10_intraday_features

September 29, 2021

1 Intraday Strategy, Part 1: Feature Engineering

In this notebook, we load the high-quality NASDAQ100 minute-bar trade-and-quote data generously provided by Algoseek (available here) and engineer a few illustrative features.

The rich set of trade and quote information contained in the Algoseek data offers various opportunities to add inforation, e.g. about relative spreads and demand/supply imbalances, but since the data is fairly large we limit our efforts to a small number of features.

> Note that we will assume throughout that we can always buy (sell) at the first (last) trade price for a given bar at no cost and without market impact; this is unlikely to be true in reality but simplifies the example).

The next notebook will use this dataset to train a model that predicts 1-minute returns using LightGBM.

1.1 Imports & Settings

[1]:
```
import warnings
warnings.filterwarnings('ignore')
```

[2]:
```
%matplotlib inline

from pathlib import Path
from tqdm import tqdm

import numpy as np
import pandas as pd

from scipy.stats import spearmanr
import talib

import matplotlib.pyplot as plt
from matplotlib.ticker import FuncFormatter
import seaborn as sns
```

[3]:
```
sns.set_style('whitegrid')
idx = pd.IndexSlice
deciles = np.arange(.1, 1, .1)
```

1.2 Algoseek Trade & Quote Minute Bar Data

1.2.1 Data Dictionary

The Quote fields are based on changes to the NBBO (National Best Bid Offer) from the top-of-book price and size from each of the exchanges.

The enhanced Trade & Quote bar fields include the following fields: - **Field**: Name of Field. - **Q / T**: Field based on Quotes or Trades - **Type**: Field format - **No Value**: Value of field when there is no value or data. - Note: "Never" means field should always have a value EXCEPT for the first bar of the day. - **Description**: Description of the field.

See docs for additional detail.

id	Field	Q/T	Type	No Value	Description
1	`Date`		YYYYMMDD	Never	Trade Date
2	`Ticker`		String	Never	Ticker Symbol
3	`TimeBarStart`		HHMM HHMMSS HHMMSSMMM	Never	For minute bars: HHMM. For second bars: HHMMSS. Examples- One second bar 130302 is from time greater than 130301 to 130302.- One minute bar 1104 is from time greater than 1103 to 1104.
4	`OpenBarTime`	Q	HHMMSSMMM	Never	Open Time of the Bar, for example one minute:11:03:00.000
5	`OpenBidPrice`	Q	Number	Never	NBBO Bid Price as of bar Open
6	`OpenBidSize`	Q	Number	Never	Total Size from all Exchanges withOpenBidPrice
7	`OpenAskPrice`	Q	Number	Never	NBBO Ask Price as of bar Open
8	`OpenAskSize`	Q	Number	Never	Total Size from all Exchange withOpenAskPrice
9	`FirstTradeTime`	T	HHMMSSMMM	Blank	Time of first Trade
10	`FirstTradePrice`	T	Number	Blank	Price of first Trade
11	`FirstTradeSize`	T	Number	Blank	Number of shares of first trade
12	`HighBidTime`	Q	HHMMSSMMM	Never	Time of highest NBBO Bid Price
13	`HighBidPrice`	Q	Number	Never	Highest NBBO Bid Price
14	`HighBidSize`	Q	Number	Never	Total Size from all Exchanges with HighBidPrice
15	`AskPriceAtHighBidPrice`	Q	Number	Never	Ask Price at time of Highest Bid Price
16	`AskSizeAtHighBidPrice`	Q	Number	Never	Total Size from all Exchanges with `AskPriceAtHighBidPrice`
17	`HighTradeTime`	T	HHMMSSMMM	Blank	Time of Highest Trade
18	`HighTradePrice`	T	Number	Blank	Price of highest Trade
19	`HighTradeSize`	T	Number	Blank	Number of shares of highest trade
20	`LowBidTime`	Q	HHMMSSMMM	Never	Time of lowest Bid
21	`LowBidPrice`	Q	Number	Never	Lowest NBBO Bid price of bar.
22	`LowBidSize`	Q	Number	Never	Total Size from all Exchanges with `LowBidPrice`
23	`AskPriceAtLowBidPrice`	Q	Number	Never	Ask Price at lowest Bid price
24	`AskSizeAtLowBidPrice`	Q	Number	Never	Total Size from all Exchanges with `AskPriceAtLowBidPrice`
25	`LowTradeTime`	T	HHMMSSMMM	Blank	Time of lowest Trade
26	`LowTradePrice`	T	Number	Blank	Price of lowest Trade
27	`LowTradeSize`	T	Number	Blank	Number of shares of lowest trade
28	`CloseBarTime`	Q	HHMMSSMMM	Never	Close Time of the Bar, for example one minute: 11:03:59.999

id	Field	Q/T	Type	No Value	Description
29	CloseBidPrice	Q	Number	Never	NBBO Bid Price at bar Close
30	CloseBidSize	Q	Number	Never	Total Size from all Exchange with CloseBidPrice
31	CloseAskPrice	Q	Number	Never	NBBO Ask Price at bar Close
32	CloseAskSize	Q	Number	Never	Total Size from all Exchange with CloseAskPrice
33	LastTradeTime	T	HHMMSSMMM	Blank	Time of last Trade
34	LastTradePrice	T	Number	Blank	Price of last Trade
35	LastTradeSize	T	Number	Blank	Number of shares of last trade
36	MinSpread	Q	Number	Never	Minimum Bid-Ask spread size. This may be 0 if the market was crossed during the bar.If negative spread due to back quote, make it 0.
37	MaxSpread	Q	Number	Never	Maximum Bid-Ask spread in bar
38	CancelSize	T	Number	0	Total shares canceled. Default=blank
39	VolumeWeightPrice	T	Number	Blank	Trade Volume weighted average price Sum((Trade1Shares*Price)+(Trade2Shares*Price)+…)/TotalShares. Note: Blank if no trades.
40	NBBOQuoteCount	Q	Number	0	Number of Bid and Ask NNBO quotes during bar period.
41	TradeAtBidQty	T	Number	0	Sum of trade volume that occurred at or below the bid (a trade reported/printed late can be below current bid).
42	TradeAtBidMidQty	T	Number	0	Sum of trade volume that occurred between the bid and the mid-point:(Trade Price > NBBO Bid) & (Trade Price < NBBO Mid)
43	TradeAtMidQty	T	Number	0	Sum of trade volume that occurred at mid.TradePrice = NBBO MidPoint
44	TradeAtMidAskQty	T	Number	0	Sum of ask volume that occurred between the mid and ask:(Trade Price > NBBO Mid) & (Trade Price < NBBO Ask)
45	TradeAtAskQty	T	Number	0	Sum of trade volume that occurred at or above the Ask.
46	TradeAtCrossLockedQty	T	Number	0	Sum of trade volume for bar when national best bid/offer is locked or crossed. Locked is Bid = Ask Crossed is Bid > Ask
47	Volume	T	Number	0	Total number of shares traded
48	TotalTrades	T	Number	0	Total number of trades
49	FinraVolume	T	Number	0	Number of shares traded that are reported by FINRA. Trades reported by FINRA are from broker-dealer internalization, dark pools, Over-The-Counter, etc. FINRA trades represent volume that is hidden or not public available to trade.
50	UptickVolume	T	Integer	0	Total number of shares traded with upticks during bar.An uptick = (trade price > last trade price)
51	DowntickVolume	T	Integer	0	Total number of shares traded with downticks during bar.A downtick = (trade price < last trade price)
52	RepeatUpTickVolume	T	Integer	0	Total number of shares where trade price is the same (repeated) and last price change was up during bar. Repeat uptick = (trade price == last trade price) & (last tick direction == up)

id	Field	Q/TType	No Value	Description
53	RepeatDownTickVolume	Integer	0	Total number of shares where trade price is the same (repeated) and last price change was down during bar. Repeat downtick = (trade price == last trade price) & (last tick direction == down)
54	UnknownVolume	Integer	0	When the first trade of the day takes place, the tick direction is "unknown" as there is no previous Trade to compare it to.This field is the volume of the first trade after 4am and acts as an initiation value for the tick volume directions.In future this bar will be renamed to `UnkownTickDirectionVolume` .

1.2.2 Notes

Empty Fields

An empty field has no value and is "Blank" , for example FirstTradeTime and there are no trades during the bar period. The field `Volume` measuring total number of shares traded in bar will be `0` if there are no Trades (see `No Value` column above for each field).

No Bid/Ask/Trade OHLC

During a bar timeframe there may not be a change in the NBBO or an actual Trade. For example, there can be a bar with OHLC Bid/Ask but no Trade OHLC.

Single Event

For bars with only one trade, one NBBO bid or one NBBO ask then Open/High/Low/Close price,size andtime will be the same.

`AskPriceAtHighBidPrice`, `AskSizeAtHighBidPrice`, `AskPriceAtLowBidPrice`, `AskSizeAtLowBidPrice` Fields

To provide consistent Bid/Ask prices at a point in time while showing the low/high Bid/Ask for the bar, AlgoSeek uses the low/high `Bid` and the corresponding `Ask` at that price.

1.2.3 FAQ

Why are Trade Prices often inside the Bid Price to Ask Price range?

The Low/High Bid/Ask is the low and high NBBO price for the bar range. Very often a Trade may not occur at these prices as the price may only last a few seconds or executions are being crossed at mid-point due to hidden order types that execute at mid-point or as price improvement over current `Bid`/`Ask`.

How to get exchange tradable shares?

To get the exchange tradable volume in a bar subtract `Volume` from `FinraVolume`. - `Volume` is the total number of shares traded. - `FinraVolume` is the total number of shares traded that are reported as executions by FINRA.

When a trade is done that is off the listed exchanges, it must be reported to FINRA by the brokerage firm or dark pool. Examples include: - internal crosses by broker dealer - over-the-counter block trades, and - dark pool executions.

1.3 Data prep

We use the 'Trade and Quote' dataset - see documentation for details on the definition of the numerous fields.

[4]:
```
tcols = ['openbartime',
         'firsttradetime',
         'highbidtime',
         'highasktime',
         'hightradetime',
         'lowbidtime',
         'lowasktime',
         'lowtradetime',
         'closebartime',
         'lasttradetime']
```

[5]:
```
drop_cols = ['unknowntickvolume',
             'cancelsize',
             'tradeatcrossorlocked']
```

[6]:
```
keep = ['firsttradeprice',
        'hightradeprice',
        'lowtradeprice',
        'lasttradeprice',
        'minspread',
        'maxspread',
        'volumeweightprice',
        'nbboquotecount',
        'tradeatbid',
        'tradeatbidmid',
        'tradeatmid',
        'tradeatmidask',
        'tradeatask',
        'volume',
        'totaltrades',
        'finravolume',
        'finravolumeweightprice',
        'uptickvolume',
        'downtickvolume',
        'repeatuptickvolume',
        'repeatdowntickvolume',
        'tradetomidvolweight',
        'tradetomidvolweightrelative']
```

We will shorten most of the field names to reduce typing:

[7]:
```
columns = {'volumeweightprice'           : 'price',
           'finravolume'                 : 'fvolume',
           'finravolumeweightprice'      : 'fprice',
           'uptickvolume'                : 'up',
           'downtickvolume'              : 'down',
           'repeatuptickvolume'          : 'rup',
           'repeatdowntickvolume'        : 'rdown',
           'firsttradeprice'             : 'first',
           'hightradeprice'              : 'high',
           'lowtradeprice'               : 'low',
           'lasttradeprice'              : 'last',
           'nbboquotecount'              : 'nbbo',
           'totaltrades'                 : 'ntrades',
           'openbidprice'                : 'obprice',
           'openbidsize'                 : 'obsize',
           'openaskprice'                : 'oaprice',
           'openasksize'                 : 'oasize',
           'highbidprice'                : 'hbprice',
           'highbidsize'                 : 'hbsize',
           'highaskprice'                : 'haprice',
           'highasksize'                 : 'hasize',
           'lowbidprice'                 : 'lbprice',
           'lowbidsize'                  : 'lbsize',
           'lowaskprice'                 : 'laprice',
           'lowasksize'                  : 'lasize',
           'closebidprice'               : 'cbprice',
           'closebidsize'                : 'cbsize',
           'closeaskprice'               : 'caprice',
           'closeasksize'                : 'casize',
           'firsttradesize'              : 'firstsize',
           'hightradesize'               : 'highsize',
           'lowtradesize'                : 'lowsize',
           'lasttradesize'               : 'lastsize',
           'tradetomidvolweight'         : 'volweight',
           'tradetomidvolweightrelative': 'volweightrel'}
```

The Algoseek minute-bar data comes in compressed csv files that contain the data for one symbol and day, organized in three directories for each year (2015-17). The function `extract_and_combine_data` reads the ~80K source files and combines them into a single `hdf5` file for faster access.

> The data is fairly large (>8GB), and if you run into memory constraints, please modify the code to process the data in smaller chunks. One options is to iterate over the three directories containing data for a single year only, and storing each year separately.

[8]:
```
nasdaq_path = Path('../data/nasdaq100')
```

[9]:
```
def extract_and_combine_data():
    path = nasdaq_path / '1min_taq'

    data = []
    # ~80K files to process
    for f in tqdm(list(path.glob('*/**/*.csv.gz'))):
        data.append(pd.read_csv(f, parse_dates=[['Date', 'TimeBarStart']])
                    .rename(columns=str.lower)
                    .drop(tcols + drop_cols, axis=1)
                    .rename(columns=columns)
                    .set_index('date_timebarstart')
                    .sort_index()
                    .between_time('9:30', '16:00')
                    .set_index('ticker', append=True)
                    .swaplevel()
                    .rename(columns=lambda x: x.replace('tradeat', 'at')))
    data = pd.concat(data).apply(pd.to_numeric, downcast='integer')
    data.index.rename(['ticker', 'date_time'])
    print(data.info(show_counts=True))
    data.to_hdf(nasdaq_path / 'algoseek.h5', 'min_taq')
```

[10]:
```
# extract_and_combine_data()
```

1.4 Loading Algoseek Data

[11]:
```
ohlcv_cols = ['first', 'high', 'low', 'last', 'price', 'volume']
```

[12]:
```
data_cols = ohlcv_cols + ['up', 'down', 'rup', 'rdown', 'atask', 'atbid']
```

[13]:
```
with pd.HDFStore(as_path / 'algoseek.h5') as store:
    df = store['min_taq'].loc[:, data_cols].sort_index()
```

[14]:
```
df['date'] = pd.to_datetime(df.index.get_level_values('date_time').date)
```

We persist the reduced dataset:

[17]:
```
df.to_hdf('data/algoseek.h5', 'data')
```

[18]:
```
df = pd.read_hdf('data/algoseek.h5', 'data')
```

[19]:
```
df.info(null_counts=True)
```

```
<class 'pandas.core.frame.DataFrame'>
MultiIndex: 31355463 entries, ('AAL', Timestamp('2015-01-02 09:30:00')) to
('YHOO', Timestamp('2017-06-16 16:00:00'))
Data columns (total 13 columns):
 #   Column  Non-Null Count     Dtype
```

```
---  ------  --------------     -----
 0   first   30955838 non-null  float64
 1   high    30955838 non-null  float64
 2   low     30955838 non-null  float64
 3   last    30955838 non-null  float64
 4   price   30386944 non-null  float64
 5   volume  31355463 non-null  int32
 6   up      31355463 non-null  int32
 7   down    31355463 non-null  int32
 8   rup     31355463 non-null  int32
 9   rdown   31355463 non-null  int32
 10  atask   31355463 non-null  int32
 11  atbid   31355463 non-null  int32
 12  date    31355463 non-null  datetime64[ns]
dtypes: datetime64[ns](1), float64(5), int32(7)
memory usage: 2.4+ GB
```

1.5 Feature Engineering

All of the features above were normalized in a standard fashion by subtracting their means, dividing by their standard deviations, and time-averaging over a recent interval. In order to obtain a finite state space, features were discretized into bins in multiples of standard deviation units

We will compute feature per ticker or ticker and date:

[20]:
```
by_ticker = df.sort_index().groupby('ticker', group_keys=False)
by_ticker_date = df.sort_index().groupby(['ticker', 'date'])
```

Create empty `DataFrame` with original ticker/timestamp index to hold our features:

[21]:
```
data = pd.DataFrame(index=df.index)
```

[22]:
```
data['date'] = pd.factorize(df['date'], sort=True)[0]
```

[23]:
```
data['minute'] = pd.to_timedelta(data.index.get_level_values('date_time').time.
 ↪astype(str))
data.minute = (data.minute.dt.seconds.sub(data.minute.dt.seconds.min()).div(60).
 ↪astype(int))
```

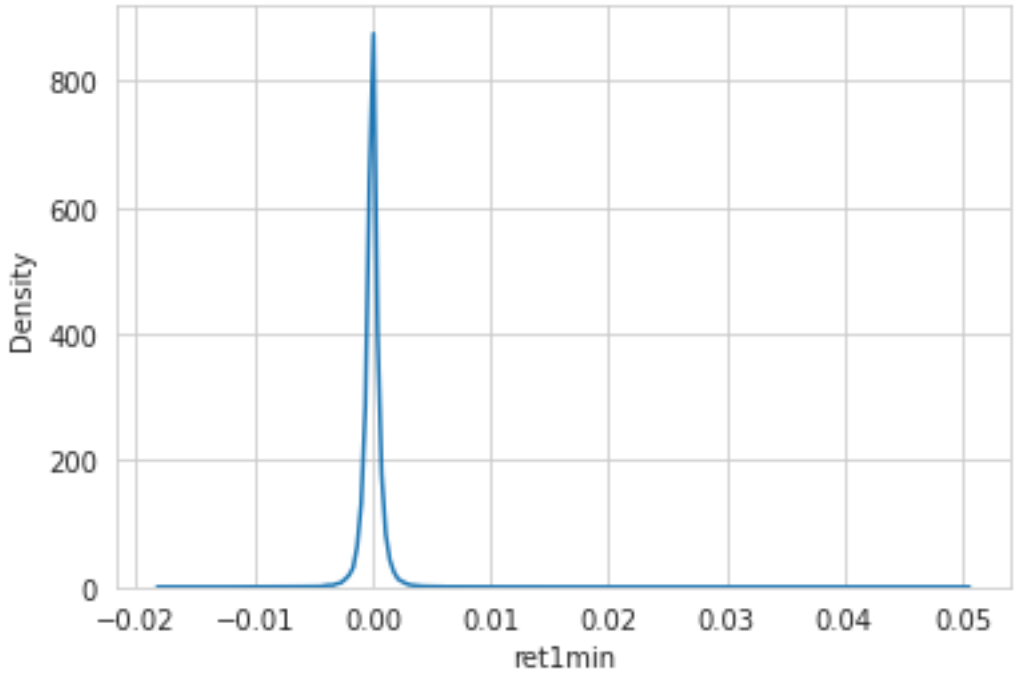
1.5.1 Lagged Returns

We create lagged returns with respect to first and last price per bar for each the past 10 minutes:

[24]:
```
data[f'ret1min'] = df['last'].div(df['first']).sub(1)
```

1-min returns have rather heavy tails:

[25]:
```
sns.kdeplot(data.ret1min.sample(n=100000));
```



[26]:
```
data.ret1min.describe(percentiles=np.arange(.1, 1, .1)).iloc[1:].apply(lambda x:
↪ f'{x:.3%}')
```

[26]:
```
mean      -0.000%
std        0.086%
min      -12.448%
10%       -0.075%
20%       -0.041%
30%       -0.023%
40%       -0.009%
50%        0.000%
60%        0.009%
70%        0.022%
80%        0.040%
90%        0.074%
max       13.392%
Name: ret1min, dtype: object
```

[27]:
```
print(f'Skew: {data.ret1min.skew():.2f} | Kurtosis: {data.ret1min.kurtosis():.
↪2f}')
```

```
Skew: 0.63 | Kurtosis: 399.53
```

Intra-bar price moves with the highest returns:

[28]:
```
data.join(df[['first', 'last']]).nlargest(10, columns=['ret1min'])
```

[28]:

ticker	date_time	date	minute	ret1min	first	last
TSCO	2016-12-22 10:01:00	498	31	0.133921	68.1000	77.2200
AMGN	2017-03-06 15:46:00	546	376	0.132842	158.7600	179.8500
LILA	2015-07-02 09:39:00	125	9	0.121998	50.0001	56.1000
BIDU	2015-08-24 09:32:00	161	2	0.119729	111.2300	124.5475
NXPI	2016-09-29 13:10:00	439	220	0.119144	81.7500	91.4900
HSIC	2015-10-26 15:38:00	205	368	0.105501	135.0700	149.3200
CELG	2015-08-24 09:35:00	161	5	0.100645	93.0000	102.3600
LILAK	2015-07-02 09:38:00	125	8	0.098778	50.0101	54.9500
CTRP	2017-12-11 10:51:00	741	81	0.097899	43.3100	47.5500
LMCK	2016-02-23 09:30:00	286	0	0.095641	30.7400	33.6800

We compute similarly for the remaining periods:

[29]:
```
for t in tqdm(range(2, 11)):
    data[f'ret{t}min'] = df['last'].div(by_ticker_date['first'].shift(t-1)).
 ↪sub(1)
```

```
100%|      | 9/9 [00:20<00:00,  2.24s/it]
```

1.5.2 Forward Returns

We obtain our 1-min forward return target by shifting the one-period return by one minute into the past (which implies the assumption that we always enter and exit a position at those prices, also ignoring trading cost and potential market impact):

[30]:
```
data['fwd1min'] = (data
                   .sort_index()
                   .groupby(['ticker', 'date'])
                   .ret1min
                   .shift(-1))
```

[31]:
```
data = data.dropna(subset=['fwd1min'])
```

[32]:
```
data.info(null_counts=True)
```

```
<class 'pandas.core.frame.DataFrame'>
MultiIndex: 30875649 entries, ('AAL', Timestamp('2015-01-02 09:30:00')) to
('YHOO', Timestamp('2017-06-16 15:59:00'))
Data columns (total 13 columns):
 #   Column    Non-Null Count     Dtype
---  ------    --------------     -----
 0   date      30875649 non-null  int64
 1   minute    30875649 non-null  int64
 2   ret1min   30612848 non-null  float64
```

```
 3   ret2min   30302846 non-null  float64
 4   ret3min   30220887 non-null  float64
 5   ret4min   30141503 non-null  float64
 6   ret5min   30063236 non-null  float64
 7   ret6min   29983969 non-null  float64
 8   ret7min   29903822 non-null  float64
 9   ret8min   29824607 non-null  float64
 10  ret9min   29745431 non-null  float64
 11  ret10min  29666821 non-null  float64
 12  fwd1min   30875649 non-null  float64
dtypes: float64(11), int64(2)
memory usage: 3.2+ GB
```

1.5.3 Normalized up/downtick volume

[33]:
```
for f in ['up', 'down', 'rup', 'rdown']:
    data[f] = df.loc[:, f].div(df.volume).replace(np.inf, np.nan)
```

[34]:
```
data.loc[:, ['rup', 'up', 'rdown', 'down']].describe(deciles)
```

[34]:

	rup	up	rdown	down
count	3.008378e+07	3.008378e+07	3.008378e+07	3.008378e+07
mean	5.115708e-01	7.005788e-01	5.133731e-01	7.195690e-01
std	1.574588e+01	3.330319e+01	1.715537e+01	3.393822e+01
min	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
10%	0.000000e+00	6.575102e-02	0.000000e+00	6.686489e-02
20%	9.647853e-02	1.111111e-01	9.905957e-02	1.129661e-01
30%	1.980198e-01	1.521226e-01	2.012931e-01	1.546516e-01
40%	2.859422e-01	1.957295e-01	2.914713e-01	1.992032e-01
50%	3.702796e-01	2.457865e-01	3.758913e-01	2.500000e-01
60%	4.582528e-01	3.063010e-01	4.637681e-01	3.122179e-01
70%	5.554740e-01	3.860160e-01	5.598733e-01	3.939394e-01
80%	6.797847e-01	5.042373e-01	6.824063e-01	5.152091e-01
90%	8.663207e-01	7.783313e-01	8.666443e-01	7.998253e-01
max	4.860000e+04	9.947025e+04	6.020700e+04	1.051000e+05

1.5.4 Balance of Power

[35]:
```
data['BOP'] = (by_ticker.apply(lambda x: talib.BOP(x['first'],
                                                   x.high,
                                                   x.low,
                                                   x['last'])))
```

1.5.5 Commodity Channel Index

[36]:
```
data['CCI'] = (by_ticker.apply(lambda x: talib.CCI(x.high,
                                                   x.low,
                                                   x['last'],
                                                   timeperiod=14)))
```

1.5.6 Money Flow Index

[37]:
```
data['MFI'] = (by_ticker.apply(lambda x: talib.MFI(x.high,
                                                   x.low,
                                                   x['last'],
                                                   x.volume,
                                                   timeperiod=14)))
```

[38]:
```
data[['BOP', 'CCI', 'MFI']].describe(deciles)
```

[38]:

	BOP	CCI	MFI
count	3.061285e+07	2.851777e+07	3.087372e+07
mean	-2.087998e-03	3.296217e-01	4.997376e+01
std	6.266554e-01	1.088812e+02	1.969084e+01
min	-1.000000e+00	-4.666667e+02	-1.116565e-06
10%	-9.000000e-01	-1.376036e+02	2.396008e+01
20%	-6.633333e-01	-9.977407e+01	3.241035e+01
30%	-4.500000e-01	-6.911730e+01	3.886505e+01
40%	-1.818182e-01	-3.690746e+01	4.454481e+01
50%	0.000000e+00	7.306860e-01	4.992163e+01
60%	1.672241e-01	3.807433e+01	5.531387e+01
70%	4.438265e-01	6.977712e+01	6.102497e+01
80%	6.551724e-01	9.999456e+01	6.754293e+01
90%	9.000000e-01	1.376381e+02	7.610819e+01
max	1.000000e+00	4.666667e+02	1.000000e+02

1.5.7 Stochastic RSI

[39]:
```
data['STOCHRSI'] = (by_ticker.apply(lambda x: talib.STOCHRSI(x['last'].ffill(),
                                                             timeperiod=14,
                                                             fastk_period=14,
                                                             fastd_period=3,
                                                             ␣
 ↪fastd_matype=0)[0]))
```

1.5.8 Stochastic Oscillator

[40]:
```
def compute_stoch(x, fastk_period=14, slowk_period=3, slowk_matype=0,␣
↪slowd_period=3, slowd_matype=0):
    slowk, slowd = talib.STOCH(x.high.ffill(), x.low.ffill(), x['last'].ffill(),
                               fastk_period=fastk_period,
                               slowk_period=slowk_period,
                               slowk_matype=slowk_matype,
                               slowd_period=slowd_period,
                               slowd_matype=slowd_matype)
    return pd.DataFrame({'slowd': slowd,
                         'slowk': slowk},
                        index=x.index)
```

[41]:
```
data = data.join(by_ticker.apply(compute_stoch))
```

1.5.9 Average True Range

[42]:
```
data['NATR'] = by_ticker.apply(lambda x: talib.NATR(x.high.ffill(),
                                                    x.low.ffill(),
                                                    x['last'].ffill()))
```

1.5.10 Transaction Volume by price point

[43]:
```
data['trades_bid_ask'] = df.atask.sub(df.atbid).div(df.volume).replace((np.inf,␣
↪-np.inf), np.nan)
```

[44]:
```
del df
```

[45]:
```
data.info(show_counts=True)
```

```
<class 'pandas.core.frame.DataFrame'>
MultiIndex: 30875649 entries, ('AAL', Timestamp('2015-01-02 09:30:00')) to
('YHOO', Timestamp('2017-06-16 15:59:00'))
Data columns (total 25 columns):
 #   Column          Non-Null Count     Dtype
---  ------          --------------     -----
 0   date            30875649 non-null  int64
 1   minute          30875649 non-null  int64
 2   ret1min         30612848 non-null  float64
 3   ret2min         30302846 non-null  float64
 4   ret3min         30220887 non-null  float64
 5   ret4min         30141503 non-null  float64
 6   ret5min         30063236 non-null  float64
 7   ret6min         29983969 non-null  float64
 8   ret7min         29903822 non-null  float64
 9   ret8min         29824607 non-null  float64
```

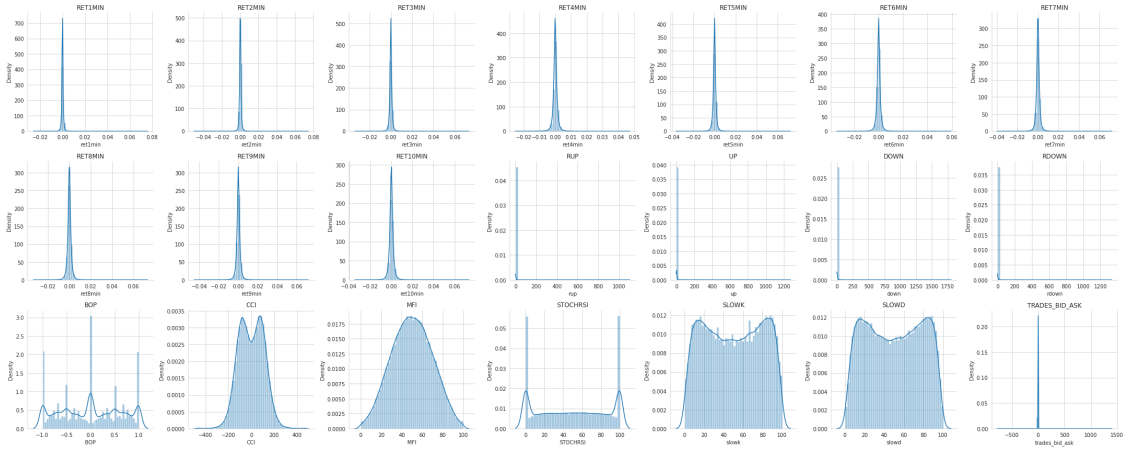
```
 10  ret9min          29745431 non-null  float64
 11  ret10min         29666821 non-null  float64
 12  fwd1min          30875649 non-null  float64
 13  up               30083777 non-null  float64
 14  down             30083777 non-null  float64
 15  rup              30083777 non-null  float64
 16  rdown            30083777 non-null  float64
 17  BOP              30612848 non-null  float64
 18  CCI              28517773 non-null  float64
 19  MFI              30873719 non-null  float64
 20  STOCHRSI         30871639 non-null  float64
 21  slowd            30873302 non-null  float64
 22  slowk            30873302 non-null  float64
 23  NATR             30873719 non-null  float64
 24  trades_bid_ask   30083777 non-null  float64
dtypes: float64(23), int64(2)
memory usage: 6.9+ GB
```

1.5.11 Evaluate features

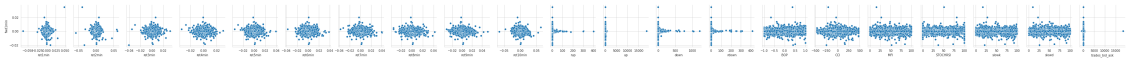
[65]:
```
features = ['ret1min', 'ret2min', 'ret3min', 'ret4min', 'ret5min',
            'ret6min', 'ret7min', 'ret8min', 'ret9min', 'ret10min',
            'rup', 'up', 'down', 'rdown', 'BOP', 'CCI', 'MFI', 'STOCHRSI',
            'slowk', 'slowd', 'trades_bid_ask']
```

[ ]:
```
sample = data.sample(n=100000)
```

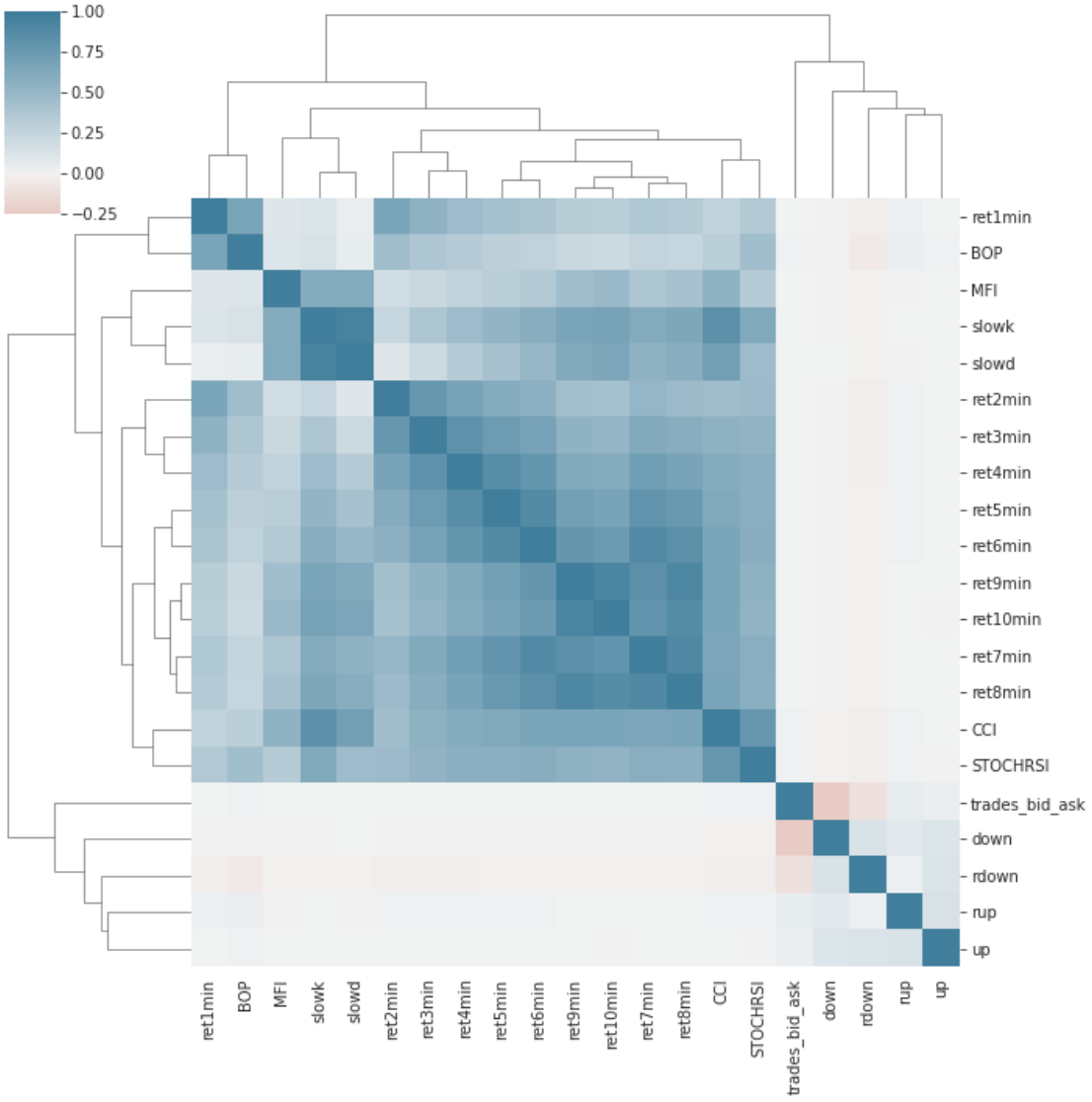
[69]:
```
fig, axes = plt.subplots(nrows=3, ncols=7, figsize=(30, 12))
axes = axes.flatten()

for i, feature in enumerate(features):
    sns.distplot(sample[feature], ax=axes[i])
    axes[i].set_title(feature.upper())

sns.despine()
fig.tight_layout()
```



[47]:
```
sns.pairplot(sample, y_vars=['fwd1min'], x_vars=features);
```



[63]:
```
corr = sample.loc[:, features].corr()
sns.clustermap(corr, cmap = sns.diverging_palette(20, 230, as_cmap=True),
               center=0, vmin=-.25);
```



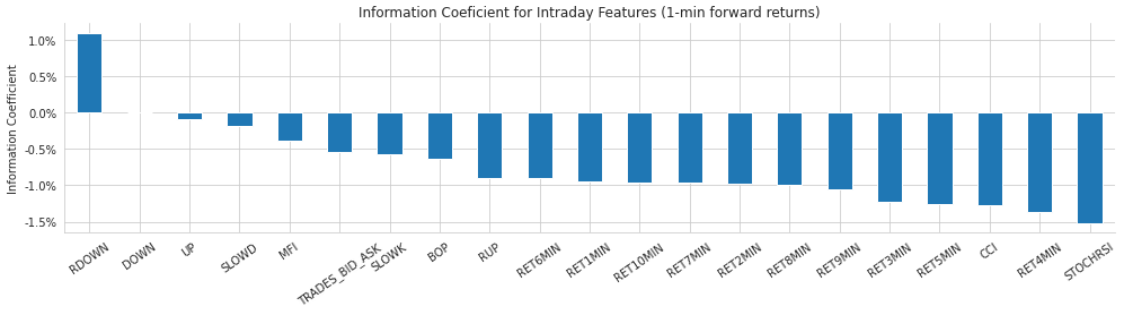
[48]:
```
ic = {}
for feature in tqdm(features):
    df = data[['fwd1min', feature]].dropna()
    by_day = df.groupby(df.index.get_level_values('date_time').date) # calc per␣
 ↪min is very time-consuming
    ic[feature] = by_day.apply(lambda x: spearmanr(x.fwd1min, x[feature])[0]).
 ↪mean()
ic = pd.Series(ic)
```

```
100%|      | 21/21 [04:44<00:00, 13.54s/it]
```

[49]:
```
ic.sort_values()
```

[49]:
```
STOCHRSI         -0.015177
ret4min          -0.013636
CCI              -0.012663
ret5min          -0.012534
ret3min          -0.012235
ret9min          -0.010546
ret8min          -0.009978
ret2min          -0.009834
ret7min          -0.009678
ret10min         -0.009596
ret1min          -0.009468
ret6min          -0.009047
rup              -0.008965
BOP              -0.006312
slowk            -0.005720
trades_bid_ask   -0.005406
MFI              -0.003847
slowd            -0.001772
up               -0.000832
down              0.000038
rdown             0.010978
dtype: float64
```

[50]:
```
title = 'Information Coeficient for Intraday Features (1-min forward returns)'
ic.index = ic.index.map(str.upper)
ax = ic.sort_values(ascending=False).plot.bar(figsize=(14, 4), title=title,␣
 ↪rot=35)
ax.set_ylabel('Information Coefficient')
ax.yaxis.set_major_formatter(FuncFormatter(lambda y, _: '{:.1%}'.format(y)))
sns.despine()
plt.tight_layout();
```



1.5.12 Store results

[51]:
```
data.info(null_counts=True)
```

```
<class 'pandas.core.frame.DataFrame'>
MultiIndex: 30875649 entries, ('AAL', Timestamp('2015-01-02 09:30:00')) to
('YHOO', Timestamp('2017-06-16 15:59:00'))
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 13  up              30083777 non-null  float64
 14  down            30083777 non-null  float64
 15  rup             30083777 non-null  float64
 16  rdown           30083777 non-null  float64
 17  BOP             30612848 non-null  float64
 18  CCI             28517773 non-null  float64
 19  MFI             30873719 non-null  float64
 20  STOCHRSI        30871639 non-null  float64
 21  slowd           30873302 non-null  float64
 22  slowk           30873302 non-null  float64
 23  NATR            30873719 non-null  float64
 24  trades_bid_ask  30083777 non-null  float64
dtypes: float64(23), int64(2)
memory usage: 6.9+ GB
```

[52]:
```
data.drop(['date', 'up', 'down'], axis=1).to_hdf('data/algoseek.h5',␣
↪'model_data')
```