



Arik Ben Dor
+1 212 526 7713
arik.bendor@barclays.com
BCI, US

Carlo Rosa
+1 212 526 4168
carlo.rosa@barclays.com
BCI, US

Exploiting Intraday Return Predictability in European Markets

September 2019

Barclays Capital Inc. and/or one of its affiliates does and seeks to do business with companies covered in its research reports. As a result, investors should be aware that the firm may have a conflict of interest that could affect the objectivity of this report. Investors should consider this report as only a single factor in making their investment decision.

PLEASE SEE ANALYST CERTIFICATIONS AND IMPORTANT DISCLOSURES STARTING AFTER PAGE 44.

Overview

- There is evidence of positive autocorrelation at the index and single-stock level in the U.S. between overnight returns and returns during the last half-hour trading on the next day (Heston et al., 2010; Gao et al., 2018, Deshpande et al., 2017)
- **Economic rationale:** The intraday momentum may be driven by some institutional investors (such as Index funds) rebalancing their portfolios infrequently and/or the presence of late-informed investors who trade the overnight information in the last half-hour (Bogousslavsky, 2016)

References

- Bogousslavsky, V., 2016. Infrequent rebalancing, return autocorrelation, and seasonality. The Journal of Finance, 71(6), pp. 2967-3006.
- Deshpande, M.S., Chawla, J., Sen, A., Xu, J., [2017](#). Impact of intra-day hedging on volatility selling strategies. Barclays Research, 6 November 2017.
- Gao, L., Han, Y., Li, S.Z. and Zhou, G., 2018. Market intraday momentum. Journal of Financial Economics, 129(2), pp. 394-414.
- Heston, S.L., Korajczyk, R.A. and Sadka, R., 2010. Intraday patterns in the cross-section of stock returns. The Journal of Finance, 65(4), pp. 1369-1407.

Objective of This Study

- Assess the extent of the intraday return predictability present in European markets
- Develop a trading strategy that exploits such predictability

Key Results

- We find strong intraday predictability in **European markets** (UK, France, Germany and Italy): overnight returns can be used to forecast the returns of the last 30min of the next trading day
 - Effects are non-linear and concentrated in the largest overnight returns
- An **Intraday momentum strategy** that exploits this predictability by going long (or short) the index in the last half hour when its overnight return is positive (or negative) generates annual average returns above 4% and Sharpe ratios above 1
 - Introducing thresholds (i.e., trading only when the overnight returns are large enough) boosts the Sharpe ratio above 3 but are used less frequently
- The returns of a strategy based on this intraday return predictability are uncorrelated with standard European daily risk factors and display highly significant alpha

Road Map

Data and Methodology



Predictive Regressions



Strategy Performance



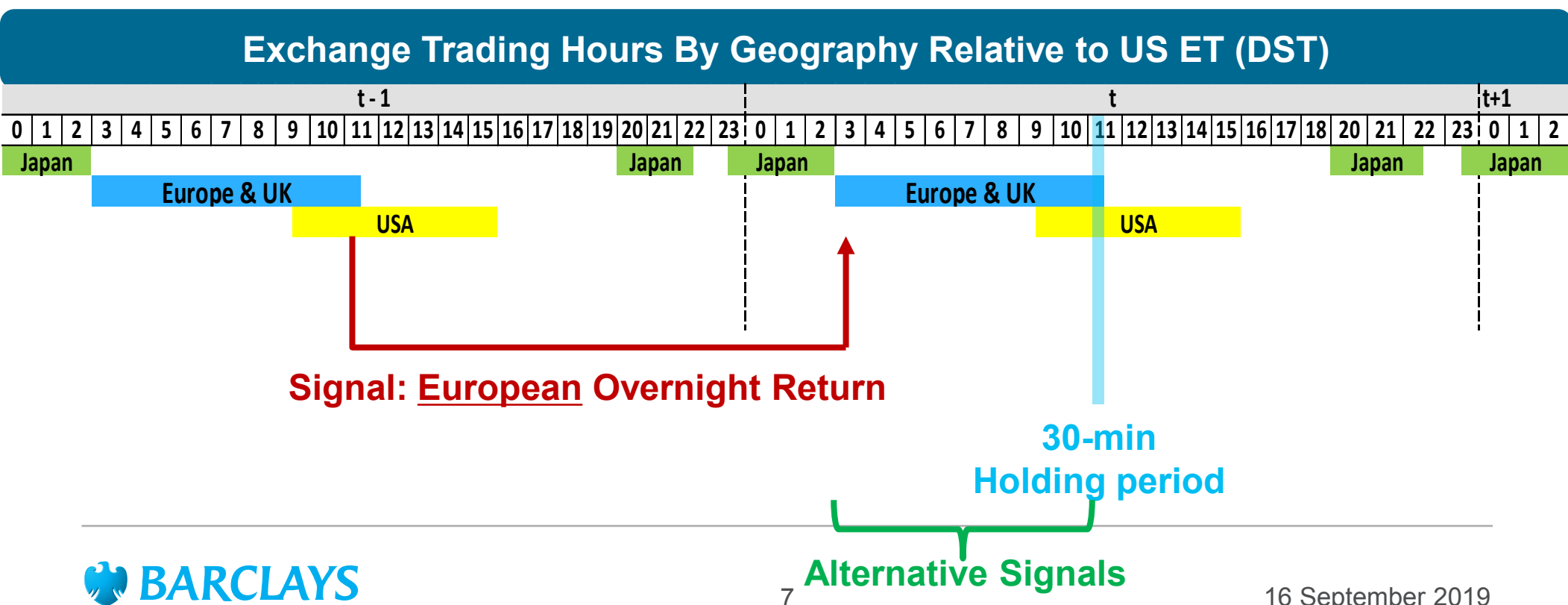
Diversification Benefits

Data and Methodology

Data

- Intraday data (front-month futures contracts) on key European markets with liquid futures:

Country	Index
UK	FTSE 100
Germany	DAX 30
France	CAC 40
Italy	MIB FTSE



Methodology

Two approaches to assess predictability:

- 1. Statistical approach:** Predict the last half-hour return (dependent variable) using:
 - Overnight return (i.e., the first half-hour return from the previous day's market close)
 - Overnight return & second-to-last half-hour return
- 2. Economic approach:** Intraday Momentum Strategy to trade the index in the last 30-min before market close

Signal		Trade open	Trade close
Overnight return > 0	\Rightarrow	Buy the index in the last 30-min before market close	Unwind the trade at market close
Overnight return < 0	\Rightarrow	Sell the index in the last 30-min before market close	Unwind the trade at market close

Statistical Approach: Predictive Regressions

Predictability Is Present in European Markets

- The overnight return predicts the last 30-min return in UK, Germany, France and Italy
- The second-to-last 30-min return does not predict the last 30-min return (contrary to US)
- Same-day (intraday) returns display limited predictability of the last 30-min returns (see *Appendix*)

The Dependent Variable is the 30-min Return (in %) Before Market Close

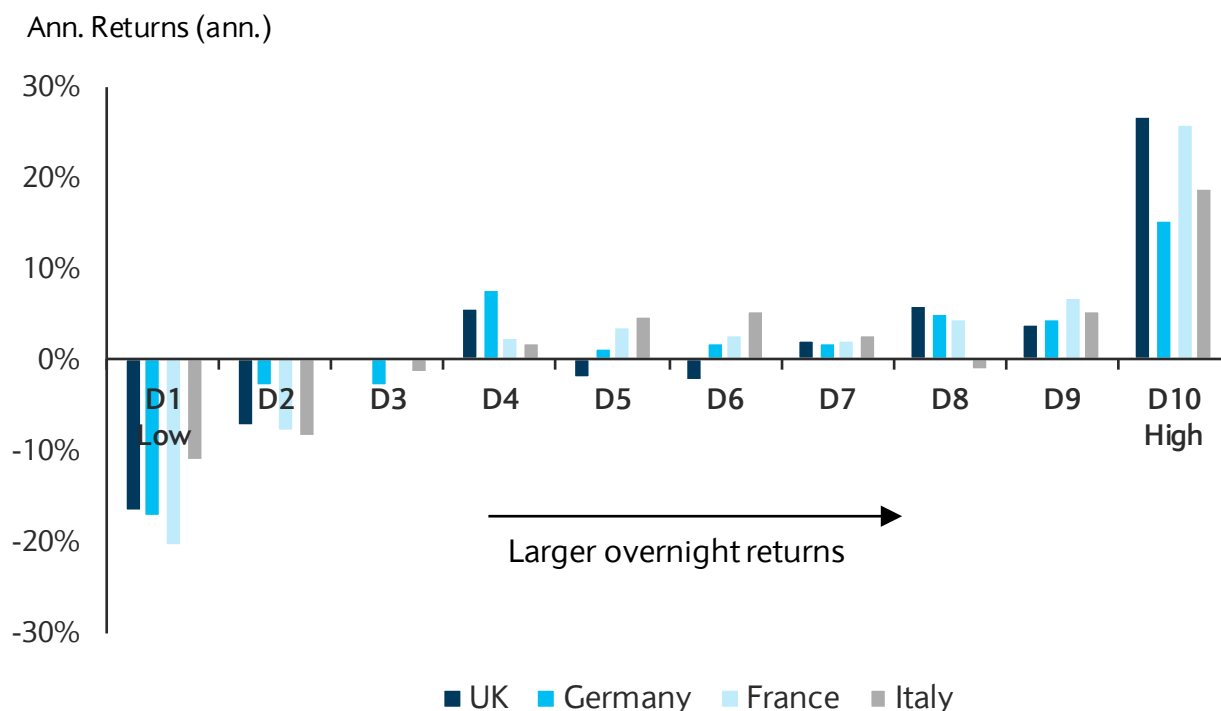
	UK (2000-2019)		Germany (2000-2019)		France (2000-2019)		Italy (2004-2019)	
Constant	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
$\log(\text{Open}+30\text{min}_t / \text{Close}_{t-1})$	7.88***	7.86***	4.14***	4.12***	6.49***	6.56***	4.85***	4.83***
$\log(\text{Close}-30\text{min}_t / \text{Close}-60\text{min}_t)$		1.02		-1.37		0.85		2.05
R ² (%)	4.1	4.1	1.6	1.7	3.3	3.3	1.9	1.9
Observations	4,514	4,508	4,690	4,685	4,301	4,282	3,592	3,591

Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. The econometric method is Ordinary Least Squares. The regression specification is: $100 \log\left(\frac{\text{Close}_t}{\text{Close}-30\text{min}_t}\right) = \alpha + \beta_1 \log\left(\frac{\text{Open}+30\text{min}_t}{\text{Close}_{t-1}}\right) + \varepsilon_t$ and $100 \log\left(\frac{\text{Close}_t}{\text{Close}-30\text{min}_t}\right) = \alpha + \beta_1 \log\left(\frac{\text{Open}+30\text{min}_t}{\text{Close}_{t-1}}\right) + \beta_2 \log\left(\frac{\text{Close}-30\text{min}_t}{\text{Close}-60\text{min}_t}\right) + \varepsilon_t$. The superscripts ***, **, and * indicate statistical significance at the 1%, 5% and 10% level. Source: Refinitiv, Barclays Research.

But is Mostly Concentrated in the Tails

- Overnight returns in the whole sample are grouped in 10 deciles (Decile 1 corresponds to the lowest returns and Decile 10 to the largest returns)
- The performance of intraday momentum is significant in the top and bottom decile (see *Appendix* for estimation results)

Last 30-min Returns (ann.) as a Function of Overnight Returns



Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy.

Source: Refinitiv, Barclays Research.

Predictability Using a Piecewise Linear Model

- The non-linear behavior of predictability suggests the specification of a non-linear model
- Holding period return is significantly higher when the signal is stronger

Dep. Var. is the Last 30-min Return (%)				
	UK	Germany	France	Italy
Constant	0.0	0.0	0.0	0.0
Overnight*D1	7.3***	4.4***	5.8***	5.0**
Overnight*D2	5.0*	0.5	4.3	7.5**
Overnight*D3	-1.8	0.9	-0.9	4.8
Overnight*D4	-19.0**	-19.9**	-7.2	4.3
Overnight*D5	30.3	-28.4	-37.0	-20.7
Overnight*D6	-5.7	6.5	5.1	7.8
Overnight*D7	5.2	4.7	3.7	-0.4
Overnight*D8	6.9*	5.7	4.6	-2.9
Overnight*D9	3.3	3.1	4.0	1.1
Overnight*D10	10.8***	5.1***	9.2***	5.6***
R ² (%)	4.7	1.9	3.7	2.1
Observations	4,514	4,690	4,301	3,592
H ₀ : D1 = D10 (p-val)	0.28	0.81	0.22	0.86
H ₀ : D2 = D9 (p-val)	0.73	0.55	0.95	0.24
H ₀ : D3 to D8=0 (p-val)	0.09	0.13	0.83	0.76

Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. The econometric method is Ordinary Least Squares. The superscripts ***, **, and * indicate statistical significance at the 1%, 5% and 10% level. Source: Refinitiv, Barclays Research. 16 September 2019

Simple Model between Strategy Returns and Overnight Returns

- The predictability of the intraday momentum return is concentrated in the two top and bottom deciles. The effect on other deciles is positive but not significant

Dep. Var. is the Last 30-min Return (%)				
	UK	Germany	France	Italy
Constant	0.0	0.0	0.0	0.0
Overnight*(D1+D10)	9.0***	4.7***	7.3***	5.3***
Overnight*(D2+D9)	4.0***	1.8	4.1***	3.9**
Overnight*OtherDeciles	1.5	1.7	1.3	0.9
R ² (%)	4.4	1.8	3.5	2.0
Observations	4,514	4,690	4301	3,592

Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. The econometric method is Ordinary Least Squares. The superscripts ***, **, and * indicate statistical significance at the 1%, 5% and 10% level. Source: Refinitiv, Barclays Research.

Robustness

Additional robustness tests (see *Appendix* for the results):

- Results are not sensitive to outliers (page 36)
- The predictability stems from the overnight return (page 37)
- Intraday returns contain limited information (page 38)
- The predictability is present in subsamples (page 39)

Economic Approach: Strategy Performance

Intraday Momentum Strategy Generates a Sharpe Ratio Around 1: Germany and UK

- An intraday mom. strategy generates an ann. return of 4% and a Sharpe ratio around 1
- The skew is positive, so the performance is not driven by crash-risk

UK						
Passive Strategies (Used as Benchmark)	Avg Ret (% , ann)	Vol (% , ann)	Sharpe Ratio	Min (% , day)	Skew	Kurtosis
Buy and Hold	3.67	18.68	0.20	-8.88	0.05	10.39
Always Long in the last 30 min	1.81	4.34	0.42	-2.45	0.17	10.45
Active Strategies by Signal						
[Close _{t-1} , Open+30min _t]	5.58	4.33	1.29	-1.49	0.80	10.30
[Close-60min _t , Close-30min _t]	0.25	4.35	0.06	-2.06	0.27	10.47
[Close _{t-1} , Open+30min _t] & [Close-60min _t , Close-30min _t]	2.93	3.15	0.93	-1.36	1.56	21.31

Germany						
Passive Strategies (Used as Benchmark)	Avg Ret (% , ann)	Vol (% , ann)	Sharpe Ratio	Min (% , day)	Skew	Kurtosis
Buy and Hold	5.43	22.35	0.24	-7.39	0.05	7.77
Always Long in the last 30 min	1.64	4.51	0.36	-2.54	-0.27	9.96
Active Strategies by Signal						
[Close _{t-1} , Open+30min _t]	4.16	4.50	0.92	-2.16	0.42	9.87
[Close-60min _t , Close-30min _t]	-0.20	4.50	-0.04	-2.14	0.49	9.96
[Close _{t-1} , Open+30min _t] & [Close-60min _t , Close-30min _t]	1.98	3.20	0.62	-1.25	1.38	19.61

Note: The sample period is 2000-2019. The “Buy and Hold” strategy takes a long position in the market from the beginning of the sample and holds it until the end of the sample period. The “Always Long in the last 30 min” strategy takes a long position in the market at the beginning of the last half-hour and closes it at the market close. Source: Refinitiv, Barclays Research.

Intraday Momentum Strategy Generates a Sharpe Ratio Above 1: France and Italy

- An intraday mom. strategy generates an ann. ret. of 5% and a Sharpe ratio above 1
- The skew is positive, so the performance is not driven by crash-risk

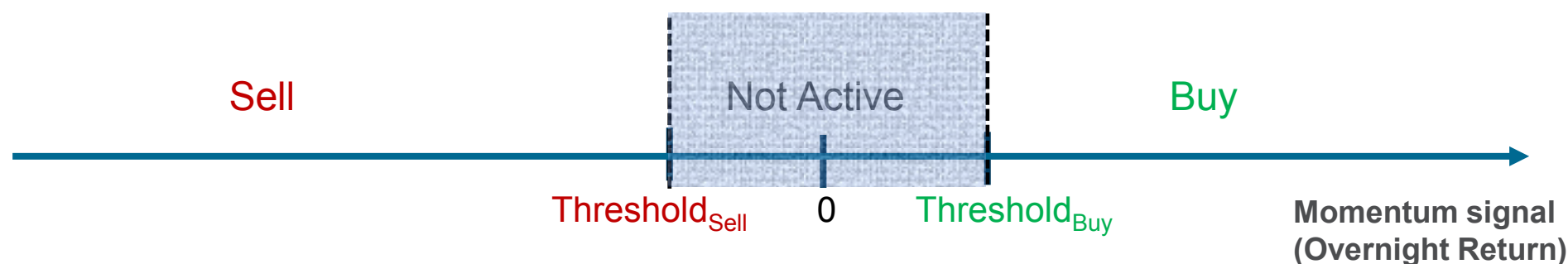
France						
Passive Strategies (Used as Benchmark)	Avg Ret (% , ann)	Vol (% , ann)	Sharpe Ratio	Min (% , day)	Skew	Kurtosis
Buy and Hold	4.11	22.33	0.18	-8.47	0.04	7.73
Always Long in the last 30 min	1.99	4.88	0.41	-2.30	-0.08	9.96
Active Strategies by Signal						
[Close _{t-1} ,Open+30min _t]	6.55	4.86	1.35	-2.19	0.37	9.92
[Close-60min _t ,Close-30min _t]	1.39	4.88	0.28	-1.90	0.39	9.95
[Close _{t-1} ,Open+30min _t] & [Close-60min _t ,Close-30min _t]	3.96	3.38	1.17	-1.87	1.39	21.36

Italy						
Passive Strategies (Used as Benchmark)	Avg Ret (% , ann)	Vol (% , ann)	Sharpe Ratio	Min (% , day)	Skew	Kurtosis
Buy and Hold	1.63	23.48	0.07	-8.14	0.01	8.06
Always Long in the last 30 min	1.86	4.74	0.39	-2.60	-0.34	8.92
Active Strategies by Signal						
[Close _{t-1} ,Open+30min _t]	5.04	4.73	1.07	-1.71	0.32	8.85
[Close-60min _t ,Close-30min _t]	1.92	4.74	0.41	-2.60	-0.06	8.89
[Close _{t-1} ,Open+30min _t] & [Close-60min _t ,Close-30min _t]	3.48	3.34	1.04	-1.66	0.56	15.80

Note: The sample period is 2000-2019 for France and 2004-2019 for Italy. The “Buy and Hold” strategy takes a long position in the market from the beginning of the sample and holds it until the end of the sample period. The “Always Long in the last 30 min” strategy takes a long position in the market at the beginning of the last half-hour and closes it at the market close. Source: Refinitiv, Barclays Research.

Trading Strategy with Thresholds

- The presence of nonlinearities implies that using thresholds may improve the efficacy of the signal
- Simple view of an enhanced trading strategy:

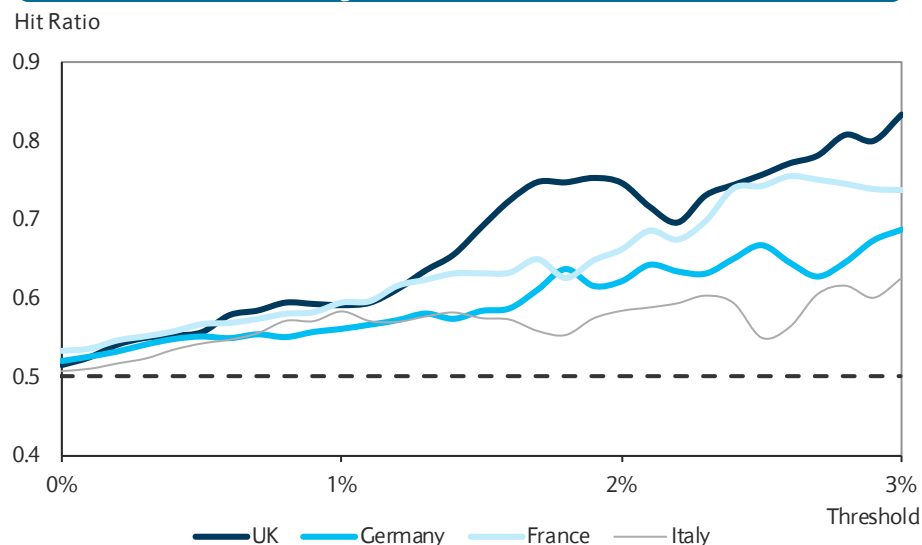


- Various extensions:
 - Thresholds may be asymmetric
 - Signal may be based on multiple intraday momentum signals
 - Position size may be non-linear (i.e., weighting by the intensity of the signal)

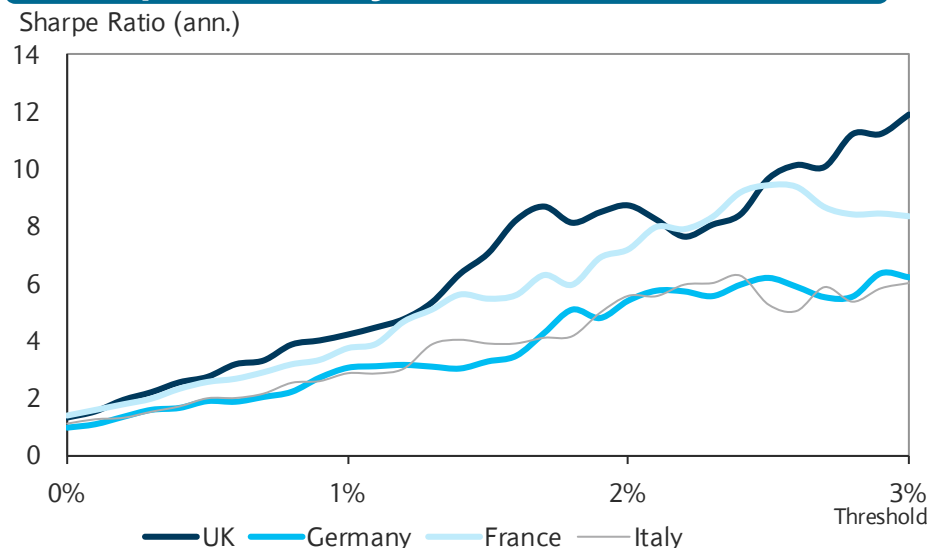
Hit and Sharpe Ratios Increase with Threshold

- The hit and Sharpe ratios increase with the threshold

Hit Ratios by Threshold and Market



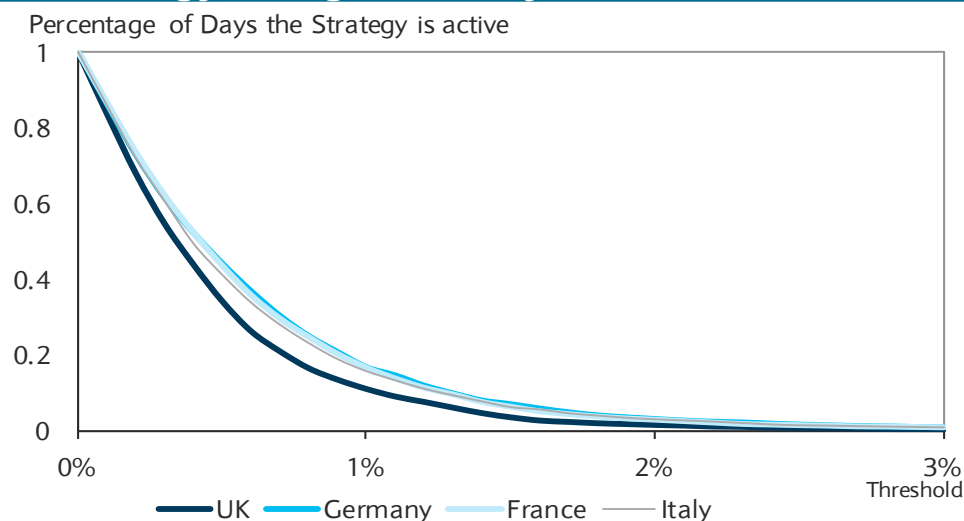
Sharpe Ratios by Threshold and Market



But the percentage of days when the market timing strategy is active declines sharply as the threshold increases

Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. The threshold is symmetric. Only active days are considered for the computation of the Hit and Sharpe ratios. Source: Refinitiv, Barclays Research.

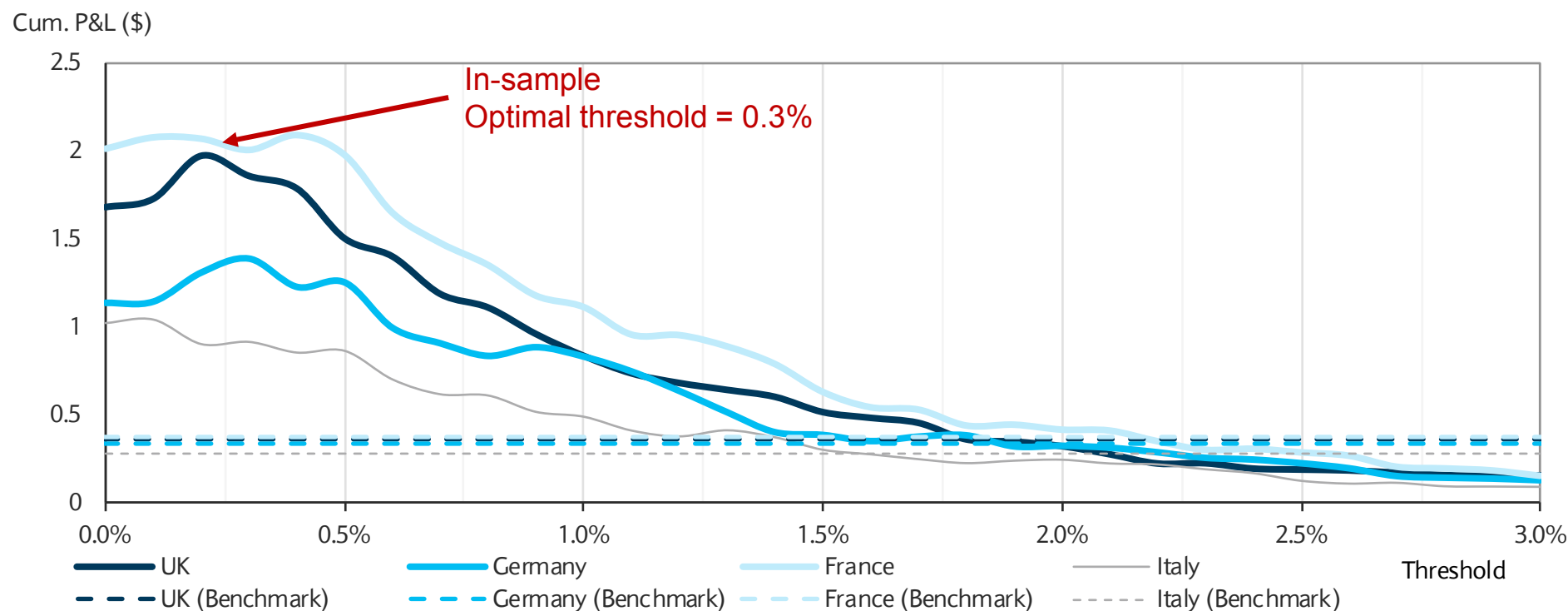
% Strategy being Active by Threshold and Market



Trade-Off Between P&L and Sharpe Ratios

- A threshold above 0.3%, reduces the P&L because the strategy is active less often

P&L of Investing \$1 in 2000 (2004 for Italy) as a Function of Threshold by Market



Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. The threshold is symmetric. Only active days are considered for the computation of the Sharpe ratio. The benchmark is always being long in the last half-hour.

Source: Refinitiv, Barclays Research.

Extensions

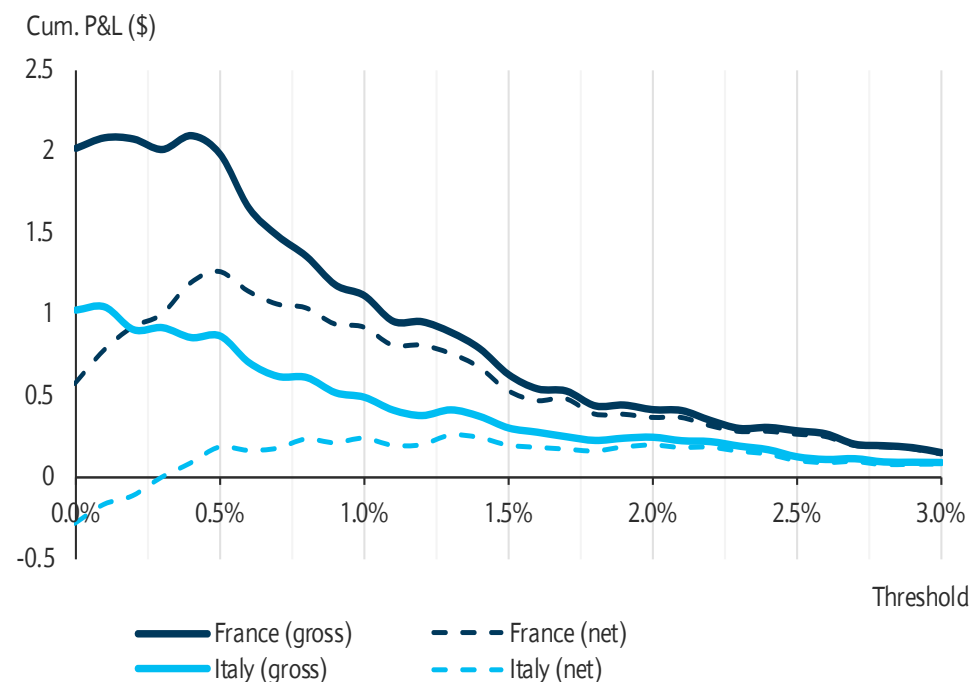
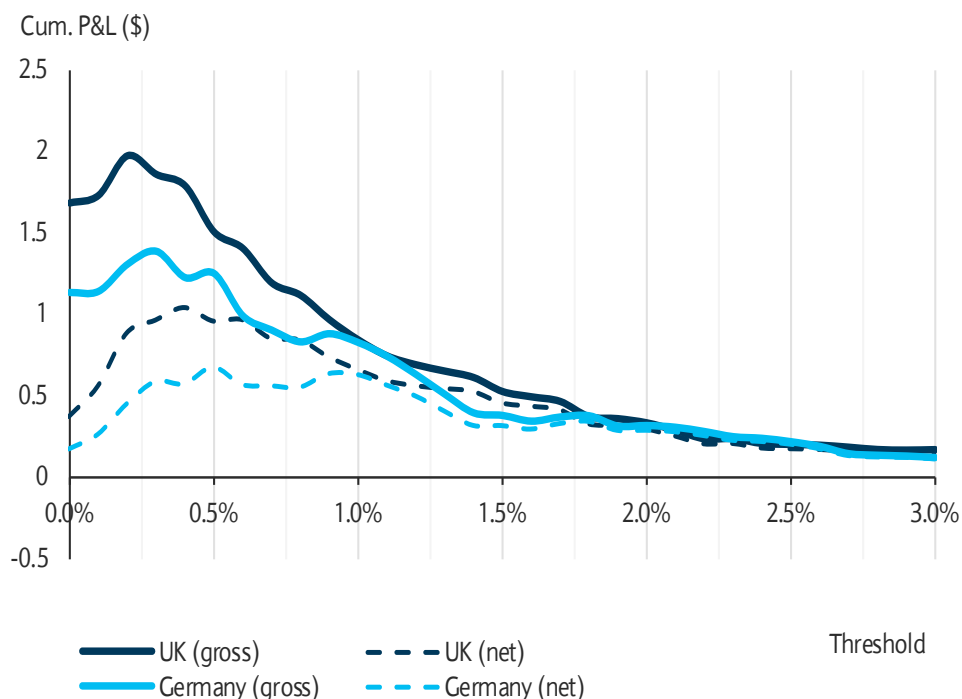
We look at the effects on strategy performance of:

- Transaction costs
- Timing of the execution
- Asymmetric thresholds
- Non-linear positions (signal weighting)
- Time variation
 - Calendar (by year, month and day-of-the-week)
 - Economic states (US and European recessions, 2008-9 financial crisis, and level of VSTOXX)

The Effects of Transaction Costs on Strategy P&L

- We consider transaction costs: Buy at Ask and Sell at Bid
- Intraday Mom. remains profitable with transaction costs, but the optimal threshold is higher

P&L of Investing \$1 in 2000 (2004 for Italy) as a Function of Threshold by Market w. and w/o Transaction Costs



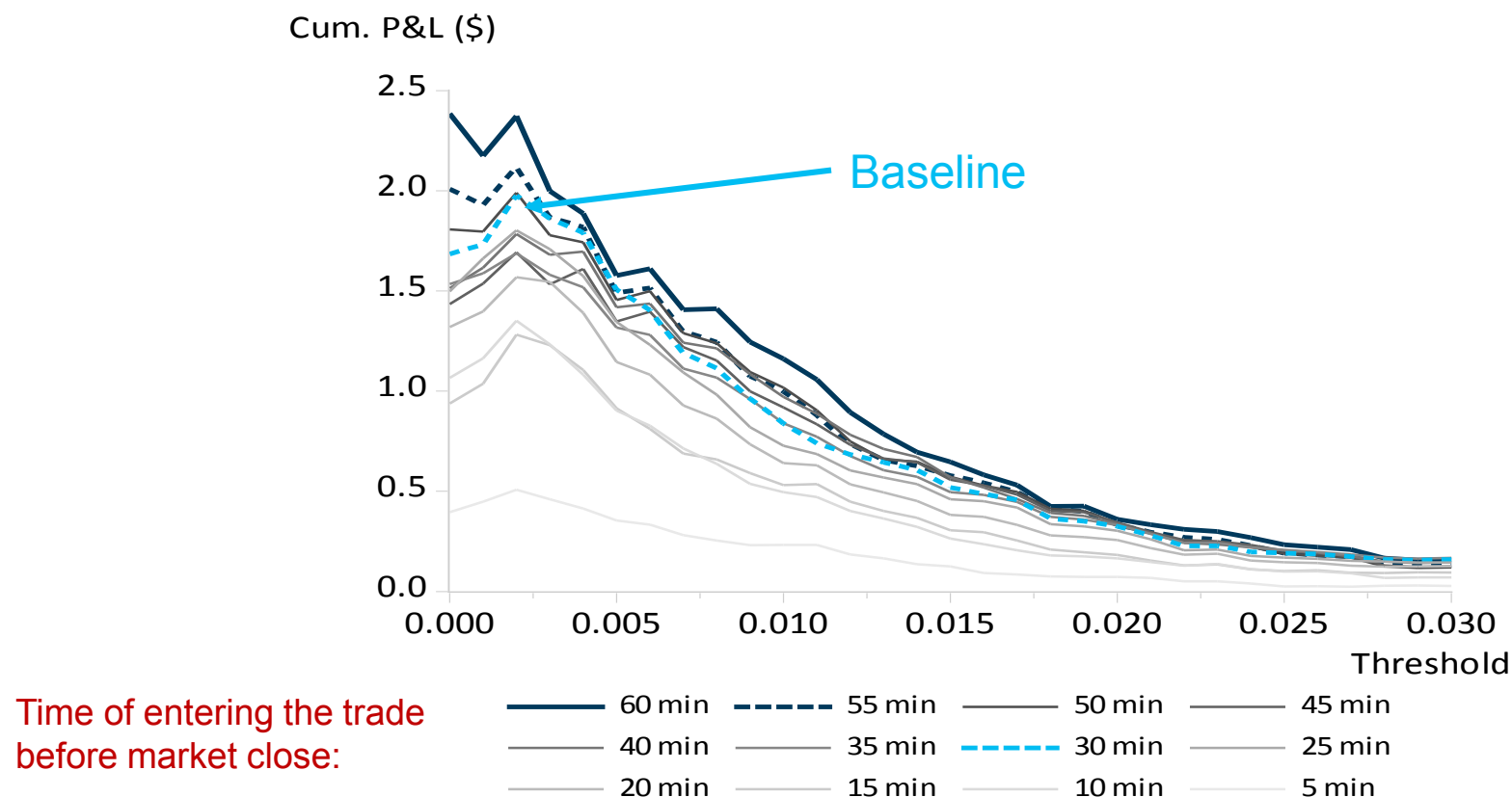
Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. The threshold is symmetric. Only active days are considered for the computation of the Sharpe ratio. The benchmark is always being long in the last half-hour.

Source: Refinitiv, Barclays Research.

The Effects of Execution Timing on Strategy P&L: The UK case

- There is a cost associated with delaying the execution of the trade near the market close
- Results are similar in Germany, France and Italy (see *Appendix*)

P&L of Investing \$1 in 2000 as a Function of Threshold By Entry Time of the Trade

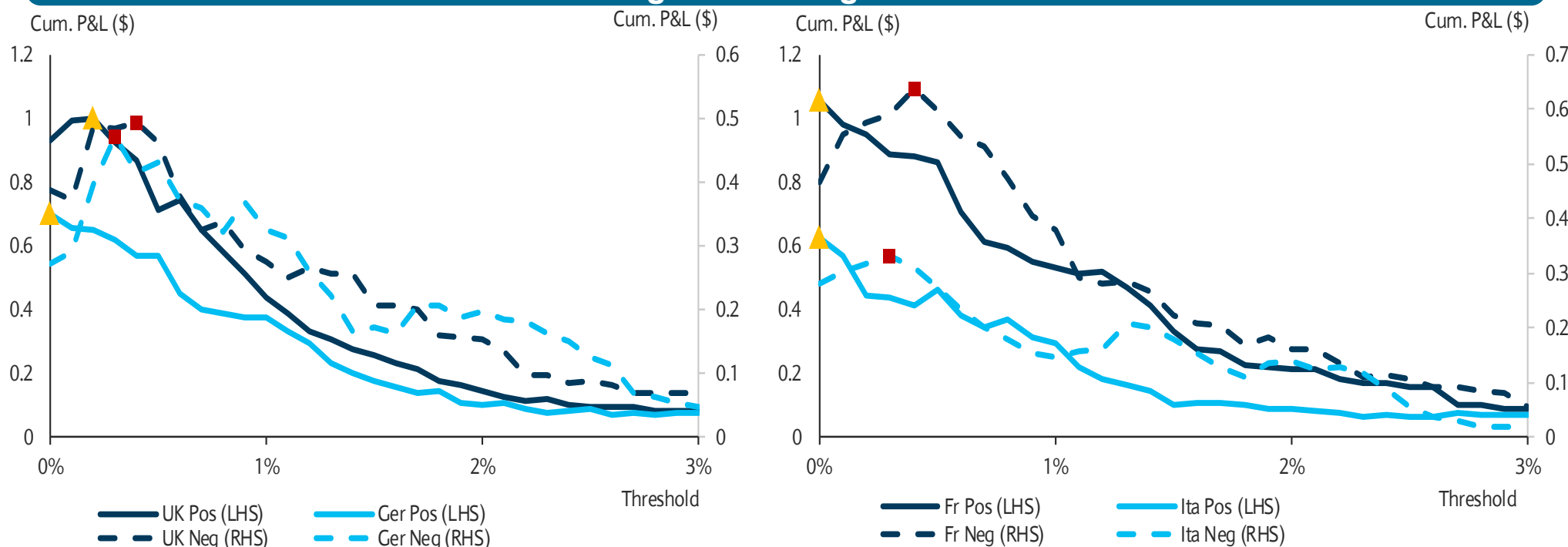


Note: The sample period is 2000-2019. The threshold is symmetric. Only active days are considered for the computation of the cumulative P&L. The lines indicate different times before market close of entering the trade. Source: Refinitiv, Barclays Research.

Non-Symmetric Thresholds

- We look for the optimal threshold by country and sign of the overnight returns
- The thresholds for negative overnight returns are larger than those for positive overnight returns

P&L of Investing \$1 in 2000 (2004 for Italy) as a Function of Threshold by Market and Sign of Overnight Returns

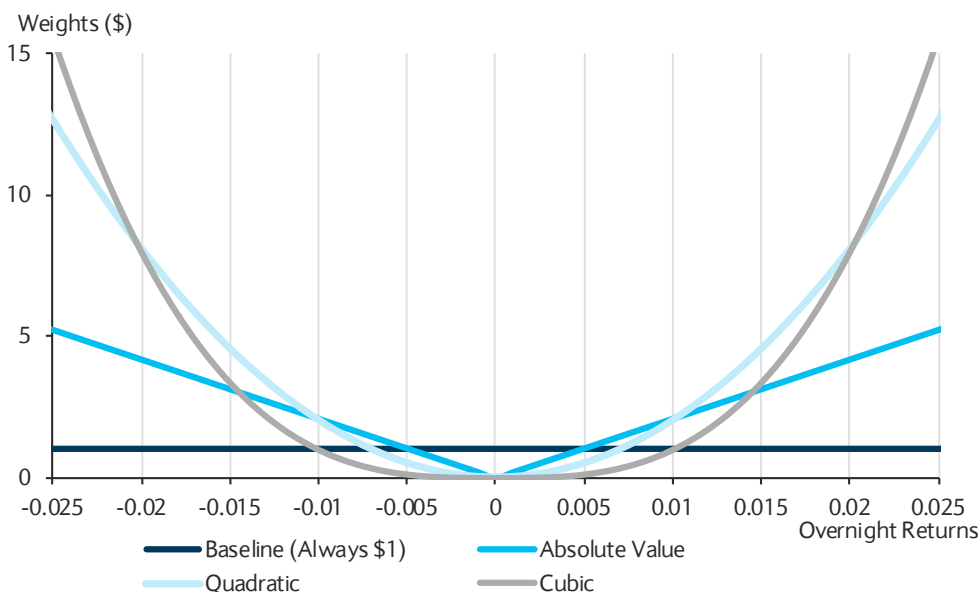


Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. Only active days are considered for the computation of the cum. P&L. The red square (yellow triangle) indicates the optimal threshold for positive (negative) overnight returns. Source: Refinitiv, Barclays Research.

Non-linear Positions: The Case for Signal Weighting

- Instead of thresholds, the position size may vary by the strength of the signal (including the possibility of leverage, rather than -\$1 or +\$1)
- Non-linear signals increase returns but also the volatility of returns. A linear signal improves slightly the Sharpe ratio

Position Size as a Function of the Overnight Return



Performance of the Strategy for Non-linear Positions

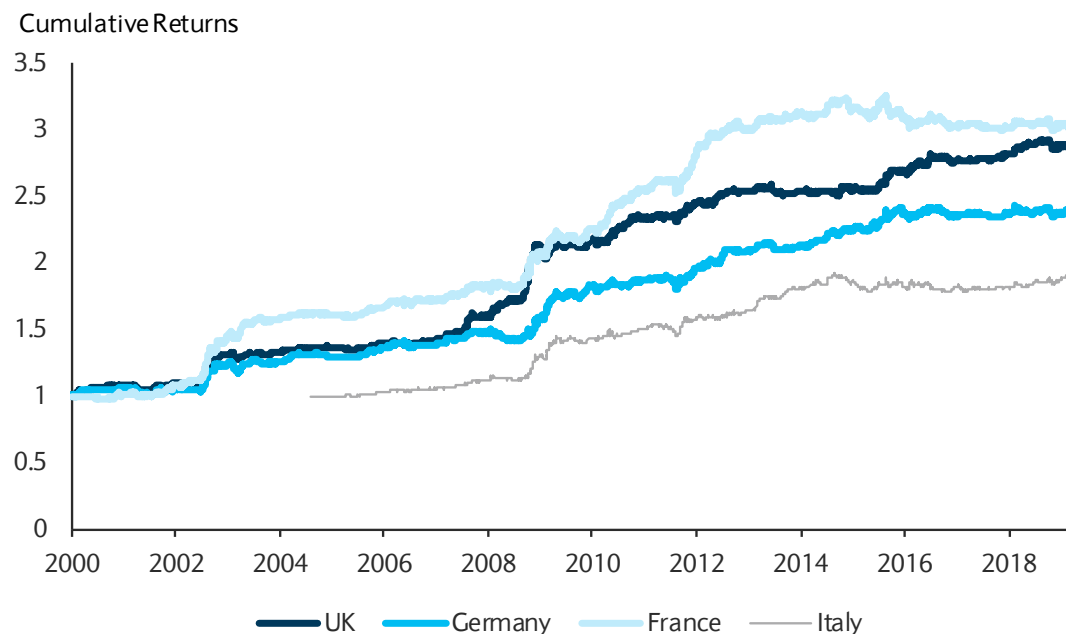
UK	Baseline	Linear	Quadratic	Cubic
Avg. Ret. (%/yr)	5.6	20.6	57.8	121.7
Vol. (%/yr)	4.3	14.2	60.2	171.1
Sharpe Ratio (ann.)	1.29	1.45	0.96	0.71

Note: The sample period is 2000-2019. Source: Refinitiv, Barclays Research.

Returns are Persistent Over Time

- Time series of cum. ret. for a 0.3% threshold (See *Appendix* for performance by year)
- Results are robust to different thresholds (i.e., for no threshold and 0.5%, see *Appendix*)

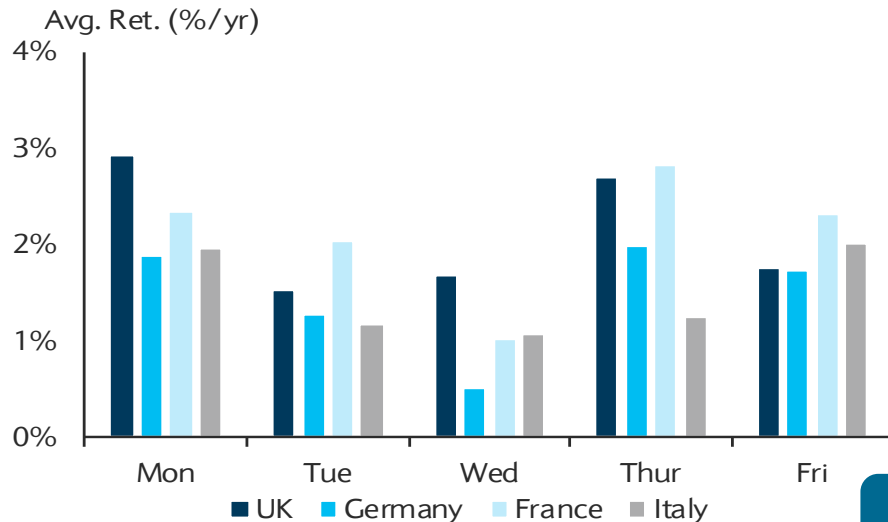
Cum. Ret. of Market Timing Signal Over Time with a Threshold of 0.3% (2000 - 2019)



Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. Source: Refinitiv, Barclays Research.

Strategy Returns Display Limited Calendar Effects

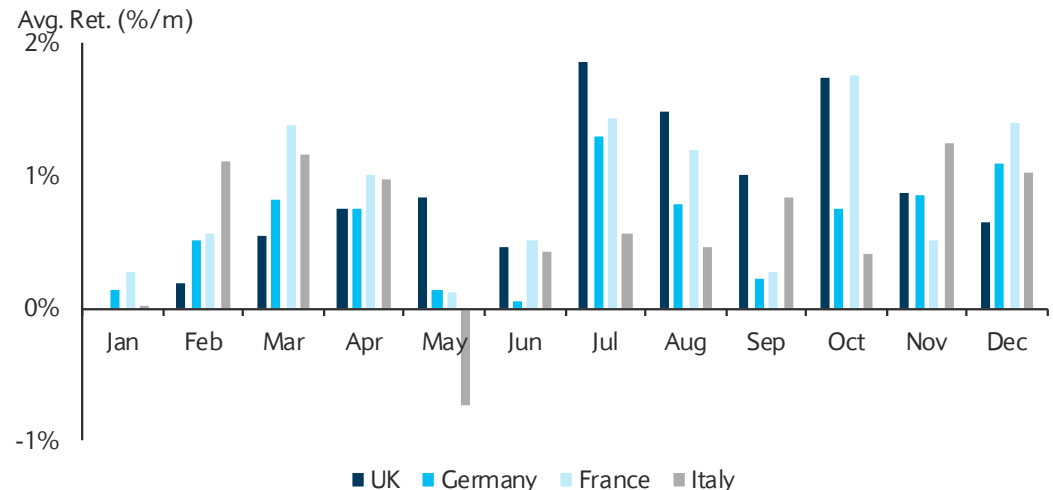
Intraday Mom. Returns By Day-of-the-Week (2000 - 2019)



- Intraday Mom. returns are positive every day of the week

- Intraday Mom. returns are positive every month, with the only exception of Italy in May

Intraday Mom. Returns By Month (2000 - 2019)

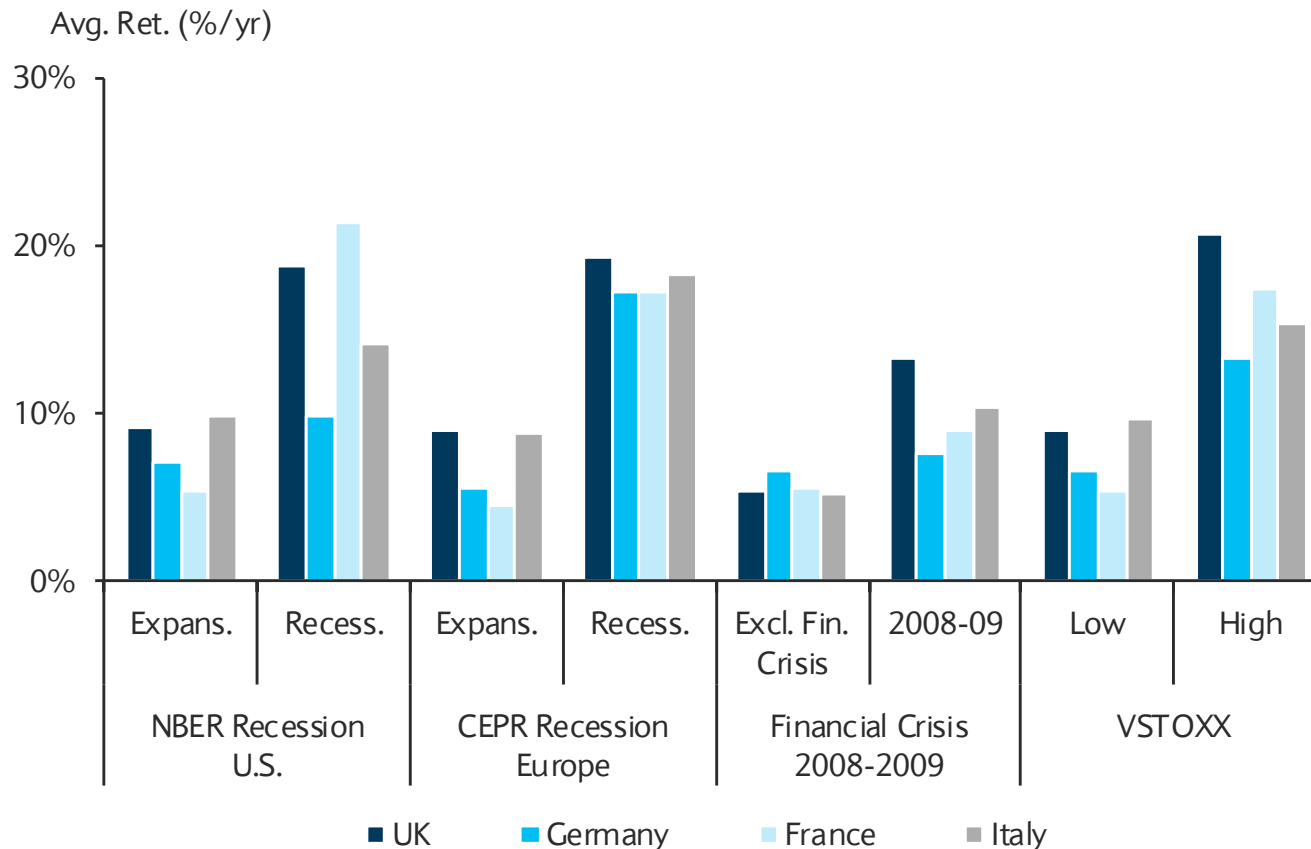


Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. Source: Refinitiv, Barclays Research.

Strategy Returns are Higher When Vol. Is High

- Intraday Mom. returns are higher when vol. is high or the economy is in a recession

Intraday Mom. Returns in Various Economic States (2000 - 2019)



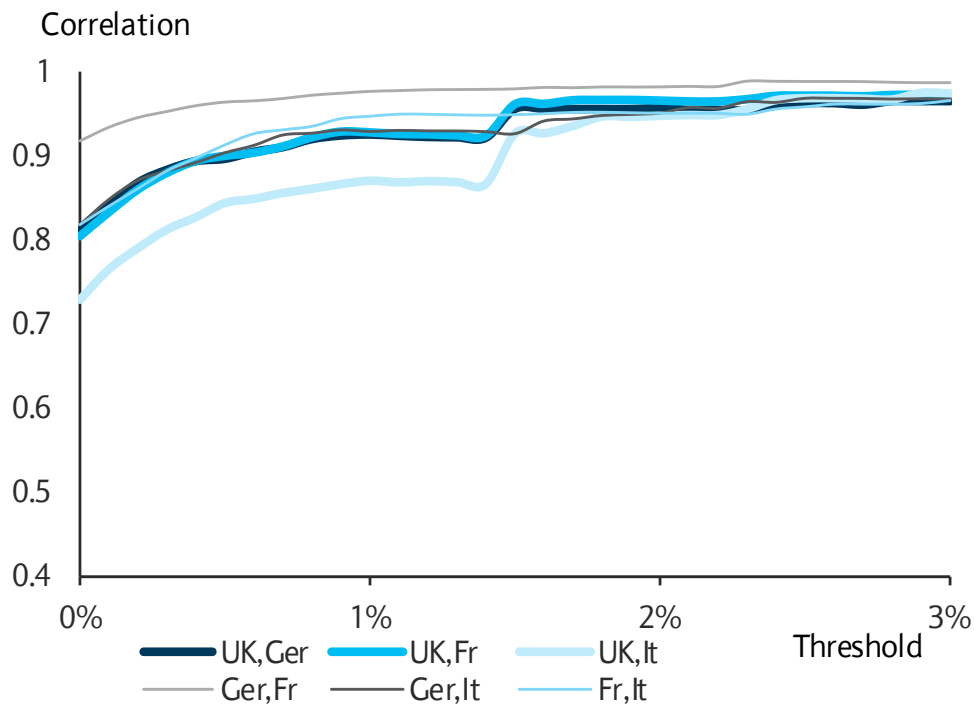
Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy.
Source: Refinitiv, NBER, CEPR, Barclays Research.

Diversification Benefits

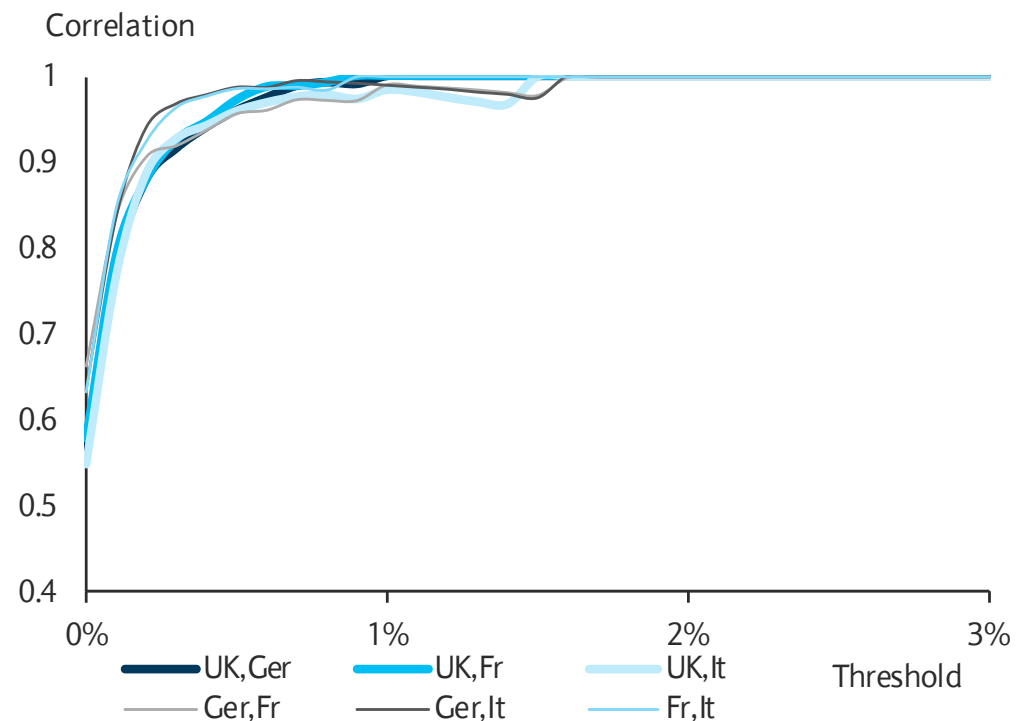
Correlation between Overnight Returns Is High

- The correlation between the level or the sign of overnight returns is large even with no threshold

**Corr. between Overnight Returns
as a Function of Threshold by Market**



**Corr. between Sign of Overnight Returns
as a Function of Threshold by Market**



Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. Source: Refinitiv, Barclays Research.

Intraday Mom. Has Low Correlation with Daily Risk Factors in EU

- Strategy returns have very low (level and rank) correlation with European Fama-French 5 factors, but high correlation among each others

**Daily Return Correlations between pairs of factors
(2000 - 2019)**

	Mkt - Rf	SMB	HML	CMA	RMW	UK	Germany	France	Italy
Mkt - Rf		-0.67	0.14	-0.30	-0.18	0.00	0.00	0.03	0.02
SMB	-0.59		-0.06	0.16	0.15	-0.01	0.02	-0.03	0.01
HML	0.14	-0.09		0.44	-0.51	0.02	0.01	0.01	0.03
CMA (Investment)	-0.17	0.07	0.39		-0.23	-0.01	-0.03	-0.04	0.01
RMW (Profitability)	-0.18	0.12	-0.56	-0.28		-0.01	0.05	0.02	-0.05
UK	-0.02	-0.01	0.00	0.01	-0.01		0.69	0.75	0.65
Germany	0.03	-0.01	0.00	-0.02	0.01	0.65		0.83	0.74
France	0.00	0.00	0.01	-0.03	0.00	0.71	0.82		0.79
Italy	0.03	-0.02	0.04	-0.01	-0.03	0.61	0.72	0.77	

Note: The sample period is Jan. 2000 - May 2019 for UK, Germany and France, and Jan. 2004 - May 2019 for Italy. The level (Pearson) correlation is reported in the upper triangular matrix, the rank (Spearman) correlation is reported in the lower triangular matrix. The intraday momentum returns are based on a 0.3% threshold. Source: Refinitiv, Barclays Research.

Intraday Mom. Generates Significant Alpha, Controlling for EU FF5 Risk Factors

- Alpha of Intraday Mom. strategy is significant and economically meaningful (btw. 7% and 10% per year)

**Daily Regression of Intraday Mom. Returns on Various Risk Factors
(2000 - 2019)**

	UK			Germany			France			Italy		
Alpha	10.6***	10.5***	10.6***	7.4***	7.5***	7.2***	10.5***	10.4***	10.3***	7.3***	7.5***	7.7***
Mkt - Rf	-0.00	-0.01	-0.01	0.00	0.01	0.00	0.01	0.00	-0.00	0.00	0.01	0.01
SMB		-0.01	-0.02		0.02	0.01		-0.01	-0.01		0.02	0.02
HML		0.01	0.02		0.01	0.04		0.01	0.03		0.02	-0.01
CMA			-0.02			-0.04			-0.05			0.01
RMW			-0.00			0.06**			0.04			-0.06
Adj. R ²	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	-0.00	0.00	-0.00	0.00	0.00
Observations	2,420	2,420	2,420	2,818	2,818	2,818	2,671	2,671	2,671	2,125	2,125	2,125

Note: The sample period is Jan. 2000 - May 2019 for UK, Germany and France, and Jan. 2004 - May 2019 for Italy. The intraday momentum returns are based on a 0.3% threshold. The econometric method is Ordinary Least Squares. The superscripts ***, **, and * indicate statistical significance at the 1%, 5% and 10% level. Source: Refinitiv, Barclays Research.

Summary

- In European markets, the last 30-min return can be predicted by the overnight return
- An intraday momentum strategy generates average returns above 4% and Sharpe ratios above 1
- The strategy with thresholds that is active only when overnight returns are large enough boosts the Sharpe ratio above 3 but it is used less frequently.
- Intraday momentum returns are not spanned by standard European daily risk factors

Appendix

Predictability is Mostly Concentrated In the Tails

- The performance of intraday momentum is significant in the top and bottom decile

Dep. Var. is the Last 30-min Return (ann.)				
	UK	Germany	France	Italy
Decile 1	-16.6***	-17.3***	-20.4***	-11.1*
Decile 2	-7.2**	-2.8	-7.6*	-8.3*
Decile 3	0.2	-2.8	0.0	-1.3
Decile 4	5.8**	7.7***	2.4	2.0
Decile 5	-1.9	1.4	3.8	4.8
Decile 6	-2.2	1.7	2.8	5.4*
Decile 7	2.2	1.8	2.2	2.9
Decile 8	6.1**	5.2*	4.4	-0.9
Decile 9	3.8	4.4	6.8*	5.3
Decile 10	26.9***	15.5***	26.0***	18.9***
R ² (%)	2.2	1.2	1.9	1.1
Observations	4,747	4,839	4,631	3,727

Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. The econometric method is Ordinary Least Squares. The superscripts ***, **, and * indicate statistical significance at the 1%, 5% and 10% level. Source: Refinitiv, Barclays Research.

Results Are Not Sensitive to Outliers

- The overnight return is predictive of the last 30-min return in UK, Germany, France and Italy using robust regressions

The Dependent Variable is the 30-min Return (in %) Before Market Close

	UK (2000-2019)		Germany (2000-2019)		France (2000-2019)		Italy (2004-2019)	
Constant	0.01	0.01*	0.02***	0.02***	0.01***	0.01***	0.02***	0.02***
$\log(\text{Open}+30\text{min}_t / \text{Close}_{t-1})$	5.81***	5.87***	3.48***	3.57***	5.83***	5.96***	3.76***	3.76***
$\log(\text{Close}-30\text{min}_t / \text{Close}-60\text{min}_t)$		-0.88		-4.45***		-1.49		0.31
R ² (%)	1.1	1.1	0.6	0.7	1.2	1.3	0.6	0.6
Observations	4,514	4,508	4,690	4,685	4,301	4,282	3,592	3,591

Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. The econometric method is Quantile regression. The superscripts ***, **, and * indicate statistical significance at the 1%, 5% and 10% level.

Source: Refinitiv, Barclays Research.

The Predictability Stems From the Overnight Return

- The Predictability stems mostly from the overnight return, rather than from the first 30-min return

Dep. Var. is the 30-min Return (in %) Before Market Close				
	UK	Germany	France	Italy
Constant	0.00	0.00	0.01	0.00
$\log(\text{Open-30min}_t / \text{Open}_t)$	3.96*	3.17	2.61	2.83*
$\log(\text{Open}_t / \text{Close}_{t-1})$	8.48***	4.21***	7.13***	5.26***
R ² (%)	4.4	1.6	3.5	1.8
Observations	4,507	4,637	4,295	3,582

Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. The econometric method is Ordinary Least Squares. The regression specification is: $100 \log \left(\frac{\text{Close}_t}{\text{Close}_{t-30\text{min}_t}} \right) = \alpha + \beta_1 \log \left(\frac{\text{Open}_t}{\text{Close}_{t-1}} \right) + \beta_2 \log \left(\frac{\text{Open}_{t+30\text{min}_t}}{\text{Open}_t} \right) + \varepsilon_t$. The superscripts ***, **, and * indicate statistical significance at the 1%, 5% and 10% level. Source: Refinitiv, Barclays Research.

Intraday Returns Contain Limited Information

- The 30-min returns during the day contain some, but limited, information

Dep. Var. is the 30-min Return (in %) Before Market Close								
	UK		Germany		France		Italy	
Constant	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Overnight	8.33***	8.01***	4.12***	4.12***	7.29***	7.16***	5.19***	5.28***
Intraday	2.83***		0.85		3.52***		1.98***	
Ret_1		3.68		3.40*		2.98		2.33
Ret_2		2.51		0.52		4.32*		3.85**
Ret_3		4.54		2.40		2.78		4.08*
Ret_4		1.91		0.52		1.76		-0.88
Ret_5		-0.43		-1.19		5.82		1.75
Ret_6		12.51***		3.38		8.56**		3.5
Ret_7		10.00***		2.41		6.46*		9.08***
Ret_8		1.64		0.10		4.33		2.36
Ret_9		-0.93		-0.69		1.95		-1.71
Ret_10		-5.84		-0.20		-1.6		-3.18
Ret_11		4.57		0.45		3.53		-1.46
Ret_12		4.54		2.36		5.53**		5.45**
Ret_13		4.72		5.32*		2.68		8.96***
Ret_14		0.94		0.09		3.13		0.3
Ret_15		2.28		-0.53		5.91**		-0.74
Ret_16		0.35		-1.18	4.9	-0.41		2.03
R ² (%)	5.0	6.0	1.6	2.0	4.9	5.5	2.3	3.9
Number of Observations	4510	4480	4638	4566	4300	4253	3599	3559
H ₀ : All Returns = 0		0.00		0.00		0.00		0.00
H ₀ : All Intraday Returns = 0		0.00		0.68		0.00		0.00

Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. The econometric method is Ordinary Least Squares. The dependent variable is $100 \log \left(\frac{Close_t}{Close_{t-30min_t}} \right)$. The Ret_k variable stands for the kth 30-min return during the day. The superscripts ***, **, and * indicate statistical significance at the 1%, 5% and 10% level. Source: Refinitiv, Barclays Research.

The Predictability Is Present in Subsamples

- The overnight return is predictive also in the most recent subsample, though predictability has declined

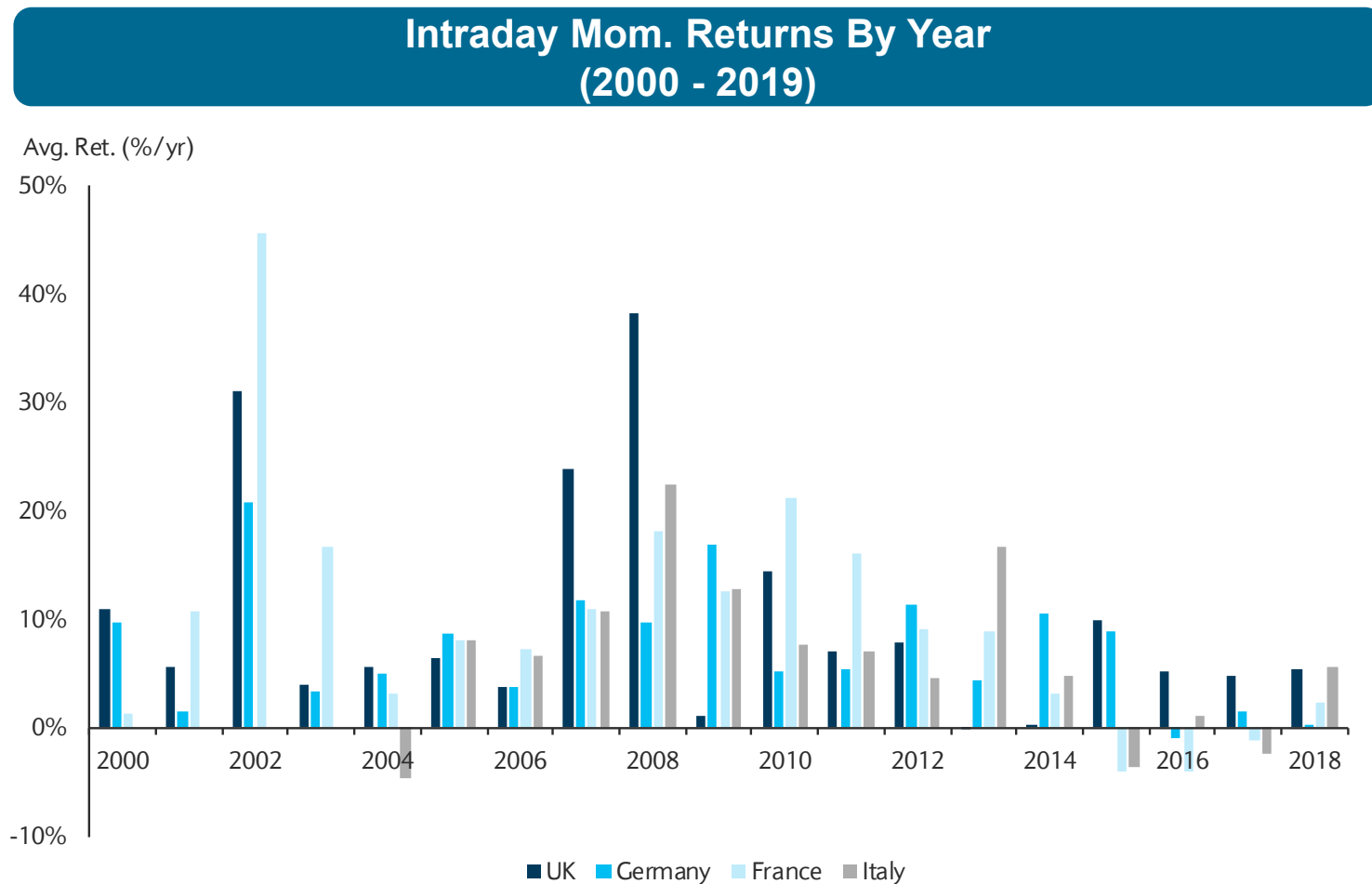
The Dependent Variable is the 30-min Return (in %) Before Market Close

	UK		Germany		France		Italy	
	00-13	14-19	00-13	14-19	00-13	14-19	04-13	14-19
Constant	0.01*	-0.01	0.01	0.00	0.01*	0.00	0.01	0.00
$\log(\text{Open}+30\text{min}_t / \text{Close}_{t-1})$	8.60***	4.98***	4.48***	2.76**	8.07***	0.56	6.19***	1.87
R ² (%)	4.6	2.1	1.9	0.8	4.7	0.0	3.0	0.3
Observations	3,244	1,270	3,346	1,344	3,065	1,236	2,260	1,332

Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. The econometric method is Ordinary Least Squares. The superscripts ***, **, and * indicate statistical significance at the 1%, 5% and 10% level. Source: Refinitiv, Barclays Research.

Intraday Mom. Returns Generated Positive Returns in Most Years

- Intraday Mom. returns have been positive almost every year since 2000

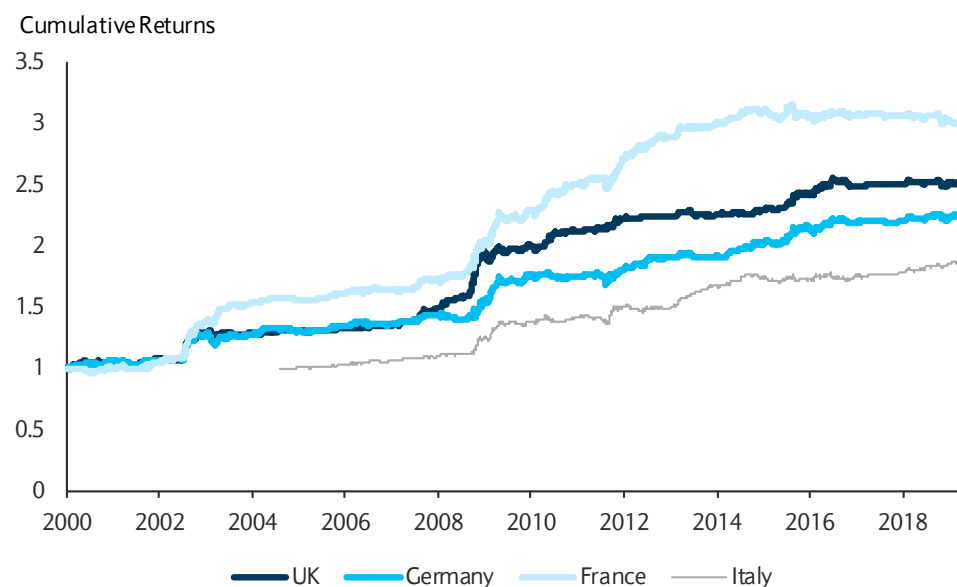
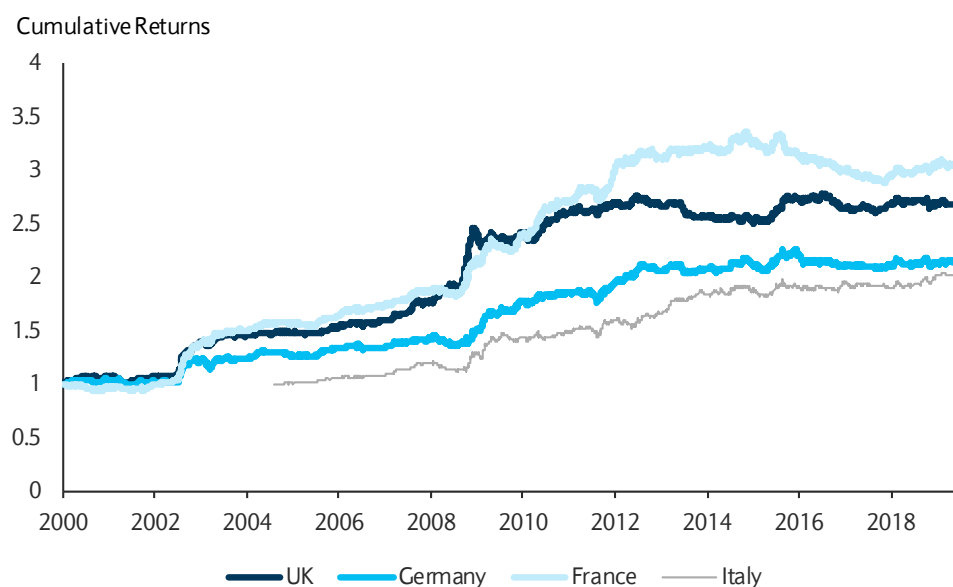


Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy.
Source: Refinitiv, NBER, CEPR, Barclays Research.

Time Series of Cumulative Returns

- The dynamics of cumulative returns is robust to different threshold levels

Cum. Ret. of Market Timing Signal Over Time with Thresholds of 0 (Left) and 0.5% (Right) (2000 - 2019)

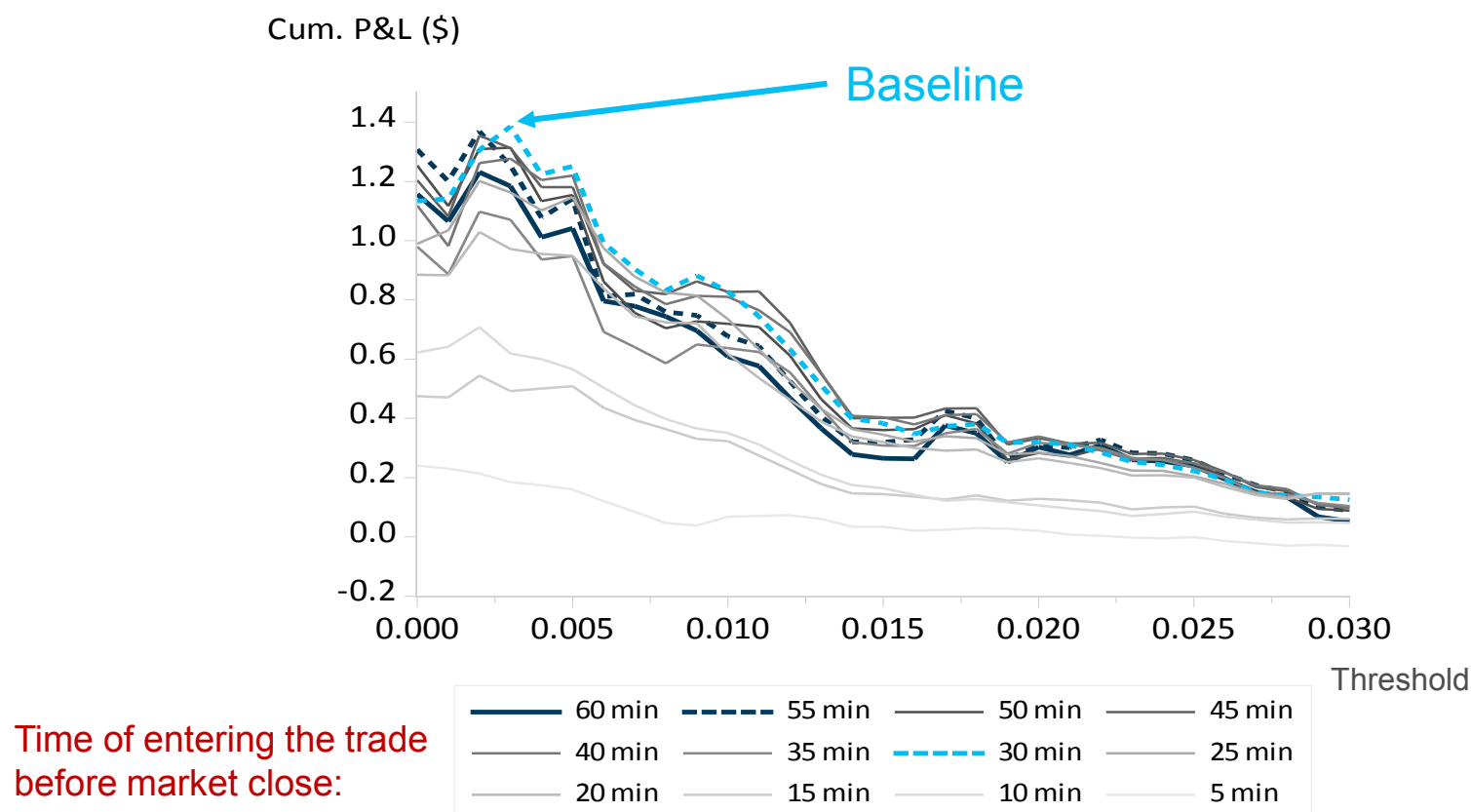


Note: The sample period is 2000-2019 for UK, Germany and France, and 2004-2019 for Italy. Source: Refinitiv, Barclays Research.

The Effects of Execution Timing on Strategy P&L: Germany

- There is a cost associated with delaying the execution of the trade

P&L of Investing \$1 in 2000 as a Function of Threshold By Entry Time of the Trade

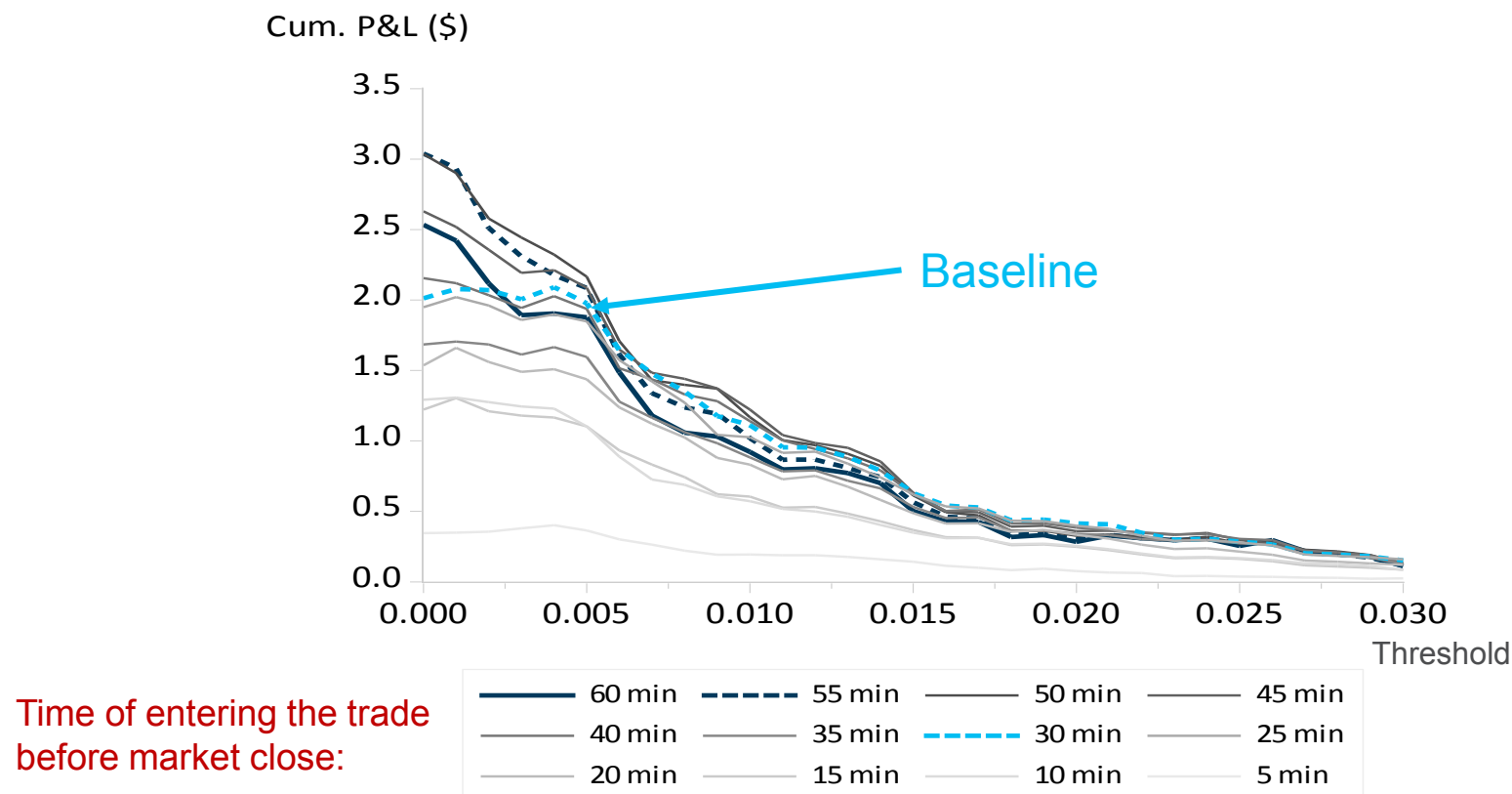


Note: The sample period is 2000-2019. The threshold is symmetric. Only active days are considered for the computation of the cum. P&L. The lines indicate different times before market close of entering the trade. Source: Refinitiv, Barclays Research.

The Effects of Execution Timing on Strategy P&L: France

- There is a cost associated with delaying the execution of the trade

P&L of Investing \$1 in 2000 as a Function of Threshold By Entry Time of the Trade

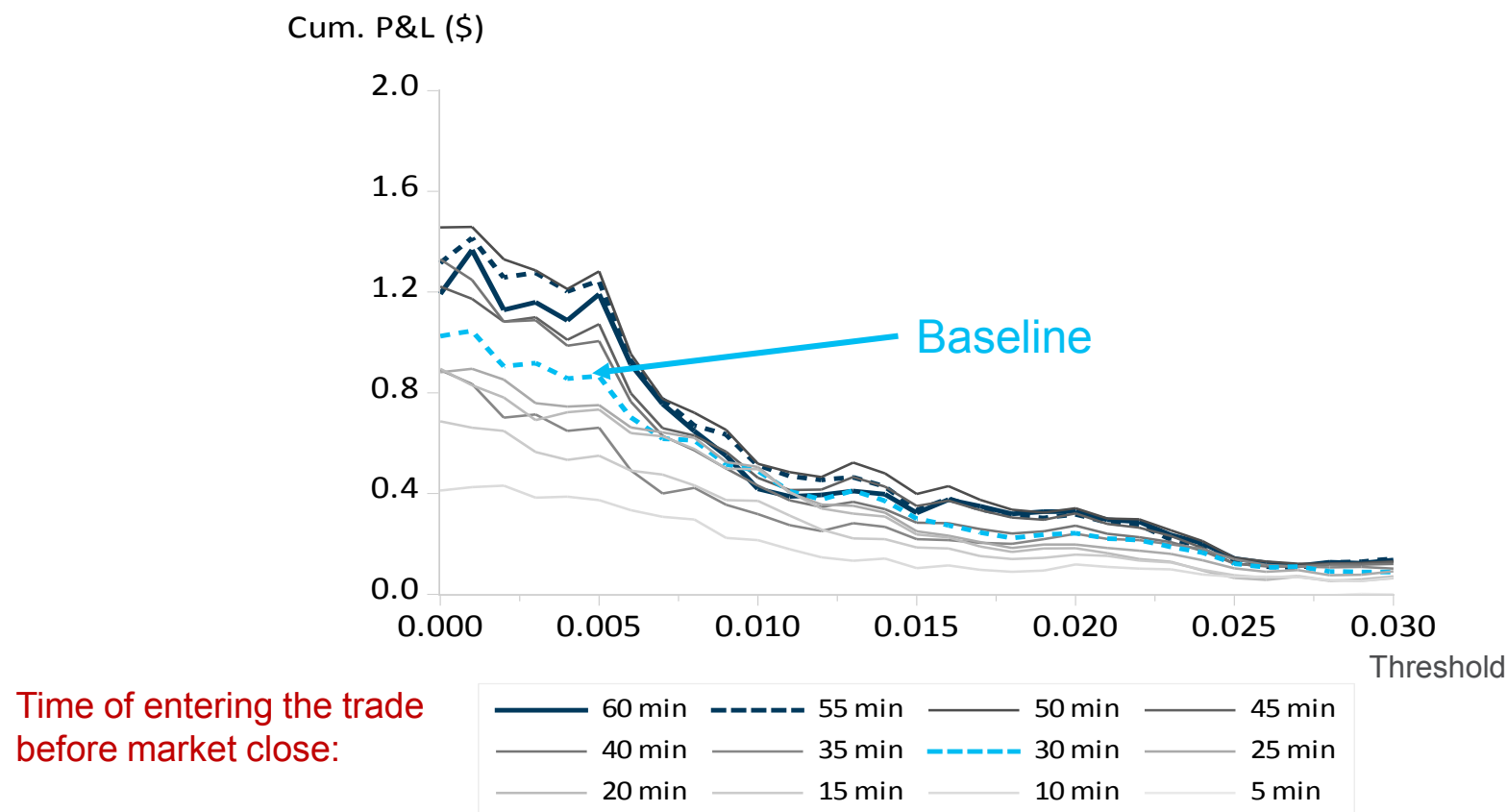


Note: The sample period is 2000-2019. The threshold is symmetric. Only active days are considered for the computation of the cum. P&L. The lines indicate different times before market close of entering the trade. Source: Refinitiv, Barclays Research.

The Effects of Execution Timing on Strategy P&L: Italy

- There is a cost associated with delaying the execution of the trade

P&L of Investing \$1 in 2004 as a Function of Threshold By Entry Time of the Trade



Note: The sample period is 2004-2019. The threshold is symmetric. Only active days are considered for the computation of the cum. P&L. The lines indicate different times before market close of entering the trade. Source: Refinitiv, Barclays Research.

Analyst Certifications and Important Disclosures

Analyst Certification(s)

We, Arik Ben Dor and Carlo Rosa, hereby certify (1) that the views expressed in this research report accurately reflect our personal views about any or all of the subject securities or issuers referred to in this research report and (2) no part of our compensation was, is or will be directly or indirectly related to the specific recommendations or views expressed in this research report.

Important Disclosures:

Barclays Research is produced by the Investment Bank of Barclays Bank PLC and its affiliates (collectively and each individually, "Barclays")

All authors contributing to this research report are Research Analysts unless otherwise indicated. The publication date at the top of the report reflects the local time where the report was produced and may differ from the release date provided in GMT.

Availability of Disclosures:

To the extent that the information about the companies mentioned in this publication is sufficient to constitute a research report, for current important disclosures regarding those companies please refer to <https://publicresearch.barclays.com> or alternatively send a written request to: Barclays Research Compliance, 745 Seventh Avenue, 13th Floor, New York, NY 10019 or call +1-212-526-1072.

The analysts responsible for preparing this research report have received compensation based upon various factors including the firm's total revenues, a portion of which is generated by investment banking activities, the profitability and revenues of the Markets business and the potential interest of the firm's investing clients in research with respect to the asset class covered by the analyst.

Analysts regularly conduct site visits to view the material operations of covered companies, but Barclays policy prohibits them from accepting payment or reimbursement by any covered company of their travel expenses for such visits.

Barclays Research Department produces various types of research including, but not limited to, fundamental analysis, equity-linked analysis, quantitative analysis, and trade ideas. Recommendations contained in one type of Barclays Research may differ from those contained in other types of Barclays Research, whether as a result of differing time horizons, methodologies, or otherwise.

In order to access Barclays Statement regarding Research Dissemination Policies and Procedures, please refer to <https://publicresearch.barclays.com/S/RD.htm>. In order to access Barclays Research Conflict Management Policy Statement, please refer to: <https://publicresearch.barclays.com/S/CM.htm>.

Risk Disclosure(s)

Master limited partnerships (MLPs) are pass-through entities structured as publicly listed partnerships. For tax purposes, distributions to MLP unit holders may be treated as a return of principal. Investors should consult their own tax advisors before investing in MLP units.

Types of investment recommendations produced by Barclays Equity Research:

In addition to any ratings assigned under Barclays' formal rating systems, this publication may contain investment recommendations in the form of trade ideas, thematic screens, scorecards or portfolio recommendations that have been produced by analysts within Equity Research. Any such investment recommendations shall remain open until they are subsequently amended, rebalanced or closed in a future research report.

Disclosure of other investment recommendations produced by Barclays Equity Research:

Barclays Equity Research may have published other investment recommendations in respect of the same securities/instruments recommended in this research report during the preceding 12 months. To view all investment recommendations published by Barclays Equity Research in the preceding 12 months please refer to <https://live.barclays.com/go/research/Recommendations>.

Important Disclosures Continued

Legal entities involved in producing Barclays Research:

Barclays Bank PLC (Barclays, UK)

Barclays Capital Inc. (BCI, US)

Barclays Bank Ireland PLC, Frankfurt Branch (BBI, Frankfurt)

Barclays Bank Ireland PLC, Paris Branch (BBI, Paris)

Barclays Bank Ireland PLC, Milan Branch (BBI, Milan)

Barclays Securities Japan Limited (BSJL, Japan)

Barclays Bank PLC, Hong Kong branch (Barclays Bank, Hong Kong)

Barclays Capital Canada Inc. (BCCI, Canada)

Barclays Bank Mexico, S.A. (BBMX, Mexico)

Barclays Securities (India) Private Limited (BSIPL, India)

Barclays Bank PLC, India branch (Barclays Bank, India)

Barclays Bank PLC, Singapore branch (Barclays Bank, Singapore)

Disclaimer

This publication has been produced by Barclays Research Department in the Investment Bank of Barclays Bank PLC and/or one or more of its affiliates (collectively and each individually, "Barclays"). It has been prepared for institutional investors only and not for retail investors. It has been distributed by one or more Barclays affiliated legal entities listed below. It is provided to our clients for information purposes only, and Barclays makes no express or implied warranties, and expressly disclaims all warranties of merchantability or fitness for a particular purpose or use with respect to any data included in this publication. To the extent that this publication states on the front page that it is intended for institutional investors and is not subject to all of the independence and disclosure standards applicable to debt research reports prepared for retail investors under U.S. FINRA Rule 2242, it is an "institutional debt research report" and distribution to retail investors is strictly prohibited. Barclays also distributes such institutional debt research reports to various issuers, media, regulatory and academic organisations for their own internal informational news gathering, regulatory or academic purposes and not for the purpose of making investment decisions regarding any debt securities. Media organisations are prohibited from re-publishing any opinion or recommendation concerning a debt issuer or debt security contained in any Barclays institutional debt research report. Any such recipients that do not want to continue receiving Barclays institutional debt research reports should contact debtresearch@barclays.com. Barclays will not treat unauthorized recipients of this report as its clients and accepts no liability for use by them of the contents which may not be suitable for their personal use. Prices shown are indicative and Barclays is not offering to buy or sell or soliciting offers to buy or sell any financial instrument.

Without limiting any of the foregoing and to the extent permitted by law, in no event shall Barclays, nor any affiliate, nor any of their respective officers, directors, partners, or employees have any liability for (a) any special, punitive, indirect, or consequential damages; or (b) any lost profits, lost revenue, loss of anticipated savings or loss of opportunity or other financial loss, even if notified of the possibility of such damages, arising from any use of this publication or its contents.

Other than disclosures relating to Barclays, the information contained in this publication has been obtained from sources that Barclays Research believes to be reliable, but Barclays does not represent or warrant that it is accurate or complete. Barclays is not responsible for, and makes no warranties whatsoever as to, the information or opinions contained in any written, electronic, audio or video presentations of third parties that are accessible via a direct hyperlink in this publication or via a hyperlink to a third-party web site ('Third-Party Content'). Any such Third-Party Content has not been adopted or endorsed by Barclays, does not represent the views or opinions of Barclays, and is not incorporated by reference into this publication. Third-Party Content is provided for information purposes only and Barclays has not independently verified its accuracy or completeness.

The views in this publication are solely and exclusively those of the authoring analyst(s) and are subject to change, and Barclays Research has no obligation to update its opinions or the information in this publication. Unless otherwise disclosed herein, the analysts who authored this report have not received any compensation from the subject companies in the past 12 months. If this publication contains recommendations, they are general recommendations that were prepared independently of any other interests, including those of Barclays and/or its affiliates, and/or the subject companies. This publication does not contain personal investment recommendations or investment advice or take into account the individual financial circumstances or investment objectives of the clients who receive it. The securities and other investments discussed herein may not be suitable for all investors. Barclays is not a fiduciary to any recipient of this publication. Investors must independently evaluate the merits and risks of the investments discussed herein, consult any independent advisors they believe necessary, and exercise independent judgment with regard to any investment decision. The value of and income from any investment may fluctuate from day to day as a result of changes in relevant economic markets (including changes in market liquidity). The information herein is not intended to predict actual results, which may differ substantially from those reflected. Past performance is not necessarily indicative of future results. The information provided does not constitute a financial benchmark and should not be used as a submission or contribution of input data for the purposes of determining a financial benchmark.

United Kingdom: This document is being distributed (1) only by or with the approval of an authorised person (Barclays Bank PLC) or (2) to, and is directed at (a) persons in the United Kingdom having professional experience in matters relating to investments and who fall within the definition of "investment professionals" in Article 19(5) of the Financial Services and Markets Act 2000 (Financial Promotion) Order 2005 (the "Order"); or (b) high net worth companies, unincorporated associations and partnerships and trustees of high value trusts as described in Article 49(2) of the Order; or (c) other persons to whom it may otherwise lawfully be communicated (all such persons being "Relevant Persons"). Any investment or investment activity to which this communication relates is only available to and will only be engaged in with Relevant Persons. Any other persons who receive this communication should not rely on or act upon it. Barclays Bank PLC is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority and is a member of the London Stock Exchange.

European Economic Area ("EEA"): This material is being distributed in the EEA by Barclays Bank PLC. Barclays Bank PLC is not registered in France with the Autorité des marchés financiers or the Autorité de contrôle prudentiel.

Americas: The Investment Bank of Barclays Bank PLC undertakes U.S. securities business in the name of its wholly owned subsidiary Barclays Capital Inc., a FINRA and SIPC member. Barclays Capital Inc., a U.S. registered broker/dealer, is distributing this material in the United States and, in connection therewith accepts responsibility for its contents. Any U.S. person wishing to effect a transaction in any security discussed herein should do so only by contacting a representative of Barclays Capital Inc. in the U.S. at 745 Seventh Avenue, New York, New York 10019.

Non-U.S. persons should contact and execute transactions through a Barclays Bank PLC branch or affiliate in their home jurisdiction unless local regulations permit otherwise.

This material is distributed in Canada by Barclays Capital Canada Inc., a registered investment dealer, a Dealer Member of IIROC (www.iiroc.ca), and a Member of the Canadian Investor Protection Fund (CIPF).

This material is distributed in Mexico by Barclays Bank Mexico, S.A.

Japan: This material is being distributed to institutional investors in Japan by Barclays Securities Japan Limited. Barclays Securities Japan Limited is a joint-stock company incorporated in Japan with registered office of 6-10-1 Roppongi, Minato-ku, Tokyo 106-6131, Japan. It is a subsidiary of Barclays Bank PLC and a registered financial instruments firm regulated by the Financial Services Agency of Japan. Registered Number: Kanto Zaimukyokucho (kinsho) No. 143.

Disclaimer (continued)

Asia Pacific (excluding Japan): Barclays Bank PLC, Hong Kong Branch is distributing this material in Hong Kong as an authorised institution regulated by the Hong Kong Monetary Authority. Registered Office: 41/F, Cheung Kong Center, 2 Queen's Road Central, Hong Kong.

All Indian securities-related research and other equity research produced by Barclays' Investment Bank are distributed in India by Barclays Securities (India) Private Limited (BSIPL). BSIPL is a company incorporated under the Companies Act, 1956 having CIN U67120MH2006PTC161063. BSIPL is registered and regulated by the Securities and Exchange Board of India (SEBI) as a Research Analyst: INH000001519; Portfolio Manager INP000002585; Stock Broker/Trading and Clearing Member: National Stock Exchange of India Limited (NSE) Capital Market INB231292732, NSE Futures & Options INF231292732, NSE Currency derivatives INE231450334, Bombay Stock Exchange Limited (BSE) Capital Market INB011292738, BSE Futures & Options INF011292738; Depository Participant (DP) with the National Securities & Depositories Limited (NSDL): DP ID: IN-DP-NSDL-299-2008; Investment Adviser: INA000000391. The registered office of BSIPL is at 208, Ceejay House, Shivsagar Estate, Dr. A. Besant Road, Worli, Mumbai – 400 018, India. Telephone No: +91 2267196000. Fax number: +91 22 67196100. Any other reports produced by Barclays' Investment Bank are distributed in India by Barclays Bank PLC, India Branch, an associate of BSIPL in India that is registered with Reserve Bank of India (RBI) as a Banking Company under the provisions of The Banking Regulation Act, 1949 (Regn No BOM43) and registered with SEBI as Merchant Banker (Regn No INM000002129) and also as Banker to the Issue (Regn No INBI00000950). Barclays Investments and Loans (India) Limited, registered with RBI as Non Banking Financial Company (Regn No RBI CoR-07-00258), and Barclays Wealth Trustees (India) Private Limited, registered with Registrar of Companies (CIN U93000MH2008PTC188438), are associates of BSIPL in India that are not authorised to distribute any reports produced by Barclays' Investment Bank.

This material is distributed in Singapore by the Singapore branch of Barclays Bank PLC, a bank licensed in Singapore by the Monetary Authority of Singapore. For matters in connection with this material, recipients in Singapore may contact the Singapore branch of Barclays Bank PLC, whose registered address is 10 Marina Boulevard, #23-01 Marina Bay Financial Centre Tower 2, Singapore 018983.

This material is distributed to persons in Australia by Barclays Bank PLC. None of Barclays Bank PLC, nor any other Barclays group entity, holds an Australian financial services licence and instead relies on an exemption from the requirement to hold such a licence. This material is intended to only be distributed to "wholesale clients" as defined by the Australian Corporations Act 2001.

Middle East: Nothing herein should be considered investment advice as defined in the Israeli Regulation of Investment Advisory, Investment Marketing and Portfolio Management Law, 1995 ("Advisory Law"). This document is being made to eligible clients (as defined under the Advisory Law) only. Barclays Israeli branch previously held an investment marketing license with the Israel Securities Authority but it cancelled such license on 30/11/2014 as it solely provides its services to eligible clients pursuant to available exemptions under the Advisory Law, therefore a license with the Israel Securities Authority is not required. Accordingly, Barclays does not maintain an insurance coverage pursuant to the Advisory Law.

This material is distributed in the United Arab Emirates (including the Dubai International Financial Centre) and Qatar by Barclays Bank PLC. Barclays Bank PLC in the Dubai International Financial Centre (Registered No. 0060) is regulated by the Dubai Financial Services Authority (DFSA). Principal place of business in the Dubai International Financial Centre: The Gate Village, Building 4, Level 4, PO Box 506504, Dubai, United Arab Emirates. Barclays Bank PLC-DIFC Branch, may only undertake the financial services activities that fall within the scope of its existing DFSA licence. Related financial products or services are only available to Professional Clients, as defined by the Dubai Financial Services Authority. Barclays Bank PLC in the UAE is regulated by the Central Bank of the UAE and is licensed to conduct business activities as a branch of a commercial bank incorporated outside the UAE in Dubai (Licence No.: 13/1844/2008, Registered Office: Building No. 6, Burj Dubai Business Hub, Sheikh Zayed Road, Dubai City) and Abu Dhabi (Licence No.: 13/952/2008, Registered Office: Al Jazira Towers, Hamdan Street, PO Box 2734, Abu Dhabi). Barclays Bank PLC in the Qatar Financial Centre (Registered No. 00018) is authorised by the Qatar Financial Centre Regulatory Authority (QFCRA). Barclays Bank PLC-QFC Branch may only undertake the regulated activities that fall within the scope of its existing QFCRA licence. Principal place of business in Qatar: Qatar Financial Centre, Office 1002, 10th Floor, QFC Tower, Diplomatic Area, West Bay, PO Box 15891, Doha, Qatar. Related financial products or services are only available to Business Customers as defined by the Qatar Financial Centre Regulatory Authority.

Russia: This material is not intended for investors who are not Qualified Investors according to the laws of the Russian Federation as it might contain information about or description of the features of financial instruments not admitted for public offering and/or circulation in the Russian Federation and thus not eligible for non-Qualified Investors. If you are not a Qualified Investor according to the laws of the Russian Federation, please dispose of any copy of this material in your possession.

IRS Circular 230 Prepared Materials Disclaimer: Barclays does not provide tax advice and nothing contained herein should be construed to be tax advice. Please be advised that any discussion of U.S. tax matters contained herein (including any attachments) (i) is not intended or written to be used, and cannot be used, by you for the purpose of avoiding U.S. tax-related penalties; and (ii) was written to support the promotion or marketing of the transactions or other matters addressed herein. Accordingly, you should seek advice based on your particular circumstances from an independent tax advisor.

© Copyright Barclays Bank PLC (2019). All rights reserved. No part of this publication may be reproduced or redistributed in any manner without the prior written permission of Barclays. Barclays Bank PLC is registered in England No. 1026167. Registered office 1 Churchill Place, London, E14 5HP. Additional information regarding this publication will be furnished upon request. US35722