

Lecture 4: Exchange-Traded Funds

Marco Avellaneda

G63.2936.001

Spring Semester 2009

Structure

- ETF: Investment vehicles, similar to funds but that look like stocks
 - traded on an exchange
 - trading is similar to stocks (long, short, intraday trading, Reg T admissible)
- ETF: can be viewed as a holding company or a fund
 - started as **index trackers**
 - 67% of investment professionals find that ETFs are among the most important financial innovations of the last 20 years
- Structure: **authorized participants** can create or redeem ETFs in creation units
 - creation units: 25K to 100K shares
 - APs often act as market makers, providing liquidity

History

Milestones:

1993: first US ETF

1998: first European ETFs

2008: first actively managed ETFs

History:

1989: Index Participation Shares, stopped by Chicago Mercantile Exchange

1993: SPY Tracking S&P 500 (a.k.a. Spiders or SPDRS, issuer: State Street)

1996: BGI creates WEBS (World Equity Benchmark Shares), later called I-Shares

1998: Sector SPDRS track 9 sectors of the S&P 500

2008: 680 ETFs in US with 610B in assets, increase of 125B in 12 months

Main advantages

- Diversification at an affordable price
- Low expense ratios
- Behave like index mutual funds
- Limit orders, short-selling, options
- Lower fees
- Used for hedging by pros
- Tax efficiency: lower turnover than MFs (no need to sell assets each time someone sells, less capital gains)
- No ``load'' (Entrance fees, or exit fees, like many mutual funds)

20 most active US ETFs

TICKER	DESCRIPTION	AUM	AVG VOL (3m)	EX RATIO (bps)
SPY	0.1 SP500	93B	366M	8
EFA	MSCI Intl Eq	31B	36M	34
GLD	Gold 0.1 oz	21B	13M	NA
EEM	MSCI Emerging Mkts.	19B	100M	72
IVV	SP 500 I-Share	15B	7M	9
QQQQ	Nasdaq 100 Index 1/10	12B	150M	20
IWM	Russel 2000	10B	77M	20
IWF	Russel 1000 Growth	10B	8M	20
AGG	Bond ETF	9.5B	0.7 M	20
IWD	Russel 1000 Value	9.2B	7M	20
VTI	Vanguard MSCI 1300 Stocks	9.2B	11M	71
DIA	Dow 30	8.9B	32M	14
TIP	Inflation-protected bonds	8.6B	0.7M	20
XLF	Financial SPDR	7.7B	200M	23
SHY	1-3 yr Treasurys	7.7B	1.3M	15
LQD	IG Corporates	6.9B	1.4M	15
MDY	Mid-Cap SPDR	6.8B	10M	25
FXI	China Xinghua 25	5.9B	43M	74
IWB	Russel 1000	5.7B	9M	15
EWJ	Japan	5.6B	32M	52

US Sector ETFs

TICKER	DESC	AUM (\$B)	VOL (\$M)	LAST (\$)
XLF	Financial SPDR	7.7	177	10
XLE	Energy SPDR	4.4	40	49.8
OIH	Oil Services HLDR	5	11	83.99
XLK	Tech	1.8	8	16.5
IGE	Natural Resources	1.2	0.8	25.96
PHO	Water Resources	1.3	0.5	13.25
XLP	Consumer Staples	2.23	6.7	22
XLV	Health Care	2.06	6	27
XLU	Utilities	1.9	8	30.12
MOO	Agribusiness	0.6	0.5	31.19
GDX	Gold Miners	2.7	7.5	35.49
PPH	Pharmaceuticals	1.5	0.6	61.78
PBW	Clean Energy	0.6	0.8	8.38
IYR	Real Estate	1.66	37	32
BBH	Biotech HOLDRS	1.38	0.1	175.69
XLI	Industrials	1.1	12.1	21.1
SMH	Semiconductors	0.75	12	18.88
IYE	Energy Ishare	0.6	1.5	28.38
IBB	Biotechnology	na	0.9	73.99
IYW	Technology	0.6	0.3	36.27
XME	Metals & Mining	0.2	1.8	30.5
RTH	Retail	0.35	5	72.5
RKH	Regional Banks	0.3	2.5	50.36
IYT	Transportation	0.37	0.8	57.5
XLY	Consumer Discretionary	0.6	7	20.2

Country ETFs

TICKER	DESCRIPTION	AUM (\$B)	VOL (\$M)	LAST (\$)
EWZ	MSCI Brazil	3.5	20	40.86
EWJ	MSCI Japan	5.6	32	8.75
FXI	Xinhua 25	5.94	43	29.02
EWT	Taiwan	1.3	12	7.45
EWY	Korea	1.26	3.8	29.53
EWC	Canada	1	1.8	17.49
EWB	Hong Kong	1.1	5	10.24
EWS	Singapore	0.7	3	6.68
RSX	Mk Vectors Russia	0.4	1.3	11.95
EWA	Australia	0.5	2.9	12.67
EWX	Mexico	0.5	3.2	29.11

ETFs and PCA Factors

Do the PCA factors that we calculate with, say, S&P 500
``span'' the ETF universe?

$I =$ ETF price

$$\frac{dI}{I} = \sum_{k=1}^{N_{\text{factors}}} \gamma_{Ik} F_k + \zeta_I$$

How important are the residuals?

Regressing ETF on QQQQ Factors

Using 11/2 years of data, regress Biotech HOLDR, Semiconductors HOLDR
Technology SPDR or first 5 factors

	F1	F2	F3	F4	F5	ERROR
BBH	0.157832	0.011329	-0.00669	0.006812	0.002875	0.106781463
SMH	0.318487	0.031763	0.002882	-0.00024	-0.00533	0.263980395
XLK	0.283287	0.027421	-0.00916	-0.00618	-0.00837	0.196128499

Error= sum of squares of residuals in regression

ETFs as risk-factors

Idea: use sector ETFs to explain stock returns.

$$\frac{dS}{S} = \sum_{k=1}^{N_{etf}} \beta_{Sk} \frac{dI_k}{I_k} + \varepsilon_S$$

- Unlike eigenvectors, ETFs can have strong correlations
- Use sparse regression techniques to map stock to ETFs
- Use stock's sector to match stock to ETF
- In case of several ETFs per sector, use liquidity, highest R-squared

X_{1t}, \dots, X_{Nt} explanatory variables $E(X_i) = 0, E(X_i^2) = 1$

Y_t dependent variable $E(Y) = 0, E(Y^2) = 1$

$$j(1) = \arg \max_j \langle Y, X_j \rangle = \arg \max_j \frac{1}{T} \sum_{t=1}^T Y_t X_{jt}$$

Find largest inner product
Subtract projection

$$\mathcal{E}_t^{(1)} = Y_t - \langle Y, X_{j(1)} \rangle X_{j(1)t}$$

.....

$$j(n) = \arg \max_j \langle \mathcal{E}^{(n-1)}, X_{j(n)} \rangle X_{j(n)t}; \quad \gamma_n = \langle \mathcal{E}^{(n-1)}, X_{j(n)} \rangle$$

Iterate, replacing Y by
residuals

$$\mathcal{E}_t^{(n)} = Y_t - \langle \mathcal{E}_t^{(n-1)}, X_{j(n)} \rangle X_{j(n)t}$$

.....

$$\text{If } \left\langle \left| \mathcal{E}^{(n)} - \mathcal{E}^{(n-1)} \right|^2 \right\rangle \leq \alpha \quad \text{stop}$$

Stop when “gain” is
negligible

$$\beta_i = \sum \{ \gamma_m : j(m) = i \}$$

$$Y_t = \sum_{i=1}^N \beta_i X_{it} + \zeta_t$$

Matching Pursuit Algorithm

Gives sparse representation of Y
in terms of explanatory variables

Comparing regression with matching pursuit of ETFs on eigenportfolios

Using 11/2 years of data, regress Biotech HOLDR, Semiconductors HOLDR Technology SPDR or first 5 factors

Regression

	F1	F2	F3	F4	F5	ERROR
BBH	0.157832	0.011329	-0.00669	0.006812	0.002875	0.106781463
SMH	0.318487	0.031763	0.002882	-0.00024	-0.00533	0.263980395
XLK	0.283287	0.027421	-0.00916	-0.00618	-0.00837	0.196128499

Matching pursuit

	F1	F2	F3	F4	F5	VARIANCE RATIO
BBH	0.157649	0.011733	-0.00683	0.006574	0	0.718852199
SMH	0.319725	0.029492	0	0	-0.00512	0.524386271
XLK	0.284732	0.027219	-0.00916	-0.00603	-0.00801	0.496136246

ALTR	SMH	1.01262177	0.595836908
ALTR	BKX	0.212555416	0.595836908
ALTR	DFI	0.19277197	0.595836908
ALTR	XBD	0.134002267	0.595836908
ALTR	OSX	0.107427857	0.595836908
ALTR	SWH	0.061095328	0.595836908
ALTR	XNG	0.06070072	0.595836908
ALTR	XAL	0.032385487	0.595836908
ALTR	BBH	0	0.595836908
ALTR	DFX	0	0.595836908
ALTR	GHA	0	0.595836908
ALTR	GOX	0	0.595836908
ALTR	IXE	0	0.595836908
ALTR	IXI	0	0.595836908
ALTR	IXM	0	0.595836908
ALTR	IXT	0	0.595836908
ALTR	MSH	0	0.595836908
ALTR	OEX	0	0.595836908
ALTR	PPH	0	0.595836908
ALTR	QQQQ	0	0.595836908
ALTR	RKH	0	0.595836908
ALTR	TTH	0	0.595836908
ALTR	XAU	0	0.595836908
ALTR	XCI	0	0.595836908
ALTR	XOI	0	0.595836908
ALTR	OIH	-0.037741301	0.595836908
ALTR	RTH	-0.071274438	0.595836908
ALTR	UTH	-0.119016448	0.595836908
ALTR	IXV	-0.244051205	0.595836908
ALTR	DJX	-0.586755118	0.595836908

Altera Corp.
ALTR

Semiconductors

IVGN	QQQQ	1.030883843	0.818623084
IVGN	IXI	0.294854373	0.818623084
IVGN	BBH	0.285243936	0.818623084
IVGN	UTH	0.233399814	0.818623084
IVGN	IXV	0.194286003	0.818623084
IVGN	GHA	0.144497489	0.818623084
IVGN	DFX	0.091090841	0.818623084
IVGN	TTH	0.070839882	0.818623084
IVGN	XOI	0.054586767	0.818623084
IVGN	MSH	0.050538504	0.818623084
IVGN	SMH	0.036181337	0.818623084
IVGN	BKX	0	0.818623084
IVGN	GOX	0	0.818623084
IVGN	IXE	0	0.818623084
IVGN	IXM	0	0.818623084
IVGN	IXT	0	0.818623084
IVGN	OEX	0	0.818623084
IVGN	OIH	0	0.818623084
IVGN	OSX	0	0.818623084
IVGN	PPH	0	0.818623084
IVGN	RKH	0	0.818623084
IVGN	RTH	0	0.818623084
IVGN	XAU	0	0.818623084
IVGN	XNG	0	0.818623084
IVGN	XBD	-0.04171478	0.818623084
IVGN	XAL	-0.045563584	0.818623084
IVGN	DFI	-0.100638992	0.818623084
IVGN	SWH	-0.229027733	0.818623084
IVGN	XCI	-0.405543542	0.818623084
IVGN	DJX	-0.415221006	0.818623084

Invitrogen Corp.
IVGN

QQQQ and IXI are
broad indexes

MRK	PPH	2.399190777	0.710266122
MRK	OIH	0.1998206	0.710266122
MRK	BKX	0.113254572	0.710266122
MRK	RTH	0.111780844	0.710266122
MRK	IXI	0.091916087	0.710266122
MRK	DFX	0.075515707	0.710266122
MRK	DJX	0	0.710266122
MRK	GHA	0	0.710266122
MRK	GOX	0	0.710266122
MRK	IXE	0	0.710266122
MRK	IXM	0	0.710266122
MRK	IXT	0	0.710266122
MRK	MSH	0	0.710266122
MRK	OEX	0	0.710266122
MRK	OSX	0	0.710266122
MRK	QQQQ	0	0.710266122
MRK	SWH	0	0.710266122
MRK	TTH	0	0.710266122
MRK	UTH	0	0.710266122
MRK	XAL	0	0.710266122
MRK	XCI	0	0.710266122
MRK	XNG	0	0.710266122
MRK	XOI	0	0.710266122
MRK	SMH	-0.040117992	0.710266122
MRK	XAU	-0.07283849	0.710266122
MRK	XBD	-0.082003136	0.710266122
MRK	BBH	-0.150533637	0.710266122
MRK	DFI	-0.278063956	0.710266122
MRK	IXV	-0.359787644	0.710266122
MRK	RKH	-0.671801448	0.710266122

Merck & Co. Inc.
MRK

Pharmaceuticals

Ticker	ETF_Regressor	Beta	Residual
FITB	RKH	1.171983202	0.710636889
FITB	PPH	0.174735883	0.710636889
FITB	OSX	0.088324298	0.710636889
FITB	BKX	0.053474964	0.710636889
FITB	GHA	0.039252263	0.710636889
FITB	GOX	0.020157309	0.710636889
FITB	BBH	0	0.710636889
FITB	DJX	0	0.710636889
FITB	IXE	0	0.710636889
FITB	IXI	0	0.710636889
FITB	IXM	0	0.710636889
FITB	IXT	0	0.710636889
FITB	IXV	0	0.710636889
FITB	MSH	0	0.710636889
FITB	OEX	0	0.710636889
FITB	OIH	0	0.710636889
FITB	RTH	0	0.710636889
FITB	SWH	0	0.710636889
FITB	TTH	0	0.710636889
FITB	UTH	0	0.710636889
FITB	XAL	0	0.710636889
FITB	XAU	0	0.710636889
FITB	XBD	0	0.710636889
FITB	XCI	0	0.710636889
FITB	XNG	0	0.710636889
FITB	QQQQ	-0.034968585	0.710636889
FITB	SMH	-0.043916793	0.710636889
FITB	DFI	-0.049558033	0.710636889
FITB	XOI	-0.09974654	0.710636889
FITB	DFX	-0.108614465	0.710636889

Fifth-third Bancorp
FITB

Ticker	ETF_Regressor	Beta	Residual
GS	XBD	0.619567244	0.600696979
GS	IXM	0.307102361	0.600696979
GS	TTH	0.166382297	0.600696979
GS	XOI	0.059133084	0.600696979
GS	OSX	0.033358639	0.600696979
GS	QQQQ	0.029737422	0.600696979
GS	BBH	0	0.600696979
GS	BKX	0	0.600696979
GS	DJX	0	0.600696979
GS	GHA	0	0.600696979
GS	GOX	0	0.600696979
GS	IXE	0	0.600696979
GS	IXI	0	0.600696979
GS	IXT	0	0.600696979
GS	IXV	0	0.600696979
GS	MSH	0	0.600696979
GS	OEX	0	0.600696979
GS	OIH	0	0.600696979
GS	RKH	0	0.600696979
GS	SMH	0	0.600696979
GS	UTH	0	0.600696979
GS	XAL	0	0.600696979
GS	XCI	0	0.600696979
GS	XNG	0	0.600696979
GS	XAU	-0.015181417	0.600696979
GS	DFI	-0.034987163	0.600696979
GS	SWH	-0.044320675	0.600696979
GS	PPH	-0.073302517	0.600696979
GS	DFX	-0.085578865	0.600696979
GS	RTH	-0.088058836	0.600696979

Goldman Sachs Group Inc.
GS

Comparing regression with matching pursuit of ETFs on eigenportfolios

Using 11/2 years of data, regress Biotech HOLDR, Semiconductors HOLDR Technology SPDR or first 5 factors

Regression

	F1	F2	F3	F4	F5	ERROR
BBH	0.157832	0.011329	-0.00669	0.006812	0.002875	0.106781463
SMH	0.318487	0.031763	0.002882	-0.00024	-0.00533	0.263980395
XLK	0.283287	0.027421	-0.00916	-0.00618	-0.00837	0.196128499

Matching pursuit

	F1	F2	F3	F4	F5	VARIANCE RATIO
BBH	0.157649	0.011733	-0.00683	0.006574	0	0.718852199
SMH	0.319725	0.029492	0	0	-0.00512	0.524386271
XLK	0.284732	0.027219	-0.00916	-0.00603	-0.00801	0.496136246