Global Economics Paper

The Case for a Financial Conditions Index

- The effect of the short-term interest rate on GDP—known as the "IS curve"—is a central relationship in standard macroeconomic models. But we show that the IS curve for the US has broken down empirically over the past few decades.
- This breakdown provides a natural motivation for considering a financial conditions index (FCI). Our FCI is defined as a weighted average of riskless interest rates, the exchange rate, equity valuations, and credit spreads, with weights that correspond to the direct impact of each variable on GDP.
- We can decompose the IS curve into 1) the response of GDP to the FCI and 2) the response of the FCI to the federal funds rate. The GDP-FCI link is largely unchanged; FCI changes remain highly significant predictors of real GDP changes. By contrast, the FCI-funds rate link has broken down and this is why the IS curve has broken down as well.
- The latter finding does not mean that Fed officials are now unable to influence financial conditions, and ultimately GDP. We show that monetary policy innovations—measured as changes in Treasury yields in one-hour windows around FOMC announcements—remain highly significant predictors of FCI changes. So Fed officials can *influence* the FCI via monetary policy innovations, even though they cannot *control* it just by setting a path for the funds rate.
- Concerns about reverse causation from GDP to the FCI look overdone. Although growth shocks—measured via data surprises—have significant effects on *individual* asset prices, these effects tend to offset one another in an FCI; in fact, they cancel out almost exactly in the case of the GS FCI.
- Concerns about the sensitivity of the FCI to changes in the neutral funds rate r* also look overdone. To show this, we construct an "equilibrium" FCI that varies with perceived changes in r*. We find that movements in the equilibrium FCI account for only a small share of the year-to-year variation in the actual FCI.
- Based on these results, we amend a standard New Keynesian macroeconomic model to include an FCI. This produces a Taylor-type rule which implies that the central bank should use its tools to ease the FCI (or keep it easy) when inflation and/or employment are below mandate-consistent levels, and vice versa.

Jan Hatzius
+1(212)902-0394 | jan.hatzius@gs.com
Goldman Sachs & Co. LLC

Sven Jari Stehn
+44(20)7774-8061 | jari.stehn@gs.com
Goldman Sachs International

Since the 1990s, many central banks, including the Federal Reserve, have framed their policy in terms of a New Keynesian model for monetary policy. This model contains an IS curve (which describes the relationship between the output gap and the real policy rate), a Phillips curve (which describes the relationship between inflation and the output gap) and a Taylor-type rule (which relates the policy rate to deviations of inflation and employment from the central bank's target).

One problem with this setup is that the Phillips curve does not fit very well in practice. As discussed in Yellen (2017), the Phillips curve is relatively flat and, for this reason, the output gap only explains a modest share of the ups and downs of inflation. But another issue is that the fit of the IS curve is also poor, especially in recent decades. In some ways, this issue is even more central than the poor fit of the Phillips curve. If the Phillips curve does not fit, the central bank will have trouble controlling inflation but will still be able to control output. But if the IS curve does not fit, the central bank will not be able to control either inflation or output.

A Standard IS Curve No Longer Fits Well

We can illustrate the poor fit of the IS curve in recent decades using the specification of Rudebusch and Svensson (1999). Exhibit 1 shows regressions of the output gap on two of its own lags and a measure of the lagged policy rate. For the latter, we use three alternative definitions. The first is simply the real federal funds rate deflated by year-on-year core PCE inflation. The second is the real funds rate minus the estimated equilibrium rate according to Holston, Laubach, and Williams (2016). The third is the funds rate "shock" constructed according to the "narrative approach" in Christina and David Romer (2004), which defines monetary policy shock as the difference between the intended funds rate and the rate implied by the Fed's normal operating procedure, given its forecasts for the economy.

Exhibit 1: OLS Results Show that Impact of Funds Rate on Growth Has Become Insignificant

Dependent Variable: CBO Output gap

	Real Funds Rate			Real Funds Rate Gap*			Romer-Romer Shock		
Sample:	1960Q1-2017Q3	1985Q1-2017Q3	1995Q1-2017Q3	1963Q1-2017Q2	1985Q1-2017Q2	1995Q1-2017Q2	1963Q1-2008Q2	1985Q1-2008Q2	1995Q1-2008Q2
Output Gap (-1)	1.18	1.26	1.27	1.17	1.26	1.27	1.24	1.31	1.34
	[18.17]**	[15.05]**	[12.56]**	[18.03]**	[14.97]**	[12.42]**	[16.87]**	[14.16]**	[11.28]**
Output Gap (-2)	-0.24	-0.33	-0.34	-0.24	-0.34	-0.35	-0.34	-0.39	-0.4
	[-3.58]**	[-3.77]**	[-3.17]**	[-3.74]**	[-3.90]**	[-3.32]**	[-4.63]**	[-4.09]**	[-3.30]**
Real Rate (-2)	-0.06	0.00	0.00						
	[-3.44]**	[-0.17]	[0.11]						
Real Rate HLW Gap (-2)^				-0.08	0.01	0.03			
				[-3.98]**	[0.22]	[0.63]			
Romer-Romer Shock (-8)							-0.2	0.04	0.04
							[-2.00]*	[0.19]	[0.16]
Observations	218	131	91	216	129	89	160	104	64
R^2	0.90	0.91	0.92	0.91	0.91	0.92	0.88	0.91	0.92

Note: Figures in squared brackets are t-statistics; * and ** denote significance at 5% and1% levels.

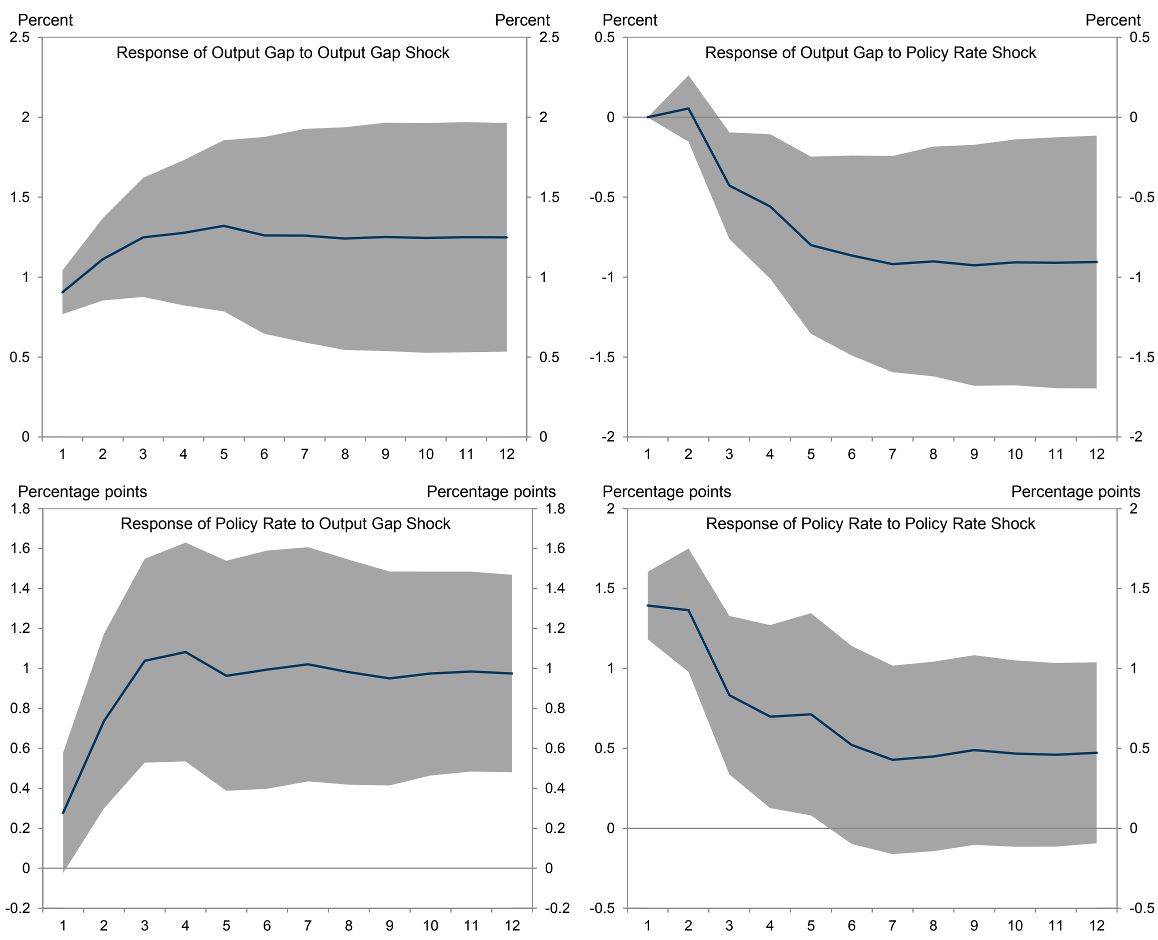
^ Using the estimates of Holston-Laubach-Williams (2016).

Source: Goldman Sachs Global Investment Research

Over the sample period as a whole, we find a statistically significant impact from the real funds rate on output, for all three of our policy rate definitions. But if we only look at more recent data, this effect disappears. The point estimate is now positive (though statistically insignificant) for all three of our policy rate definitions, including even the Romer-Romer shock variable, which has been designed carefully to reduce the risk of simultaneity bias.

These results are robust to alternative measures of the output gap and to looking at GDP growth instead of the output gap. Exhibit A1 in Appendix A shows that the findings are similar using the Fed staff, OECD and IMF measures of the output gap. Exhibit A2 shows that similar results hold when the IS curve is expressed in terms of changes in the output gap or real GDP growth.

Exhibit 2: VAR Results Show that Impact of Funds Rate Shocks on Growth Was Significant in 1960-1984

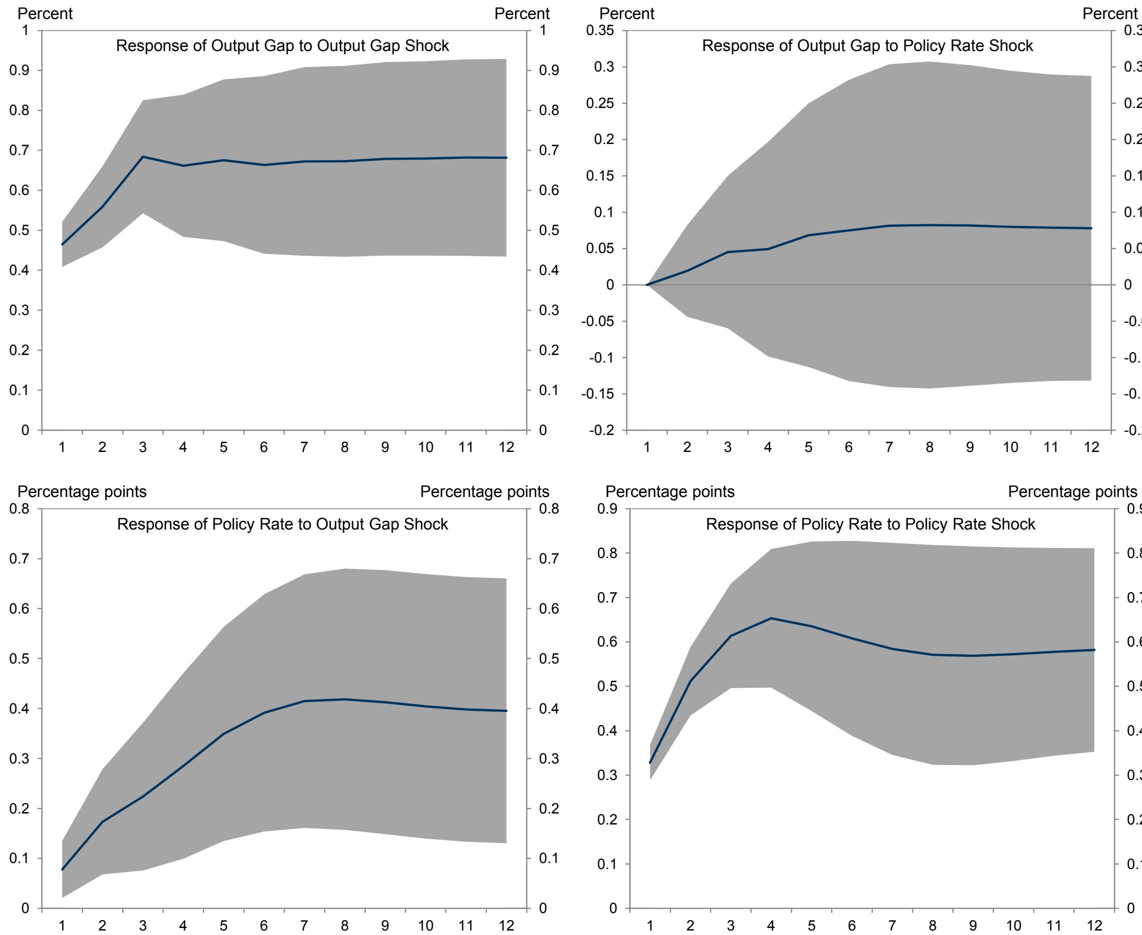


Note: The horizontal axes denote quarters and the gray areas show +/- 2 standard error bands.

Source: Goldman Sachs Global Investment Research

An alternative way to look at the impact of monetary policy shocks is to estimate a vector autoregression (VAR) using the policy rate and the output gap. We use a Cholesky decomposition and order the output gap first and the policy rate variable second. This means that within-quarter correlation is assigned to the impact of the output gap on the policy rate. Exhibits 2 (above) and 3 (below) show the impulse responses for 1960Q1-1984Q4 sample and a 1985Q1-2017Q3 sample.

Exhibit 3: VAR Results Show that Impact of Funds Rate Shocks on Growth Turned Insignificant in 1985-2017



Note: The horizontal axes denote quarters and the gray areas show +/- 2 standard error bands.

Source: Goldman Sachs Global Investment Research

The results are consistent with the single-equation estimates. Over the early (1960-84) sample, the impulse response functions from our VAR show that policy rate shocks have a negative and statistically significant impact on the output gap. But over the period since 1985, the impulse responses are insignificantly different from zero. Exhibits A3 and A4 in Appendix A show that this is true not only for the real funds rate but also for the Romer-Romer measure of monetary policy shocks.

Measuring Financial Conditions

The results of the previous section suggest that the standard IS curve has not worked well in the last couple of decades. One possible reason is that the policy rate only has a small direct impact on aggregate demand. Instead, most of the impact of changes in the policy rate occurs indirectly via changes in broader financial conditions, including longer-term interest rates, credit spreads, exchange rates, and equity prices. This suggests that it is useful to monitor a summary measure of how different financial variables—not just the policy rate—affect the real economy, i.e. a financial conditions index.

Our preferred FCI is constructed as a weighted average of short-term interest rates, long-term interest rates, the trade-weighted dollar, an index of credit spreads, and the ratio of equity prices to the 10-year average of earnings per share. We set the weights using the estimated impact of shocks to each variable on real GDP growth over the following four quarters using a stylized macro model. Moreover, we estimate the *partial* impact of changes in each financial variable while holding the other financial variables constant. This avoids giving too much weight to some variables—such as the short-term policy rate—whose effect on GDP actually comes via their (potentially time-varying) impact on other series such as long-term yields and the exchange rate. Appendix B describes the model and the construction of our FCI in more detail.

In theory, it might be best to measure financial conditions in real terms. But in practice, there is likely to be a significant amount of measurement error in any one definition of inflation expectations, especially at longer horizons. Moreover, an argument can be made that changes in nominal financial variables also matter for aggregate demand, e.g. in the case of the impact of interest rate changes on credit availability for liquidity-constrained borrowers. Hence, we focus primarily on a nominal version of our FCI, which we believe is the better choice for the period since the 1990s when inflation has been low and stable. We also provide a research FCI that is adjusted for changes in trend inflation and is available back to 1960.

Exhibit 4 compares our FCI with a few other leading indices produced by Bloomberg, the Chicago Fed, the IMF, the Kansas City Fed and the OECD. The indices vary across a number of dimensions:

- **Scope**. The FCIs differ in terms of the number of inputs, ranging from just five in our FCI to 105 in the Chicago Fed index. Significant differences also emerge in terms of the included variables. The Bloomberg index, for example is heavily focused on spreads and volatility measures, while our FCI also includes measures of "safe" funding (including the ten-year Treasury yield).
- **Frequency**. The OECD measure is quarterly, the IMF monthly, the Chicago and Kansas Fed weekly, and the Bloomberg and GS indices are available on a daily basis.
- **Methodology**. The FCIs fall into two groups. The first uses purely statistical techniques to summarize the co-movement of the financial variables (with simple averages, principal components or dynamic factor models). The second (including our FCI) sets the weights using an estimate of the impact of each variable on GDP growth. The advantage of the latter over dynamic factor models, in particular, is that the weights provide a more intuitive interpretation and the FCI components can be used for further analysis (see below).

Exhibit 4: The Features of Selected Financial Conditions Indices (FCIs)

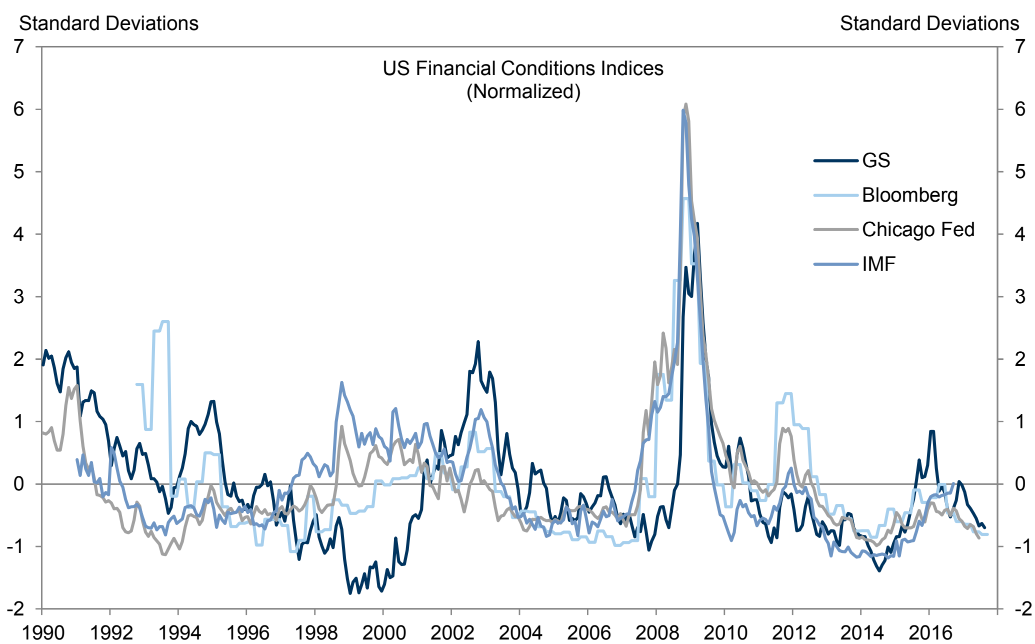
Overview of Selected US FCIs

	Frequency	Sample start	Methodology	Components
Bloomberg	daily	1991	Equally weighted sum	10 variables from money, bond and equity markets
Chicago Fed NFCI	weekly	1971	Dynamic factor model	105 series from money, debt and equity markets
IMF	monthly	1990	Dynamic factor model	16 series including interest rates, spreads, credit growth, equity returns, exchange rates and the VIX
Kansas City Financial Stress Index	weekly	1990	Principal component	11 variables including interest rates, yield spreads, exchange rate and inflation pressure-linked variables
OECD	quarterly	1995	Weights based on GDP effects	6 series including real short-term rate, HY spread, credit standards, real exchange rate, stock market cap.
Goldman Sachs	daily	2000 (main) 1960 (research)	Macro model to set weights by 1-year GDP impact	5 series, including the funds rate, 10y Treasury yields, BBB spread, S&P 500 and TWI

Source: Goldman Sachs Global Investment Research

Exhibit 5 compares the behavior of the selected FCIs over time. The broad movements are similar in that all indices show tighter financial conditions in the early 1990s, the early 2000s and, especially, during the financial crisis. But differences emerge during more normal times. For example, the GS index showed a sharper swing during 1999-2002 and a more notable deterioration in financial conditions in 2015-16.

Exhibit 5: The Trajectory of Selected Financial Conditions Indices (FCIs)



Source: Goldman Sachs Global Investment Research

Financial Conditions Link Monetary Policy with GDP

The conventional IS curve can be viewed as the combination of two relationships: the response of the economy to financial conditions and the response of financial conditions to monetary policy. In this section, we show that the former relationship still works well but the latter has weakened significantly in the last few decades. Although monetary policy *innovations* still move financial conditions, the funds rate alone is no longer a reliable predictor of financial conditions. It is therefore not surprising that the funds rate is also no longer a reliable predictor of the output gap.

The Response of GDP to Financial Conditions

In this subsection, we show that the output gap still responds to financial conditions. We start with a simple OLS regression of the output gap on two of its own lags and two lags of financial conditions. Exhibit 6 shows the results for three samples: 1960Q1-2017Q3, 1985Q1-2017Q3 and 1995Q1-2017Q3.

Exhibit 6: OLS Results for the Impact of the GS FCI on the Output Gap

Dependent Variable: Output gap

Sample:		**GS FCI**	
Variable:	**1960Q1-2017Q3**	**1985Q1-2017Q3**	**1995Q1-2017Q3**
Output Gap (-1)	1.14	1.17	1.04
	[17.70]**	[13.44]**	[8.50]**
Output Gap (-2)	-0.24	-0.24	-0.13
	[-3.74]**	[-2.69]**	[-1.14]
FCI(-1)	-0.42	-0.33	-0.43
	[-4.18]**	[-3.12]**	[-3.08]**
FCI(-2)	0.36	0.3	0.28
	[3.47]**	[2.98]**	[2.12]*
Observations	221	129	89
R^2	0.91	0.91	0.93

Note: Figures in squared brackets are t-statistics;
* and ** denote significance at 5% and1% levels.

Source: Goldman Sachs Global Investment Research

The results in Exhibit 6 show that our FCI has a negative and statistically significant effect on the output gap, including in the two post-1985 samples. That is, unlike in the real funds rate regressions in Exhibit 2, financial conditions continue to affect economic activity in recent decades. Exhibits C1 and C2 in Appendix C show that these results are again robust to using alternative output gap measures and GDP growth rates instead of the output gap.

The results in Exhibit 6 also show that it is mainly the *change* in our FCI that matters for the output gap and GDP growth. (Given that the two lags on the output gap roughly sum to one, the specification in Exhibit 6 suggests that the economy grows above trend following an easing in financial conditions.) However, it is worth noting that this result is somewhat specific to the GS financial conditions index. When we use the FCIs from other institutions described in the previous section, we find that it is sometimes the change but more often the level of the FCI that matters for the output gap. From a broader perspective, however, Exhibit 7 shows that each of these other FCIs also shows a significant relationship with the output gap in the 1995-2017 period.

Exhibit 7: OLS Results for the Impact of Other FCIs on the Output Gap

Dependent Variable: Output gap

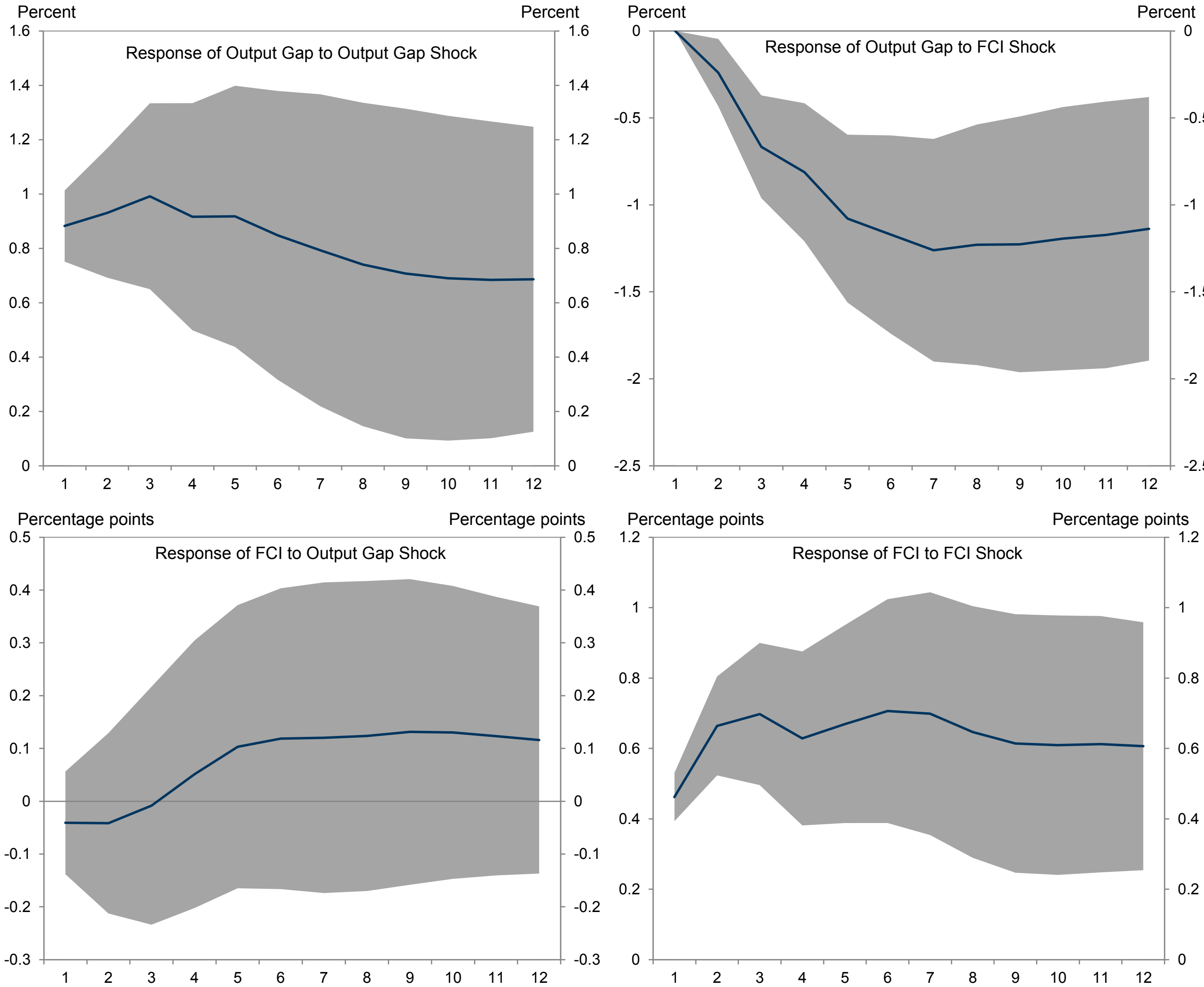
Sample:		**1995Q1-2017Q3**	
Variable:	**BBG**	**Chicago Fed**	**IMF**
Output Gap (-1)	0.82	0.95	0.98
	[7.14]**	[8.34]**	[8.84]**
Output Gap (-2)	0.03	-0.04	-0.01
	[0.29]	[-0.40]	[-0.08]
FCI(-1)	-0.22	-0.65	-0.49
	[-3.62]**	[-3.27]**	[-4.45]**
FCI(-2)	-0.03	0.11	0.23
	[-0.50]	[0.56]	[2.23]*
Observations	89	89	88
R^2	0.94	0.93	0.94

Note: Figures in squared brackets are t-statistics;
* and ** denote significance at 5% and1% levels.

Source: Goldman Sachs Global Investment Research

As a cross-check on our finding that the FCI still works in recent samples, we again estimate a VAR and report the impulse response of the output gap to an FCI shock (identified by ordering the FCI last). This is shown in Exhibits 8 and 9 using our financial conditions index. Consistent with the single-equation results, we find that the effect of financial conditions changes on the output gap has diminished somewhat over time but remains statistically significant in the post-1985 sample. Exhibits C3, C4 and C5 in Appendix C show that the results are similar for the Bloomberg, Chicago Fed, and IMF FCIs.

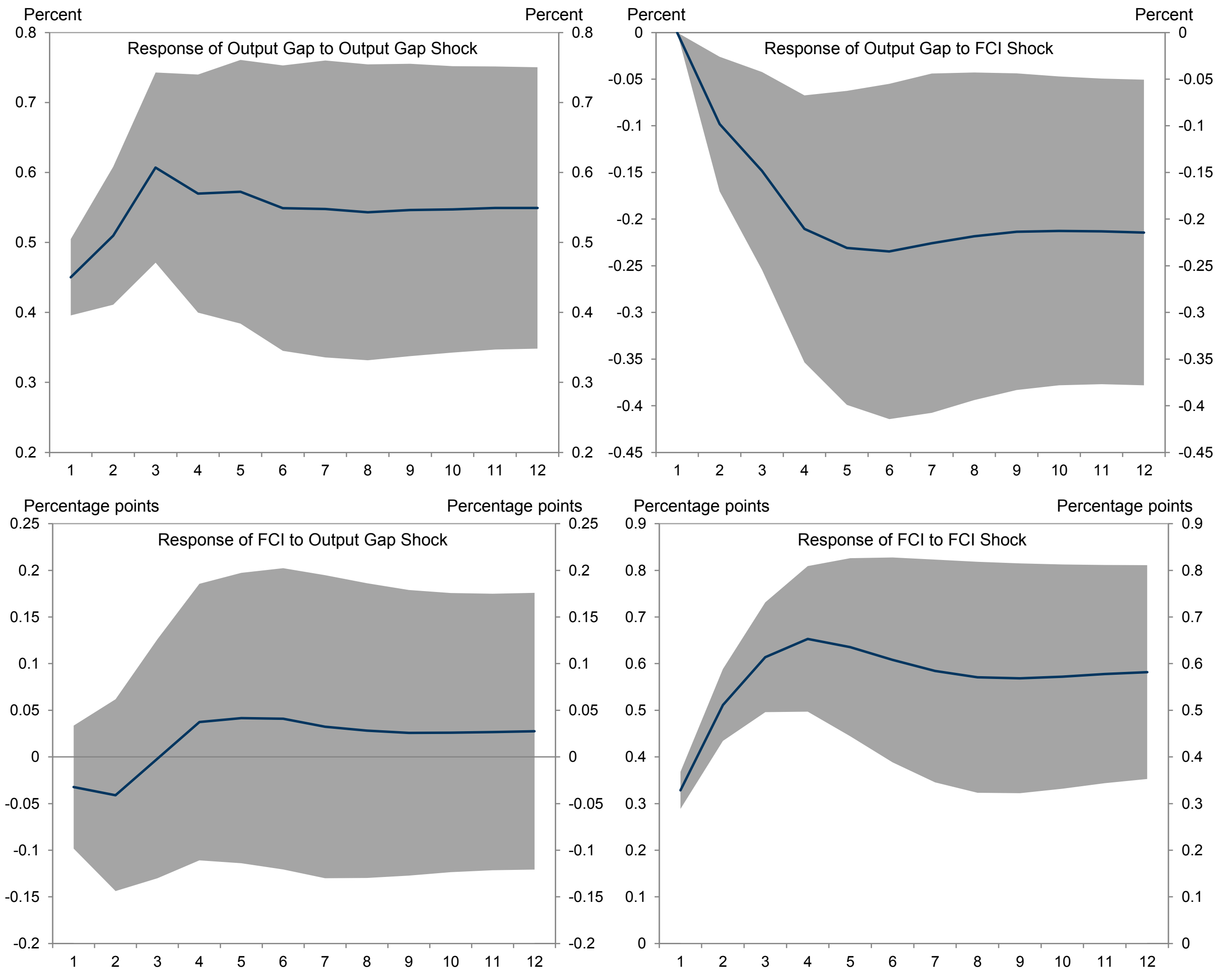
Exhibit 8: VAR Results for the Impact of GS FCI Shocks on the Output Gap, 1960-1984



Note: The horizontal axes denote quarters and the gray areas show +/- 2 standard error bands.

Source: Goldman Sachs Global Investment Research

Exhibit 9: VAR Results for the Impact of GS FCI Shocks on the Output Gap, 1985-2017



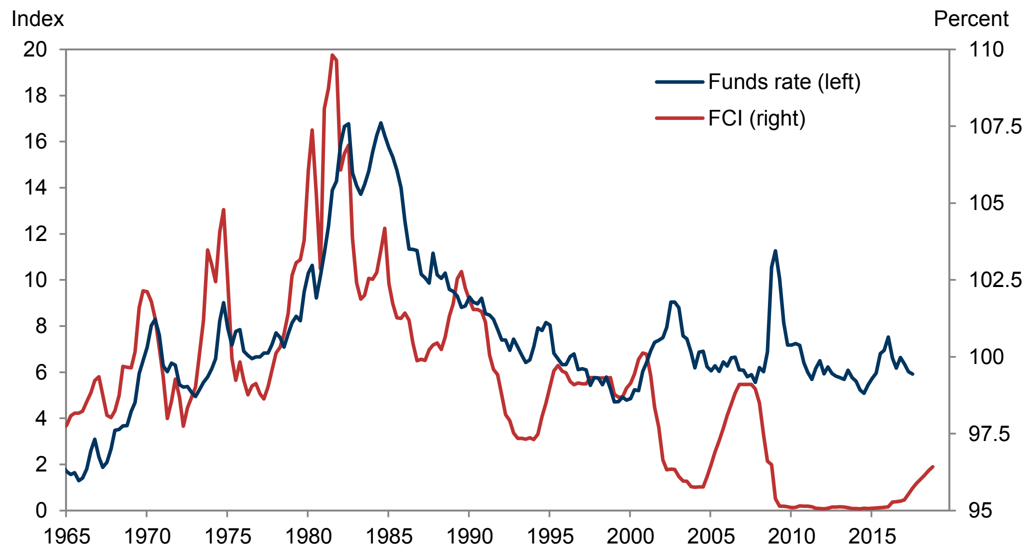
Note: The horizontal axes denote quarters and the gray areas show +/- 2 standard error bands. Source: Goldman Sachs Global Investment Research

The Response of Financial Conditions to the Funds Rate

If the response of the output gap to financial conditions has remained largely unchanged, the deterioration in the conventional IS curve must logically reflect a deterioration in the response of financial conditions to the funds rate.

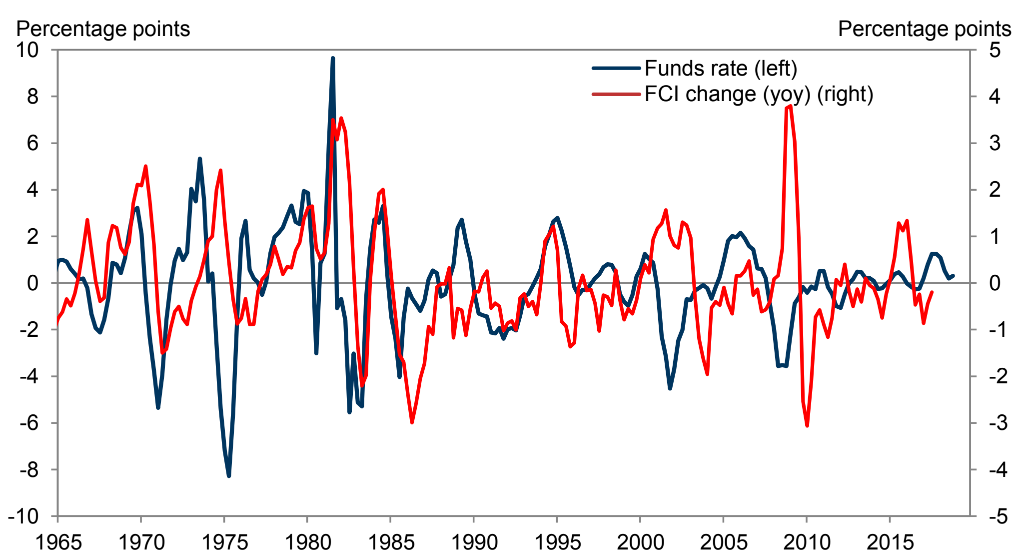
Indeed, that is what the data show. Exhibit 10 plots the level of the federal funds rate against the research version of our FCI back to 1965. From the 1960s to the 1980s, there was a strong visual relationship between a higher funds rate and tighter financial conditions. However, since the 1980s this relationship has broken down. Along similar lines, Exhibit 11 plots the year-on-year change in the funds rate against the year-on-year change in the research version of our FCI. Again, we see a close positive relationship between funds rate changes and FCI changes from the 1960s to the 1980s or early 1990s, and at best a much looser relationship since then.

Exhibit 10: Funds Rate Level vs. GS FCI Level



Source: Goldman Sachs Global Investment Research

Exhibit 11: Funds Rate Changes vs. GS FCI Changes



Source: Goldman Sachs Global Investment Research

We can also document this deterioration econometrically. Exhibit 12 reports simple regression estimates for the relationship between the funds rate and the FCI in both levels and changes since 1965, breaking the sample in either 1985 or 1995. There is a strong positive relationship in the earlier part of the sample but a weaker, insignificant, or even negative relationship in the later part of the sample.

Exhibit 12: Regressions of the GS FCI on the Federal Funds Rate

Dependent Variable: GS FCI

Sample:	Pre-85	Post-85	Pre-95	Post-95
Variable:				
Funds Rate Level	0.56	0.25	0.50	-0.11
	[10.0]**	[5.9]**	[9.4]**	[-3.0]**
Funds Rate Change	0.14	-0.08	0.15	-0.35
	[4.4]**	[-0.9]	[5.02]**	[-3.04]**
Observations	91	131	131	91
R^2	0.18	0.01	0.16	0.09

Note: Figures in squared brackets are t-statistics; * and ** denote significance at 5% and1% levels.

Source: Goldman Sachs Global Investment Research

The data therefore show clearly that the previously close and relatively stable relationship between the funds rate and our financial conditions index has loosened substantially in recent decades. It might once have been an acceptable simplification to ignore financial conditions in the transmission of monetary policy to the real economy, but this is no longer the case.

If the relationship between the funds rate and the FCI has broken down, does this mean that the Fed can no longer influence financial conditions (and ultimately the economy)? To answer this question, we take a narrower perspective than in Exhibits 10-12 and focus on monetary policy innovations, defined as changes in bond yields in one-hour windows around FOMC announcements. The identifying assumption is that bond yield changes that take place in such tight windows around FOMC announcements reflect news about monetary policy and are therefore more likely to be causal drivers of changes in financial conditions, compared with longer-term correlations. We construct these innovations using 2-, 5-, and 10-year Treasury yields back to January 2000, with a total of 113 observations. We then regress the daily change in the 10-year Treasury yield, the S&P 500, the trade-weighted dollar index, and our FCI as a whole on these monetary policy shocks. We estimate one regression per asset price and innovation (i.e. 12 regressions in total). Exhibit 13 shows our results.

Exhibit 13: Response of the GS FCI to FOMC Shocks

Dependent Variable: Change in

	10-Year Yield	S&P 500	TWI	GS FCI
2Y Fed Shock	0.62	-7.34	2.34	0.64
	[4.14]**	[-3.34]**	[3.19]**	[4.98]**
5Y Fed Shock	0.95	-6.87	3.50	0.74
	[7.79]**	[-3.85]**	[5.87]**	[7.09]**
10Y Fed Shock	1.07	-5.93	2.69	0.62
	[7.76]**	[-2.92]**	[3.96]**	[5.24]**

Note: Figures in squared brackets are t-statistics;
* and ** denote significance at 5% and1% levels.

Source: Goldman Sachs Global Investment Research

The estimates show that our measure of monetary policy news has statistically powerful effects both on the key components of the FCI and on the overall index. For example, a hawkish monetary policy innovation typically raises long-term interest rates, reduces equity prices, and strengthens the dollar. As a result, our financial conditions index tightens notably in response to hawkish policy news. For example, the coefficient of 0.64 in the 2-year note regression implies that a Fed-driven 25bp increase in 2-year note yields tightens financial conditions by about 16bp.

Summing up the results from this section, the empirical results show that the conventional IS curve has seemingly broken down because the relationship between the funds rate and financial conditions has weakened substantially. It was stable and highly significant until the 1980s or early 1990s but has become insignificant or even wrongly signed since then. However, this does not mean that monetary policy has lost its power to influence financial conditions, and thus the real economy. In fact, if we focus more narrowly on monetary policy innovations around FOMC meetings, hawkish monetary policy shocks cause a clear tightening in financial conditions via higher interest rates, lower equity prices, and a stronger dollar, and vice versa. This is consistent with the analysis by Barakchian and Crowe (2010). They show that standard approaches to estimating monetary policy effects on output no longer deliver significant results, but monetary policy innovations measured around FOMC meetings still work well.

Addressing the Concerns about FCIs

We have shown that an FCI provides a useful link between monetary policy on the one hand and the real economy on the other hand. Nevertheless, many economists are skeptical of the idea that central banks should assign an important role to FCIs in setting monetary policy. Much of the skepticism falls into two categories—1) reverse causation with respect to growth and 2) sensitivity to structural changes in the economy (such as a decline in r*). We discuss each in turn.

Concern #1: Reverse Causation

If an easing in financial conditions not only predicts but also *reflects* stronger growth, then it might be a form of "double counting" to treat easier financial conditions as a reason to tighten policy, over and above the response to the economic growth (and inflation) data. For example, policymakers might observe a simultaneous economic boom and FCI easing (driven by a strong stock market), and might treat each observation as a separate reason to raise interest rates, culminating in an aggressive response. But if the FCI easing merely *reflects* the economic boom, then one should expect that a slowdown in growth will naturally tighten financial conditions and should only raise interest rates more moderately.

How serious is this concern? A simple check is provided by the VARs that we showed earlier in Exhibits 8 and 9. We see that our FCI does not respond systematically to growth shocks in either sample (see lower left panel). This already suggests that policymakers might not need to worry too much about "double counting."

A more sophisticated way to investigate the impact of growth shocks on the FCI is to look at high-frequency financial market responses to surprises in the economic data. To do so, we regress the response of our FCI and its components on economic data deviations from Bloomberg consensus forecasts (standardized by the mean and standard deviation of each surprise). We use daily data since 2000 across 24 US economic activity indicators, including all of the major ones such as payrolls, GDP, and the ISM.

Exhibit 14 summarizes the 24 regressions by reporting the average response of each component of the FCI and the FCI itself to a one standard deviation surprise in the activity data. The F-test reports the joint significance of the 24 coefficients. Exhibit C6 in Appendix C reports the individual results for each of the indicators.

Exhibit 14: OLS Results for the Impact of Growth Shocks on the GS FCI

Dependent Variable: Change in

	10-Year Yield	S&P 500	TWI	GS FCI
Simple average	0.011	0.079	0.018	0.001
F-Test	109.4	24.0	10.7	0.0
prob	0.00	0.00	0.00	0.98
Observations	9177	9891	9891	9891

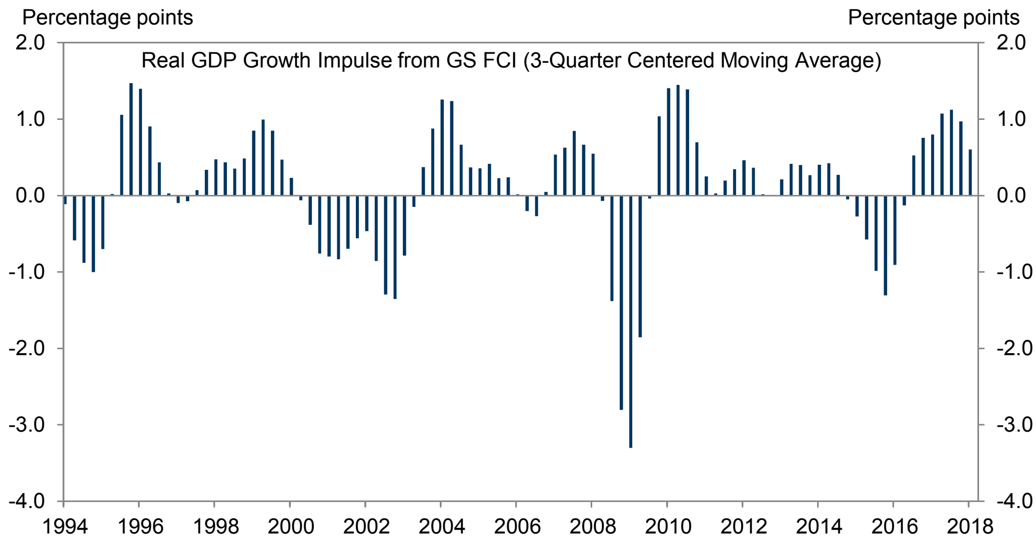
Source: Goldman Sachs Global Investment Research

Our results show that data surprises (i.e. growth shocks) have significant effects on *individual* asset prices. On average, a positive surprise raises bond yields, boosts equity prices, and strengthens the dollar; moreover, the effects are highly significant. However, these effects tend to offset one another; higher interest rates and a stronger dollar tighten financial conditions while higher equity prices loosen financial conditions. This means that reverse causation—an impact from growth shocks to financial conditions—is less of a problem from the perspective of an FCI than from the perspective of each of its components.

In fact, if we focus on the GS FCI, Exhibit 14 shows that the offset is nearly perfect, with a statistical impact of almost exactly zero. This is highly convenient but somewhat of a coincidence, as there is nothing in the construction of the weights that ensures this. Indeed, Exhibits C3 to C5 in Appendix C show that the Chicago Fed and IMF FCIs, for example, tend to tighten in response to better growth news. (Even in these cases, concerns about "double counting" of good growth news are misplaced, however.)

The fact that our FCI is not driven by growth shocks makes it particularly useful for forecasting future activity. One way to show this is to use the estimated VAR in Exhibit 9 to provide a historical decomposition of real GDP growth into contributions from financial conditions. Exhibit 15 shows this "FCI impulse" over time. We see that the estimated impulse captures the ups and downs of the US business cycle quite well, including the early 2000s recession, the financial crisis and the drag from financial conditions in the run-up to the first post-crisis hike in December 2015. We also see that there was a sizable positive FCI impulse in 2017, but this has recently diminished.

Exhibit 15: The Growth Impulse Constructed from the GS FCI



Source: Goldman Sachs Global Investment Research

*Concern #2: Sensitivity to r**

Another worry is that FCI moves might, in practice, pick up not only cyclical variations but also moves in the longer-term "equilibrium" level of financial conditions. The most common concern is that a decline in the equilibrium (or neutral) federal funds rate, r*, might have artificially pushed down standard FCIs. For example, while the July 2017 FOMC minutes noted a view among some participants that the increase in the funds rate had been largely offset by an easing in financial conditions, this view was contrasted with a concern by other participants that

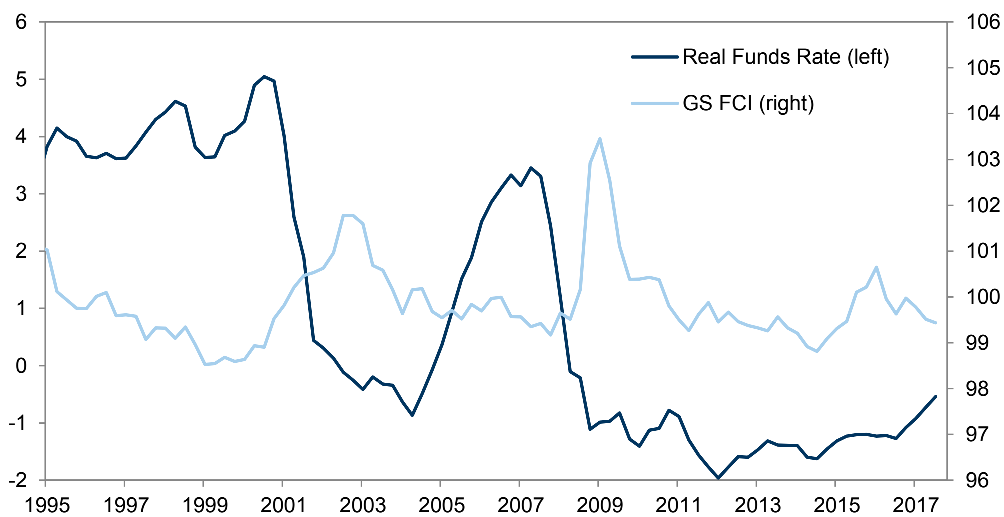
…recent rises in equity prices might be part of a broad-based adjustment of asset prices to changes in longer-term financial conditions, importantly including a lower neutral real interest rate, and, therefore, the recent equity price increases might not provide much additional impetus to aggregate spending on goods and services.

In principle, this concern is valid. A decline in r* obviously eases the FCI via lower interest rate components. In our FCI, these make up just under 50% of the total weight, so that a 100bp decline in r* would ease the index by just under 50bp. And taken by itself, a lower level of interest rates might also boost the valuation of the equity market because it implies a lower discount rate for future earnings.

But one should not overstate the importance of this issue. A decline in perceived r* lowers not only the discount rate for future earnings but—if it reflects primarily a decline in perceived potential GDP growth—also the growth rate of future earnings, as is widely believed. If so, the impact of lower perceived r* on the FCI should be limited to the interest rate components.

So how important is the concern about sensitivity to r* in practice? The most intuitive check of whether we need to worry about variations in the long-term "equilibrium" FCI is a look at its long-term trend. Exhibit 16 shows the real funds rate and our FCI since the mid-90s. We clearly see that the real funds rate has trended down over time, leading economists to conclude that r* has fallen sharply. Holston, Laubach and Williams (2016), for example, estimate that r* has fallen from about 3% in the late 1990s to 0.6% now. By contrast, we see that our FCI has not trended during this period, fluctuating around its mean in a stationary fashion. This observation suggests that the decline in real interest rates has not resulted in a meaningful decline in the equilibrium FCI over the last couple of decades.

Exhibit 16: Decline in Real Interest Rates Has Not Resulted in Downward FCI Trend

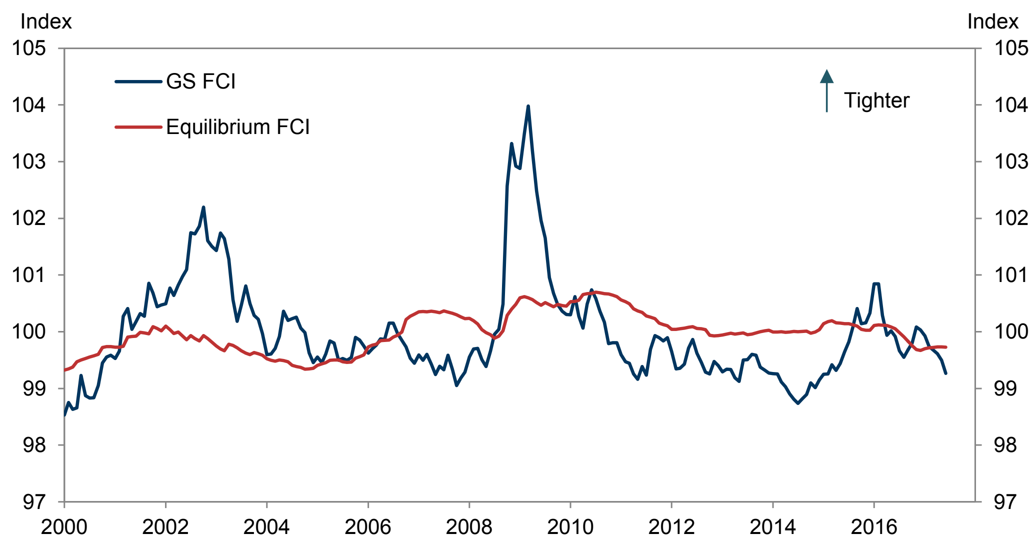


Source: Goldman Sachs Global Investment Research

In a more sophisticated approach, we follow Mericle and Struyven (2017) and construct an "equilibrium" FCI that adjusts several of the components based on changes in consensus expectations for their long-term values. Specifically, we adjust the interest rate components based on changes in consensus estimates of the real equilibrium short-term interest rate in the Survey of Professional Forecasters (SPF), and we adjust the equity component based on the changes in r* and long-term potential GDP growth in the SPF using a Gordon growth model of equity valuation. We keep the other components—the trade-weighted dollar and the corporate spread—at their sample averages as their equilibrium levels are not obviously related to changes in r*.

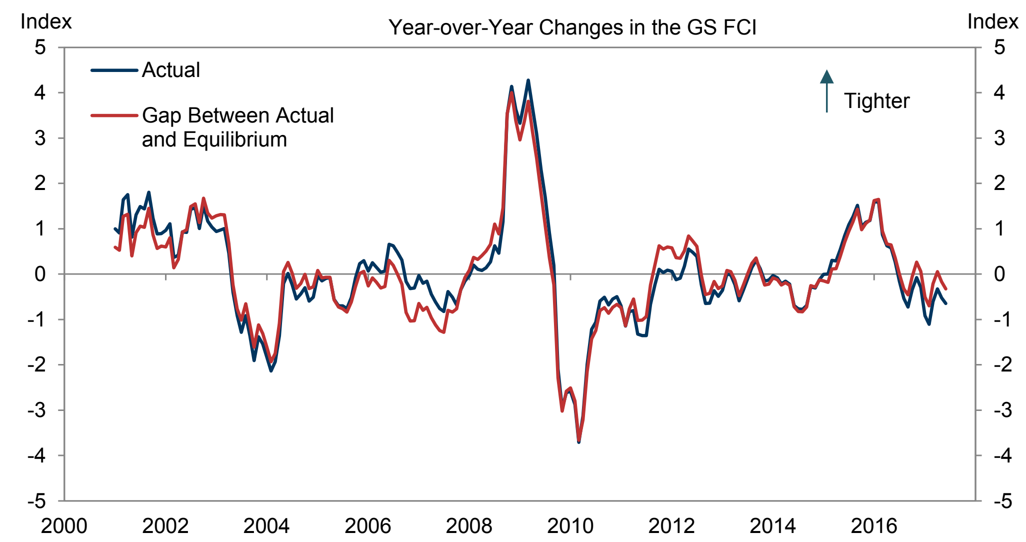
Exhibit 17 plots our estimate of the "equilibrium" FCI against the actual FCI. The chart shows that changes in the equilibrium FCI can be somewhat meaningful over longer periods of time. But Exhibit 18 shows that year-to-year changes in the actual FCI are very similar to changes in the gap between the actual and equilibrium FCI. Simply put, changes in the perceived equilibrium level of r* seem to account for only a small part of the variation of financial conditions over time.

Exhibit 17: The GS FCI and Its "Equilibrium" Value



Source: Goldman Sachs Global Investment Research

Exhibit 18: Changes in the GS FCI Mainly Reflect Cyclical Rather than Structural Factors



Source: Goldman Sachs Global Investment Research

So what drives changes in the FCI if growth shocks and secular forces have negligible effects? We noted above that changes in monetary policy are important drivers of changes in financial conditions. Mericle and Struyven (2017) show that risk premium shocks are another important source of FCI fluctuations. They regress each component of the FCI on the corresponding risk premium estimate, including the equity risk premium, the bond term premium and the credit risk premium. They then calculate the fitted values and aggregate them using our FCI weights to estimate the part of the overall FCI driven by changes in risk premia. They find that changes in risk premia account for most of the variation in the FCI. This supports the notion that we can treat

FCI moves as drivers of economic activity, not just a reflection of fundamental shifts in the economy.

A Modified New Keynesian Framework

Our results suggest that we can improve on the standard New Keynesian model of monetary policy, which assigns a central role to the policy rate but ignores financial conditions. The standard framework contains an IS curve (in which the output gap depends on lags of the real policy rate), a Phillips curve (in which inflation depends on the output gap), and a loss function (which increases with expected deviations of inflation and potentially employment from the central bank's target). In very simple terms:

$$(1)\ x_t = \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + \alpha_3 (r_{t-1} - r^*_{t-1}) + \alpha_4 (r_{t-2} - r^*_{t-2})$$

$$(2)\ \pi_t = \beta_1 \pi_{t-1} + \beta_2 x_{t-1}$$

$$(3) \min L = discounted\ sum(mandate\ misses)$$

where x_t is the output gap (actual minus potential real GDP), r_t is the real policy rate, π_t is inflation and r_t* is the equilibrium (or neutral) real funds rate.

This framework implies that the central bank should set the real policy gap via a form of Taylor rule, that is, as a function of the inflation gap, the output gap (which determines the future inflation gap) and lags of the real policy gap (turning the reaction function into an "inertial" Taylor rule).

$$(4)\ r_t = r^*_t + \theta_0 (r_{t-1} - r^*_{t-1}) + \pi_t + \theta_1 (\pi_t - \pi^*_t) + \theta_2 x_t$$

Various modifications of this stylized specification are possible. For example, the model may be forward-looking; the Phillips curve may be expressed in terms of the unemployment gap instead of the output gap; and the loss function may include the unemployment gap, output gap or change in the funds rate in addition to the inflation gap. These choices will all affect the parameters of the resulting policy rule, but not the basic form of the rule itself.

We have presented evidence that the conventional IS curve (1) does not fit well, and it may be better to replace the real policy rate with financial conditions. A general specification is:

$$(1')\ x_t = \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + \alpha_3 (F_{t-1} - F^*_{t-1}) + \alpha_4 (F_{t-2} - F^*_{t-2})$$

where F_t denotes financial conditions and $F*_t$ is the equilibrium level of financial conditions. In this formulation, we leave open the question of whether it is the level or the change in financial conditions that matters for the output gap. If it is the level, a_3 will be negative while a_4 will be zero; if it is the change, a_3 will be negative while a_4 will be positive and equal in absolute value.

Assuming equations (2) and (3) of the traditional framework remain unchanged, this modified framework implies that the central bank should aim to steer financial conditions as a function of the inflation gap, the output gap and lagged financial conditions:

$$(4')\ F_t = F_t^* + \theta_0(F_{t-1} - F_{t-1}^*) + \theta_1(\pi_t - \pi_t^*) + \theta_2 x_t$$

This equation says that the central bank should aim to keep the FCI at a tight level (if the output gap depends on the FCI level) or tighten the FCI (if the output gap depends on the FCI change) when inflation exceeds the target or the output gap is positive, and vice versa. Various modifications of this stylized specification are again possible, but the basic form of the policy rule should be unaffected.

Our equation (4′) provides a targeting rule, not an instrument rule that would prescribe how to set the funds rate or other monetary policy tools. However, we could combine (4′) with the estimated relationship between monetary policy shocks and FCI changes to generate an instrument rule for the funds rate. Such a rule would indicate how much the Fed needs to shock the path of the funds rate (relative to market pricing) as a function of the starting level of financial conditions, the output gap, and inflation. Similarly, one could estimate a relationship between the FCI and shocks to other monetary policy tools, such as QE, and use this relationship to generate a similar instrument rule for QE. Allowing for a range of tools is an important advantage of the FCI targeting rule over Taylor-type rules that focus on the policy rate alone.

Implications for the Monetary Policy Framework

According to current orthodoxy, the stance of monetary policy is best measured by the gap between the actual real policy rate and the (time-varying) neutral real policy rate, r*. This gap needs to be negative when output and/or inflation are below normal levels, and it needs to close when output and inflation have returned to normal levels. In this framework, it is natural to center communications about central bank policy around the expected path of the policy rate in relation to the central bank's expectations for r*. This is effectively the approach currently taken by the Federal Reserve and best illustrated by its Summary of Economic Projections, which includes the "dot plot" of projections for the funds rate.

But this framework requires a stable IS curve in which the real policy rate has a significant and reasonably stable effect on the output gap. Only then is it possible to "back out" the appropriate real policy rate as a function of the estimated or projected level of r* at each point in time. In fact, even the estimation of r* in the standard model by Thomas Laubach and John Williams (2003) requires a stable IS curve. Without it, there is no direct link between the real rate and the output gap, and it is not possible to back out an estimate of r* from the behavior of the economy.

Unfortunately, the evidence against a stable conventional IS curve—i.e., against a stable relationship between the policy rate and the output gap—is strong. This means that the framework underlying the current orthodoxy among central bankers—and even the framework underlying the estimation of the neutral policy rate—is potentially flawed. If the policy rate does not have a significant impact on economic activity, why should we believe that a particular path for the policy rate will keep the economy at full employment (and inflation at target)? And how can we even determine whether a particular policy rate is expansionary or restrictive?

Our analysis suggests that greater focus on a financial conditions index provides a possible way out of this dilemma. The evidence that FCI changes have predictable effects on the output gap remains strong, and we also show that the Fed can influence financial conditions via hawkish or dovish policy innovations around FOMC meetings. This means that the Fed can use such innovations to target a path for financial conditions that is consistent with a return of the output gap and ultimately inflation to their mandate-consistent levels. In such an FCI-focused framework, it is no longer appropriate to project an unconditional path for the funds rate along the lines of the Fed's dot plot. Instead, the Fed should indicate that the funds rate and other monetary policy instruments will be whatever they need to be in order to generate a path for financial conditions that keeps output and inflation at mandate-consistent levels over time.

References

Barakchian, Mahdi and Christopher Crowe, 2010, "Monetary Policy Matters: New Evidence Based on a New Shock Measure," *IMF Working Paper*, WP/10/230

Hatzius, Jan, and Sven Jari Stehn, "Lower r* or Reduced Interest Rate Sensitivity?" *Global Economics Analyst*, April 24, 2017.

Holston, Kathryn, Thomas Laubach and John Williams, "Measuring the Natural Rate of Interest: International Trends and Determinants," *Journal of International Economics* , vol. 108, Issue S1, 2017.

Laubach, Thomas, and John C. Williams. 2003. "Measuring the Natural Rate of Interest," *Review of Economics and Statistics*, 85(4), November, 1063-1070.

Mericle, David, and Daan Struyven, 2017, "Is the FCI Easing Due to a Decline in r*?" *US Economics Analyst*, Goldman Sachs, September 3, 2017.

Romer, Christina, and David Romer (2004), "A New Measure of Monetary Policy Shocks: Derivation and Implications," *American Economic Review*, September 2004.

Rudebusch, Glenn D., and Lars E. O. Svensson, 1999, "Policy Rules for Inflation Targeting," in *Monetary Policy Rules*, edited by John B. Taylor, University of Chicago Press.

Yellen, Janet, 2017, "Inflation, Uncertainty, and Monetary Policy," Speech at the 59th Annual Meeting of the National Association for Business Economics, Cleveland, Ohio.

Appendix A: Robustness Check of Funds Rate Regressions

Exhibit A1: Robustness Using Different Output Gap Measures

Dependent Variable: Output gap

Sample:	**1963Q1-2017Q3**		**1985Q1-2017Q3**				**1995Q1-2017Q3**			
Output Gap Estimate:	**CBO**	**FRBUS**	**CBO**	**FRBUS**	**OECD**	**IMF**	**CBO**	**FRBUS**	**OECD**	**IMF**
Output Gap (-1)	1.18	1.5	1.26	1.65	1.32	1.32	1.27	1.72	1.32	1.33
	[18.17]**	[26.65]**	[15.05]**	[25.39]**	[15.55]**	[15.93]**	[12.56]**	[24.48]**	[13.07]**	[13.22]**
Output Gap (-2)	-0.24	-0.54	-0.33	-0.69	-0.36	-0.37	-0.34	-0.76	-0.37	-0.38
	[-3.58]**	[-9.27]**	[-3.77]**	[-10.23]**	[-4.22]**	[-4.40]**	[-3.17]**	[-10.54]**	[-3.65]**	[-3.75]**
Real Rate (-2)	-0.06	-0.040	0.00	-0.01	0.00	0.00	0.00	0.00	0.02	0.02
	[-3.44]**	[-3.01]**	[-0.17]	[-0.43]	[0.01]	[0.15]	[0.11]	[0.21]	[0.52]	[0.56]
Observations	218	216	131	129	124	129	91	89	89	89
R^2	0.9	0.96	0.91	0.98	0.95	0.94	0.92	0.98	0.95	0.95

Note: Figures in squared brackets are t-statistics; * and ** denote significance at 5% and1% levels.

Source: Goldman Sachs Global Investment Research

Exhibit A2: Robustness Using Changes in the Output Gap and Growth

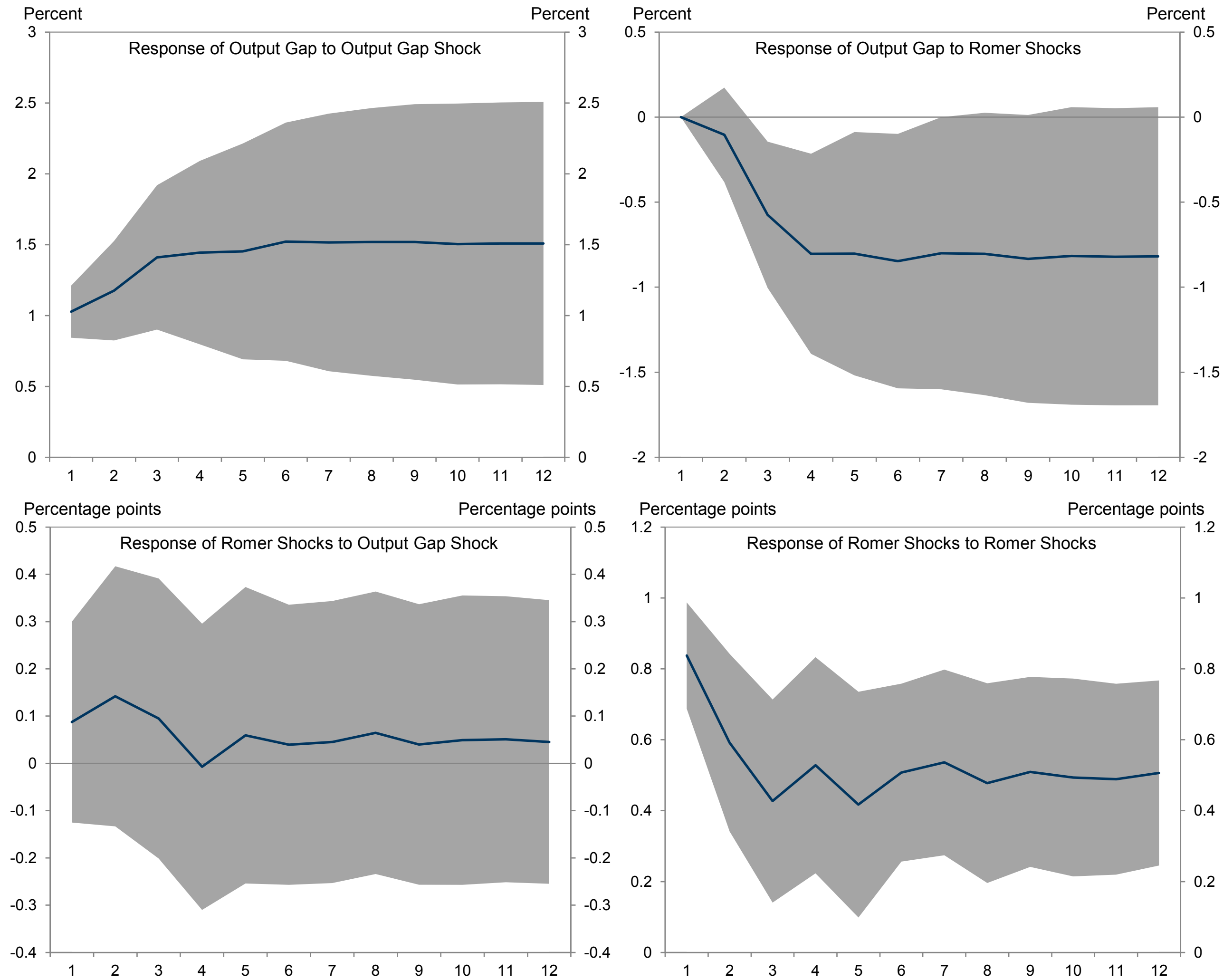
Dependent Variable: CBO Output gap

Dependent variable:	**Output Gap**			**Change in Output Gap**			**Real GDP Growth**		
Sample:	1960Q1-2017Q3	1985Q1-2017Q3	1995Q1-2017Q3	1960Q1-2017Q3	1985Q1-2017Q3	1995Q1-2017Q3	1960Q1-2017Q3	1985Q1-2017Q3	1995Q1-2017Q3
Output Gap (-1)	1.18	1.26	1.27						
	[18.17]**	[15.05]**	[12.56]**						
Output Gap (-2)	-0.24	-0.33	-0.34						
	[-3.58]**	[-3.77]**	[-3.17]**						
Change in Output Gap (-1)				0.2	0.28	0.29			
				[3.04]**	[3.31]**	[2.82]**			
Growth(-1)							1.07	0.95	0.98
							[4.46]**	[2.76]**	[2.33]*
Growth(-2)							0.12	0.21	0.17
							[1.75]	[2.24]*	[1.52]
Growth(-3)							-0.01	-0.09	-0.04
							[-0.19]	[-0.95]	[-0.33]
Growth(-4)							0.05	0.05	0.03
							[0.81]	[0.55]	[0.30]
Real Rate (-1)	-0.06	0.00	0.00	-0.08	-0.34	0.0	-0.03	-0.15	0.0
	[-3.44]**	[-0.17]	[0.11]	[-4.10]**	[-3.95]**	[-0.17]	[-1.56]	[-1.20]	[0.11]
Observations	218	218	218	131	131	131	91	91	91
R^2	0.90	0.14	0.21	0.91	0.1	0.23	0.92	0.11	0.23

Note: Figures in squared brackets are t-statistics; * and ** denote significance at 5% and1% levels.

Source: Goldman Sachs Global Investment Research

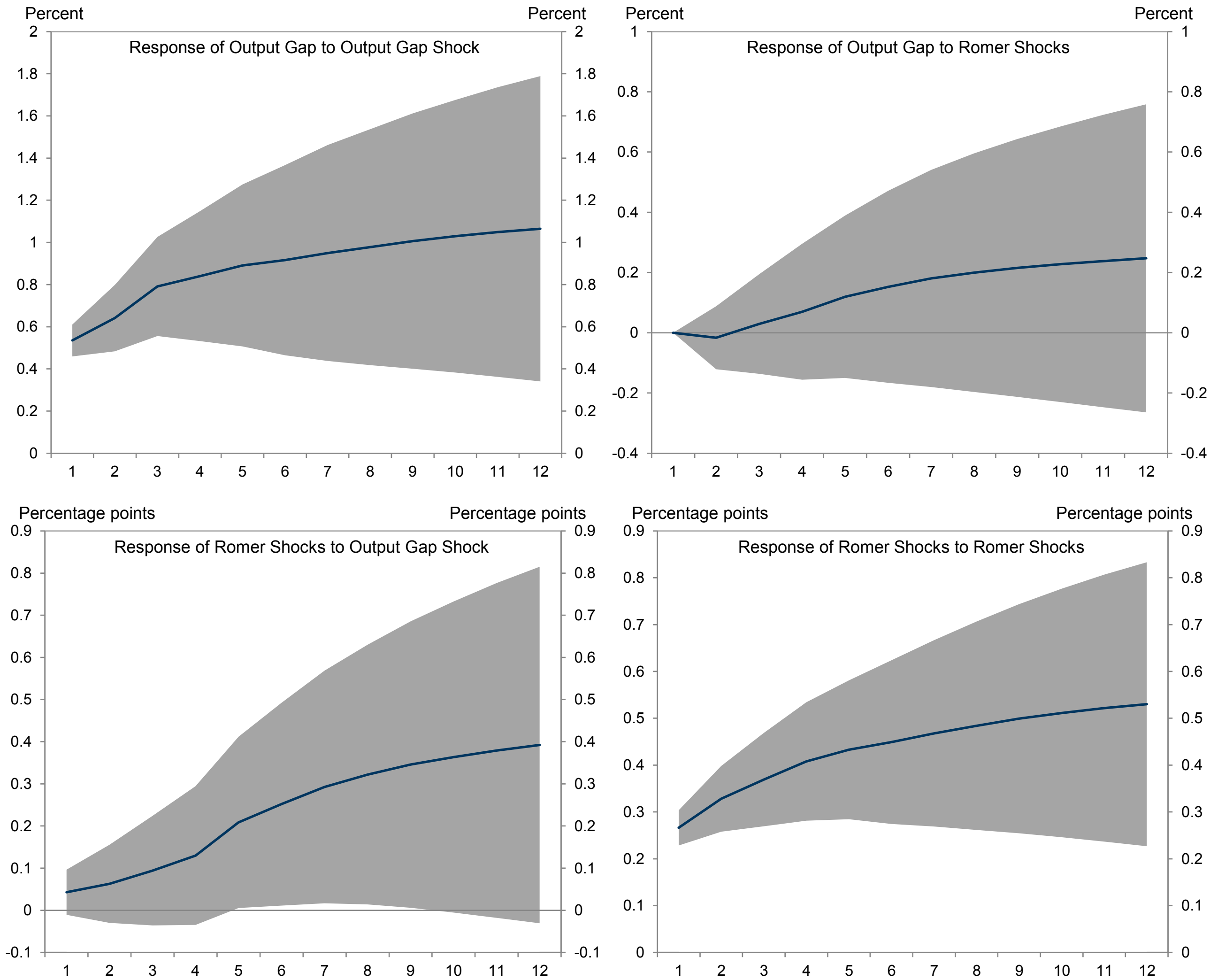
Exhibit A3: VARs with Romer-Romer Shocks 1960-84



Note: The horizontal axes denote quarters and the gray areas show +/- 2 standard error bands.

Source: Goldman Sachs Global Investment Research

Exhibit A4: VARs with Romer-Romer Shocks 1985-2008



Note: The horizontal axes denote quarters and the gray areas show +/- 2 standard error bands.

Source: Goldman Sachs Global Investment Research

Appendix B: The GS FCI

Our stylized macro model of the US economy specifies a set of long-run behavioral relationships that link the components of GDP to underlying drivers. This partly determines short-run movements in the model, as each component tends back towards its long-run equilibrium relationship; recent dynamics also explain changes in the short run.

Long-run consumption (C_t) is determined by real disposable income (Y_{td}) and wealth (W_{te}). Total wealth is broken down into equity and housing components:

$$\log(C_t) = \alpha_0 + (1-\alpha_1)\log\left(Y_t^d\right) + \alpha_1\log(W_t^e) + \alpha_2\log(W_t^r)$$

Non-residential investment as a share of potential GDP ($I_t^{NR}/Y_t{*}$) is driven by real corporate borrowing costs. This is measured by combining the 10-year government Treasury yield (r^l_t) with a corporate borrowing spread ($spread_t$):

$$\log(I_t^{NR}/Y_t^*) = \beta_0 + \log(g_t + \delta^{NR}) - \beta_1(rl_t + spread_t - \pi_t^e + \delta^{NR})$$

Residential investment ($I^R{}_T/Y_t{*}$) is driven by a weighted average of the real Funds rate (rs_t) and the 10-year Treasury yield and the growth rate of potential GDP (g_t):

$$\log(I_t^R/Y_t^*) = \gamma_0 + \log(g_t + \delta^R) - \gamma_1\left(\frac{rs_t}{2} + \frac{rl_t}{2} - \pi_t^e + \delta^R\right)$$

The trade equations are similar for both imports (M_t) and exports (X_t). The two are modelled as shares of domestic and trade-weighted world demand respectively, and depend on the real effective exchange rate ($RE\ R_t$). We allow for deterministic trends in both long-run relationships, to capture structural changes in world trade, for example caused by globalization.

$$\log(M_t/DD_t) = \kappa_0 + \kappa_1\log(RER_t) + \kappa_2 * 1/TREND$$

$$\log(X_t/FDD_t) = \phi_0 + \phi_1\log(RER_t) + \phi_2 * 1/TREND$$

GDP is then determined as the sum of the projections of these components.

The equations are estimated using quarterly data since 1985 but some of the parameters are calibrated—including the sensitivity of investment to interest rates and the sensitivity of trade flows to the exchange rate (see Exhibit B1).

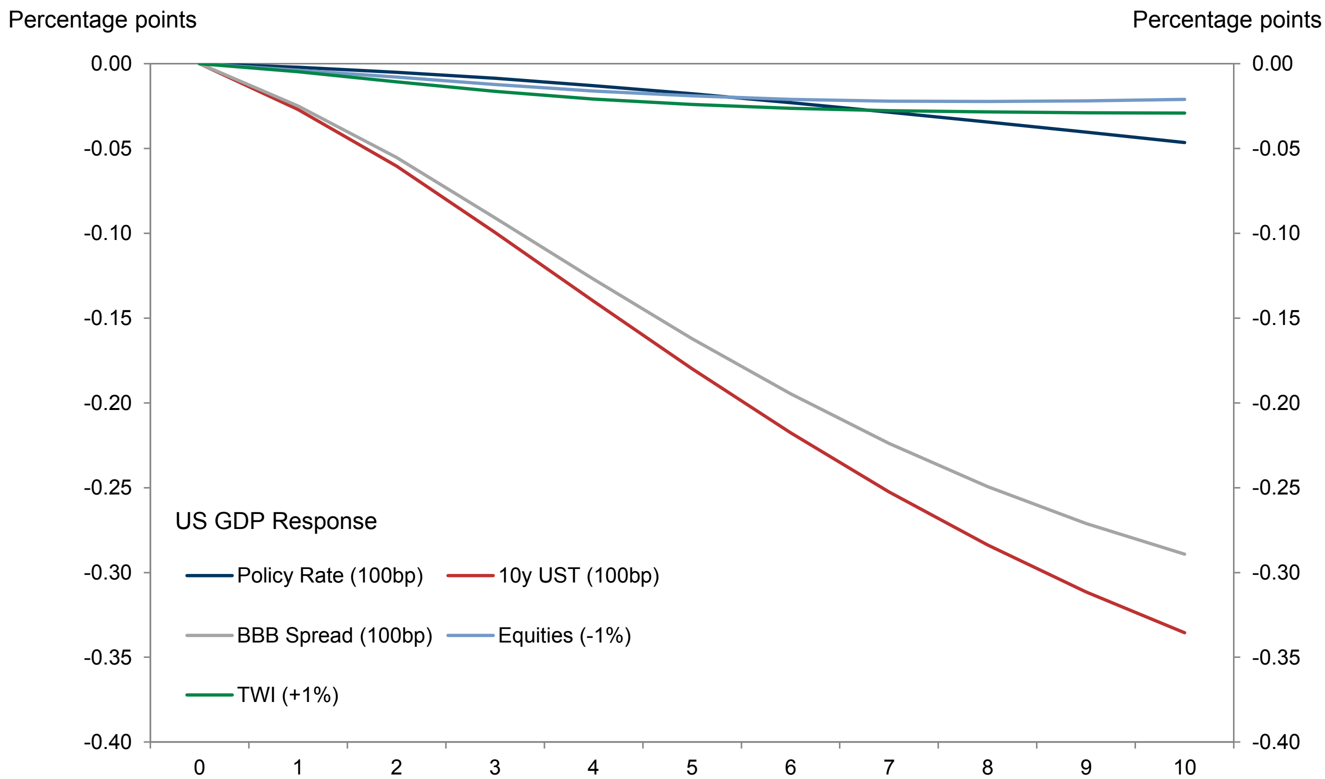
Exhibit B1: Estimated and Calibrated Coefficients

Consumption	
α_0	-0.13
α_1	0.03
α_2	0.06
Non-Residential Investment	
β_0	-4.13
β_1	0.03
Residential Investment	
γ_0	-2.81
γ_1	0.01
Imports	
κ_0	-2.27
κ_1	0.10
κ_2	-15.46
Exports	
ϕ_0	3.32
ϕ_1	0.15
ϕ_2	-17.26

Source: Goldman Sachs Global Investment Research

We then simulate the effect of FCI component shocks as follows. We shock each of the FCI components separately to compare their effect on GDP. This comparison generates the component weights in the overall FCI. In order to isolate the impact of each component on the model, we proceed as follows: we introduce a permanent shock to one component (a 100bp increase for interest rates and spreads, a 1% fall in equities, and a 1% rise in the TWI, and for the monthly extended FCIs, a 1% rise in commodity prices) but hold all other financial variables constant. This gives the cleanest estimate of the direct impact of that component on activity, without inadvertently double-counting effects that come through the other financial variables. For example, a permanent 100bp shock to the long-term rate triggers a fall in GDP three years later of 0.4%.

Exhibit B2: Simulation of GDP Effects



Note: The horizontal axis denotes quarters.

Source: Goldman Sachs Global Investment Research

We then use the GDP effect four quarters after the shock to calculate the weight of each component in the FCI. So the fact that the impact of a shock to the 10-year Treasury yield is nearly seven times as big as the impact of a shock to the exchange rate means that its weight should be nearly seven times as big. Exhibit B3 summarizes the final weights and provides the details of the included variables.

Exhibit B3: FCI Weights

FCI Components		
Variable	**Description**	**Weight**
Nominal Policy Rate	Target Federal Funds Rate	4.4%
Nominal Riskless Bond Yield	10-Year Treasury Yield	45.1%
Corporate Spread	iBoxx Domestic Non-Financials BBB 15Y+ Spread over 10-year Treasury Yield	39.6%
Equity Price	S&P 500, Scaled by 10-year Moving Average of Earnings	4.9%
Trade-Weighted Exchange Rate	GS Broad Trade-Weighted Index	6.0%

Source: Goldman Sachs Global Investment Research

Appendix C: Robustness Check of FCI Regressions

Exhibit C1: Robustness Using Different Output Gap Measures

Dependent Variable: Output gap

Sample:	1963Q1-2017Q3		1985Q1-2017Q3				1995Q1-2017Q3			
Output Gap Estimate:	CBO	FRBUS	CBO	FRBUS	OECD	IMF	CBO	FRBUS	OECD	IMF
Output Gap (-1)	1.14	1.48	1.17	1.6	1.23	1.24	1.04	1.71	1.16	1.14
	[17.70]**	[27.06]**	[13.44]**	[23.04]**	[13.70]**	[14.49]**	[8.50]**	[18.41]**	[9.61]**	[9.40]**
Output Gap (-2)	-0.24	-0.52	-0.24	-0.63	-0.26	-0.28	-0.13	-0.73	-0.2	-0.19
	[-3.74]**	[-9.65]**	[-2.69]**	[-9.05]**	[-2.90]**	[-3.29]**	[-1.14]	[-8.18]**	[-1.65]	[-1.58]
FCI (-1)	-0.42	-0.35	-0.33	-0.20	-0.34	-0.33	-0.43	-0.09	-0.37	-0.41
	[-4.18]**	[-4.95]**	[-3.12]**	[-2.53]*	[-2.95]**	[-2.91]**	[-3.08]**	[-0.96]	[-2.54]*	[-2.75]**
FCI (-2)	0.36	0.32	0.30	0.18	0.28	0.30	0.28	0.13	0.28	0.29
	[3.47]**	[4.53]**	[2.98]**	[2.53]*	[2.70]**	[2.81]**	[2.12]*	[1.50]	[2.06]*	[2.12]*
Observations	221	216	129	129	124	129	89	89	89	89
R^2	0.91	0.97	0.91	0.98	0.95	0.95	0.93	0.98	0.95	0.95

Note: Figures in squared brackets are t-statistics; * and ** denote significance at 5% and1% levels.

Source: Goldman Sachs Global Investment Research

Exhibit C2: Robustness Using Changes in the Output Gap and Growth

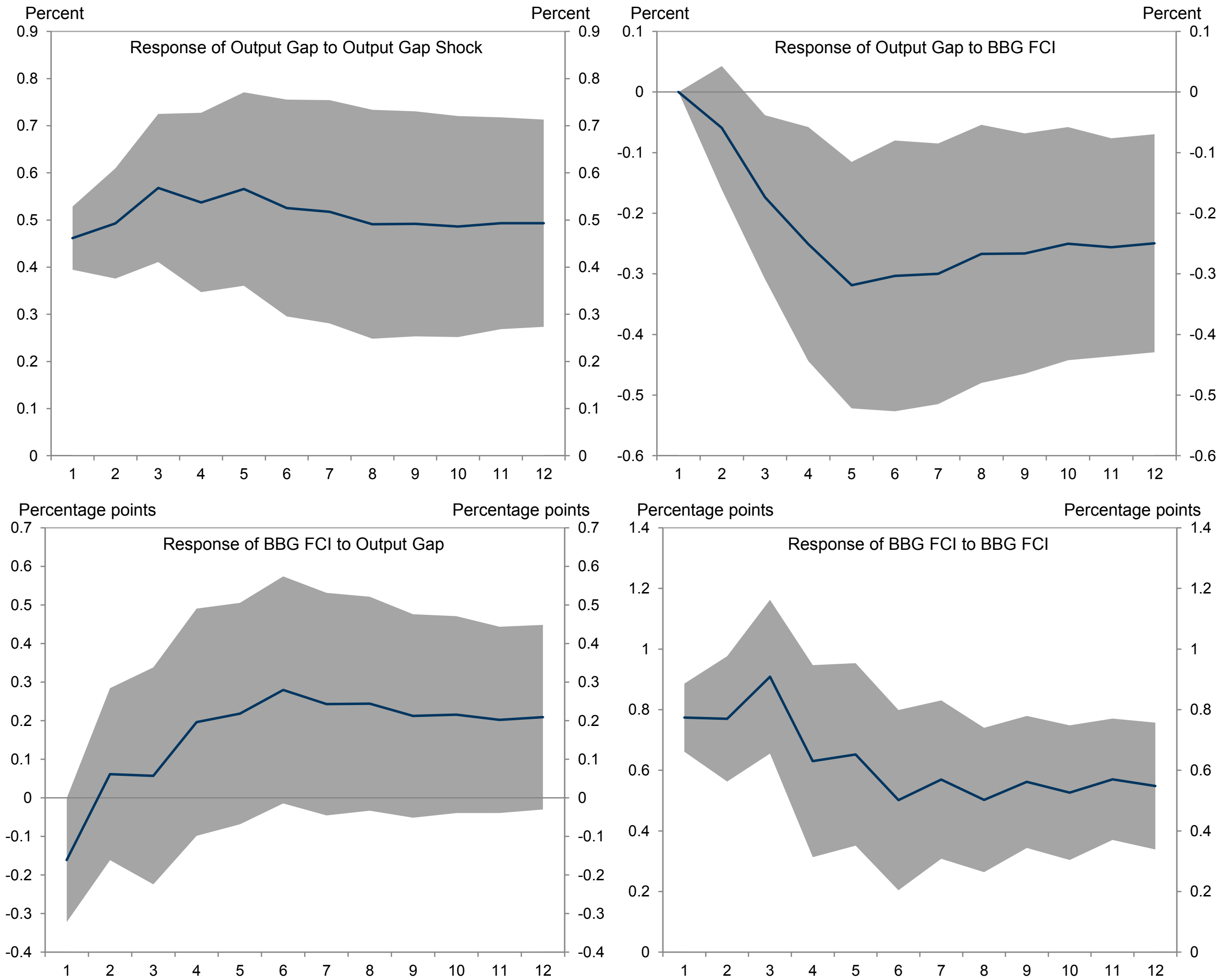
Dependent Variable: CBO Output gap

Dependent variable:	Output Gap			Change in Output Gap			Real GDP Growth		
Sample:	1960Q1-2017Q3	1985Q1-2017Q3	1995Q1-2017Q3	1960Q1-2017Q3	1985Q1-2017Q3	1995Q1-2017Q3	1960Q1-2017Q3	1985Q1-2017Q3	1995Q1-2017Q3
Output Gap (-1)	1.14	1.17	1.04						
	[17.70]**	[13.51]**	[8.58]**						
Output Gap (-2)	-0.24	-0.23	-0.13						
	[-3.74]**	[-2.67]**	[-1.13]						
Change in Output Gap (-1)				0.2	0.2	0.13			
				[3.03]**	[2.26]*	[1.09]			
Growth(-1)							0.2	0.22	0.17
							[3.02]**	[2.40]*	[1.39]
Growth(-2)							0.17	0.23	0.21
							[2.45]*	[2.51]*	[1.79]
Growth(-3)							0.02	0	0.11
							[0.28]	[-0.04]	[0.97]
Growth(-4)							0.08	0.08	0.1
							[1.19]	[0.89]	[0.93]
FCI (-1)	-0.42	-0.34	-0.44	-0.47	-1.92	-0.3	-0.36	-1.28	-0.4
	[-4.18]**	[-3.20]**	[-3.16]**	[-4.62]**	[-4.42]**	[-3.20]**	[-3.35]**	[-2.83]**	[-3.16]**
FCI (-2)	0.36	0.30	0.30	0.46	1.89	0.3	0.33	1.29	0.3
	[3.47]**	[3.06]**	[2.23]*	[4.55]**	[4.35]**	[3.06]**	[3.34]**	[3.05]**	[2.23]*
Observations	221	221	221	131	131	131	91	91	91
R^2	0.91	0.15	0.21	0.91	0.16	0.27	0.93	0.18	0.27

Note: Figures in squared brackets are t-statistics; * and ** denote significance at 5% and1% levels.

Source: Goldman Sachs Global Investment Research

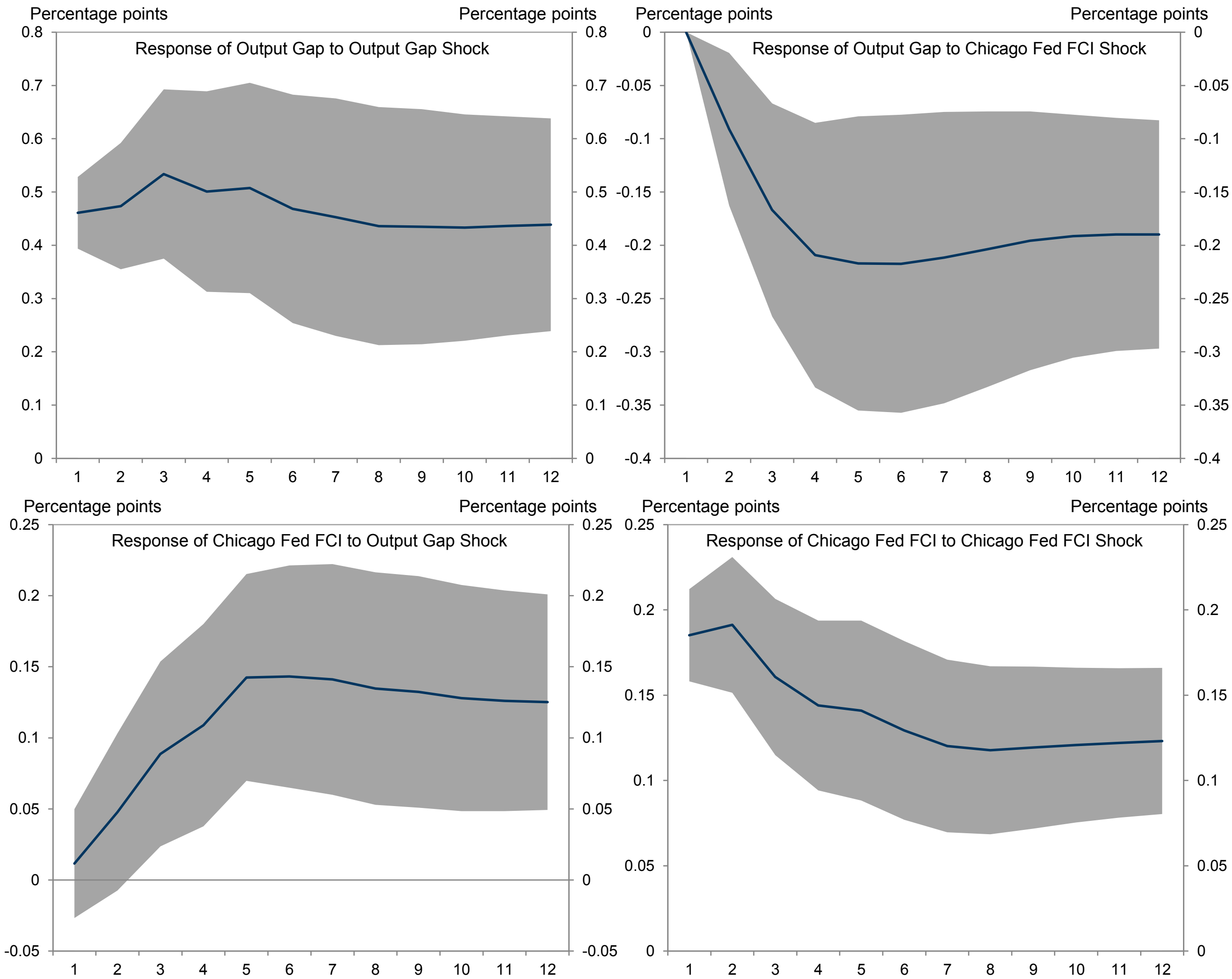
Exhibit C3: VAR with Bloomberg FCI (1995Q1-2017Q3)



Note: The horizontal axes denote quarters and the gray areas show +/- 2 standard error bands.

Source: Goldman Sachs Global Investment Research

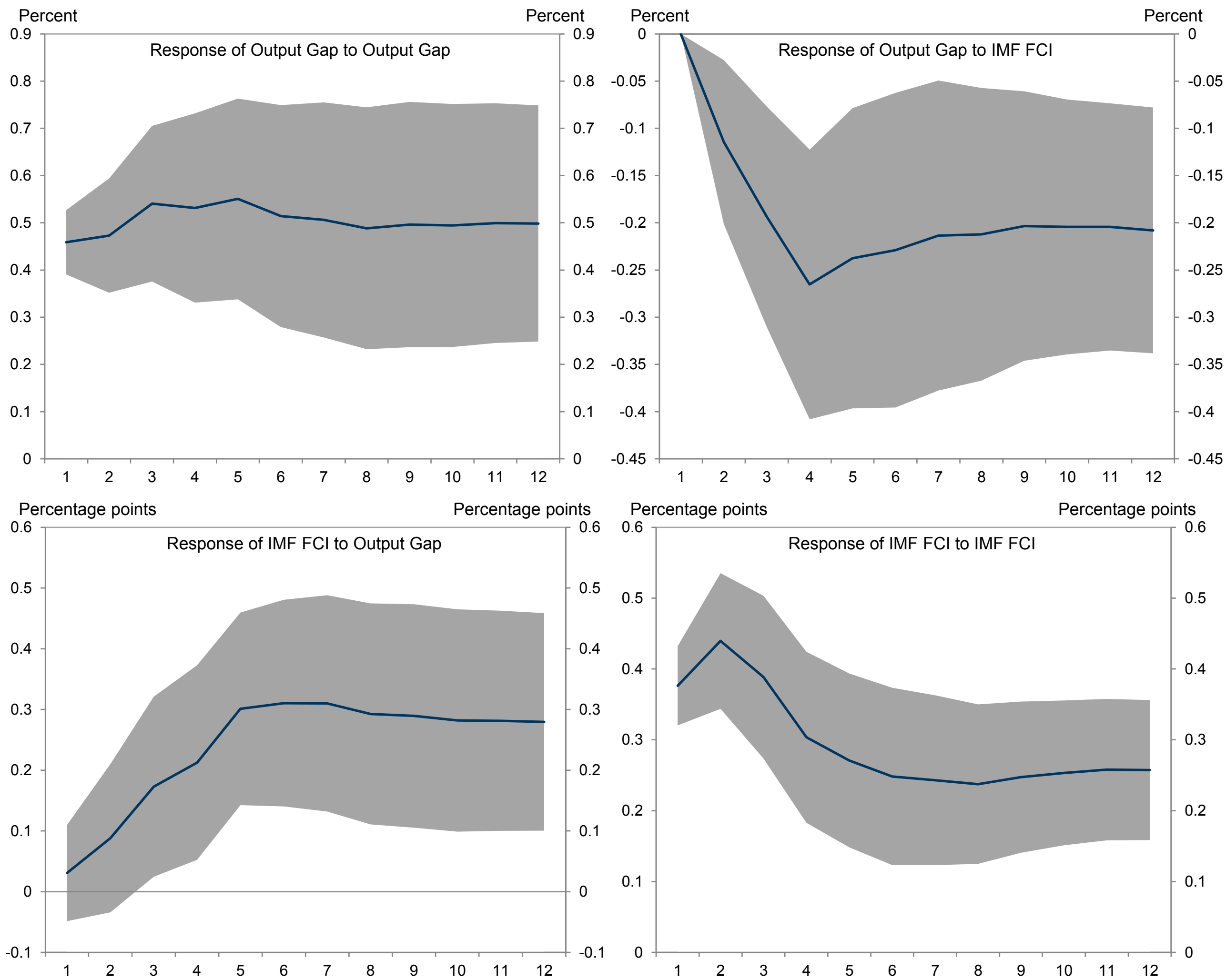
Exhibit C4: VAR with Chicago Fed FCI (1995Q1-2017Q3)



Note: The horizontal axes denote quarters and the gray areas show +/- 2 standard error bands.

Source: Goldman Sachs Global Investment Research

Exhibit C5: VAR with IMF FCI (1995Q1-2017Q3)



Note: The horizontal axes denote quarters and the gray areas show +/- 2 standard error bands.

Source: Goldman Sachs Global Investment Research

Disclosure Appendix

Reg AC

We, Jan Hatzius and Sven Jari Stehn, hereby certify that all of the views expressed in this report accurately reflect our personal views, which have not been influenced by considerations of the firm's business or client relationships.

Unless otherwise stated, the individuals listed on the cover page of this report are analysts in Goldman Sachs' Global Investment Research division.

Disclosures

Global product; distributing entities

The Global Investment Research Division of Goldman Sachs produces and distributes research products for clients of Goldman Sachs on a global basis. Analysts based in Goldman Sachs offices around the world produce equity research on industries and companies, and research on macroeconomics, currencies, commodities and portfolio strategy. This research is disseminated in Australia by Goldman Sachs Australia Pty Ltd (ABN 21 006 797 897); in Brazil by Goldman Sachs do Brasil Corretora de Títulos e Valores Mobiliários S.A.; Ombudsman Goldman Sachs Brazil: 0800 727 5764 and / or ouvidoriagoldmansachs@gs.com. Available Weekdays (except holidays), from 9am to 6pm. Ouvidoria Goldman Sachs Brasil: 0800 727 5764 e/ou ouvidoriagoldmansachs@gs.com. Horário de funcionamento: segunda-feira à sexta-feira (exceto feriados), das 9h às 18h; in Canada by either Goldman Sachs Canada Inc. or Goldman Sachs & Co. LLC; in Hong Kong by Goldman Sachs (Asia) L.L.C.; in India by Goldman Sachs (India) Securities Private Ltd.; in Japan by Goldman Sachs Japan Co., Ltd.; in the Republic of Korea by Goldman Sachs (Asia) L.L.C., Seoul Branch; in New Zealand by Goldman Sachs New Zealand Limited; in Russia by OOO Goldman Sachs; in Singapore by Goldman Sachs (Singapore) Pte. (Company Number: 198602165W); and in the United States of America by Goldman Sachs & Co. LLC. Goldman Sachs International has approved this research in connection with its distribution in the United Kingdom and European Union.

European Union: Goldman Sachs International authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority, has approved this research in connection with its distribution in the European Union and United Kingdom; Goldman Sachs AG and Goldman Sachs International Zweigniederlassung Frankfurt, regulated by the Bundesanstalt für Finanzdienstleistungsaufsicht, may also distribute research in Germany.

General disclosures

This research is for our clients only. Other than disclosures relating to Goldman Sachs, this research is based on current public information that we consider reliable, but we do not represent it is accurate or complete, and it should not be relied on as such. The information, opinions, estimates and forecasts contained herein are as of the date hereof and are subject to change without prior notification. We seek to update our research as appropriate, but various regulations may prevent us from doing so. Other than certain industry reports published on a periodic basis, the large majority of reports are published at irregular intervals as appropriate in the analyst's judgment.

Goldman Sachs conducts a global full-service, integrated investment banking, investment management, and brokerage business. We have investment banking and other business relationships with a substantial percentage of the companies covered by our Global Investment Research Division. Goldman Sachs & Co. LLC, the United States broker dealer, is a member of SIPC (http://www.sipc.org).

Our salespeople, traders, and other professionals may provide oral or written market commentary or trading strategies to our clients and principal trading desks that reflect opinions that are contrary to the opinions expressed in this research. Our asset management area, principal trading desks and investing businesses may make investment decisions that are inconsistent with the recommendations or views expressed in this research.

The analysts named in this report may have from time to time discussed with our clients, including Goldman Sachs salespersons and traders, or may discuss in this report, trading strategies that reference catalysts or events that may have a near-term impact on the market price of the equity securities discussed in this report, which impact may be directionally counter to the analyst's published price target expectations for such stocks. Any such trading strategies are distinct from and do not affect the analyst's fundamental equity rating for such stocks, which rating reflects a stock's return potential relative to its coverage group as described herein.

We and our affiliates, officers, directors, and employees, excluding equity and credit analysts, will from time to time have long or short positions in, act as principal in, and buy or sell, the securities or derivatives, if any, referred to in this research.

The views attributed to third party presenters at Goldman Sachs arranged conferences, including individuals from other parts of Goldman Sachs, do not necessarily reflect those of Global Investment Research and are not an official view of Goldman Sachs.

Any third party referenced herein, including any salespeople, traders and other professionals or members of their household, may have positions in the products mentioned that are inconsistent with the views expressed by analysts named in this report.

This research is not an offer to sell or the solicitation of an offer to buy any security in any jurisdiction where such an offer or solicitation would be illegal. It does not constitute a personal recommendation or take into account the particular investment objectives, financial situations, or needs of individual clients. Clients should consider whether any advice or recommendation in this research is suitable for their particular circumstances and, if appropriate, seek professional advice, including tax advice. The price and value of investments referred to in this research and the income from them may fluctuate. Past performance is not a guide to future performance, future returns are not guaranteed, and a loss of original capital may occur. Fluctuations in exchange rates could have adverse effects on the value or price of, or income derived from, certain investments.

Certain transactions, including those involving futures, options, and other derivatives, give rise to substantial risk and are not suitable for all investors. Investors should review current options disclosure documents which are available from Goldman Sachs sales representatives or at http://www.theocc.com/about/publications/character-risks.jsp. Transaction costs may be significant in option strategies calling for multiple purchase and sales of options such as spreads. Supporting documentation will be supplied upon request.

Differing Levels of Service provided by Global Investment Research: The level and types of services provided to you by the Global Investment Research division of GS may vary as compared to that provided to internal and other external clients of GS, depending on various factors including your individual preferences as to the frequency and manner of receiving communication, your risk profile and investment focus and perspective (e.g., marketwide, sector specific, long term, short term), the size and scope of your overall client relationship with GS, and legal and regulatory constraints. As an example, certain clients may request to receive notifications when research on specific securities is published, and certain clients may request that specific data underlying analysts' fundamental analysis available on our internal client websites be delivered to them electronically through data feeds or otherwise. No change to an analyst's fundamental research views (e.g., ratings, price targets, or material changes to earnings estimates for equity securities), will be communicated to any client prior to inclusion of such information in a research report broadly disseminated through electronic publication to our internal client websites or through other means, as necessary, to all clients who are entitled to receive such reports.