Risk-adjusted forecasts of oil prices

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Motivation

- Though the dependency of the global economic activity on crude oil has fallen steadily during the last thirty years, the oil price baseline assumption remains an important variable for all the macroeconomic forecasts
- Recent increases in nominal oil price have surprised most of the analysts for their rapidity and intensity
- A commonly used approach for forecasting oil prices relies on the prices of futures

Expectation Hypothesis

- Expectation Hypothesis is the crucial assumption for using futures as forecaster

- It says that futures are unbiased forecaster of the future spot price and hence forecast errors

$$fe_{t+n}^{(n)} = f_t^{(n)} - p_{t+n}.$$

  should be zero on average

- However, since oil spot price is highly correlated with economic activity, to reward investors for the risk entailed by holding the commodity expected spot prices should be above current futures (i.e. there is a *risk premium*)

Preview of results

We find that

- oil futures display significantly negative ex post forecast errors (=-risk premium), larger the longer the forecast horizon …
- … that vary systematically over the business cycle (risk premium tends to be anti-cyclical)
- This is particularly so especially after mid-1990s (Structural stability)
- Forecast errors are predictable using US business cycle indicators
- In a “horse-race” among forecasters, cyclical-adjusted futures give the best results

Related literature

- Other authors found a risk premium in oil futures
  - Gorton and Rouwenhorst ('04), Pindyck ('01)
  - Moosa and AL-Lougani ('94), Considine and Larson ('01), Coimbra and Esteves ('04)

- The empirical failure of expectation hypothesis, and hence the poor performance of futures as forecaster, has for instance been documented with respect to
  - US Treasury Yields (e.g. Fama and Bliss '87, Stambaugh '88, Campbell and Shiller '91, Cochrane and Piazzesi '02)
  - US Federal Funds (Piazzesi and Swanson '04)

Forecast errors/1

We run the following regression

$$fe_{t+n}^{(n)} = \alpha^{(n)} + \varepsilon_{t+n}^{(n)},$$

Results show that oil futures

- display significantly negative ex post forecast errors (larger the longer the forecast horizon) Tav.1

To investigate whether futures-based forecast errors display a cyclical component we run the following regression

$$fe_{t+n}^{(n)} = \alpha^{(n)} + \beta^{(n)} UCap_{t-1} + \varepsilon_{t+n}^{(n)},$$

Results show that futures-based forecast errors are significantly positively correlated with utilized capacity in US manufacturing Tav.2

skipstab

Table 1

Constant risk premia (whole sample: 1986:1-2004:12)

n	constant	
1	-.15	(.15)
2	-.45*	(.25)
3	-.84**	(.35)
4	-1.18***	(.45)
5	-1.48***	(.55)
6	-1.76***	(.65)
7	-2.01***	(.74)
8	-2.24***	(.85)
9	-2.45***	(.94)
10	-2.69**	(1.11)
11	-2.98**	(1.29)
12	-3.14**	(1.38)

Notes: estimation by OLS. Newey-West HAC standard error in parentheses.* denotes significance at 10 per cent; ** denotes significance at 5 per cent; *** denotes significance at 1 per cent.

Results /1

Table 2

Time-varying risk premia and capacity utilization (whole sample: 1986:1-2004:12)

n	constant		capacity$_{t-1}$	
1	-1.54	(3.91)	0.02	(0.05)
2	-6.77	(6.51)	0.08	(0.08)
3	-12.46	(8.35)	0.14	(0.10)
4	-18.25*	(10.09)	0.21*	(0.12)
5	-25.14**	(11.95)	0.29**	(0.15)
6	-32.09**	(13.71)	0.38**	(0.17)
7	-38.41**	(15.49)	0.45**	(0.19)
8	-44.50**	(17.50)	0.53**	(0.22)
9	-49.65**	(19.35)	0.59**	(0.24)
10	-53.63**	(21.51)	0.64**	(0.26)
11	-60.40**	(23.79)	0.72**	(0.29)
12	-64.23**	(25.88)	0.76**	(0.32)

Notes: estimation by OLS. Newey-West HAC standard error in parentheses.* denotes significance at 10 per cent; ** denotes significance at 5 per cent; *** denotes significance at 1 per cent.

Stability

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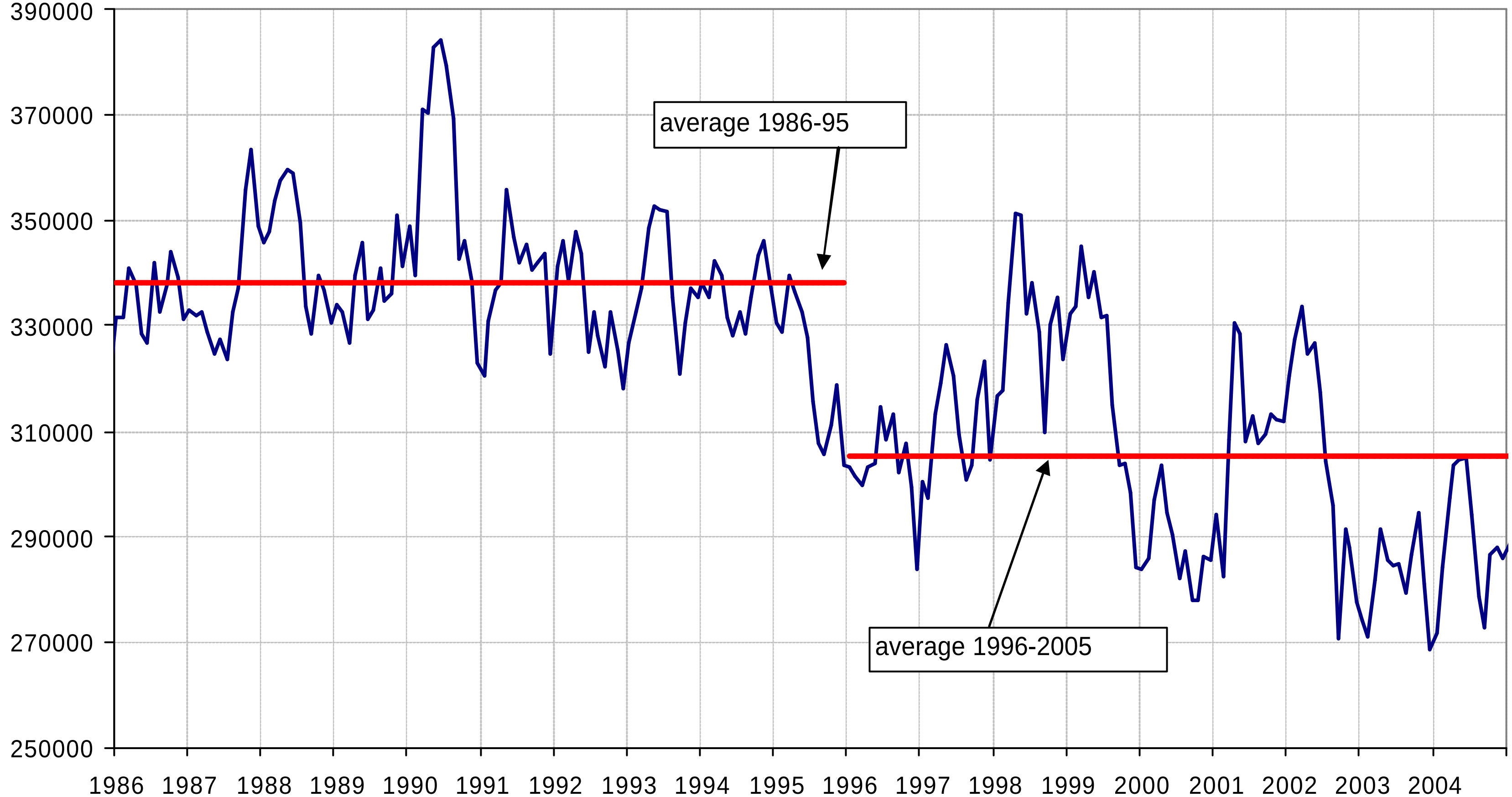
Structural Stability

- Recursive residuals reveal the possibility of a structural break in the mid-1990s
- This could be due to the fact that in that period the oil industry moved to "just-in-time inventories" (figinv) …
- … which may have induced higher price volatility (figvola)
- … and higher sensitivity to business cycle indicators. Our tests suggest to concentrate on the period starting in 1996.

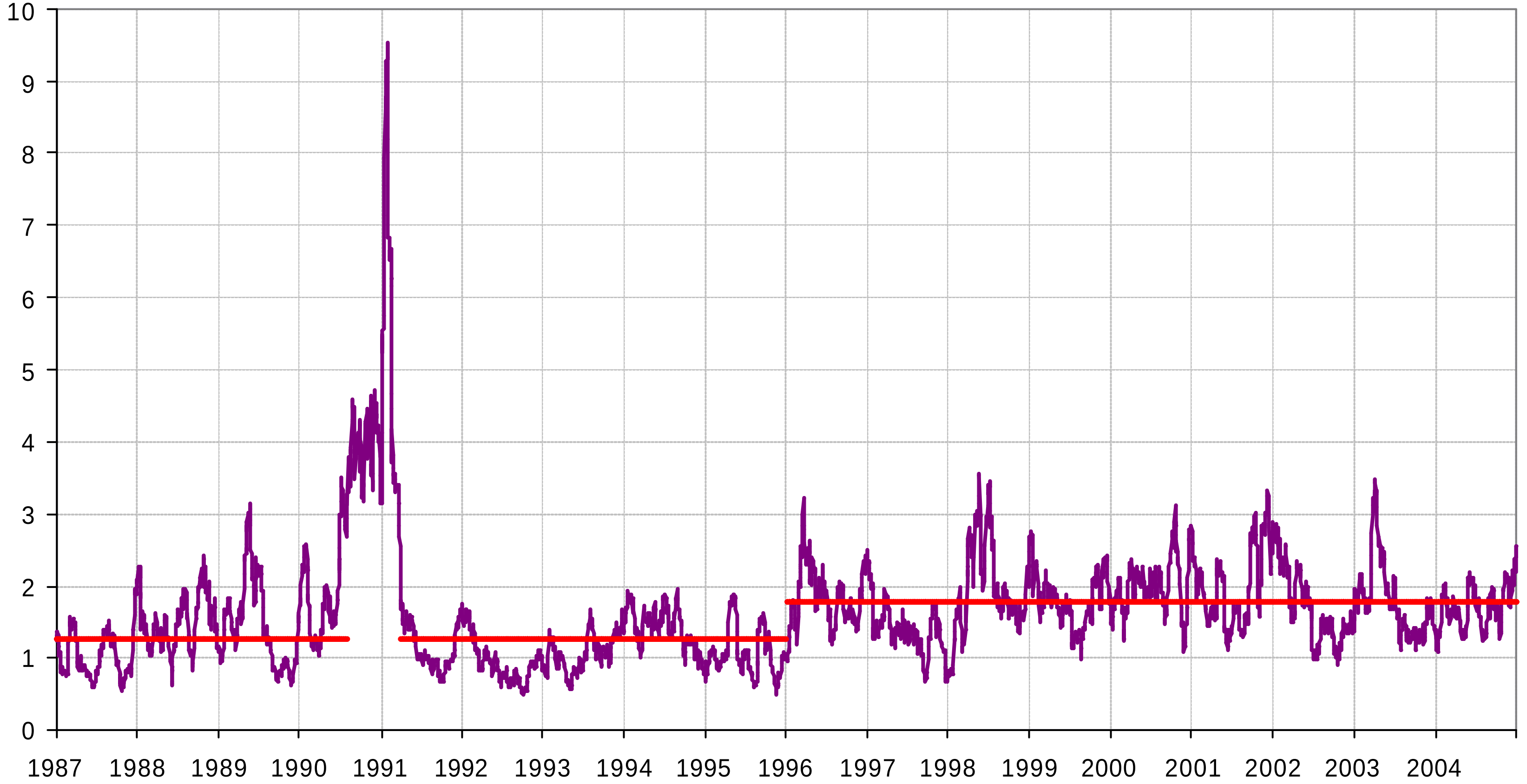
Fore /2

US crude oil ending stocks



sstab

oil spot price volatility



one-month moving average of absolute daily percentage change

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Forecast errors/2

When we concentrate on the sub-period starting in January 1996, we find that futures-based forecast errors

- display a larger sensitivity to utilized capacity in US manufacturing Tav.6

- Robustness 1: year-on-year growth in non farm payrolls or industrial production provide qualitatively similar results.
- Robustness 2: forward-looking indicators significant only at 3-6 month horizons.
- Robustness 3: Chinese industrial production shows no correlation at all with forecast errors.

china

Table 6

Time-varying risk premia and capacity utilization (sample: 1996:1-2004:12)

n	constant		capacity$_{t-1}$		R^2
1	-4.19	(5.28)	.05	(.07)	.00
2	-11.95	(8.39)	.14	(.10)	.02
3	-20.85*	(10.85)	.25*	(.14)	.05
4	-29.73**	(13.18)	.35**	(.17)	.08
5	-40.18**	(15.76)	.48**	(.20)	.12
6	-50.39***	(18.25)	.61**	(.23)	.15
7	-60.66***	(20.29)	.73***	(.26)	.19
8	-71.13***	(22.47)	.86***	(.29)	.22
9	-80.90***	(24.28)	.98***	(.31)	.26
10	-91.06***	(25.76)	1.10***	(.33)	.31
11	-101.17***	(27.26)	1.23***	(.35)	.35
12	-110.18***	(28.50)	1.34***	(.36)	.38

Notes: estimation by OLS. Newey-West HAC standard error in parentheses.* denotes significance at 10 per cent; ** denotes significance at 5 per cent; *** denotes significance at 1 per cent.

Forerr2

Table 8

Time-varying risk premia and Chinese industrial production (sample: 1996:1-2004:12)

n	constant		capacity_{t-1}		$\text{Chinese ind. prod.}_{t-2}$	
1	-3.77	(5.37)	.05	(.07)	-1.73	(6.05)
2	-10.28	(8.97)	.13	(.11)	-6.91	(9.45)
3	-17.76	(11.55)	.23	(.14)	-13.00	(12.70)
4	-26.06*	(13.60)	.33**	(.17)	-15.64	(16.13)
5	-37.03**	(15.51)	.46**	(.20)	-13.70	(16.51)
6	-48.01***	(17.33)	.59**	(.22)	-10.63	(19.38)
7	-60.37***	(20.07)	.73***	(.26)	-1.37	(19.72)
8	-69.81***	(21.31)	.85***	(.28)	-6.51	(23.91)
9	-79.65***	(22.92)	.97***	(.30)	-6.92	(28.43)
10	-89.57***	(24.50)	1.10***	(.32)	-7.74	(30.28)
11	-99.49***	(26.51)	1.22***	(.34)	-9.32	(31.54)
12	-110.79***	(28.66)	1.34***	(.37)	3.68	(31.24)

Notes: estimation by OLS. Newey-West HAC standard error in parentheses.* denotes significance at 5 per cent; ** denotes significance at 1 per cent

Forecasting/1

We can use these results to build "adjusted" forecasts of oil prices such as

$$E_t\left[p_{t+n}\right] = f_t^{(n)} \underbrace{- \hat{\alpha}^{(n)} - \hat{\beta}^{(n)} UCap_{t-1}}_{+\ Risk\ Premium}$$

and compare it to three other methodologies

1) Random walk
2) Unadjusted futures
3) Constant-adjusted futures

More formally: we run rolling end-point (expanding window) and moving window regressions

Tables 9/10

Out-of-the sample forecasts of oil price (expanding window; sample 1996:1-2004:12)

	benchmark			futures based								
	random walk			unadjusted			constant-adjusted			risk-adjusted		
n	ME	SE	ρ_n	ME	SE	ρ_n	ME	SE	ρ_n	ME	SE	ρ_n
1	-.40	2.90	-.14	-.43	2.96	-.13	-.27	2.97	-.13	.13	3.04	-.10
2	-.85	3.87	-.16	-1.14	3.85	-.15	-.73	3.76	-.16	-.11	3.85	-.10
3	-1.38	4.56	-.10	-1.99	4.60	-.04	-1.32	4.35	-.04	-.45	4.41	.00
4	-1.86	5.14	.00	-2.79	5.38	.09	-1.89	4.94	.09	-.65	4.93	.11
5	-2.36	5.64	.06	-3.61	6.15	.14	-2.47	5.51	.16	-.69	5.37	.13
6	-2.81	6.35	.09	-4.37	7.00	.15	-2.98	6.20	.18	-.63	5.89	.11
7	-3.21	6.95	.06	-5.06	7.77	.13	-3.45	6.82	.17	-.41	6.29	.01
8	-3.67	7.57	.01	-5.76	8.46	.09	-3.94	7.36	.13	-.09	6.61	.07
9	-4.03	8.04	-.04	-6.34	9.04	.05	-4.35	7.81	.09	.29	6.85	.05
10	-4.37	8.56	-.13	-6.86	9.58	-.01	-4.74	8.23	.02	.77	7.04	.03
11	-4.70	9.14	-.16	-7.36	10.09	-.08	-5.08	8.65	-.04	1.34	7.22	.02
12	-5.03	9.74	-.21	-7.84	10.61	-.14	-5.46	9.09	-.11	1.70	7.42	.01

Notes: n is the forecasting horizon. ME is the mean error (in US dollars), SE is the root mean squared error (in US dollars) and ρ_n is the nth autocorrelation of the forecast error.

Out-of-the sample forecasts of oil price (expanding window; sample 1996:1-2004:12)

	benchmark			futures based								
	random walk			unadjusted			constant-adjusted			risk-adjusted		
n	ME	SE	ρ_n	ME	SE	ρ_n	ME	SE	ρ_n	ME	SE	ρ_n
1	-.40	2.90	-.14	-.43	2.96	-.13	-.27	2.97	-.13	.13	3.04	-.10
2	-.85	3.87	-.16	-1.14	3.85	-.15	-.73	3.76	-.16	-.11	3.85	-.10
3	-1.38	4.56	-.10	-1.99	4.60	-.04	-1.32	4.35	-.04	-.45	4.41	.00
4	-1.86	5.14	.00	-2.79	5.38	.09	-1.89	4.94	.09	-.65	4.93	.11
5	-2.36	5.64	.06	-3.61	6.15	.14	-2.47	5.51	.16	-.69	5.37	.13
6	-2.81	6.35	.09	-4.37	7.00	.15	-2.98	6.20	.18	-.63	5.89	.11
7	-3.21	6.95	.06	-5.06	7.77	.13	-3.45	6.82	.17	-.41	6.29	.01
8	-3.67	7.57	.01	-5.76	8.46	.09	-3.94	7.36	.13	-.09	6.61	.07
9	-4.03	8.04	-.04	-6.34	9.04	.05	-4.35	7.81	.09	.29	6.85	.05
10	-4.37	8.56	-.13	-6.86	9.58	-.01	-4.74	8.23	.02	.77	7.04	.03
11	-4.70	9.14	-.16	-7.36	10.09	-.08	-5.08	8.65	-.04	1.34	7.22	.02
12	-5.03	9.74	-.21	-7.84	10.61	-.14	-5.46	9.09	-.11	1.70	7.42	.01

Notes: n is the forecasting horizon. ME is the mean error (in US dollars), SE is the root mean squared error (in US dollars) and ρ_n is the nth autocorrelation of the forecast error.

Out-of-the sample forecasts of oil price (expanding window; sample 1996:1-2004:12)

	benchmark			futures based								
	random walk			unadjusted			constant-adjusted			risk-adjusted		
n	ME	SE	ρ_n	ME	SE	ρ_n	ME	SE	ρ_n	ME	SE	ρ_n
1	-.40	2.90	-.14	-.43	2.96	-.13	-.27	2.97	-.13	.13	3.04	-.10
2	-.85	3.87	-.16	-1.14	3.85	-.15	-.73	3.76	-.16	-.11	3.85	-.10
3	-1.38	4.56	-.10	-1.99	4.60	-.04	-1.32	4.35	-.04	-.45	4.41	.00
4	-1.86	5.14	.00	-2.79	5.38	.09	-1.89	4.94	.09	-.65	4.93	.11
5	-2.36	5.64	.06	-3.61	6.15	.14	-2.47	5.51	.16	-.69	5.37	.13
6	-2.81	6.35	.09	-4.37	7.00	.15	-2.98	6.20	.18	-.63	5.89	.11
7	-3.21	6.95	.06	-5.06	7.77	.13	-3.45	6.82	.17	-.41	6.29	.01
8	-3.67	7.57	.01	-5.76	8.46	.09	-3.94	7.36	.13	-.09	6.61	.07
9	-4.03	8.04	-.04	-6.34	9.04	.05	-4.35	7.81	.09	.29	6.85	.05
10	-4.37	8.56	-.13	-6.86	9.58	-.01	-4.74	8.23	.02	.77	7.04	.03
11	-4.70	9.14	-.16	-7.36	10.09	-.08	-5.08	8.65	-.04	1.34	7.22	.02
12	-5.03	9.74	-.21	-7.84	10.61	-.14	-5.46	9.09	-.11	1.70	7.42	.01

Notes: n is the forecasting horizon. ME is the mean error (in US dollars), SE is the root mean squared error (in US dollars) and ρ_n is the nth autocorrelation of the forecast error.

Out-of-the sample forecasts of oil price (moving window: sample 1996:1-2004:12)

	benchmark		futures based				
	random walk		unadjusted		constant adj.		risk adj.
n	SE	D-M	SE	D-M	SE	D-M	SE
1	2.90	0.97	2.96	0.97	3.02	0.85	3.18
2	3.88	0.79	3.85	0.88	3.88	0.56	4.07
3	4.56	0.72	4.60	0.76	4.50	0.47	4.63
4	5.14	0.76	5.38	0.63	5.12	0.40	5.10
5	5.64	0.69	6.15	0.38	5.71	0.25	5.46
6	6.36	0.41	7.00	0.14	6.43	0.08	6.03
7	6.95	0.27	7.77	0.07	7.08	0.03	6.48
8	7.57	0.10	8.46	0.02	7.61	0.01	6.71
9	8.04	0.04	9.04	0.01	8.06	0.00	6.87
10	8.56	0.01	9.58	0.00	8.45	0.00	6.98
11	9.14	0.00	10.09	0.00	8.83	0.00	6.94
12	9.74	0.00	10.61	0.00	9.21	0.00	6.96

Notes: n is the forecasting horizon. SE is the root mean squared error (in US dollars), D-M is the P-value of the Diebold-Mariano test: the null hypothesis is no difference in the forecasting precision between the model considered and the cyclically adjusted future; the alternative hypothesis is that the cyclically adjusted future produces better forecasts. The risk adjusted root mean square error is obtained by running regression (3) on a moving window of 30 monthly observations.

examples

Forecasting/2

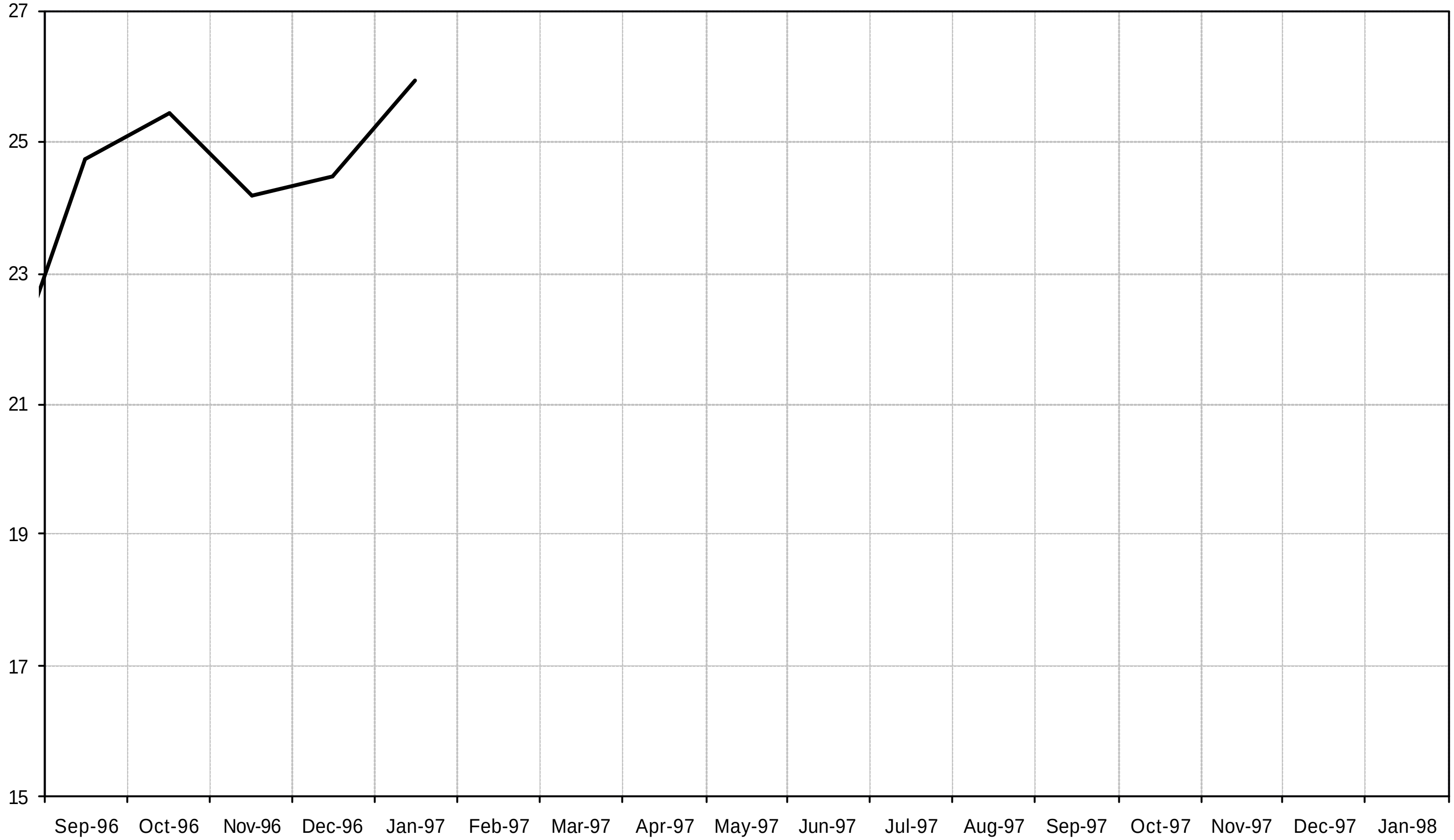
Two examples

1. January 1997

fig(1997)

2. September 2003

fig(2003)



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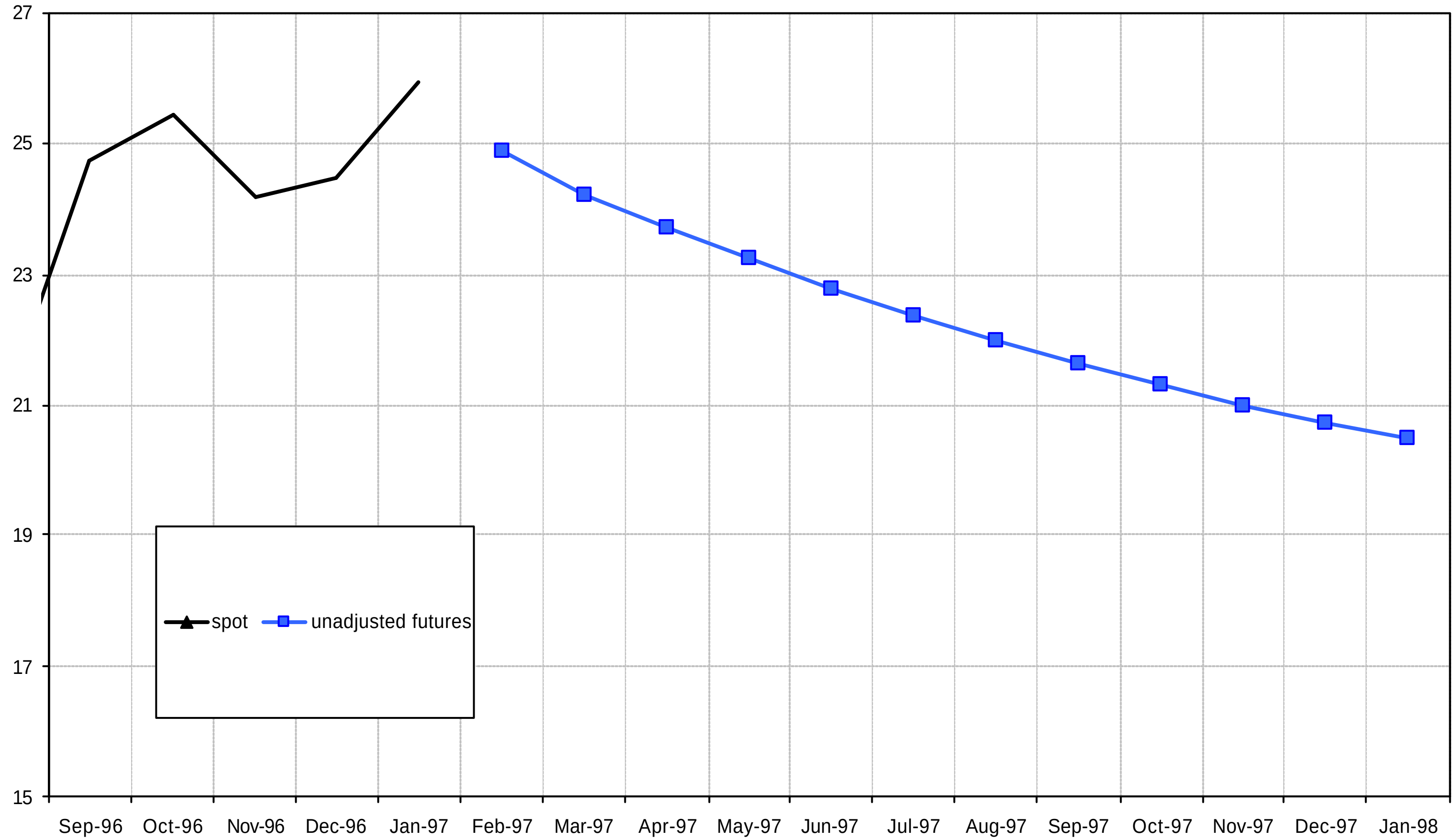

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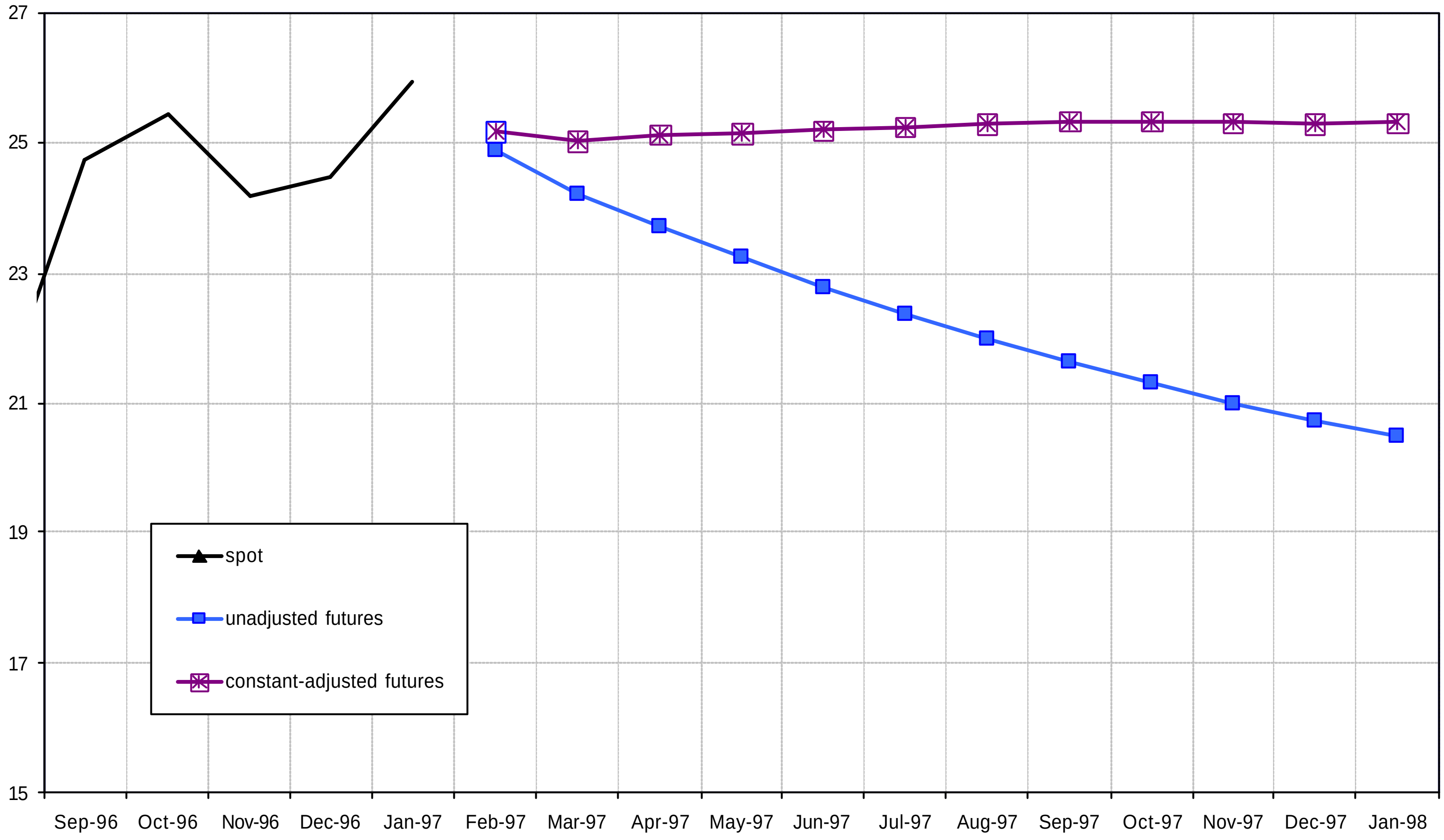
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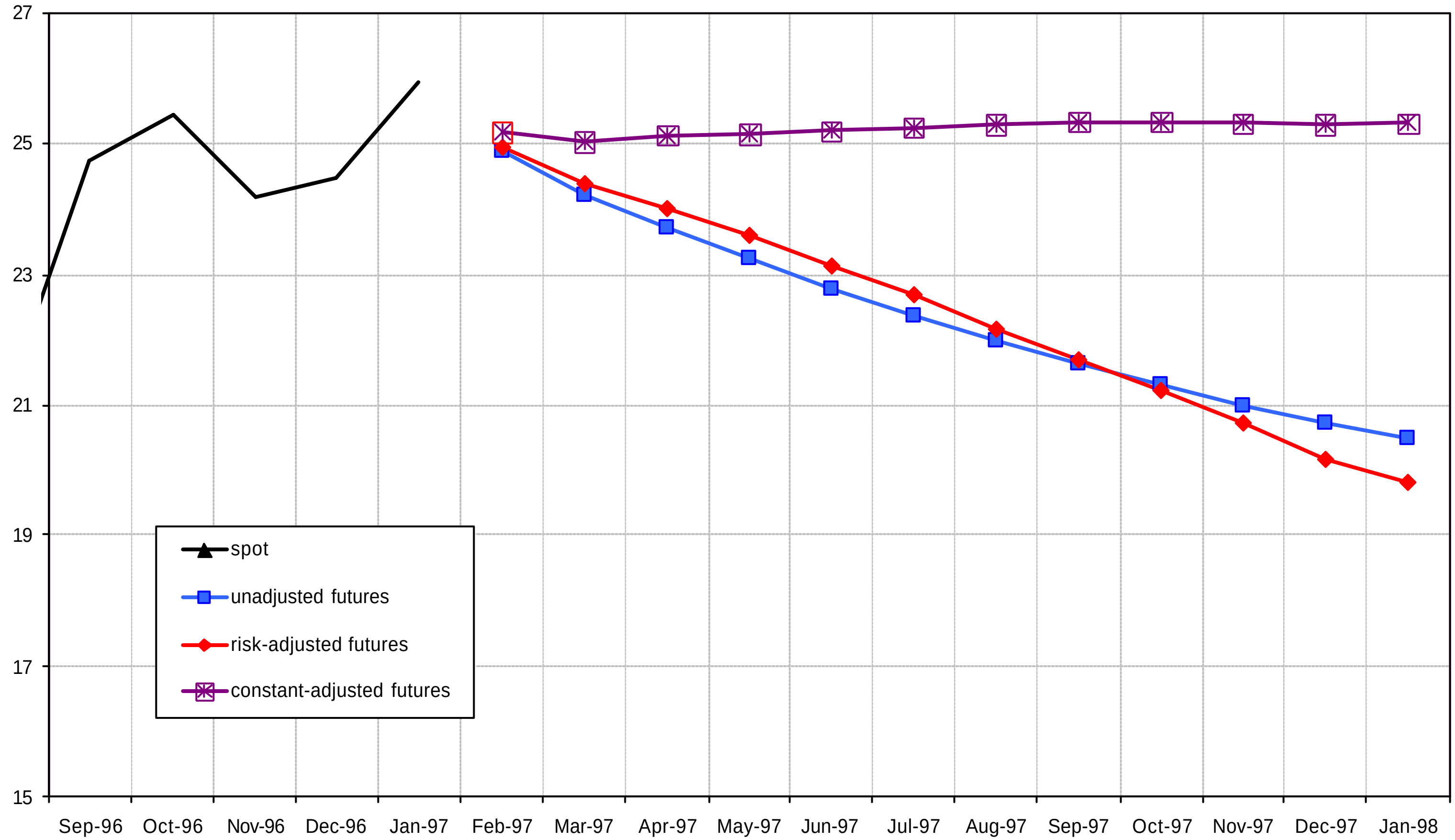
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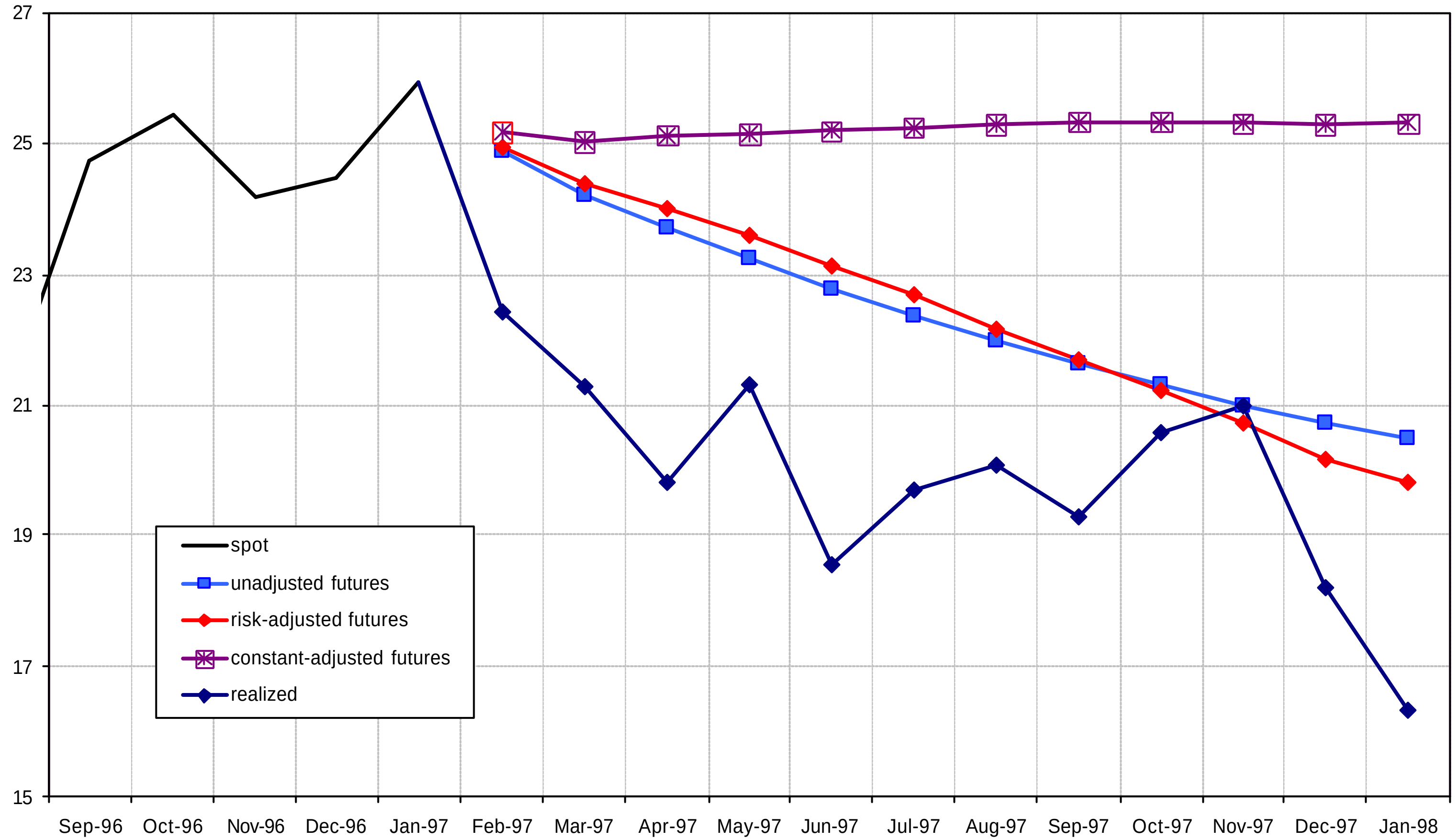
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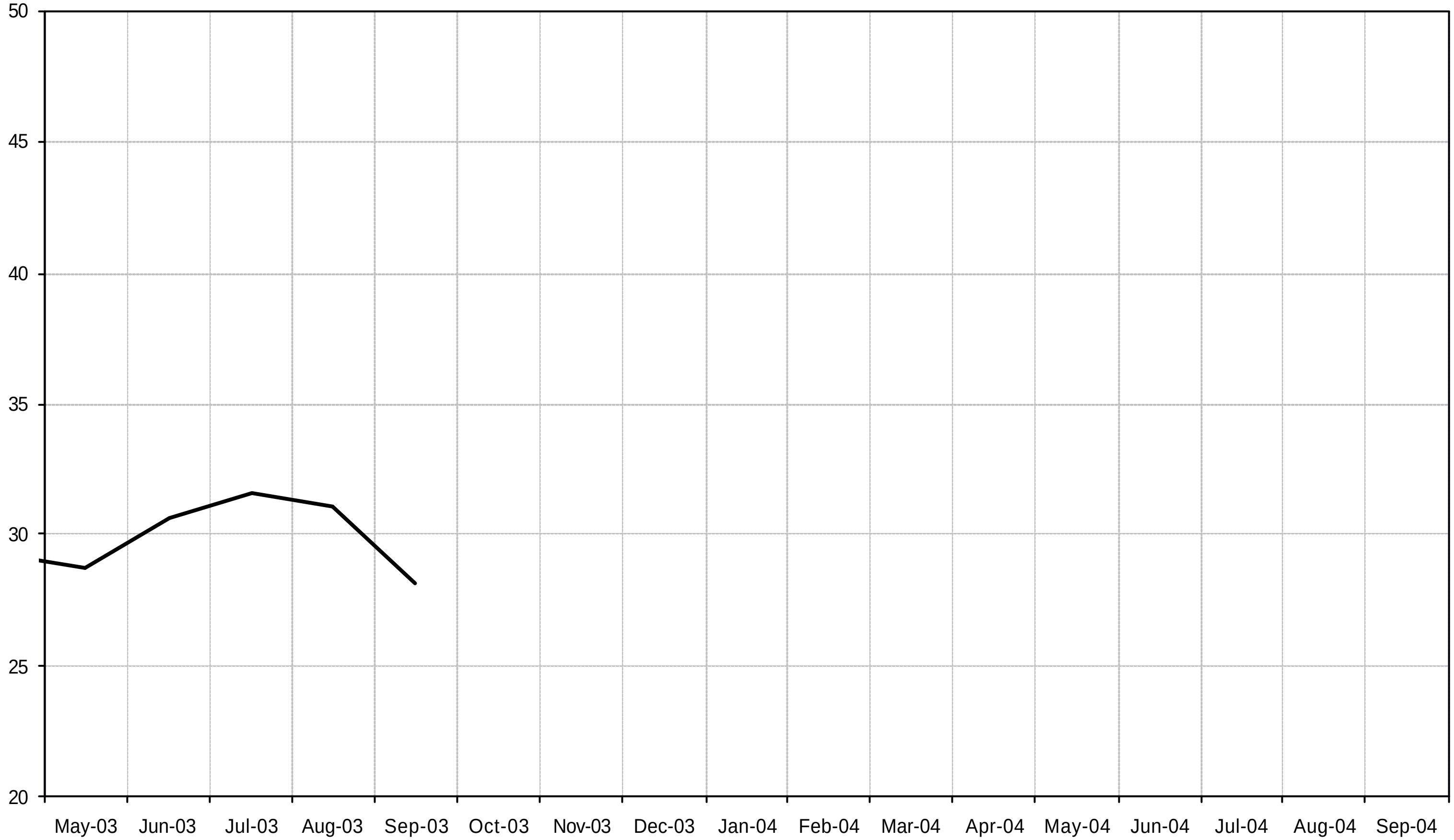
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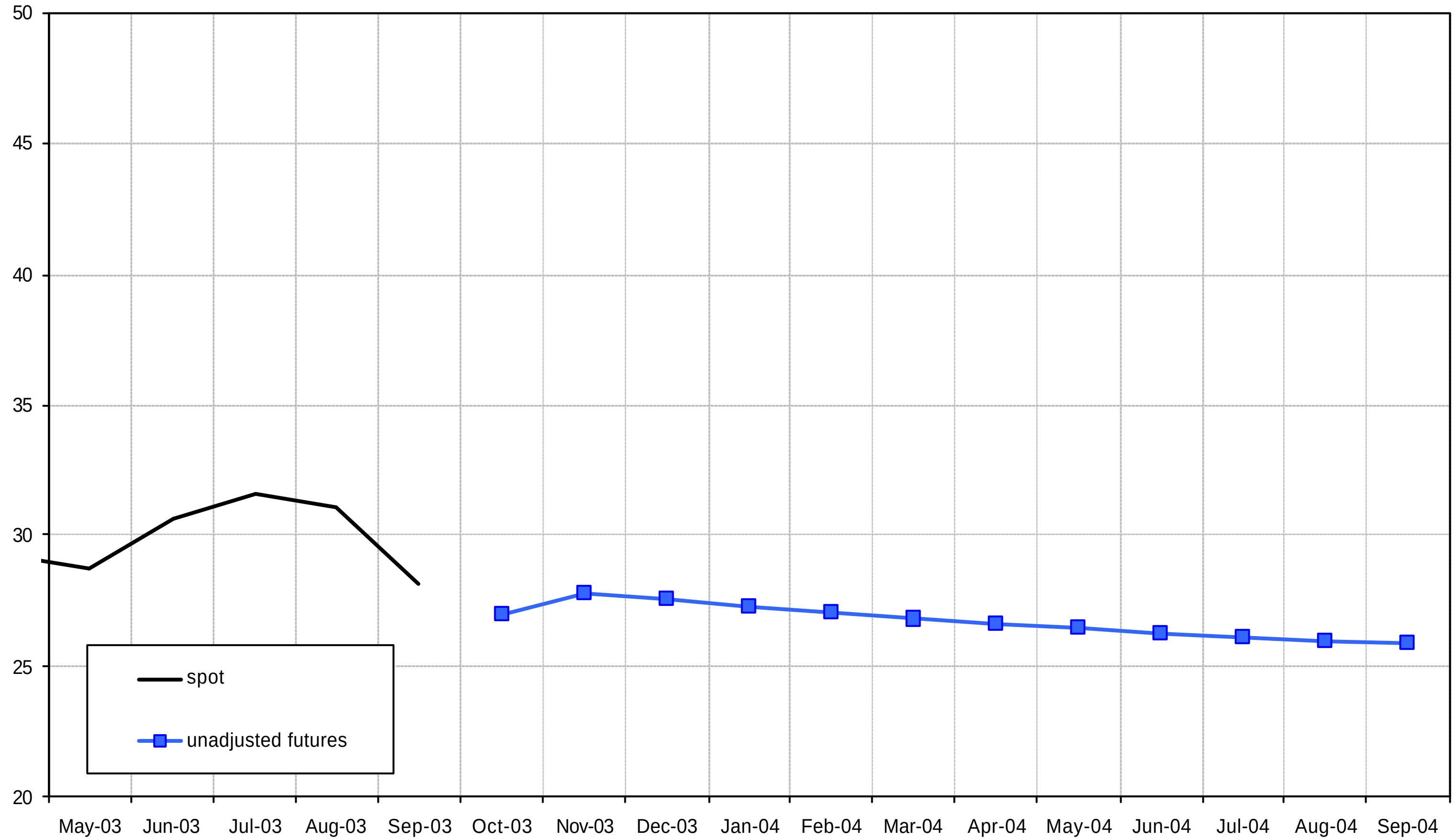

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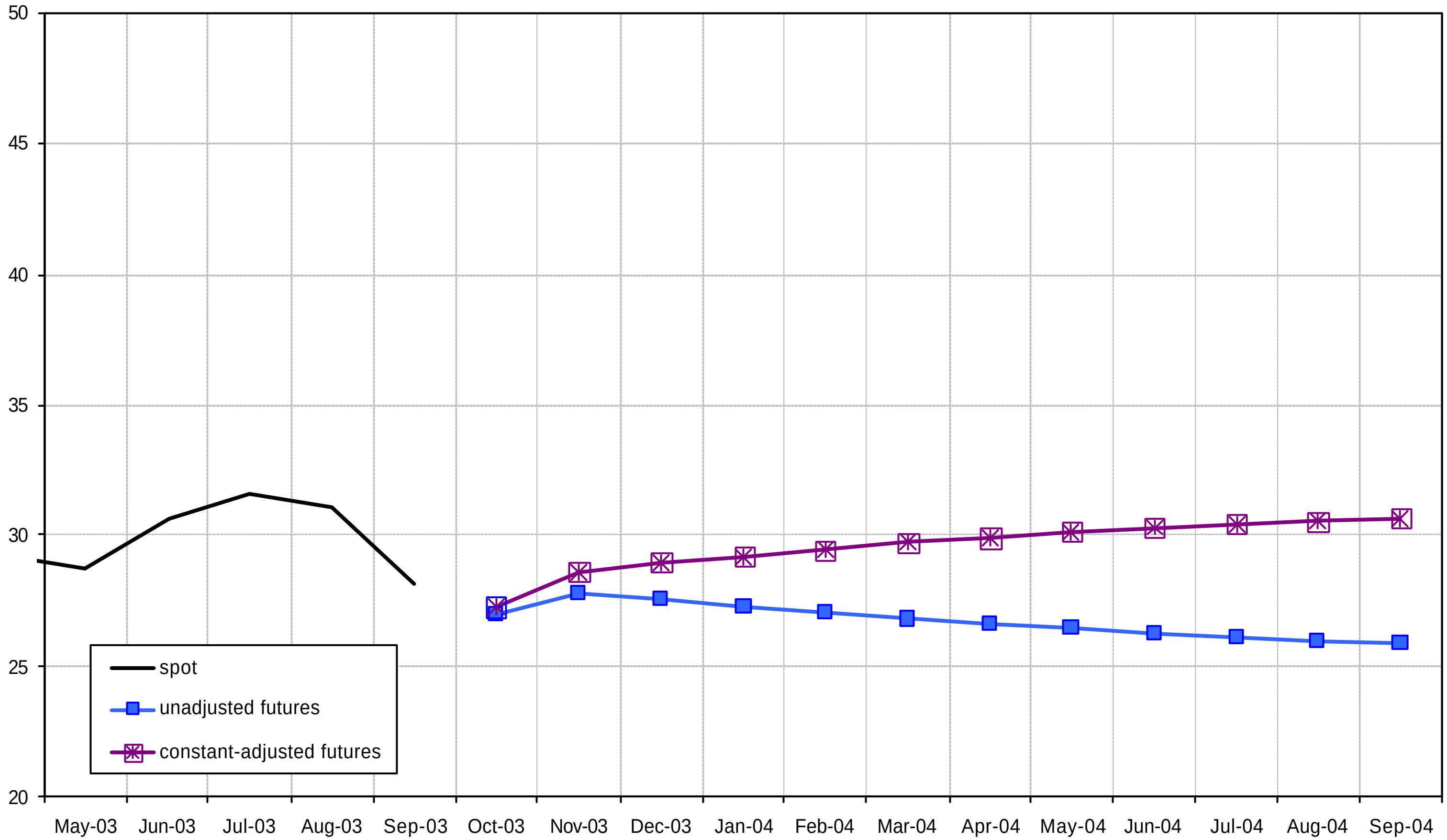
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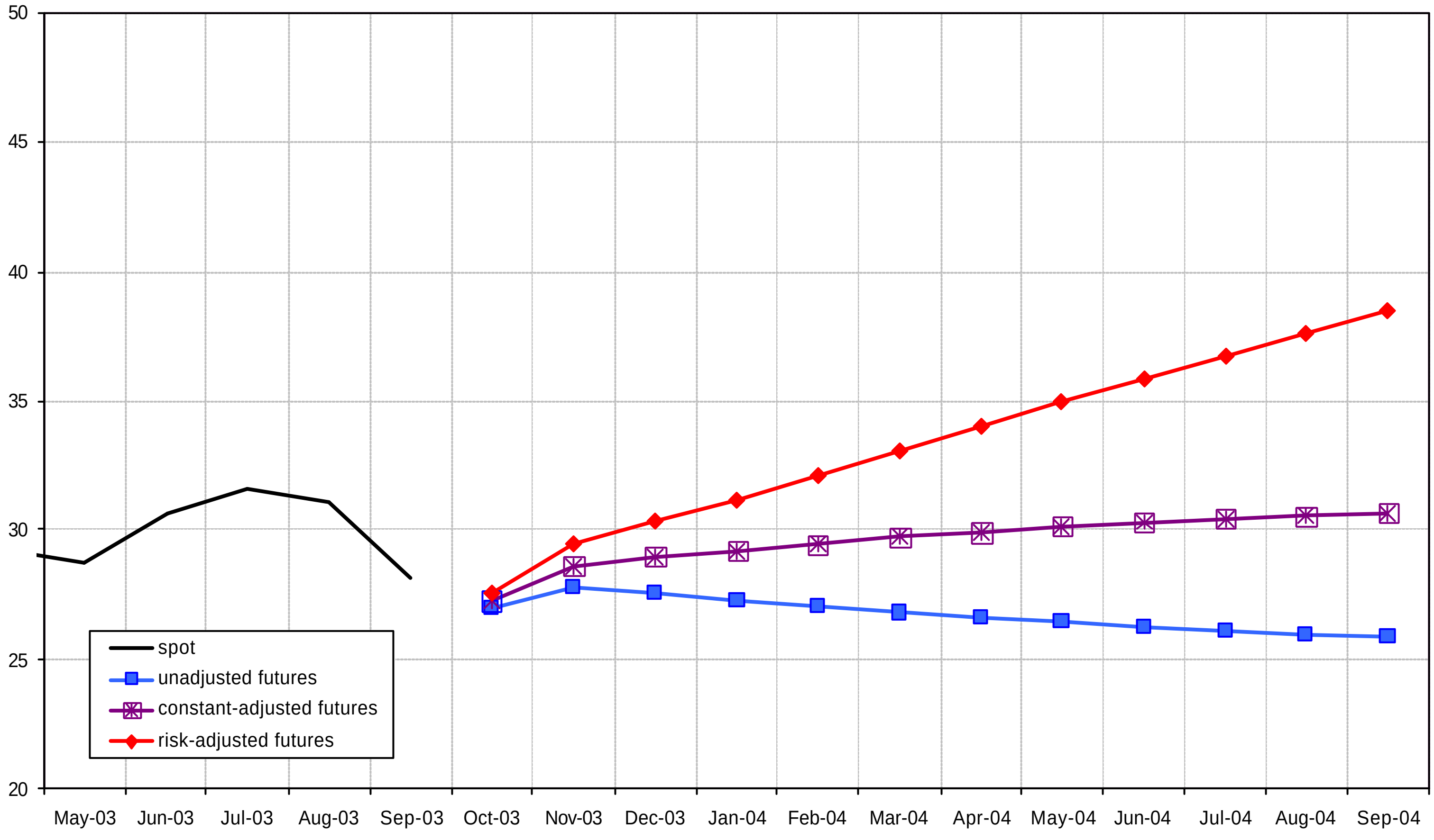
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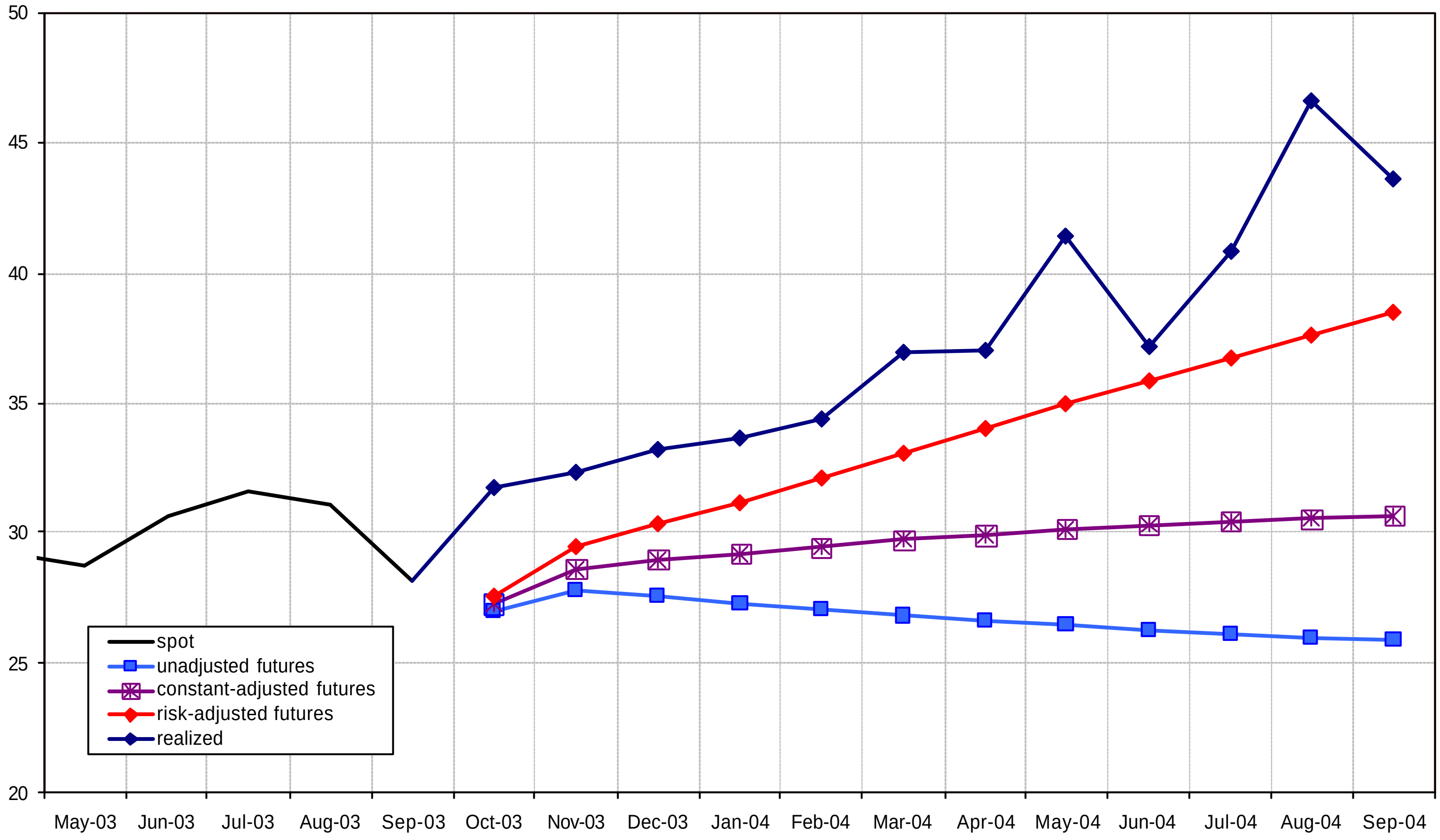

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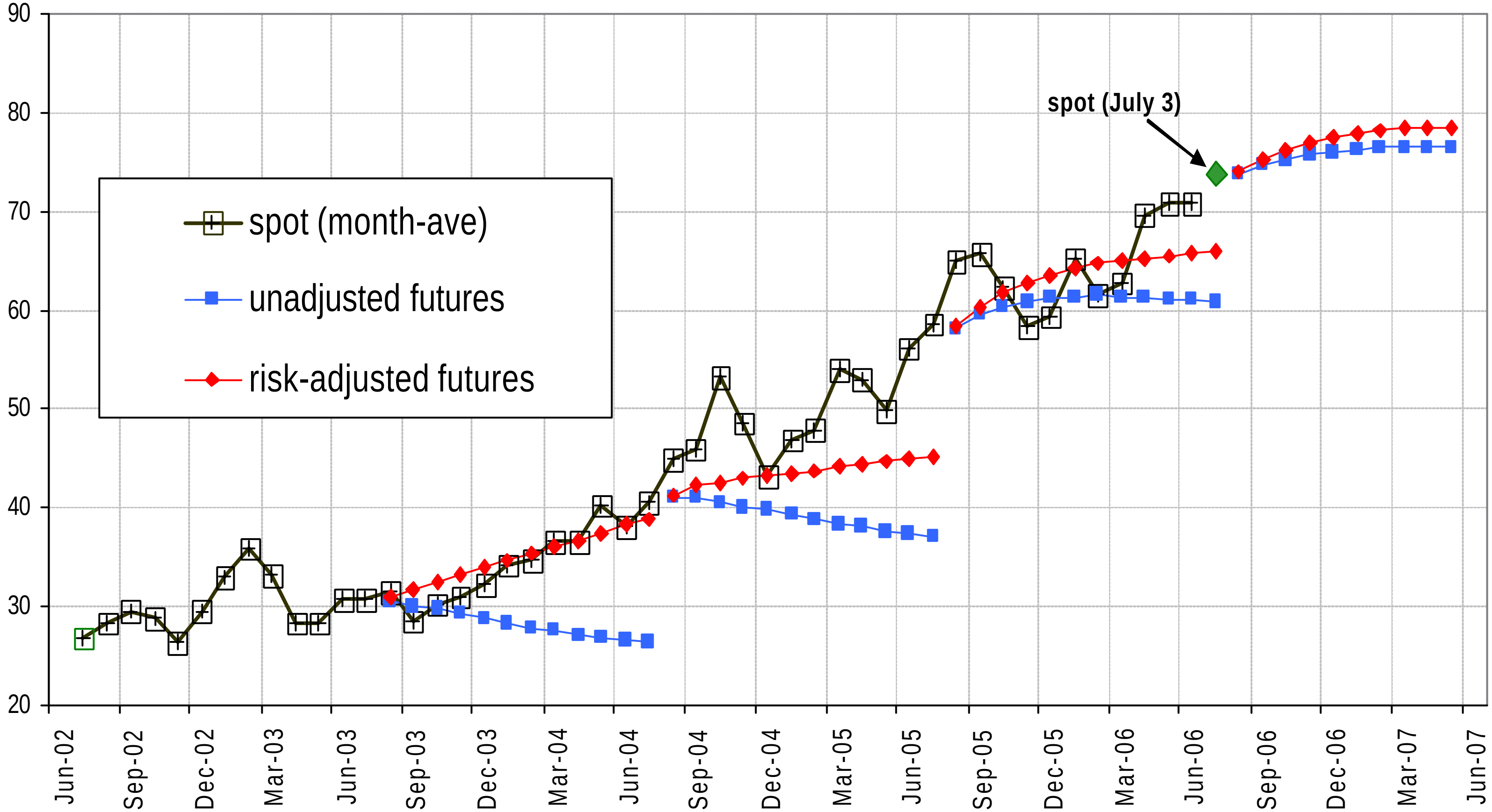
where?

Where do we go from here?



Concluding remarks

- Crude oil futures display a significant ex-post forecast error, which is negative on average (i.e. they underpredict prices) and time-varying
- These “risk-premia” are strongly countercyclical. Not taking them into account may yield high errors, especially in downturns
- This adjustment may be exploited to better identify unexpected oil price changes (“shocks”)

Thanks!