What Drives Aggregate Investment?

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What Do We Do?

- Tackle an old question: *What (the h . . .) drives aggregate fluctuations?*
- In this paper: investment fluctuations.
- Even more specifically: the fluctuations of the year-over-year investment growth rate.
- Novel approach: narrative, survey-based.

What Do We Do?

- Use data from the IFO manufacturing investment survey (focusing on West Germany) about determinants for investment.

- In the fall of every year decision makers in firms are asked what issues (six to choose from) determined their investment activity in the current (but ending) year, and to what extent - on an ordinal scale.

- We use the micro data to these answers, aggregate (or semi-aggregate) them up and extract things like "technology shocks" versus "non-technological shocks".

- In other words: we move from investment determinants to economic shocks.

What Do We Do?

We do this in two steps:

1. First distinguishing technology shocks versus non-technological shocks (need a minimal set of assumptions).

2. Making more assumptions and putting more structure on the empirical model: extract also finance and aggregate demand shocks.

Basic Idea

We see the advantage of a survey-based approach towards identifying shocks in its putative *directness*: the survey respondents (*decision makers*) directly report whether their investment activity in a given year was influenced by, for instance, technological considerations and, if so, how strongly.

See, for instance, Romer (2004, 2010).

Also: these data are confidential, so there is probably less danger of decision makers strategically lying.

Preview of Results

1. First, (relatively robust) result: technology shocks explain at most 19 percent of the variance of aggregate (manufacturing) investment growth.

2. Second result (intervals):
   1. Financial shocks: 9 percent to 46 percent.
   2. Aggregate demand shocks: 23 percent to 61 percent.

3. Find suggestive evidence that these demand shocks might be sentiment shocks.

What Does This *Not* Mean?

1. Our results do not mean that technological considerations are irrelevant for investment decisions. On the contrary!!! On average, technological considerations are the most important investment determinant in the survey. It simply means that technological considerations are less relevant for *fluctuations* in investment.

2. At least our first (relatively robust) result does not mean that *productivity* shocks are irrelevant for fluctuations in investment growth. It just means that productivity shocks are unlikely to come from technological considerations; i.e. economists would have to look for them elsewhere other than engineering / R&D departments.

Overview

- The IFO Investment Survey and the Data
- Empirical Strategy
- Results
- Conclusion

Some Background on the Survey

- Semi-annual. Spring and fall - with slightly different questions.
- Manufacturing.
- Starts in 1955, but the for us relevant questions start only in 1989. Our sample period: 1989-2008.
- Advantages:
  - Relatively large number of observations: roughly 1,500 obs. per survey on average.
  - Well-correlated with official aggregate investment data.
  - Has questions on investment determinants and quantitative capital expenditures.
- Drawbacks:
  - Investment determinants only annually asked (fall).
  - Relatively short time series, few data.

Our Two Questions

Q1. Gross Fixed Capital Formation in Fiscal Year *[Last Year]*

[Last Year] _____
(in 1000 Euro)

Q2. Investment Determinants *[This Year]*

Our investment activity in the Old Laender in *[This Year]* was positively/negatively affected by:

Investment Determinant	strongly positive influence	weakly positive influence	no influence	weakly negative influence	strongly negative influence
			[This Year]		
Sales Situation and Expectation	☐	☐	☐	☐	☐
Finance	☐	☐	☐	☐	☐
Profit Expectation	☐	☐	☐	☐	☐
Technical Factors	☐	☐	☐	☐	☐
Macro Policy Environment	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐
[Codification]	*[+2]*	*[+1]*	*[0]*	*[-1]*	*[-2]*

Investment Determinants

From the survey guidelines (our translation):
Technical factors: this comprises all incentives to invest which come
from technical development.

Terminology: `Tech`, `Finance`, `Sales`, `Profit`, `Macro`, and `Other`

Quantification: -2 (strongly negative influence), -1 (weakly negative
influence), 0 (no influence), +1 (weakly positive influence), or +2
(strongly positive influence)

Sample

We only consider firm-year observations where the investment growth rate and at least one investment determinant are observable. The sample size amounts to 30,557 firm-year observations in total.

Aggregation

Define firm i's share in total investment at time t by:

$$\omega_{it} = \frac{inv_{it}}{\sum_{i=1}^{N_t} inv_{it}}.$$

Then the aggregate investment growth rate, ΔI_t^{IFO}, is given by:

$$\Delta I_t^{IFO} = \sum_{i=1}^{N_t} \omega_{it-1} \frac{inv_{it} - inv_{it-1}}{inv_{it-1}}$$

Similarly, let x_{it} denote one of the six firm-level investment determinants.

Then, for every investment determinant, we aggregate up to an investment determinant index, X_t, as follows:
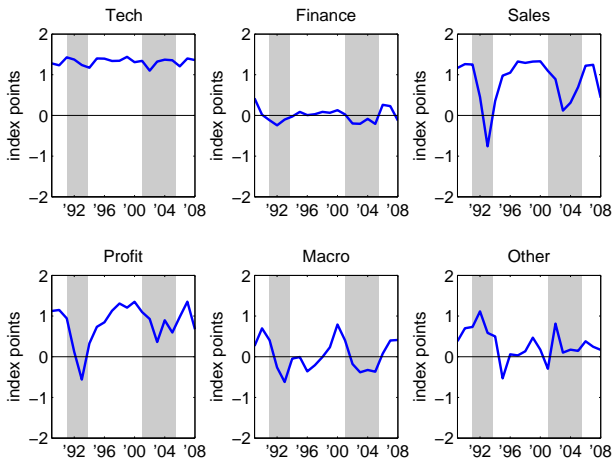
$$X_t = \sum_{i=1}^{N_t} \omega_{it} x_{it}$$

A First Look at the Data - Investment Growth Rate

Measures of aggregate investment growth ($\rho = 0.88$)
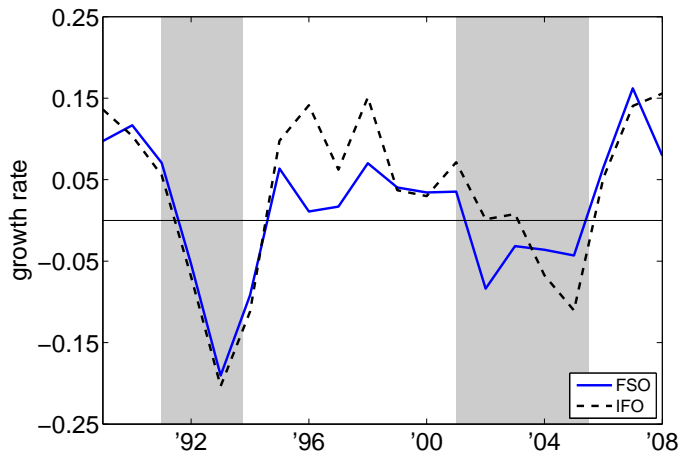
A First Look at the Data - Investment Determinant Indices

Aggregate investment determinant indices

A First Look at the Data - Pairwise Correlations

	Tech	Finance	Sales	Profit	Macro	Other
Panel A:						
Tech	1					
Finance	-0.0015	1				
Sales	0.2191	0.5502**	1			
Profit	0.2033	0.5653***	0.9154***	1		
Macro	0.0870	0.4652**	0.6340***	0.6610***	1	
Other	-0.3514	-0.2813	-0.1720	-0.2748	-0.0240	1
Panel B:						
ΔI_t^{FSO}	0.3947*	0.6161***	0.7763***	0.7903***	0.7379***	-0.2706

Economic Content: Tech

Mean of Tech, conditional on investment in restructuring and rationalization:

Tercile	N	Mean
1	12733	1.113254
2	8257	1.351336
3	9987	1.501928

Difference in means statistically significant at the 1% level.

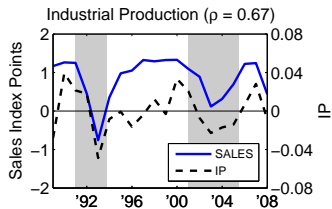# Economic Content: Tech

Product Innovation	N	Mean
Yes	5145	1.389407
No	1562	1.325075

Difference in means statistically significant at the 5% level.

Economic Content: Tech

Process Innovation	N	Mean
Yes	5437	1.355924
No	11272	1.293243

Difference in means statistically significant at the 1% level.

Economic Content: Finance

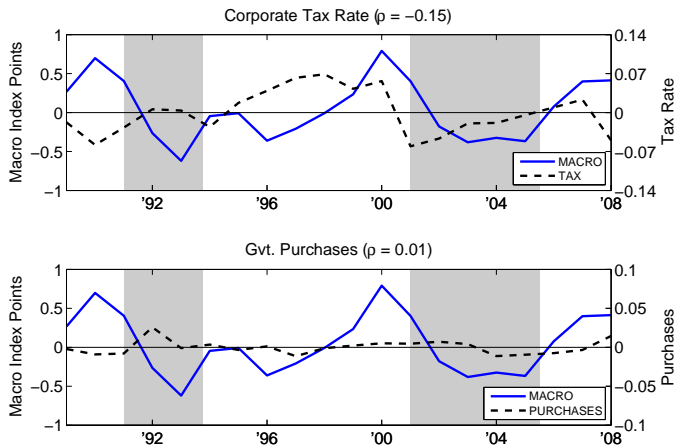
Credit Spreads (ρ = −0.28)

Uncertainty (ρ = −0.45)
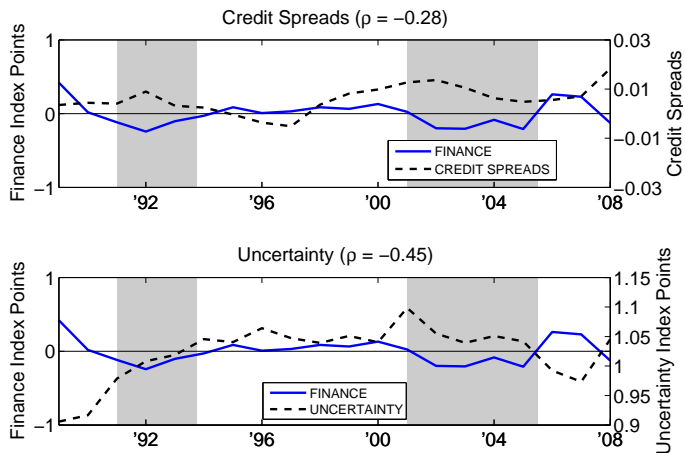
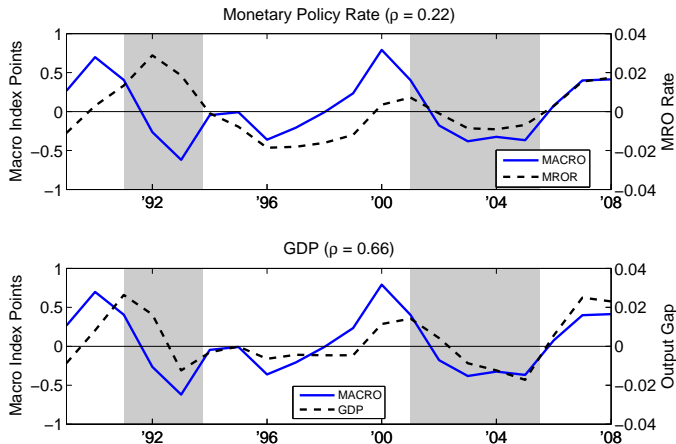Sources: Gilchrist, Mojon (2013), Bachmann, Elstner, Sims (2013)
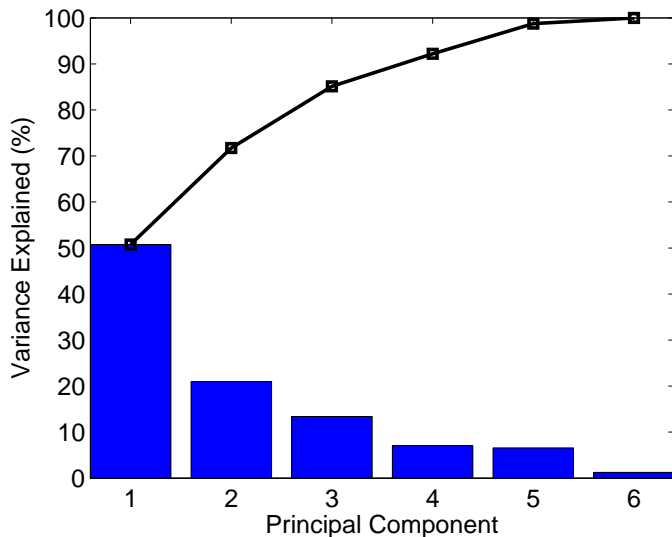
Economic Content: Sales
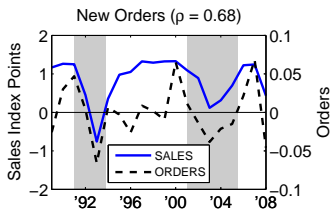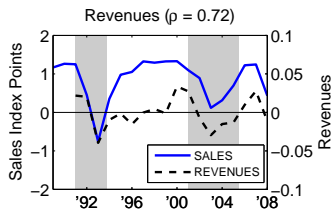
Economic Content: Macro

Economic Content: Macro

Economic Content: Principal Component Analysis

Economic Content: Principal Component Analysis

Pairwise correlations with the investment determinant indices'
principal components:

	First Principal Component	Second Principal Component	Third Principal Component
Tech	0.2852	0.7634***	0.5065**
Finance	0.7290***	-0.1230	-0.4860**
Sales	0.9142***	-0.1066	0.1582
Profit	0.9360***	-0.0608	0.0763
Macro	0.7682***	-0.3133	0.2184
Other	-0.3610	-0.7397***	0.4819**
ΔI_t^{FSO}	0.8787***	0.0506	0.1422

Identification

Two steps:

1. Technological versus non-technological shocks: innovations to `Tech` are orthogonal to innovations in the non-technological investment determinant indices. Technology within a year is determined by engineering efforts or engineering luck.

2. Within non-technological shocks:
   1. Orthogonalize `Profit`, `Macro` and `Other` with respect to `Technology`, `Finance` and `Sales`.
   2. Baseline: Orthogonalize `Finance` with respect to `Sales`. External finance is simply not that important in Germany.
   3. Study the converse, too. Implicit assumption: net worth is a slow-moving variable.

Orthogonalization - Regression Framework

$$\begin{aligned}
\text{Tech}_t &= \nu_1 + \widehat{\text{Tech}_t} \\
\text{Sales}_t &= \nu_2 + \delta_{21}\widehat{\text{Tech}_t} + \widehat{\text{Sales}_t} \\
\text{Finance}_t &= \nu_2 + \delta_{31}\widehat{\text{Tech}_t} + \delta_{32}\widehat{\text{Sales}_t} + \widehat{\text{Finance}_t} \\
\text{Profit}_t &= \nu_4 + \delta_{41}\widehat{\text{Tech}_t} + \delta_{42}\widehat{\text{Sales}_t} + \delta_{43}\widehat{\text{Finance}_t} + \widehat{\text{Profit}_t} \\
\text{Macro}_t &= \nu_5 + \delta_{51}\widehat{\text{Tech}_t} + \delta_{52}\widehat{\text{Sales}_t} + \delta_{53}\widehat{\text{Finance}_t} + \delta_{54}\widehat{\text{Profit}_t} + \widehat{\text{Macro}_t} \\
\text{Other}_t &= \nu_6 + \delta_{61}\widehat{\text{Tech}_t} + \delta_{62}\widehat{\text{Sales}_t} + \delta_{63}\widehat{\text{Finance}_t} + \delta_{64}\widehat{\text{Profit}_t} + \delta_{65}\widehat{\text{Macro}_t} + \widehat{\text{Other}_t}
\end{aligned}$$

Remark: we verify that orthogonalized series are not autocorrelated.

Final Regression

$$\Delta I_t^{FSO} = c + \beta_1 \widehat{\text{Tech}_t} + \beta_2 \widehat{\text{Sales}_t} + \beta_3 \widehat{\text{Finance}_t} +$$
$$\beta_4 \widehat{\text{Profit}_t} + \beta_5 \widehat{\text{Macro}_t} + \beta_6 \widehat{\text{Other}_t} + u_t$$

Since we have orthogonal regressors (by construction) we can decompose their contribution to the R^2 of this multivariate regression by computing a series of univariate regressions.

Recall: R^2s are additive with orthogonal regressors.

Variance Decomposition

Relative contributions to the R^2 (in percent) with different orthogonalizations of Tech - Total R^2: 82 percent!

| *Orthogonalization:*	Tech Finance Sales Profit Macro Other	Tech Sales Finance Profit Macro Other
$\widehat{\text{Tech}}$	19.04	**19.04**
$\widehat{\text{Sales}}$	23.10	**61.08**
$\widehat{\text{Finance}}$	46.48	**8.51**
$\widehat{\text{Profit}}$	2.75	
$\widehat{\text{Macro}}$	8.62	
$\widehat{\text{Other}}$	0.01	
R^2	0.8183	

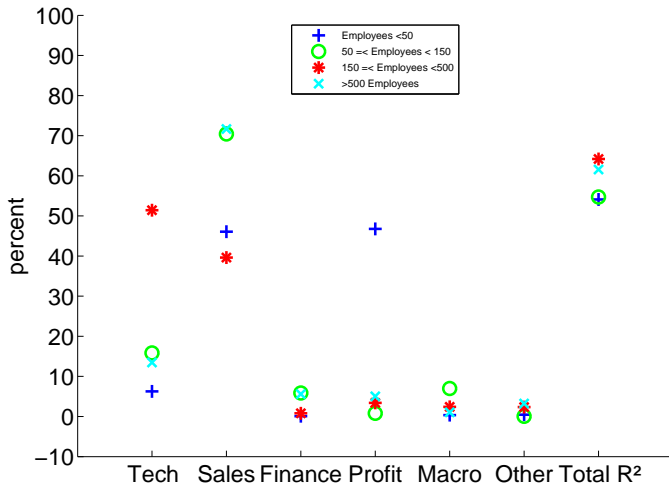# Counterfactuals - Baseline
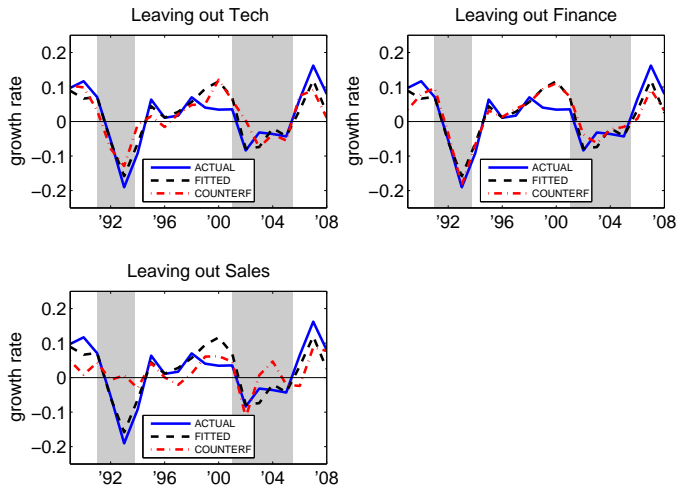
Counterfactuals - Alternative
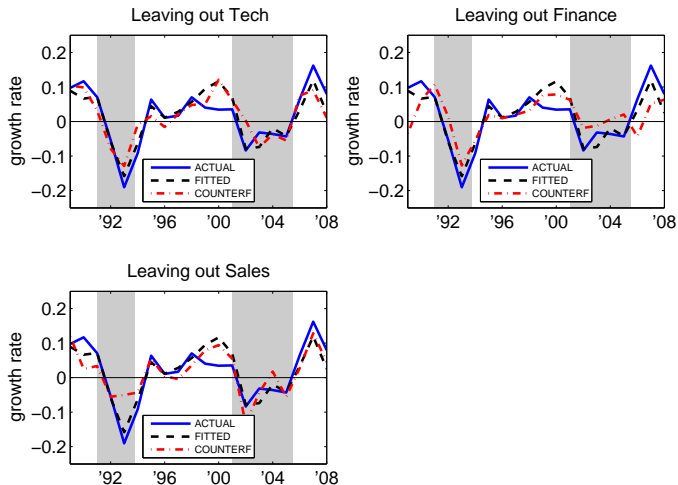
Robustness

- Run this with real investment growth on the LHS.
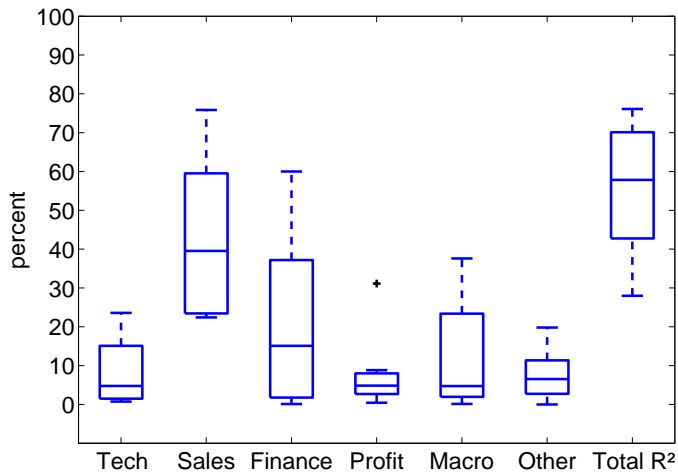- Run this with the IFO investment growth rate on the LHS.

Semi-aggregate Results (Baseline): 2-digit Industry
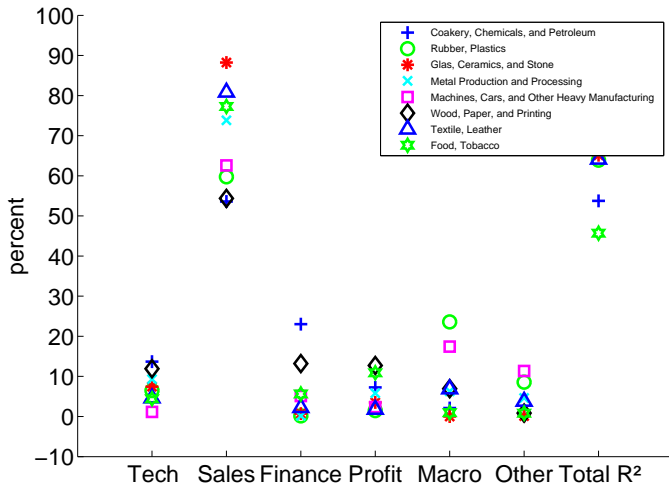
Semi-aggregate Results (Baseline): Size

Semi-aggregate Results ((Baseline)): Laender

Robustness: Adjustment Costs and News Shocks

Dependent Variable	ΔI_t^{FSO}	
	Lead	Lag
$\widehat{\text{Tech}}$	0.3553	0.3607
	(3.5464)	(3.2933)
$\widehat{\text{Finance}}$	0.1669	0.1342
	(2.6720)	(1.5726)
$\widehat{\text{Sales}}$	0.1075	0.1110
	(5.8650)	(5.9852)
$\widehat{\text{Profit}}$	0.0351	0.0593
	(0.7116)	(1.1465)
$\widehat{\text{Macro}}$	0.0546	0.0741
	(1.5790)	(2.2045)
$\widehat{\text{Other}}$	0.0019	0.0070
	(0.0663)	(0.2156)
Lead/Lag of $\widehat{\text{Tech}}$	0.1539	-0.1735
	(1.4139)	(-1.5292)
Constant	0.0125	0.0157
	(1.3955)	(1.5891)
N	19	19
R^2	0.8708	0.8427

IP on the LHS

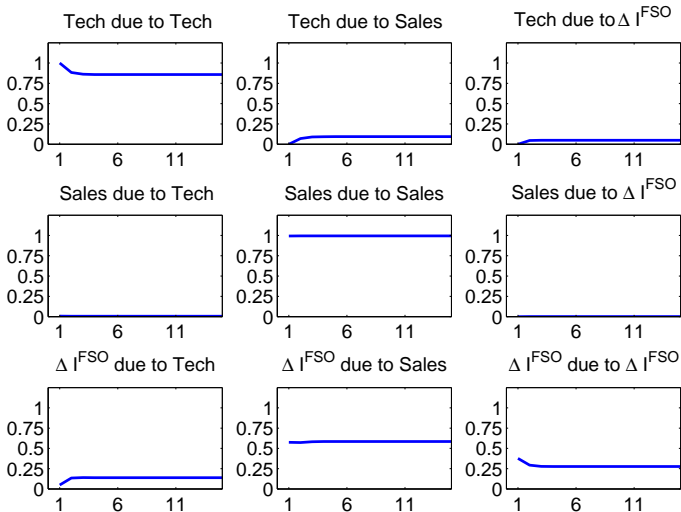|	Tech Sales Finance Profit Macro Other
Orthogonalization:	
$\widehat{\text{Tech}}$	0.37
$\widehat{\text{Sales}}$	67.81
$\widehat{\text{Finance}}$	13.09
$\widehat{\text{Profit}}$	17.26
$\widehat{\text{Macro}}$	0.23
$\widehat{\text{Other}}$	1.24
R^2	0.6279

VAR with Tech, Sales, and ΔI_t

IRFs:
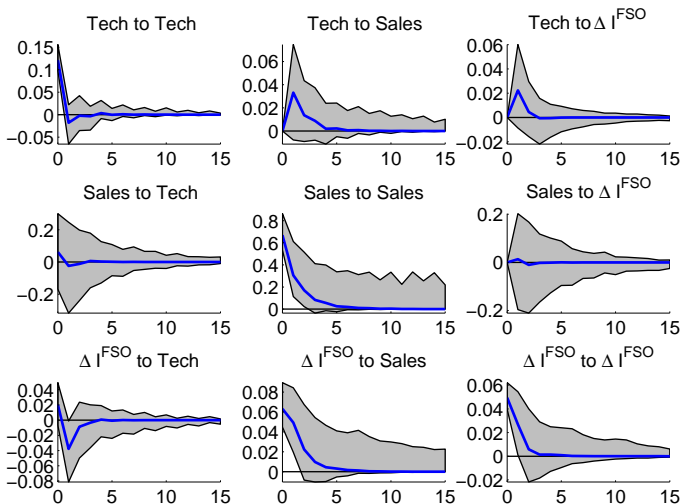
VAR with Tech, Sales, and ΔI_t
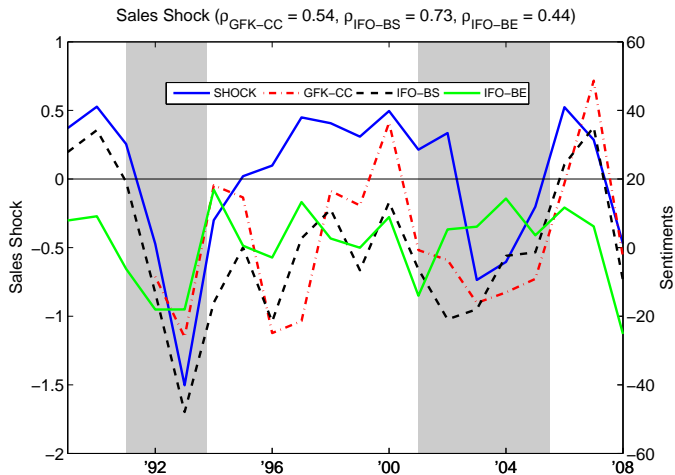
Forecast Error Variance Decomposition:

Technology Shocks in one Industry = Demand Shock in Another?

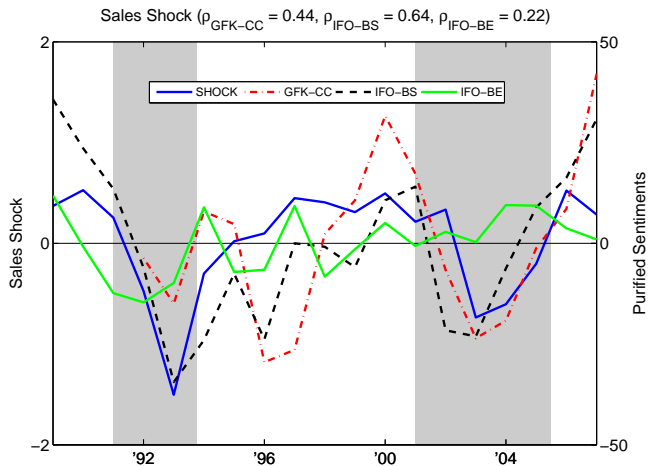$$\text{DSI}_t^i = \sum_{j \neq i} \lambda_i^j \, \widehat{\text{Sales}_{jt}}$$

where λ_i^j is the share of intermediate output that sector i sells to sector j and $\widehat{\text{Sales}_{jt}}$ is our measure of demand shocks in sector j. Linear Pairwise Correlation Coefficients between DSI_t^i and $\widehat{\text{Tech}_{it}}$.

Coakery, Chemicals, Petroleum	Rubber, Plastics	Glas, Ceramics, Stone	Metal Production and Processing	Machines, Cars, and Other Heavy Manufacturing	Wood, Paper, Printing	Textile, Leather	Food, Tobacco
0.3337	-0.0783	0.1180	0.5907	0.0964	0.4871	0.2059	0.0122

What Are Demand Shocks?

Sales Shock ($\rho_{GFK-CC} = 0.54$, $\rho_{IFO-BS} = 0.73$, $\rho_{IFO-BE} = 0.44$)

What Are Demand Shocks?

Sales Shock ($\rho_{GFK-CC} = 0.44$, $\rho_{IFO-BS} = 0.64$, $\rho_{IFO-BE} = 0.22$)
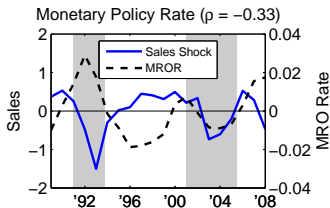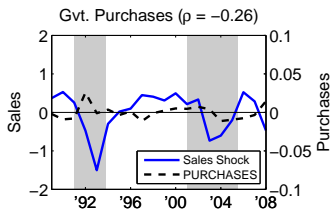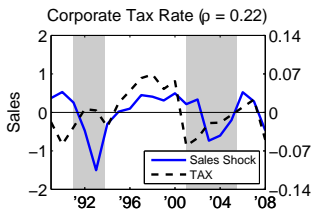
Purification: orthogonalized w.r.t. one-year-ahead technology

What Are Demand Shocks?

Conclusion

- Use information on investment determinants from the IFO investment survey to construct aggregate and semi-aggregate investment determinant indices for West German manufacturing investment.
- Orthogonalize these indices to plausibly exogenous shocks, in two steps: technological versus non-technological and then within the non-technological determinants.
- Narrative approach.
- Find that both economically and statistically there are not more than two or three independent driving forces behind fluctuations in the manufacturing investment growth rate.
- The upper bound for technology-driven investment growth fluctuations is 19 percent.
- The bulk of investment growth fluctuations seems to be caused by aggregate demand shocks, which are likely sentiment shocks.