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

Second result (intervals):

1. Financial shocks: 9 percent to 46 percent.
2. Aggregate demand shocks: 23 percent to 61 percent.

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

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.

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:

<table>
<thead>
<tr>
<th>Investment Determinant</th>
<th>strongly positive influence</th>
<th>weakly positive influence</th>
<th>no influence</th>
<th>weakly negative influence</th>
<th>strongly negative influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales Situation and Expectation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit Expectation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical Factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macro Policy Environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[Codification]</td>
<td>[+2]</td>
<td>[+1]</td>
<td>[0]</td>
<td>[-1]</td>
<td>[-2]</td>
</tr>
</tbody>
</table>

R. Bachmann (SAFE)
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, $\Delta I_t^{IFO}$, 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

Tech
Finance
Sales
Profit
Macro
Other
The IFO Investment Survey and the Data

A First Look at the Data - Pairwise Correlations

<table>
<thead>
<tr>
<th></th>
<th>Tech</th>
<th>Finance</th>
<th>Sales</th>
<th>Profit</th>
<th>Macro</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tech</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finance</td>
<td>-0.0015</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td>0.2191</td>
<td>0.5502**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit</td>
<td>0.2033</td>
<td>0.5653***</td>
<td>0.9154***</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macro</td>
<td>0.0870</td>
<td>0.4652**</td>
<td>0.6340***</td>
<td>0.6610***</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>-0.3514</td>
<td>-0.2813</td>
<td>-0.1720</td>
<td>-0.2748</td>
<td>-0.0240</td>
<td>1</td>
</tr>
<tr>
<td><strong>Panel B:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta I_t^{FSO}$</td>
<td>0.3947*</td>
<td>0.6161***</td>
<td>0.7763***</td>
<td>0.7903***</td>
<td>0.7379***</td>
<td>-0.2706</td>
</tr>
</tbody>
</table>
Economic Content: Tech

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

<table>
<thead>
<tr>
<th>Tercile</th>
<th>N</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12733</td>
<td>1.113254</td>
</tr>
<tr>
<td>2</td>
<td>8257</td>
<td>1.351336</td>
</tr>
<tr>
<td>3</td>
<td>9987</td>
<td>1.501928</td>
</tr>
</tbody>
</table>

Difference in means statistically significant at the 1% level.
Economic Content: Tech

<table>
<thead>
<tr>
<th>Product Innovation</th>
<th>N</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>5145</td>
<td>1.389407</td>
</tr>
<tr>
<td>No</td>
<td>1562</td>
<td>1.325075</td>
</tr>
</tbody>
</table>

Difference in means statistically significant at the 5% level.
### Economic Content: Tech

<table>
<thead>
<tr>
<th>Process Innovation</th>
<th>N</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>5437</td>
<td>1.355924</td>
</tr>
<tr>
<td>No</td>
<td>11272</td>
<td>1.293243</td>
</tr>
</tbody>
</table>

Difference in means statistically significant at the 1% level.
Economic Content: Finance

Credit Spreads ($\rho = -0.28$)

Uncertainty ($\rho = -0.45$)

Sources: Gilchrist, Mojon (2013), Bachmann, Elstner, Sims (2013)
Economic Content: Sales

Revenues ($\rho = 0.72$)

New Orders ($\rho = 0.68$)

Industrial Production ($\rho = 0.67$)
Economic Content: Macro

Corporate Tax Rate ($\rho = -0.15$)

Gvt. Purchases ($\rho = 0.01$)
Economic Content: Macro

Monetary Policy Rate ($\rho = 0.22$)

GDP ($\rho = 0.66$)
Economic Content: Principal Component Analysis

Principal Component Variance Explained (%)

1. 2. 3. 4. 5. 60
10
20
30
40
50
60
70
80
90
100
Principal Component

Variance Explained (%)
Economic Content: Principal Component Analysis

Pairwise correlations with the investment determinant indices’ principal components:

<table>
<thead>
<tr>
<th></th>
<th>First Principal Component</th>
<th>Second Principal Component</th>
<th>Third Principal Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech</td>
<td>0.2852</td>
<td>0.7634***</td>
<td>0.5065**</td>
</tr>
<tr>
<td>Finance</td>
<td>0.7290***</td>
<td>-0.1230</td>
<td>-0.4860**</td>
</tr>
<tr>
<td>Sales</td>
<td>0.9142***</td>
<td>-0.1066</td>
<td>0.1582</td>
</tr>
<tr>
<td>Profit</td>
<td>0.9360***</td>
<td>-0.0608</td>
<td>0.0763</td>
</tr>
<tr>
<td>Macro</td>
<td>0.7682***</td>
<td>-0.3133</td>
<td>0.2184</td>
</tr>
<tr>
<td>Other</td>
<td>-0.3610</td>
<td>-0.7397***</td>
<td>0.4819**</td>
</tr>
<tr>
<td>$\Delta I_{FSO}^t$</td>
<td>0.8787***</td>
<td>0.0506</td>
<td>0.1422</td>
</tr>
</tbody>
</table>
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:
   - Orthogonalize Profit, Macro and Other with respect to Technology, Finance and Sales.
   - Baseline: Orthogonalize Finance with respect to Sales. External finance is simply not that important in Germany.
   - Study the converse, too. Implicit assumption: net worth is a slow-moving variable.
Remark: we verify that orthogonalized series are not autocorrelated.
Final Regression

\[ \Delta l_t^{FSO} = c + \beta_1 \hat{\text{Tech}}_t + \beta_2 \hat{\text{Sales}}_t + \beta_3 \hat{\text{Finance}}_t + \beta_4 \hat{\text{Profit}}_t + \beta_5 \hat{\text{Macro}}_t + \beta_6 \hat{\text{Other}}_t + u_t \]

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: $R^2$'s 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!

<table>
<thead>
<tr>
<th>Orthogonalization:</th>
<th>Tech</th>
<th>Finance</th>
<th>Sales</th>
<th>Profit</th>
<th>Macro</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech</td>
<td>19.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td>23.10</td>
<td></td>
<td>61.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finance</td>
<td>46.48</td>
<td>8.51</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit</td>
<td></td>
<td>2.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macro</td>
<td></td>
<td>8.62</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td></td>
<td>0.8183</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Counterfactuals - Baseline

Leaving out Tech

Leaving out Finance

Leaving out Sales
Counterfactuals - Alternative

Leaving out Tech

Leaving out Finance

Leaving out Sales

R. Bachmann (SAFE) Investment Tarragona, May 2014
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

Coakery, Chemicals, and Petroleum
Rubber, Plastics
Glass, Ceramics, and Stone
Metal Production and Processing
Machines, Cars, and Other Heavy Manufacturing
Wood, Paper, and Printing
Textile, Leather
Food, Tobacco
Semi-aggregate Results (Baseline): Size

The graph shows the relationship between different categories of employees (employees <50, 50 ≤ employees < 150, 150 ≤ employees <500, >500 employees) and various sectors like Tech, Sales, Finance, Profit, Macro, Other, and the Total R². The data points are color-coded to represent the employee categories.
Semi-aggregate Results ((Baseline)): Laender
## Robustness: Adjustment Costs and News Shocks

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>$\Delta I_t^{FSO}$</th>
<th>Lead</th>
<th>Lag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech</td>
<td>0.3553</td>
<td>0.3607</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.5464)</td>
<td>(3.2933)</td>
<td></td>
</tr>
<tr>
<td>Finance</td>
<td>0.1669</td>
<td>0.1342</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.6720)</td>
<td>(1.5726)</td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td>0.1075</td>
<td>0.1110</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(5.8650)</td>
<td>(5.9852)</td>
<td></td>
</tr>
<tr>
<td>Profit</td>
<td>0.0351</td>
<td>0.0593</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.7116)</td>
<td>(1.1465)</td>
<td></td>
</tr>
<tr>
<td>Macro</td>
<td>0.0546</td>
<td>0.0741</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.5790)</td>
<td>(2.2045)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0.0019</td>
<td>0.0070</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0663)</td>
<td>(0.2156)</td>
<td></td>
</tr>
<tr>
<td>Lead/Lag of Tech</td>
<td>0.1539</td>
<td>-0.1735</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.4139)</td>
<td>(-1.5292)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.0125</td>
<td>0.0157</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.3955)</td>
<td>(1.5891)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N</th>
<th>19</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>0.8708</td>
<td>0.8427</td>
</tr>
</tbody>
</table>
## Results

**IP on the LHS**

<table>
<thead>
<tr>
<th>Orthogonalization:</th>
<th>Tech</th>
<th>Sales</th>
<th>Finance</th>
<th>Profit</th>
<th>Macro</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech</td>
<td>0.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td></td>
<td>67.81</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finance</td>
<td></td>
<td></td>
<td>13.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit</td>
<td></td>
<td></td>
<td></td>
<td>17.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macro</td>
<td>0.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ R^2 = 0.6279 \]
VAR with Tech, Sales, and $\Delta I_t$

IRFs:
VAR with Tech, Sales, and $\Delta I_t$

Forecast Error Variance Decomposition:

- Tech due to Tech
- Tech due to Sales
- Tech due to $\Delta I_{FSO}$
- Sales due to Tech
- Sales due to Sales
- Sales due to $\Delta I_{FSO}$
- $\Delta I_{FSO}$ due to Tech
- $\Delta I_{FSO}$ due to Sales
- $\Delta I_{FSO}$ due to $\Delta I_{FSO}$
Technology Shocks in one Industry = Demand Shock in Another?

\[
D_{SI_t} = \sum_{j \neq i} \lambda_{ij} \hat{Sales}_{jt}
\]

where \( \lambda_{ij} \) is the share of intermediate output that sector \( i \) sells to sector \( j \) and \( \hat{Sales}_{jt} \) is our measure of demand shocks in sector \( j \).

Linear Pairwise Correlation Coefficients between \( D_{SI_t} \) and \( Tech_{it} \).

<table>
<thead>
<tr>
<th>Coakery, Chemicals, Petroleum</th>
<th>Rubber, Plastics</th>
<th>Glass, Ceramics, Stone</th>
<th>Metal Production and Processing</th>
<th>Machines, Cars, and Other Heavy Manufacturing</th>
<th>Wood, Paper, Printing</th>
<th>Textile, Leather</th>
<th>Food, Tobacco</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3337</td>
<td>-0.0783</td>
<td>0.1180</td>
<td>0.5907</td>
<td>0.0964</td>
<td>0.4871</td>
<td>0.2059</td>
<td>0.0122</td>
</tr>
</tbody>
</table>
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?

Corporate Tax Rate ($\rho = 0.22$)

Gvt. Purchases ($\rho = -0.26$)

Monetary Policy Rate ($\rho = -0.33$)
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.