SALES FORECASTING WITH FINANCIAL INDICATORS AND EXPERTS' INPUT

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Agenda for this talk

- Motivation and literature
- Forecast evolution model
- Empirical study
  - Firm-level data
    - Retail
    - Wholesale and manufacturing
  - Aggregate data
  - Discussion of the results
- Example

Research questions

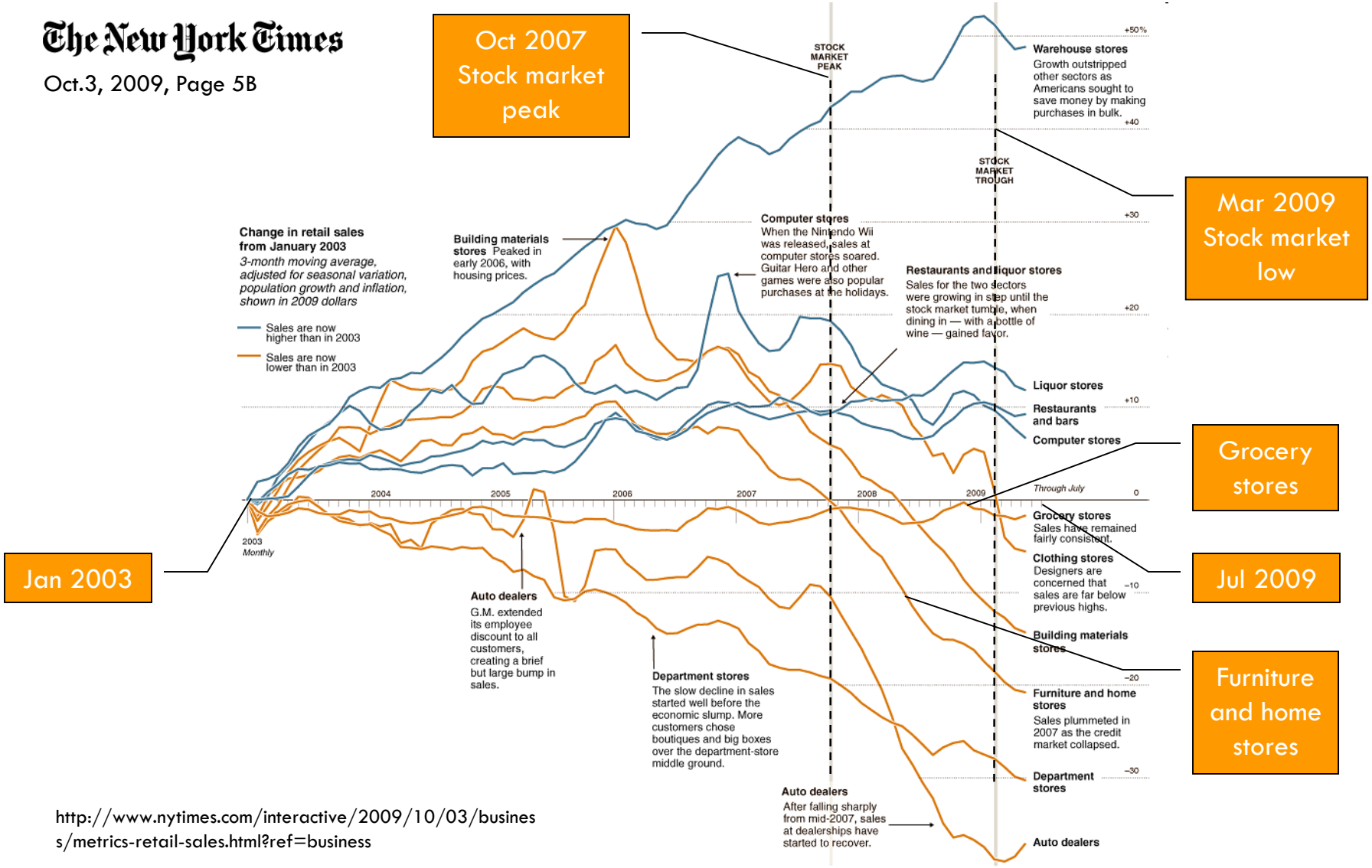
- What is the correlation between sales forecast errors and the returns on a broad financial index for different types of firms?
- Are financial data useful for improving the accuracy of sales forecasts?
- Are they useful in operational hedging decisions such as postponement of inventory procurement or capacity reservation?

Why study correlation?

- Market can be a source of information
  - If forecasts do not reflect recent market performance, they can be improved
- Systematic component in sales uncertainty
  - Priced by the market
- Affects the cost of capital (McDonald, Siegel (1985, 1986))
- Sales-based measures more valuable than Beta to price a firm's risk (Hendricks, Singhal (2005))
- Supply chain structure
- Opportunities for hedging and risk management
  - Financial vs. operational
  - Customers' base diversification

Recent examples: Retail sales and stock market

The New York Times
Oct.3, 2009, Page 5B



http://www.nytimes.com/interactive/2009/10/03/business/metrics-retail-sales.html?ref=business

Office Depot

REUTERS

Office Depot Falls on Gloomy Forecast

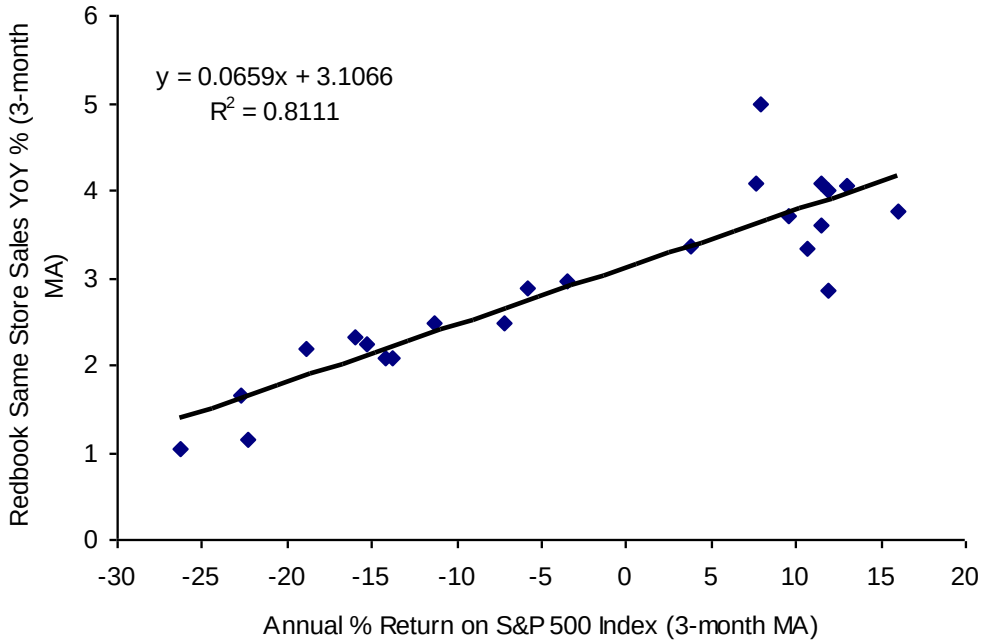
Fri Sep 7, 2007 5:09 PM BST

NEW YORK (Reuters) - Office Depot Inc<ODP.N> shares fell as much as l0.25 percent on Friday, a day after the office supplies retailer said third and fourth quarter earnings would likely fall below year-ago levels as small business customers cut back on spending in response to the housing slowdown.

"Our small-business customers have changed their buying habits as a result of this environment, and traffic remains slower than normal in our retail stores," Chief Financial Officer Patricia McKay said at a Goldman Sachs retailer conference in New York on Thursday.

…"The macro backdrop is no doubt presenting some headwinds, though given ongoing industrial production and GDP growth, **we are surprised by the magnitude of spillover to the office products retail segment**," Goldman Sachs analyst Matthew Fassler wrote in a research note. "Office Depot seems to be bearing more than its fair share of the fallout."

Correlation of sales growth with return on S&P 500 index (using Redbook Average data)



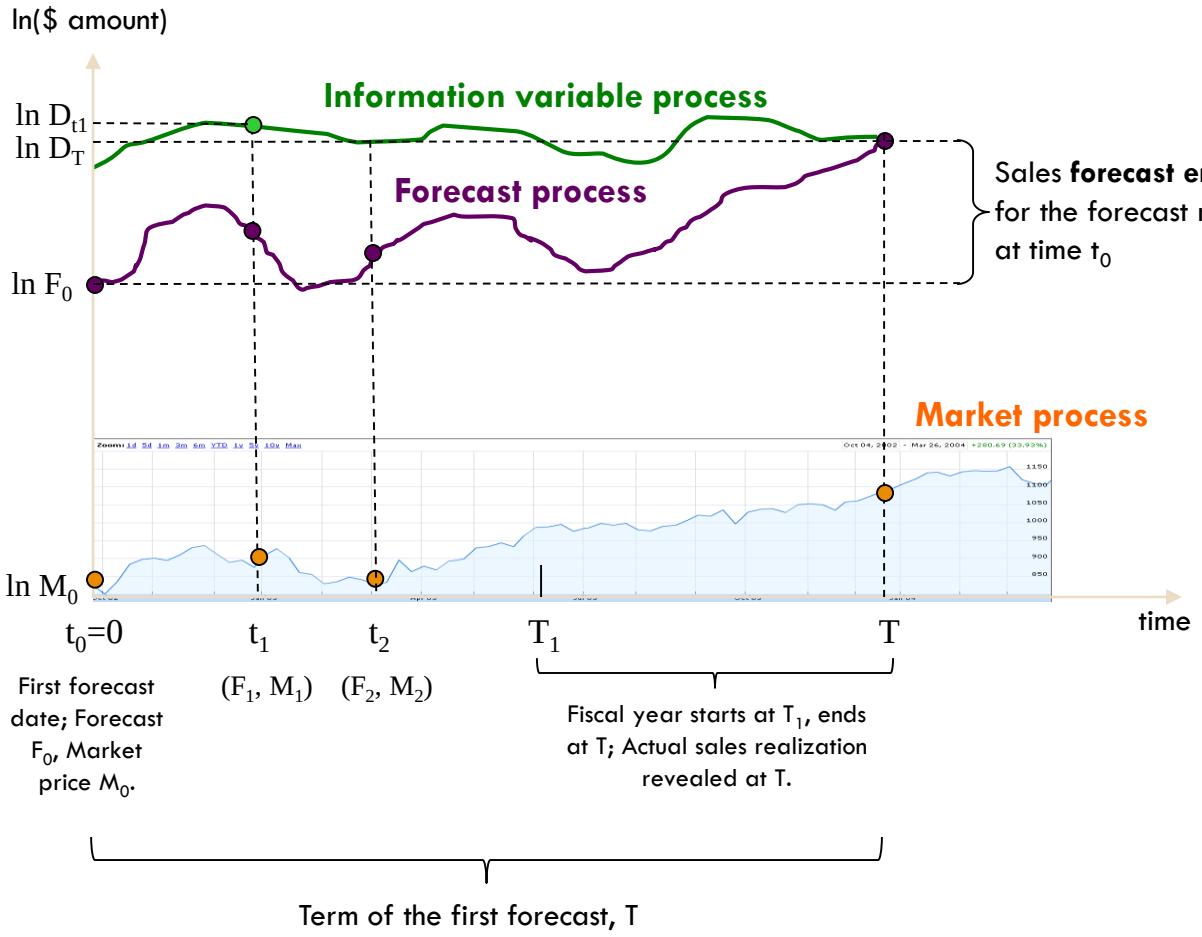
- Redbook Average: seasonally-adjusted sales-weighted average of year-to-year same-store sales growth in a sample of 60 large US general merchandise retailers representing about 9000 stores. Released by Instinet Research on the first Thursday of every month.
- Data for Nov 1999-Nov 2001.

Gaur and Seshadri (2005)

Literature

- Operational and financial hedging when demand is correlated with the return on a financial asset
  - Gaur and Seshadri (2005), Caldentey and Haugh (2006), Chod, Rudi and Van Mieghem (2009)
  - McDonald and Siegel (1985, 1986)
- Demand forecasting models
  - MMFE: Graves et al. (1986, 1998), Heath and Jackson (1994)
  - Kalman Filter: Aviv (2003)
  - World-driven demand: Zipkin (2000)
  - Other predictors: Kesavan et al. (2009), Lundholm et al. (2009)
- Propensity and structure of the consumption
  - Friedman (1957): permanent income hypothesis; Ando and Modigliani (1968), Brayton and Tinsley (1996), Dynan and Maki (2001), Banks et al. (1997)

Sales uncertainty and the market



Forecasts of the total sales for the next fiscal year can be generated by equity analysts or time series models

Market process is the price of a broad equity index, such as value-weighted NYSE/NASDAQ/AMEX market index

Model

- Timeline: [0, *T*], where 0 denotes the date of first available forecast, and *T* denotes end of a fiscal year
- D_t: value of sales to be realized during [T_1, T] as seen at time t ; converges to the realized sales at time T.
- ln D_t evolves as a martingale, <u>for a given company in a given year</u>

$$\mathbb{E}[\ln(D_t)|\mathcal{F}_s] = \ln(D_s),\ 0 \le s \le t \le T \qquad d(\ln D_t) = \sigma_D dB_D$$

- Forecast at time t: $F_t = \mathbb{E}[D_T|\mathcal{F}_t] = D_0 e^{\sigma_D B_{Dt}} e^{\sigma_D^2 (T-t)/2}$
- Under this specification, the forecast is martingale

- (ln) Error of time t forecast: $\delta_t = \ln D_T - \ln F_t$

- Stock market evolution:

$$\frac{dM_t}{M_t} = \mu_M dt + \sigma_M dB_M$$

$$dB_D dB_M = \rho dt$$

- Correlation of the <u>sales forecast error</u> (not just sales!) and the market return:

$$\mathbb{C}\mathbf{orr}(\delta_t, \ln(1 + r_{tT})) = \rho$$

Estimation equations

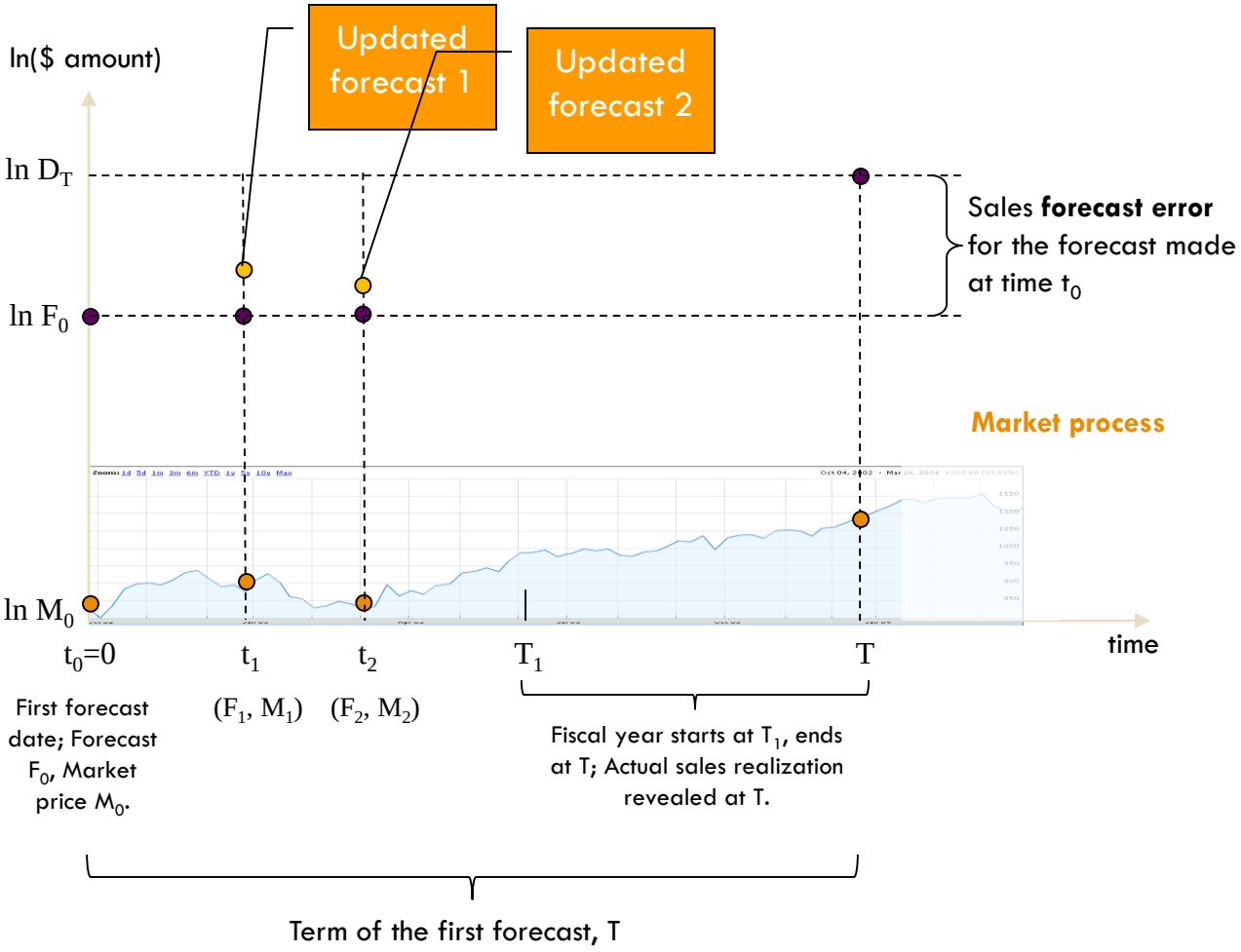
- Given the market return up to time T, the conditional expectation and variance of the sales are:

Proposition 1: Ex-post uncertainty resolution

$$\begin{aligned}\mathbb{E}[\ln D_T|\mathcal{F}_0, M_T] &= \ln F_0 + \frac{\rho\sigma_D}{\sigma_M}\ln(1+r_{0T}) + T\frac{\rho\sigma_D}{\sigma_M}\left(-\mu_M + \frac{\sigma_M^2}{2} - \frac{\sigma_D\sigma_M}{2\rho}\right),\\ \mathbb{V}\mathbf{ar}[\ln D_T|\mathcal{F}_0, M_T] &= \sigma_D^2\mathbb{V}\mathbf{ar}[B_{DT}|\mathcal{F}_0, M_T] = \sigma_D^2 T(1-\rho^2),\end{aligned}$$

- Effect of the market on the mean is proportional to $\rho\sigma_D$
- The variance of sales is reduced by ρ^2x100%
- Parameters ρ, σ_D can be estimated by MLE

Forecast updating



Forecast updating formulae

- Use the estimates of ρ, σ_D, and the market return r_{0t} to update the initial forecast in <u>real time</u>

Proposition 2: Forecast by model

$$\begin{aligned}\mathbb{E}[\ln D_T|\mathcal{F}_0, M_t] &= \ln F_0 + \frac{\rho\sigma_D}{\sigma_M}\left(\ln(1+r_{0t}) - \left(\mu_M - \frac{1}{2}\sigma_M^2\right)t\right) - \frac{1}{2}\sigma_D^2 T,\\ \mathbb{V}\mathbf{ar}[\ln D_T|\mathcal{F}_0, M_t] &= \sigma_D^2(T - t\rho^2).\end{aligned}$$

- Combine the experts forecasts and the model (assn: experts do not completely incorporate the financial information)

Alternative method: Combined forecast

$$\begin{aligned}F_t^c &= \ln \hat{F}_t + \frac{\rho\sigma_D}{\sigma_M}\left(\ln(1+r_{0t}) - \left(\mu_M - \frac{1}{2}\sigma_M^2\right)t\right) - \frac{1}{2}\sigma_D^2 T,\\ \mathbb{V}\mathbf{ar}\, F_t^c &= \sigma_D^2(T - t).\end{aligned}$$

Empirical Study

- Firm-level data
  - Retail
  - Manufacturing and wholesale trade
- Aggregate data

Firm level study: data set

- Fit (FY1997-2007) and test (FY2008) samples
- Data sources: I/B/E/S (summary file), S&P's Compustat NA, CRSP
- Includes **both** market **growth and decline** periods of the stock market
- I/B/E/S: experts' consensus forecasts; Compustat: sales, operational parameters; CRSP: market return
- Market indices:
  - Value-weighted market return including dividends (all stocks at NYSE/AMEX/Nasdaq)
  - SP500, Equal-weighted market return

Primary NAICS	# obs.	# firms	Coverage, % sales (FY2005)	Filters	Examples of companies
Retail	6860	105	32%	Sel. segm., Non-US, 3 year data, mergers*	Wal-Mart, Best Buy, Office Depot
Wholesale	4541	123	11%	Non-US, 3 year data	Ingram Micro, AmerisourceBergen
Manufacturing	38931	1335	76%	Non-US, 3 year data	Apple, K2, Boeing, Nike, Coca-Cola

*- no significant selection bias due to filtering found (Heckman sample selection test)

Methodology

- MLE naturally incorporates the relationship between the regression coefficients and the heteroskedasticity structure.
- Bias in forecasts is controlled by introducing intercept and the forecast coefficient.
- Reinstatement of the analysts' forecasts in the same firm-year is controlled:
  - Subsampling (Politis et al., 1999)
    - 1 observation per company, per year.
- The martingale assumption is verified using the trajectories of forecast updates
  - Variance ratio tests (Lo and MacKinlay, 1998).
- Robustness checks:
  - Random coefficients model
    - Estimates are similar under both methods.

Retail: Segment-wise estimates

Retail Segment	Segment-wise MLE ρ	σ_D	Intercept, a	Coeff. of ln F_{iiy}, b_1	Firm-wise MLE of ρ Min.	Median	Max.
Pooled (overall)	**0.129*** **	**0.179*** **	**0.105**	**0.990**	**-0.866**	**0.283**	**0.907**
Sports and Hobby	-0.035	0.079***	-0.036	1.001	-0.579	-0.123	0.807
Home Furnishings	0.001	0.072***	0.001	0.999	-0.696	0.21	0.486
Discount. and Whse Clubs	0.035	0.359	0.426	0.969	-0.703	-0.096	0.797
Cons. Electronics	0.071	0.194**	0.118	0.991	-0.682	0.477	0.511
Shoe Stores	0.094	0.079***	0.011	0.999	-0.002	0.346	0.628
Supermarkets	0.222	0.189	0.234	0.98	-0.273	0.444	0.707
Apparel Stores	0.237***	0.112***	0.142***	0.982***	-0.866	0.257	0.907
Department Stores	0.339***	0.058***	0.206**	0.974***	-0.56	0.366	0.663
Home Improvement	0.412***	0.047***	-0.042	1.003	0.276	0.383	0.716
Jewelry Stores	0.495***	0.073***	-0.072	1.009	-0.696	-0.017	0.826
Auto Parts and Acc.	0.531***	0.083***	0.462***	0.937***	-0.565	0.306	0.897
Pharmacies	0.543***	0.066***	-0.1	1.009	0.367	0.783	0.867
Office Supplies	0.763***	0.088***	-0.346	1.033	0.503	0.879	0.891

Selected firms

Name	ρ	st.err. ρ	σ_D	st.err. σ_D
FAMILY DOLLAR STORES	-0.588***	0.136	0.018***	0.005
ROSS STORES INC	-0.425**	0.215	0.040***	0.006
WAL-MART STORES INC	0.224	0.178	0.261	0.423
BEST BUY CO INC	0.456***	0.129	0.048***	0.005
AMAZON.COM INC	0.624***	0.072	0.373***	0.045
HOME DEPOT INC	0.717***	0.155	0.038***	0.006
COSTCO WHOLESALE CORP	0.796***	0.160	0.030***	0.006
GAP INC	0.813***	0.108	0.092***	0.027
LIMITED BRANDS INC	0.816***	0.067	0.111**	0.010
TIFFANY & CO	0.826***	0.075	0.080***	0.010
OFFICE DEPOT INC	0.878***	0.045	0.081***	0.011
STAPLES INC	0.891***	0.044	0.084***	0.008

Margin and ρ

ρ increases with margin

Margin percentile	Median firm-wise ρ	Pooled MLE
[0, 0.2] (bottom 20%)	0.082	-0.008
(0.2, 0.4]	0.141	0.121***
(0.4, 0.6]	0.122	0.160***
(0.6, 0.8]	0.260	0.196***
(0.8, 1] (top 20%)	0.360	0.268***

Margin percentile is based on the margin rank within each retail segment

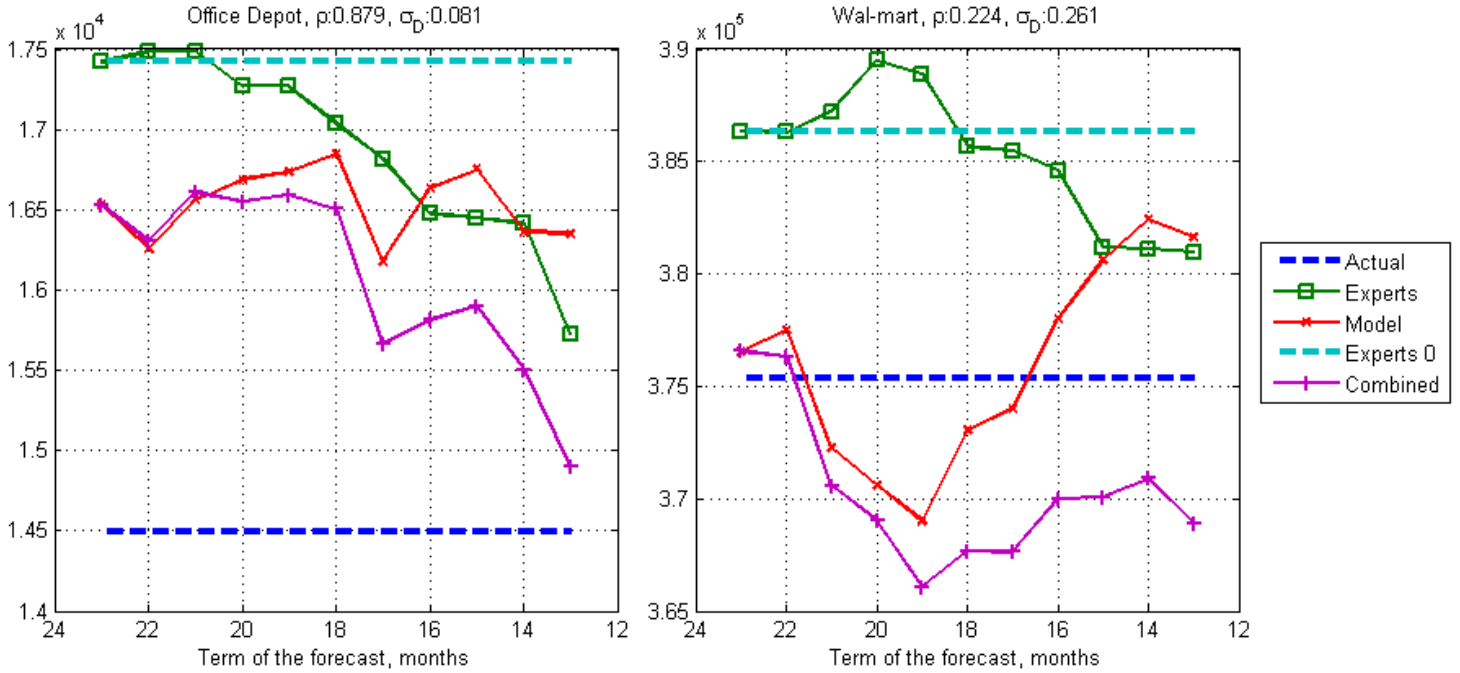
Forecast updating (test sample)

Forecast updating formulae

$$\mathbb{E}[\ln D_T|\mathcal{F}_0, M_t] = \ln F_0 + \frac{\rho\sigma_D}{\sigma_M}\left(\ln(1+r_{0t}) - \left(\mu_M - \frac{1}{2}\sigma_M^2\right)t\right) - \frac{1}{2}\sigma_D^2 T,$$

$$F_t^c = \ln \hat{F}_t + \frac{\rho\sigma_D}{\sigma_M}\left(\ln(1+r_{0t}) - \left(\mu_M - \frac{1}{2}\sigma_M^2\right)t\right) - \frac{1}{2}\sigma_D^2 T$$

Bias is corrected by adding intercept and the coefficient on the forecast



Forecast updating performance (test sample)

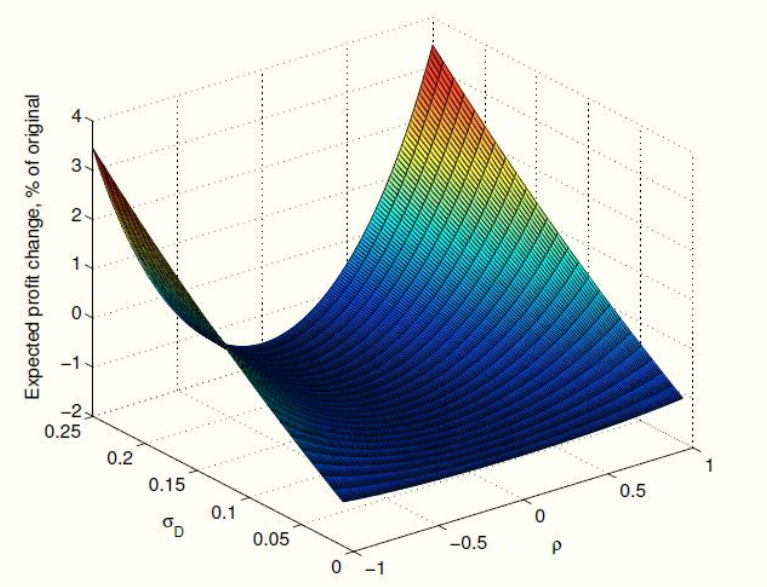
Input forecast	Standardized RMSE values (E0)	(E)	(M)	(C)
Analysts (N=876)	2.06	1.84	1.71	1.53
Time-series (N=665)	1.54	1.35	1.47	1.20

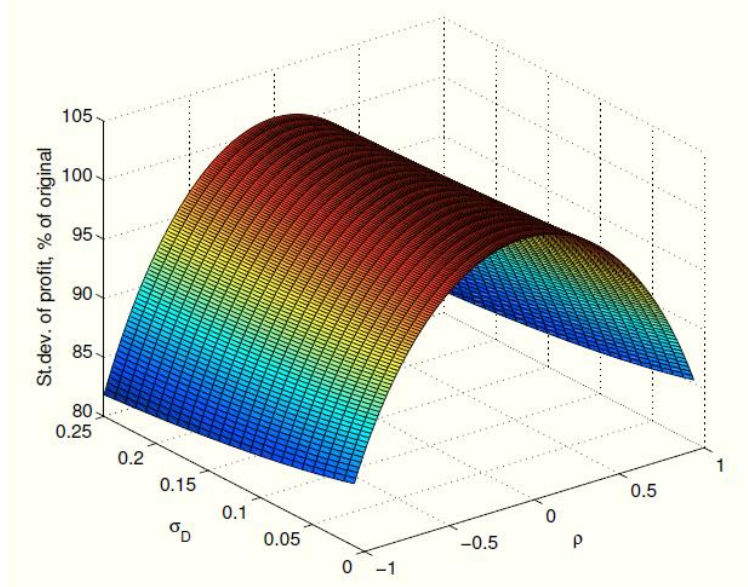
- Time-series forecasts are generated from quarterly sales data using the Holt-Winters method (Winters, 1960).
- Errors are standardized before pooling.
- Difference between (E0) and (M), and (E) and (C) is statistically significant at .05 level according to the Brown-Forsythe and Levene equal variance tests.
- % of forecasts improved (abs. error(C)<abs. error(E)):
  - Analysts: 56%, Binomial test P=0.0002;
  - Time series: 54%, Binomial test P=0.022.
- Results are consistent under various performance measures (MAPE, MedAPE)
- Reason for improvement:
  - Forecast updates do not incorporate financial information.

Value of the sourcing flexibility

- Single period newsvendor-type model, log-normal demand.
- Forecast issued 12 month ahead, ρ – correlation between sales forecast error and the market return
- Postponement time: 6 months
- Tradeoff: more accurate demand forecast vs. higher sourcing cost
- The benefit of postponement is conservatively estimated:
  - Market information is the only source of extra profit
  - Other sources of profit possible:
    - e. g., reaction to early sales, Fisher and Raman (1996)

Value of the sourcing flexibility (contd.)





- Effects of decision postponement:
  - Expected profit increases for high $|\rho|$, σ_D firms
    - 1% expected profit increase if $|\rho|>.6$: 37 firms in the dataset
    - 2% expected profit increase if $|\rho|>.8$: 13 firms in the dataset
  - Profit variance decreases for high $|\rho|$ firms

Results: wholesalers and manufacturers

- Intuitively, the correlation should …
  - Bullwhip effect (assn: covariance does not change)
    - Decrease
- In reality

	ρ	σ_D	Intercept, a	Coeff. of ln F_{ijy}, b_1
Retail	0.128***	0.179***	0.104	0.990
Wholesale	0.177***	0.344***	0.089	0.999
Manufacturing	0.356***	0.220***	-0.093*	1.012

- Segment by segment (example)

ρ	Consumer electronics		Apparel	
	NAICS	Estimate	NAICS	Estimate
Retail	443	0.071	4481	0.237
Wholesale	42343, 42362	0.394	42432, 42433	-
Manufacturing	3341-3344	0.472	315	0.297

Forecast updating: wholesale and manufacturing

- Forecasting performance (test sample)

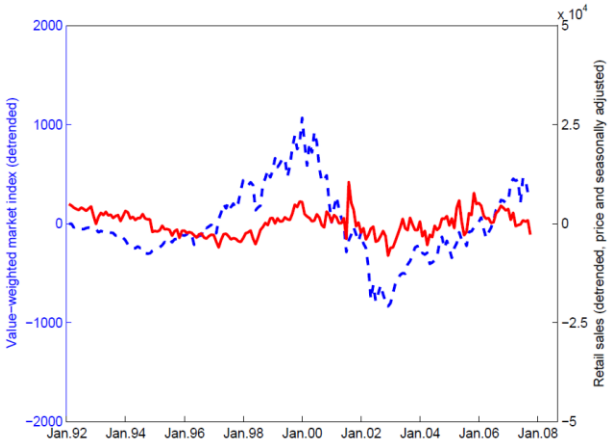
Errors explained by the market	ρ	σ_D	% improve-ment
Retail	0.128	0.179	16%
Wholesale	0.177	0.344	20%
Manufacturing	0.356	0.220	27%

In absolute terms	Volume FY2007, Bil	$\rho*\sigma_D$	Market adjustment, Bil*	% ot Volume
Retail	4432	0.023	35.5	0.8%
Wholesale	5782	0.061	115.6	2.0%
Manufacturing	5339	0.078	138.8	2.6%

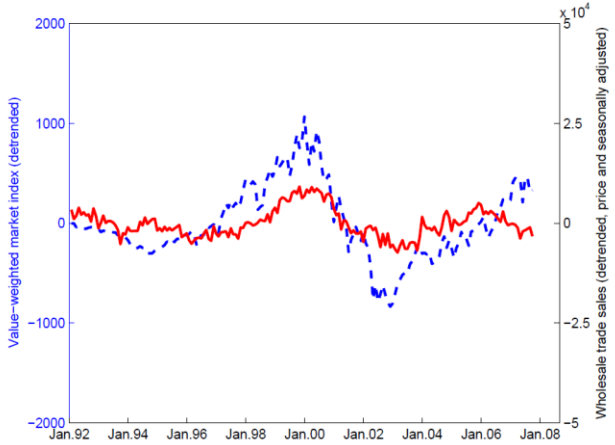
*-computed using 5% excess return

Alternative dataset: US Census

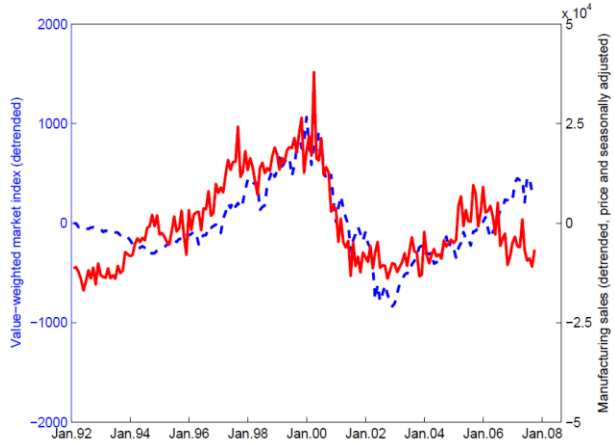
Retail



Wholesale



Manufacturing



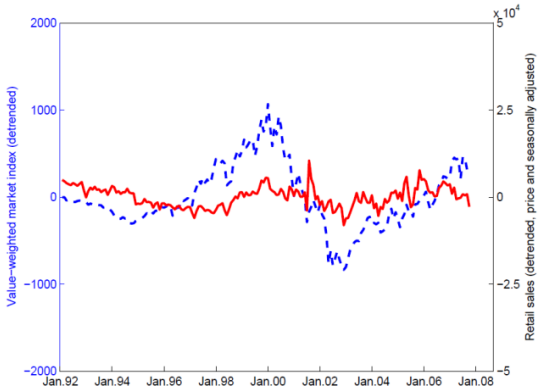
– – – value-weighted market index (detrended)

——— sales (detrended, seasonally, and price-adjusted)

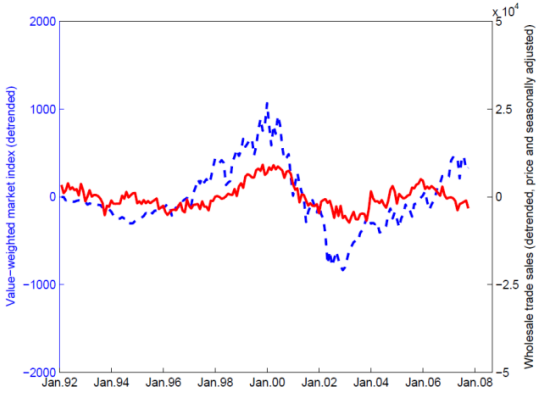
- Sources: US Census Bureau monthly surveys of Manufacturers, Retail, and Wholesale trade; BEA NIPA price deflators.
- Dataset is an expanded version of the data studied by Cachon et al. (2007)
  - Documented presence of the bullwhip effect in the seasonally-adjusted data.

Results using US census data

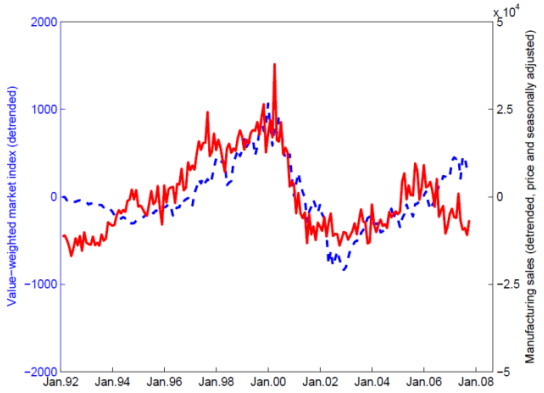
Retail



Wholesale



Manufacturing



- Regress sales growth (price and seasonally adjusted) on the market return

$$\Delta S_t = Sales_t - Sales_{t-12} = a + b * r_t + \varepsilon_t, \text{ where } r_t = \ln(1 + r_{[t-12,t]})$$

	Price adjusted (red line)	
	Corr(ΔS_t, r_t)	b
Retail	0.36	9485***
Wholesale	0.42	11399***
Manufacturing	0.52	32857***

Chow test of structural break indicate significant increase in coefficient b from the Retail to Wholesale and to Manufacturing segments

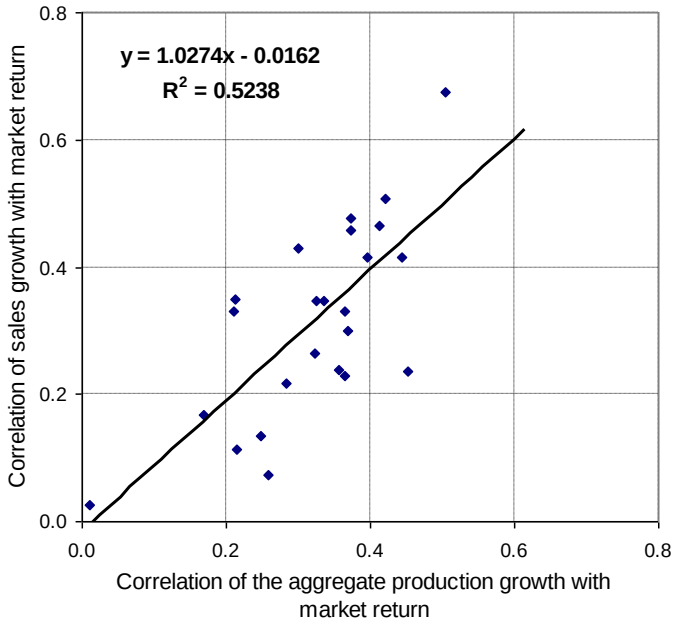
Results are robust with respect to the term of forecasts (6 to 18 months)

Can data explain increase in ρ?

- Supply chains are serial
  - Use imputed production series (Cachon et al. 2007)

    $P_t = S_t + I_t - I_{t-1}$
  - Production growth is less correlated with the market than sales growth
    - Retail: 0.17 vs 0.33
    - Wholesale: 0.29 vs 0.41
    - Manufacturing: 0.44 vs 0.50

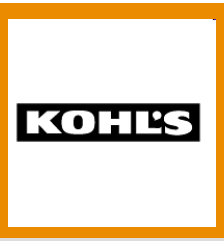
- Supply chains have network structure
  - Reconstruct flows between industries using NIPA I/O tables (year 2002)
    - Summary level, agg. to 24 industries, to match M3 segments



Conclusions

- Financial market information can be used to update sales forecasts
  - Effect varies across segments; is greater for higher margin retailers.
- Experts do not fully take financial information into account when updating forecasts.
- Correlation between sales forecast errors/growth and the market returns increases for upstream levels of a supply chain.
  - Supported by the data at:
    - Company level;
    - Aggregate level;
    - Industry segment level.
- Hypothesis of increase in the correlation due to the aggregation of demand is supported by the data.

Example: Forecasting FQ4 2009 sales

			
ρ	0.665	-0.563	0.755
Q4 2008 guidance (TS-1Q ahead)	11.0	5.01	7.21
Our Q4 2008 forecast	7.9	5.32	7.09
Actual Q4 2008 sales	8.23	5.24	7.13
Q4 2009 guidance	10.13	5.62	7.20
Our Q4 2009 forecast	10.50	5.54	7.34
Earnings release date	Jan. 14, 2010	Feb.25, 2010	Feb. 9, 2010
	Realized sales 10.65B	**Negative sales surprise possible**	**Positive sales surprise possible**

Thank you!

Details: Retailers

NAICS ID	Retail Segment Name	# of firms	# of firm-years	# of obs.	Examples of firms
441	Automotive Parts and Acc. Stores	5	35	302	Autozone, Pep Boys
442	Home Furnishings Stores	7	61	598	Haverty Furniture, Bed Bath & Beyond
443	Consumer Electronics Stores	5	39	388	Circuit City, Best Buy
444	Home Improvement Stores	3	27	274	Home Depot, Lowe's
445	Supermarkets	8	60	570	Albertson's, Safeway
446	Pharmacies	3	28	260	CVS, Rite Aid
4481	Apparel Stores	30	209	2121	GAP, Limited Brands
4482	Shoe Stores	4	27	264	Foot Locker, Shoe Carnival
4483	Jewelry Stores	4	24	245	Tiffany & Co., Zale's
451	Sports and Hobby Stores	9	50	461	Big 5 Sporting Goods, Michael's
4521	Department Stores	5	39	366	JC Penney, Saks Fifth Avenue
4529	Discounters and Warehouse Clubs	11	78	795	Costco, Wal-Mart, Dollar Tree
45321	Office Supplies Stores	3	23	216	Office Depot, Staples
	Total	97	700	6860	