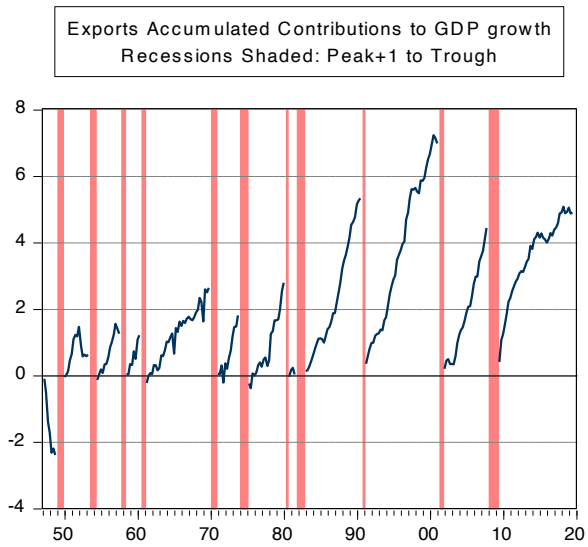

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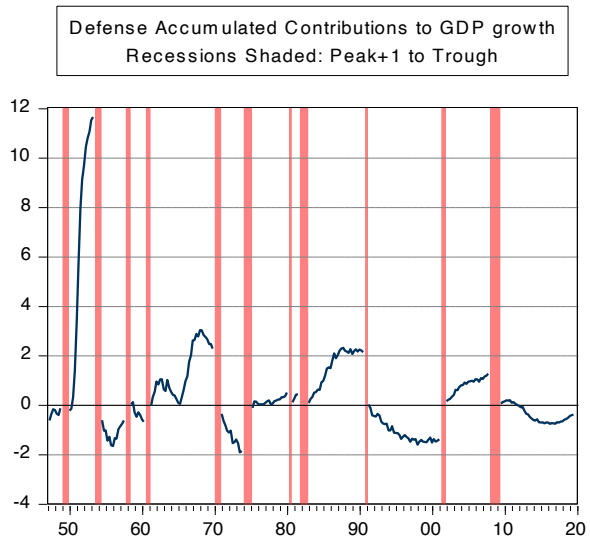

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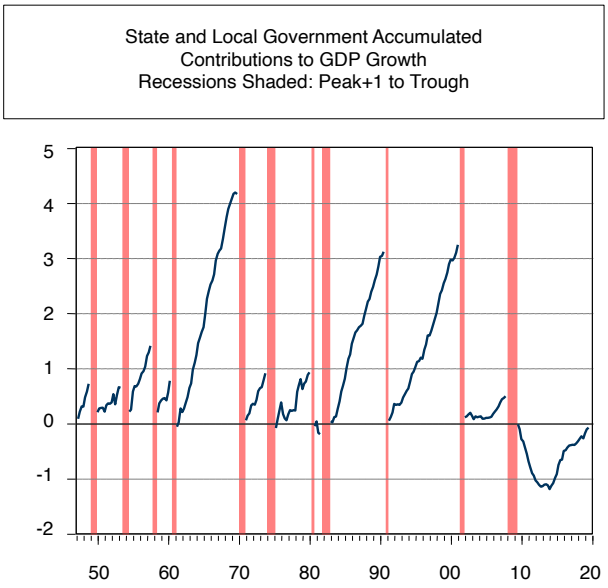

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