THE DETAILS MATTER IN MONETARY POLICY: FUTURES OR SWAPS?

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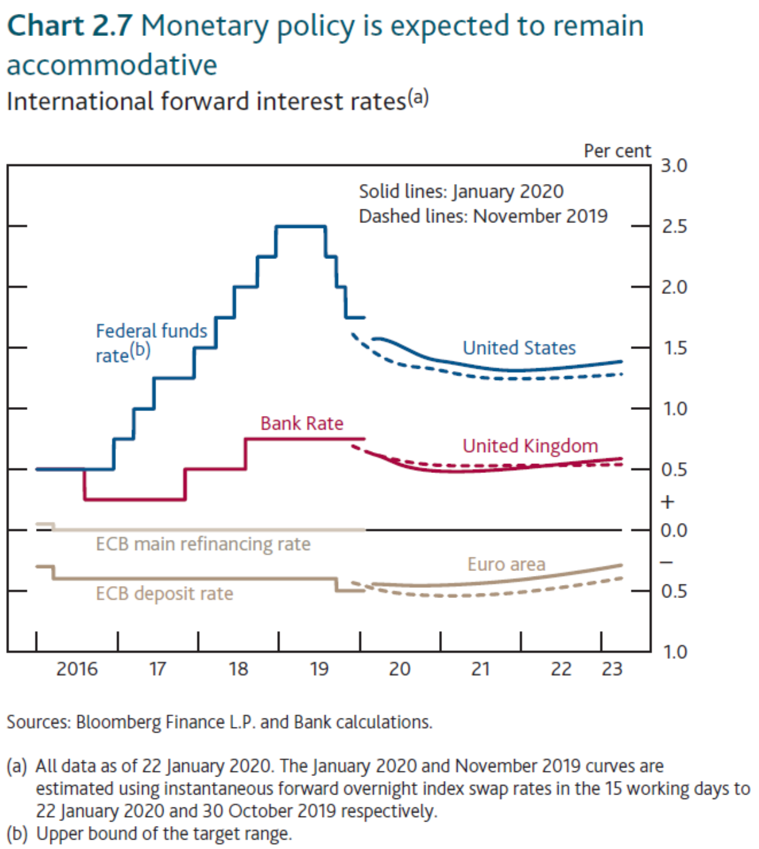
1 Introduction

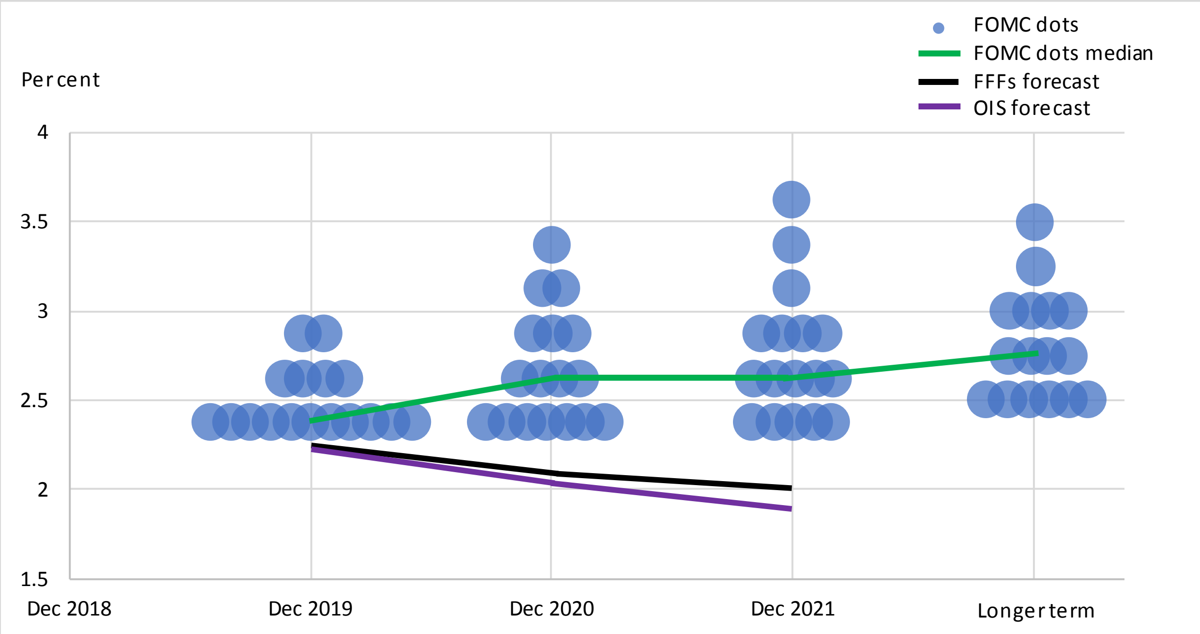
To set monetary policy effectively, policymakers must be able to interpret the interest rate expectations of financial market participants through asset pricing. Indeed, the recent dovish pivot by the Federal Open Market Committee (FOMC) in 2019, ultimately resulting in 75 basis points of rate cuts, was highly influenced by the originally conflicting views of the market and the committee members (see Matthews (2019)). Historically, the financial community has used federal funds futures (FFFs) to measure US rate expectations; this has received support from the academic literature (Gürkaynak et al. (2007), Hamilton (2009)). Despite this, overnight indexed swap (OIS) contracts are increasingly being viewed as an alternative. This is primarily because they are liquid out to longer horizons and are available in ex-US markets, allowing for global comparisons of rate expectations ((Chang et al. (2010), Lloyd (2018)). Chart 2.7 in the Bank of England's January 2020 Monetary Policy report demonstrates how instantaneous forward OIS curves can be used to measure forward rate expectations (Figure 1).

Figure 1. *Forward rate expectations in the UK, US and EA (Source: Bank of England, January 2020 Monetary Policy Report)*



To date, there is little existing literature formally assessing the ability of OIS rates to forecast interest rates, beyond the work of Lloyd (2018). As a starting point, it is natural to assess how the federal funds rate forecasts derived from US OIS contracts, compare with those of the historically dominant instrument, FFFs. Figure 2 (a recreation of the Bloomberg 'DOTS' chart) provides a snapshot of this. In this paper, I seek to formally assess whether 1. FFFs and US OIS contracts provide accurate forecasts of the near-term federal funds rate and 2. whether their forecasts are rational.

Figure 2. *The FOMC's March 2019 'DOT' plot vs. the market (Source: Bloomberg, 2019)*



2 Theoretical background

FFFs are (exchange-traded) financial contracts used to hedge against and speculate on the future federal funds rate. They settle at a price of 100 minus the daily average effective federal funds rate in a reference month. Formally, let us define $p_{t,t+n}^{FFF}$ as the price of an *n*-month ahead FFFs contract bought on a given day in month *t*. The implied rate on the *n*-month contract is $i_{t,t+n}^{FFF}$ = 100 - $p_{t,t+n}^{FFF}$. Let $\overline{ffr}_{t+n}$ be the average daily effective federal funds rate during month *t+n*. For the buyer of an n-month ahead FFFs contract, the realised excess return is defined as:

(1) $$rx_{t,t+n}^{FFF} = i_{t,t+n}^{FFF} - \overline{ffr}_{t+n}.$$

Under the assumptions of the efficient markets hypothesis (EMH) and risk-neutrality, $i_{t,t+n}^{FFF} = E[\overline{ffr}_{t+n}|I_t]$, where I_t is the information set at time *t*.

An OIS is an over-the-counter interest rate derivative, again used primarily to hedge against interest rate risk. An OIS contract is composed of a fixed and a floating leg. The former is simply the 'OIS rate'. The floating leg is calculated as the net return from investing a notional principal in the overnight federal funds market and geometrically compounding the gross returns.

As in Lloyd (2018), define $i_{t,t+n}^{OIS}$ as the annualised n-month OIS rate in month t. Let $i_{t,t+n}^{FLT}$ be the annualised realised net return from the floating leg of the contract. US OIS contracts have a two-day spot lag, so if an *n*-month (*N*-day) US OIS contract is traded on day t_{-1} in month *t*, the floating leg is calculated by rolling over federal funds loans from day t_1 of month *t* to day t_N of month *t+n*. We can express this as follows:

(2) $$i_{t,t+n}^{FLT} = \left(\left[\Pi_{j=1}^{N}\left(1 + \frac{D_j}{360} EFFR_j\right)\right] - 1\right) * \frac{360}{N}$$

where D_j is the number of days between business days t_j and t_{j+1} and $EFFR_j$ is the effective federal funds rate on day t_j.

For an agent who swaps their fixed payments for floating payments, the realised excess return is defined as:

(3) $$rx^{OIS}_{t,t+n} = i^{OIS}_{t,t+n} - i^{FLT}_{t,t+n}$$

Again, under the assumptions of the EMH and risk-neutrality, $i^{OIS}_{t,t+n} = E[i^{FLT}_{t,t+n}|I_t]$.

Making direct comparisons between the excess returns on FFFs and OIS contracts is difficult because in general, the horizons of the two financial market instruments will not align. To align their horizons, I follow the methodology of Lloyd (2018). I create 'portfolios' of FFFs contracts and compare the realised excess returns on corresponding horizon FFFs portfolios and OIS contracts, on the penultimate business day of each month.[2]

3 Empirical Strategy

The empirical analysis of this paper can be split into two parts. We first analyse the accuracy of forecasts made by FFFs portfolios and OIS contracts. That is, on average, have the excess returns on these financial market instruments been statistically significantly different from zero? Secondly, we assess the rationality of the forecasts made by the instruments; namely, can one use macroeconomic and/or financial-market indicators known in month *t,* to predict the excess returns on n-month FFFs portfolios (OIS contracts) traded in month *t*?

3.1 Assessing the accuracy of FFFs and OIS forecasts

To formally assess the accuracy of forecasts made by FFFs portfolios and OIS contracts, the main regression specifications are:

(4) $$\mathrm{rx}^{\mathrm{FFF,port}}_{\mathrm{t,t+n}} = \alpha^{\mathrm{FFF,port}}_{\mathrm{n}} + \varepsilon^{\mathrm{FFF,port}}_{\mathrm{t,t+n}}$$

(5) $$\mathrm{rx}^{\mathrm{OIS}}_{\mathrm{t,t+n}} = \alpha^{\mathrm{OIS}}_{\mathrm{n}} + \varepsilon^{\mathrm{OIS}}_{\mathrm{t,t+n}}$$

$\mathrm{rx}^{\mathrm{FFF,port}}_{\mathrm{t,t+n}}$ ($\mathrm{rx}^{\mathrm{OIS}}_{\mathrm{t,t+n}}$) is the excess return on an n-month FFFs portfolio (OIS contract) on the penultimate business day of month *t*; $\alpha^{\mathrm{FFF,port}}_{\mathrm{n}}$and $\alpha^{\mathrm{OIS}}_{\mathrm{n}}$ are constants and $\varepsilon^{\mathrm{FFF,port}}_{\mathrm{t,t+n}}$ and $\varepsilon^{\mathrm{OIS}}_{\mathrm{t,t+n}}$ are error terms.

The coefficients $\alpha^{\mathrm{FFF,port}}_{\mathrm{n}}$ and $\alpha^{\mathrm{OIS}}_{\mathrm{n}}$ are the (unconditional) average realised excess returns on *n*-month FFFs portfolios and OIS contracts, respectively. If the estimated coefficients are statistically significantly different from zero, then the corresponding n-month FFFs portfolio or OIS contract does not provide an accurate measure of the *n*-month ahead federal funds rate. We can then conclude that there is (statistically significant) risk premia in the corresponding instrument.

[2] See Appendix B for details.

3.2 Assessing the rationality of FFFs and OIS forecasts

We next turn to the rationality (predictability) of forecasts made by FFFs portfolios and OIS. Piazzesi and Swanson (2008) found that macroeconomic and financial business-cycle indicators could (substantively) predict the excess returns on FFFs.[3]

The regression equations of interest are now:

(6) $$rx_{t,t+n}^{FFF,port} = \alpha_n^{FFF,port} + X\beta_n^{FFF,port} + \varepsilon_{t,t+n}^{FFF,port}$$

(7) $$rx_{t,t+n}^{OIS} = \alpha_n^{OIS} + X\beta_n^{OIS} + \varepsilon_{t,t+n}^{OIS}$$

where X is a matrix of macroeconomic and/or financial-market indicators (known in month *t*).

Following Piazzesi and Swanson (2008), we let X equal the 1-year change in the natural logarithm of US nonfarm payroll employment (multiplied by 100) and the FFFs (or OIS) rate itself. The inclusion of employment growth allows us to assess if excess returns are (business cycle) cyclical. The FFFs (OIS) rate provides a measure of the level of interest rates, enabling us to assess if excess returns are systematically higher (or lower) when the level of interest rates is high.

4 Data

For my analysis, I obtain daily data on 1 to 9 and 12-month FFFs prices and OIS rates from March 2004 - December 2019 from Refinitiv Datastream.[4] I also source daily data on the effective federal funds rate and monthly data on real-time nonfarm payrolls employment from the FRED, Federal Reserve Bank of St. Louis, website. With my original dataset, I find very large negative excess returns on short-horizon OIS contracts in Q4 2004. Believing the results in 2004 to offer little insight into the more recent forecasting performance of OIS contracts and acknowledging that their inclusion would skew the results significantly, I drop them. Hence, I run all my regressions using data from January 2005 – (December minus n-months) 2019, where n refers to the maturity (in months) of the portfolio/contract. Figures 3a and 3b show the excess returns on 1 and 4-month FFFs portfolios and OIS contracts over these time horizons.

[3] Piazzesi and Swanson (2008) did not test OIS contracts.

[4] 10 and 11-month OIS rates are not available from Datastream. March 2004 is the first month in which there is data available for both instruments, for all maturities.

Figure 3. *Excess returns on 1 and 4-month FFFs portfolios and OIS contracts since January 2005. (Source: Datastream and personal calculations, 2020)*

a) *Excess returns* b) *Spread between excess returns*

5 Results

5.1 Assessing the accuracy of forecasts

Panels A1 and A2 of Table 1 present the results from running OLS regressions of (4) and (5).[5] We find that both financial market instruments provided statistically significantly positive average excess returns over the sample period, at all horizons. This means that, on average, these instruments predicted a higher federal funds rate than prevailed (hence their forecasts were inaccurate). Nonetheless, it is plausible that the significant excess returns do not reflect risk premia but instead reflect the unanticipated and substantial Federal Reserve easing in 2008. Following Lloyd (2018), we therefore re-run regressions (4) and (5), now including an (explanatory) dummy variable equal to 1 if the FFFs portfolio (OIS contract) spans 2008. We now interpret $\alpha_n^{\mathrm{FFF,port}}$ and α_n^{OIS} as the average realised excess returns on n-month FFFs portfolios and OIS contracts outside of the 2008 period.

[5] Full results are presented in Appendix A, Table A1. All regressions run in this paper use Newey-West (HAC) standard errors. As a robustness check, I run all the regressions using pure FFFs contracts too (Appendix A, Table A3).

Table 1. Average excess returns on FFFs portfolios and US OIS contracts

Maturity (months)	1	2	3	4	5	6
***Panel A1*: Average excess returns (FFFs)**						
$\hat{\alpha}_n^{FFF,port}$	1.30*	2.38*	3.56*	4.74*	5.99*	7.23*
(t-stat)	(1.79)	(1.86)	(1.90)	(1.88)	(1.88)	(1.88)
***Panel A2*: Average excess returns (OIS)**						
$\hat{\alpha}_n^{OIS}$	1.45*	2.48*	3.59*	4.90*	6.10*	7.33*
(t-stat)	(1.69)	(1.81)	(1.84)	(1.90)	(1.88)	(1.86)
***Panel B1*: 2008 dummy (FFFs)**						
$\hat{\alpha}_n^{FFF,port}$	0.38*	0.61*	0.80	0.92	1.01	0.81
(t-stat)	(1.91)	(1.71)	(1.52)	(1.24)	(1.04)	(0.73)
Recession dummy	12.70**	22.47***	32.52***	41.96***	51.23***	62.05***
(t-stat)	(2.14)	(2.77)	(3.40)	(3.98)	(4.59)	(5.49)
R^2	0.26	0.33	0.40	0.45	0.49	0.57
***Panel B2*: 2008 dummy (OIS)**						
$\hat{\alpha}_n^{OIS}$	0.38	0.57	0.74	1.04	1.00	0.76
(t-stat)	(1.21)	(1.44)	(1.32)	(1.34)	(1.04)	(0.67)
Recession dummy	14.72**	24.28***	33.63***	42.54***	52.49***	63.49***
(t-stat)	(2.17)	(2.82)	(3.40)	(3.91)	(4.60)	(5.38)
R^2	0.10	0.29	0.38	0.42	0.49	0.56

*Asterisks ***, **, * denote coefficients that are statistically significantly different from zero at the 1%, 5% and 10% significance levels respectively.*

The results are presented in Panels B1 and B2 of Table 1. The only intercept coefficients that are now statistically significant are those in the 1 and 2-month FFFs portfolio regressions. This indicates that outside of the 2008 period, 3 to 9 and 12-month FFFs portfolios and 1 to 9 and 12-month US OIS contracts provided accurate measures of the near-term federal funds rate. When running the regressions using pure FFFs contracts, we further cannot reject that 2-month FFFs contracts provided accurate forecasts (Appendix A, Table A3). Moreover, at 1 and 2-month horizons, FFFs portfolios have notably lower root mean squared forecast errors (RMSFEs) than OIS contracts. These results therefore support the use of risk-adjusted FFFs (portfolios) to forecast the federal funds rate at short-horizons (see Piazzesi and Swanson (2008)).

5.2 Assessing the rationality of forecasts

The results from running regressions (6) and (7) are reported in Table 2.[6] Referring first to Panel C1, we find that the FFFs rate itself is not statistically significant at any meaningful significance level, for all horizons. This indicates that, controlling for employment growth, the level of interest rates is not informative of the excess returns on FFFs contracts. In contrast, employment growth is a significant

[6] Full results are presented in Appendix A, Table A2.

predictor of the excess returns on 1 and 4 to 12-month FFFs portfolios. The estimated coefficients on employment growth are negative, indicating that the excess returns are countercyclical.

The R^2 statistics are very low, ranging from 0.03 for 1-month FFFs contracts up to 0.11 for 12-month FFFs portfolios. This contrasts with those reported by Piazzesi and Swanson (2008); for example, the R^2 for the 6-month (pure) FFFs contract regression in their paper was 0.39; in our case, it is 0.06 (Appendix A, Table A3). These results indicate that employment growth and the futures rate can no longer explain a substantial amount of the variation in the excess returns on FFFs contracts. This may be because investors have become better able to interpret the Federal Reserve's reaction function or an increase in speculative players in the market, competing away profit opportunities.

Table 2. Conditional expected excess returns on FFFs portfolios and US OIS contracts

Maturity (months)	**1**	**2**	**3**	**4**	**5**	**6**
Panel C1: Nonfarm payrolls (FFFs)						
$\hat{\alpha}_n^{FFF,port}$	1.63	2.40	3.20	3.96	4.80	5.67
$i_{t,t+n}^{FFF,port}$	0.29	0.78	1.34	1.92	2.51	3.08
(t-stat)	(1.40)	(1.44)	(1.41)	(1.38)	(1.34)	(1.30)
ΔNFP_{t-1}	-0.78*	-1.23	-1.69	-2.18*	-2.68*	-3.22*
(t-stat)	(-1.66)	(-1.63)	(-1.64)	(-1.67)	(-1.73)	(-1.80)
R^2	0.03	0.04	0.04	0.05	0.06	0.07
Panel C2: Nonfarm payrolls (OIS)						
$\hat{\alpha}_n^{OIS}$	1.93*	2.58	3.21	4.01	4.81	5.76
$i_{t,t+n}^{OIS}$	0.28	0.78	1.39	2.01	2.55	3.09
(t-stat)	(0.88)	(1.26)	(1.39)	(1.41)	(1.33)	(1.27)
ΔNFP_{t-1}	-0.93*	-1.30	-1.76*	-2.22*	-2.67*	-3.26*
(t-stat)	(-1.71)	(-1.62)	(-1.66)	(-1.67)	(-1.70)	(-1.79)
R^2	0.01	0.03	0.04	0.05	0.06	0.06

The results for OIS contracts are remarkably similar. The OIS rate is not statistically significant at the 10% significance level, for all horizons. Employment growth is a significant predictor of the excess returns on 1 and 3 to 12-month OIS contracts. Nonetheless, employment growth and the OIS rate have low explanatory power; the R^2 statistics are small but increasing in the maturity of the contract (ranging from 0.01 for 1-month contracts to 0.11 for 12-month contracts).

6 Conclusion

3 to 9 and 12-month FFFs portfolios and 1 to 9 and 12-month US OIS contracts have provided accurate measures of the federal funds rate since January 2005, excluding the year 2008. Employment growth is a statistically significant predictor of the excess returns on both these instruments (for several maturities) but has low explanatory power. These preliminary results therefore largely support the financial community's use of these instruments as measures of short-term US interest rates.

Nevertheless, the analysis can be extended. A more complete test of rationality would assess the predictive power of several other macroeconomic and financial business-cycle indicators, as in

Krueger and Kuttner (1996). Examples include the BBB corporate bond spread, the Treasury bill rate and the inflation rate. Secondly, it would be of interest to see through which channels the predictive power of these indicators has changed over time (if at all). Finally, the model applied in this paper cannot explicitly say which financial-market instrument (FFFs or OIS contracts) has more predictive power. My results suggest that risk-adjusted FFFs (portfolios) dominate at short-horizons, whilst at longer horizons, the predictive power of FFFs portfolios and OIS contracts is very similar. Nevertheless, to formally assess this, we should adopt the model of Gürkaynak et al. (2007); indeed, its application to OIS contracts would be the next step in this field.

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Appendix A: Tables

Table A1. Average excess returns on FFFs portfolios and US OIS contracts (unannualized).

Maturity in months	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**12**
***Panel A1*: Average excess returns (FFFs)**										
$\hat{\alpha}_n^{FFF,port}$	1.30*	2.38*	3.56*	4.74*	5.99*	7.23*	8.61*	9.91*	11.28*	16.06**
(t-stat)	(1.79)	(1.86)	(1.90)	(1.88)	(1.88)	(1.88)	(1.90)	(1.89)	(1.90)	(1.98)
***Panel A2*: Average excess returns (OIS)**										
$\hat{\alpha}_n^{OIS}$	1.45*	2.48*	3.59*	4.90*	6.10*	7.33*	8.82*	9.98*	11.43*	16.32*
(t-stat)	(1.69)	(1.81)	(1.84)	(1.90)	(1.88)	(1.86)	(1.88)	(1.85)	(1.87)	(1.95)
***Panel B1*: 2008 dummy (FFFs)**										
$\hat{\alpha}_n^{FFF,port}$	0.38*	0.61*	0.80	0.92	1.01	0.81	0.68	0.43	0.26	0.39
(t-stat)	(1.91)	(1.71)	(1.52)	(1.24)	(1.04)	(0.73)	(0.50)	(0.27)	(0.13)	(0.12)
Recession dummy	12.70**	22.47***	32.52***	41.96***	51.23***	62.05***	72.19***	81.51***	89.72***	109.71***
(t-stat)	(2.14)	(2.77)	(3.4)	(3.98)	(4.59)	(5.49)	(6.41)	(7.27)	(7.85)	(7.27)
R^2	0.26	0.33	0.40	0.45	0.49	0.57	0.63	0.68	0.71	0.70
***Panel B2*: 2008 dummy (OIS)**										
$\hat{\alpha}_n^{OIS}$	0.38	0.57	0.74	1.04	1.00	0.76	0.59	0.19	0.10	0.14
(t-stat)	(1.21)	(1.44)	(1.32)	(1.34)	(1.04)	(0.67)	(0.44)	(0.12)	(0.05)	(0.04)
Recession dummy	14.72**	24.28***	33.63***	42.54***	52.49***	63.49***	74.95***	84.20***	92.29***	113.26***
(t-stat)	(2.17)	(2.82)	(3.40)	(3.91)	(4.60)	(5.38)	(6.50)	(7.33)	(7.82)	(7.31)
R^2	0.10	0.29	0.38	0.42	0.49	0.56	0.65	0.69	0.71	0.71

*Table A1 reports results from regressions (4) and (5) for 1 to 9 and 12-month FFFs portfolios and OIS contracts. Sample: Monthly frequency, January 2005 – (December minus n-months) 2019, where n refers to the maturity (in months) of the portfolio/ contract. Newey-West t-statistics are reported in brackets. Asterisks ***, **, * denote coefficients that are statistically significantly different from zero at the 1%, 5% and 10% significance levels (against a two-sided alternative) respectively.*

Table A2. Conditional expected excess returns on FFFs portfolios and US OIS contracts (unannualized).

Maturity in months	1	2	3	4	5	6	7	8	9	12
Panel C1: Nonfarm payrolls (FFFs)										
$\hat{\alpha}_n^{FFF,port}$	1.63	2.40	3.20	3.96	4.80	5.67	6.69*	7.73*	8.82*	12.30**
$i_{t,t+n}^{FFF,port}$	0.29	0.78	1.34	1.92	2.51	3.08	3.65	4.21	4.81	6.99
(t-stat)	(1.40)	(1.44)	(1.41)	(1.38)	(1.34)	(1.3)	(1.26)	(1.24)	(1.22)	(1.27)
$\Delta\mathrm{NFP}_{t-1}$	-0.78*	-1.23	-1.69	-2.18*	-2.68*	-3.22*	-3.79*	-4.45**	-5.16**	-7.61***
(t-stat)	(-1.66)	(-1.63)	(-1.64)	(-1.67)	(-1.73)	(-1.80)	(-1.90)	(-2.03)	(-2.18)	(-2.69)
R^2	0.03	0.04	0.04	0.05	0.06	0.07	0.07	0.08	0.09	0.11
Panel C2: Nonfarm payrolls (OIS)										
$\hat{\alpha}_n^{OIS}$	1.93*	2.58	3.21	4.01	4.81	5.76	6.77	7.85*	8.98*	12.51**
$i_{t,t+n}^{OIS}$	0.28	0.78	1.39	2.01	2.55	3.09	3.72	4.17	4.80	6.99
(t-stat)	(0.88)	(1.26)	(1.39)	(1.41)	(1.33)	(1.27)	(1.26)	(1.20)	(1.21)	(1.25)
$\Delta\mathrm{NFP}_{t-1}$	-0.93*	-1.30	-1.76*	-2.22*	-2.67*	-3.26*	-3.83*	-4.52**	-5.27**	-7.75***
(t-stat)	(-1.71)	(-1.62)	(-1.66)	(-1.67)	(-1.70)	(-1.79)	(-1.88)	(-2.02)	(-2.16)	(-2.67)
R^2	0.01	0.03	0.04	0.05	0.06	0.06	0.07	0.08	0.08	0.11

*Table A2 reports results from regressions (6) and (7) for 1 to 9 and 12-month FFFs portfolios and OIS contracts. Sample: Monthly frequency, January 2005– (December minus n-months) 2019, where n refers to the maturity (in months) of the portfolio/ contract. Newey-West t-statistics are reported in brackets. Asterisks ***, **, * denote coefficients that are statistically significantly different from zero at the 1%, 5% and 10% significance levels (against a two-sided alternative) respectively. The t-statistics on the constants are not reported.*

Table A3. Unconditional and conditional expected excess returns on pure FFFs contracts (unannualized).

Maturity in months	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**12**
***Panel A1*: Average excess returns (FFFs)**										
$\hat{\alpha}_n^{FFF,pure}$	1.30*	3.47*	5.93*	8.40*	11.03*	13.68*	16.75*	19.80*	23.19**	35.52**
(t-stat)	(1.79)	(1.86)	(1.90)	(1.86)	(1.86)	(1.85)	(1.89)	(1.91)	(1.96)	(2.19)
***Panel B1*: 2008 dummy (FFFs)**										
$\hat{\alpha}_n^{FFF,pure}$	0.38*	0.85	1.32	1.56	1.81	1.67	1.67	1.56	1.83	4.51
(t-stat)	(1.91)	(1.61)	(1.40)	(1.05)	(0.86)	(0.62)	(0.49)	(0.38)	(0.37)	(0.56)
Recession dummy	12.70**	33.31***	54.45***	75.32***	94.86***	116.08***	137.35***	156.92***	173.94***	217.10***
(t-stat)	(2.14)	(3.04)	(3.75)	(4.41)	(5.09)	(5.84)	(6.68)	(7.54)	(8.39)	(9.47)
R^2	0.26	0.34	0.42	0.47	0.52	0.59	0.66	0.71	0.73	0.72
Panel C1: Nonfarm payrolls (FFFs)										
$\hat{\alpha}_n^{FFF,pure}$	1.63	3.21	4.89	6.48	8.38	10.46*	13.01*	15.54**	18.07**	24.78**
$i_{t,t+n}^{FFF,pure}$	0.29	1.26	2.35	3.55	4.62	5.62	6.69	7.86	9.23	15.24
(t-stat)	(1.40)	(1.40)	(1.36)	(1.30)	(1.21)	(1.14)	(1.10)	(1.08)	(1.10)	(1.29)
ΔNFP_{t-1}	-0.78*	-1.68*	-2.58*	-3.60*	-4.62*	-5.76*	-7.12**	-8.71**	-10.38***	-16.16***
(t-stat)	(-1.66)	(-1.60)	(-1.61)	(-1.67)	(-1.77)	(-1.92)	(-2.13)	(-2.40)	(-2.68)	(-3.57)
R^2	0.03	0.04	0.05	0.05	0.06	0.06	0.07	0.08	0.09	0.13

*Table A3 reports results from regressions (4), (5), (6) and (7) for 1 to 9 and 12-month pure FFFs contracts. Sample: Monthly frequency, January 2005– (December minus n-months) 2019, where n refers to the maturity (in months) of the contract. Newey-West t-statistics are reported in brackets. Asterisks ***, **, * denote coefficients that are statistically significantly different from zero at the 1%, 5% and 10% significance levels (against a two-sided alternative) respectively. The t-statistics on the constants are not reported in Panel C1.*

Appendix B: FFFs portfolios and US OIS contracts

Horizons of FFFs and US OIS contracts

In general, the horizons of an *n*-month ahead FFFs contract and an *n*-month (*N*-day) US OIS contract, will not align. An n-month ahead FFFs contract, bought on any day in month *t*, will always settle at a price of 100 minus the daily average effective federal funds rate in month *t+n*. In comparison, two n-month (N-day) US OIS contracts traded on different business days in month *t* will have different horizons. For example, an n-month (N-day) US OIS contract purchased on day t_1 of month *t* will settle based on a strategy of rolling over federal funds loans from day t_3 to day t_{N+2} (due to a two-day spot lag); an n-month (N-day) US OIS contract purchased on day t_2 of month t will have a horizon spanning t_4 to t_{N+3}.

Portfolios of FFFs

An *n*-month FFFs portfolio is a portfolio of pure FFFs contracts with maturities of less than or equal to *n*.[7] For instance, a 3-month FFFs portfolio purchased in December 2018, would consist of the January, February and March 2019 pure FFFs contracts. An n-month FFFs portfolio that is traded on any day in month *t* has a horizon spanning the first day of month *t+1* to the last day of month *t+n*. The implied rate on a FFFs portfolio on a given day in month *t*, $i_{t,t+n}^{FFF,port}$, is calculated as a weighted average of the 1,2,…,*n*-month ahead FFFs rates, where the weight is the number of days in each month. Formally the interest rate on a FFFs portfolio is:

(8) $$i_{t,t+n}^{FFF,port} = \frac{1}{N}\sum_{j=1}^{n} N_j i_{t,t+j}^{FFF}$$

where N_j is the number of days in month *t+j* and N=$\sum_{j=1}^{n} N_j$ is the total number of days in months *t+1*,t+2,…,*t+n*.

Denote the daily arithmetic average of the effective federal funds rate from the start of month *t+1* to the end of month *t+n,* by $\overline{ffr}_{t,t+n}^{port} = \frac{1}{N}\sum_{j=1}^{n} N_j\, \overline{ffr}_{t+j}$. A n-month FFFs portfolio settles at a price of 100 minus this value.

The realised excess return on the hypothetical n-month FFFs portfolio is therefore:

(9) $$rx_{t,t+n}^{FFF,port} = i_{t,t+n}^{FFF,port} - \overline{ffr}_{t,t+n}^{port}$$

Since US OIS contracts have a two-day spot lag, their horizons will only align with FFFs portfolios on the penultimate business day of each month. An *n*-month US OIS contract, that is traded on the penultimate business day of month *t,* will have a horizon that spans the first day of month *t+1* to the final day of month *t+n*. This matches exactly with the horizon of an *n*-month FFFs portfolio.

As a result, I assess the realised excess returns on corresponding horizon FFFs portfolios and OIS contracts, on the penultimate business day of each month, as in Lloyd (2018).

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[7] Note that under this definition, the 1-month FFFs portfolio is simply the 1-month FFFs contract itself.

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