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ABSTRACT

Using firm-level survey data for the West German manufacturing sector, this paper revisits the technology-driven business cycle hypothesis for the case of aggregate investment. We construct a survey-based measure of technology shocks to gauge their contribution to short-run investment fluctuations. We estimate an upper bound for the contribution of technology shocks to the variance of the aggregate investment growth rate of 19 percent. The larger part of fluctuations in aggregate investment can be attributed to finance and demand shocks, which we also extract from the survey data.

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1 Introduction

There is considerable disagreement among empirical macroeconomists about the technology-driven business cycle hypothesis. While some authors report evidence in favor (Christiano et al., 2003; Fisher, 2006; Alexopoulos, 2011), others call the idea of technology-driven business cycles into question (Hall, 1997; Galí, 1999; Shea, 1999; Francis and Ramey, 2005; Basu et al., 2006). An often used measurement tool in this literature for the validity of the technology-driven business cycle hypothesis is the conditional comovement between measures of technology and aggregate hours. This paper takes a rather different route: using survey data from the Ifo Investment Survey about firm-level capital expenditures in the West German manufacturing sector and – this is the novel contribution of this paper – subjective investment determinants reported by decision makers in firms, this paper introduces a survey-based measure of technology shocks. We then study the relative contribution of these technology innovations to the unconditional variance of aggregate manufacturing investment growth (henceforth simply aggregate investment growth). We find evidence that technology shocks explain a significant fraction of the business cycle fluctuations of investment, estimating an upper bound for the contribution of technology shocks to aggregate investment growth of 19 percent. In addition, when we impose more structure on the empirical model, we find that a combination of what we interpret as finance and demand shocks account for the bulk of the short-run fluctuations in aggregate capital expenditures. Financial shocks explain aggregate investment growth with a contribution between 9 percent and 46 percent, aggregate demand shocks with a contribution between 23 percent and 61 percent, depending on the exact empirical specification.

We see the advantage of a survey-based approach towards identifying shocks in its putative directness: the survey respondents directly report whether their investment activity in a given year was influenced by, for instance, technological considerations and, if so, how strongly.[1]

[1] In this regard, our approach is not dissimilar to other narrative methodologies that have been used in empirical macroeconomics, see, for example, (Romer and Romer, 2004, 2010).

The Ifo Investment Survey questionnaire also asks firms about non-technological investment determinants, such as finance, demand, etc. From the survey answers we construct aggregate index measures of technological and non-technological investment determinants in the manufacturing sector (henceforth simply aggregate investment determinant indices). We use these investment determinant indices to recover orthogonal technology and non-technology shocks. In a regression of aggregate investment growth in the manufacturing sector on technology and non-technology shocks, we find that the former account for a sizeable fraction (19 percent), but not the majority of the variance of aggregate manufacturing investment growth. Our findings are robust to disaggregating the data at the two-digit industry level or by region.

It bears pointing out that the empirical results presented in this paper do not imply that technology per se is unimportant for investment. In fact, technological factors are reported by the survey respondents to have a large positive effect on capital expenditures constantly throughout the sample period, indeed on average the largest positive effect of any investment determinant in the survey. They just do not matter as substantially for investment fluctuations as non-technological factors. King and Rebelo (1999) show that simulated data from a real business cycle model fed with estimated aggregate "productivity" shocks replicate business cycle dynamics in US time series fairly well, including investment fluctuations. In light of our findings, and to the extent that the German and the US business cycle are similar, this result can be interpreted in the following way: measured aggregate "productivity" shocks may have less to do with technological factors in a narrow sense, but rather capture other determinants of aggregate productivity. In this sense, our results do not invalidate real business cycle theory per se, but point to elsewhere other than engineering departments for economists to find the main source of measured aggregate productivity fluctuations.

The remainder of this paper is organized as follows. Section 2 introduces the survey data and presents the aggregate investment determinant indices. In addition, we assess whether the survey data capture the economic concepts they are supposed to measure. Section 3 lays out the empirical model for estimating the contribution of the aggregate investment determinants to aggregate investment growth, and motivates the identifying assumptions. Section 4 presents the results, both for the manufacturing sector and disaggregated at the two-digit industry level and by region. Section 5 summarizes the main findings and concludes.

2 The Survey Data

2.1 The Ifo Investment Survey

The Ifo Investment Survey is a semi-annual survey in the West German manufacturing sector[2] carried out in spring and fall by the Ifo Institute since 1955. Its main purpose is to provide firm-level quantitative actual capital expenditure data and future investment plans of the firms. In addition, it asks firms in the fall about qualitative and subjective investment determinants at an annual frequency without interruption since 1989. For disclosure reasons the micro data right now is only available until 2008. Our sample period therefore goes from 1989 to 2008.

The main advantages of the Ifo Investment Survey data are its high number of respondents, counting on average roughly 1,500 firms per year in the sample period; that it provides quantitative firm-specific capital expenditure data; and the information about qualitative and subjective investment determinants. Moreover, aggregate investment growth implied by the survey micro data is highly correlated (0.88) with West German manufacturing investment growth data from the Federal Statistical Office (see Figure 1), which means that our sample is reasonably representative of the universe of firms in the West German manufacturing sector. The low frequency of the data and the relatively small number of observations thus arising in the time dimension is a disadvantage. Nevertheless, it should be noted that the planning horizon of firms for investment typically spans a (fiscal) year and the low frequency of the data is thus not restrictive per se.

Specifically, we make use of the following two questions from the survey questionnaire:

[2] The Energy & Mining sector is also included, but is small relative to manufacturing proper.

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:

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

In **Q1** firms report their realized capital expenditures for the preceding year. It is asked in the spring and the fall surveys except for the falls of 2002 and 2003, for which we use the value reported in the spring of the corresponding year. In **Q2**, which is asked only in the fall survey, firms give information about how various investment determinants have affected their investment activity. Specifically, the survey questionnaire asks firms about the effects of their sales situation and expectations, finance, profit expectations, technical factors,[3] the macro policy environment, and other investment determinants on their capital expenditures. The possible answers are: "strongly negative", "weakly negative", "no influence", "weakly positive", or "strongly positive". The respondent is supposed to check one box for each investment determinant. The variables `Tech`, `Finance`, `Sales`, `Profit`, `Macro`, and `Other` record a firm's response to **Q2** and take on the values -2 (strongly negative influence), -1 (weakly negative influence), 0 (no influence), +1 (weakly positive influence), or +2 (strongly positive influence).

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.

2.2 Aggregation

Although the Ifo Investment Survey provides information about investment determinants and quantitative capital expenditures at the firm level, we aggregate the survey responses. The discrete variation in the micro-level investment determinants may not be sufficient to identify their effect on continuously reported capital expenditures. More importantly, the research question of this paper is about the sources of fluctuations in aggregate investment growth. Hence, we aggregate investment determinants across firms. In extensions, we study semi-aggregate specifications at the two-digit industry level and at the regional level.

[3] The guidelines for the survey state that technical factors comprise all incentives to invest which come from technical development. The survey guidelines for the other investment determinants are available in the Appendix.

Each firm-level observation is weighted by its share in total investment. Formally, let ΔI_t^{IFO} denote aggregate investment growth based on **Q1** of the Ifo Investment Survey, inv_{it} is firm i's investment in period t,[4] and N_t is the number of observations for which firm-level data is observable in periods t and $t-1$. 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:

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

Similarly, let x_{it} denote one of the six firm-level investment determinants mentioned above, ranging from -2 to +2. Then, for every investment determinant, we aggregate up to an investment determinant index, X_t, as follows:

$$X_t = \sum_{i=1}^{N_t} \omega_{it}\, x_{it} \tag{2}$$

With a slight abuse of notation, `Tech`, `Finance`, `Sales`, `Profit`, `Macro`, and `Other` will henceforth refer to the investment determinant indices.

2.3 The Raw Data

In Figure 1 we compare the aggregate investment growth rates obtained from the Ifo Investment Surevy data, ΔI_t^{IFO}, with data for the West German manufacturing sector from the Federal Statistical Office, ΔI_t^{FSO}. The correlation coefficient between both series is 0.88.

Figure 2 plots the aggregate investment determinant indices over time. Two observations stand out. First, in contrast to the other investment determinant indices which often fluctuate around zero, the effect of technology on capital expenditures is positive throughout. It is worth pointing out that, although technological factors have a positive influence

[4] We average the fall and the spring capital expenditure data, whenever they are both available, because in a few circumstances they may slightly deviate from each other. The results reported are robust when we instead only use the fall or the spring observations.

on investment over the whole sample period, their role as a source of fluctuations in aggregate investment at business cycle frequencies may still be modest. Second, the aggregate investment determinant indices are often correlated with each other and the business cycle.

Panel A of Table 1 shows their pairwise correlation coefficients. The correlation between `Tech` and the non-technological investment determinant indices is statistically insignificant. Within the group of non-technological investment determinant indices – `Finance`, `Sales`, `Profit` and `Macro` – the correlation is always positive, fairly high, and in one case substantial: `Sales` and `Profit` have a pairwise correlation coefficient of approximately 0.92. This suggests that both variables capture a similar economic concept and that `Profit` does not really seem to capture the concept of firms' input costs. The residual investment determinant index `Other` is not significantly correlated with any of the other variables.

The fact that some of these aggregated investment determinants are correlated is not surprising: for example, when there is a shock to financial intermediation in the economy, this may impact investment directly through standard finance effects, but also simultaneously through an aggregate demand effect from other firms and the households in this economy. It means, however, that we cannot interpret the investment determinants directly as shocks (hence the use of "investment determinants"). Nevertheless, we will argue below that given their interpretation as investment determinants we can use a simple orthogonalization scheme to extract orthogonal shocks that can be reasonably interpreted as technology and non-technology shocks. With additional assumptions we can go further and extract shocks that can be reasonably interpreted as financial and aggregate demand shocks.

Panel B of Table 1 reports the pairwise correlations of the investment determinant indices with the aggregate investment growth rate, ΔI_t^{FSO}. The correlation coefficient between `Tech` and ΔI_t^{FSO} is weakly significant at 0.39. The correlation with the non-technological investment determinant indices is stronger and highly significant. For example, the correlation coefficient between Sales and ΔI_t^{FSO} is 0.78. The residual category `Other` is not significantly correlated with the aggregate investment growth rate.[5] From this simple correlational analysis we may already expect that technology shocks may be a significant, but not the main source of the time series variation of aggregate investment growth.

2.4 Economic Content

Before we lay out our empirical strategy, this subsection discusses the likely economic content of the aggregated investment determinant indices and provides a few plausibility checks as to whether they indeed capture the economic concepts that they are meant to measure.

We start with `Tech`. In addition to capital expenditure data and investment determinants, the Ifo Investment Survey also asks for the fraction of investment that went into increases in capacity, restructuring, rationalization, maintenance, and other types of capital expenditures. We sum the shares for restructuring and rationalization investment to proxy for that fraction of investment undertaken mainly for reasons of technological development. Conditional on the terciles of this proxy for technology-driven investment, Table 2 shows the weighted average of `Tech` using the weights defined in Section 2.2. The conditional mean increases monotonically with the share of investment that went into restructuring or rationalization. The difference between the first and the third tercile is statistically significant at the 1% level. The evidence in Table 2 is at least suggestive that `Tech` indeed captures the effect of technological factors on capital expenditures. One additional observation lends credence to this view. On average `Tech` is the most important investment determinant. This squares well with standard Neoclassical growth theory that in the long-run economic activity is mainly determined by technological progress.

In Figure 3 we compare `Finance` and two covariate candidates. The top panel shows linearly detrended yields on outstanding corporate bonds obtained from the Bundesbank. Although corporate bonds are only a minor source of external finance in Germany, their yields are a good proxy for bank loans of different sizes and maturities, which are the major source of

[5] All these results are very similar with ΔI_t^{IFO}.

external finance for German firms.[6] As Figure 3 also shows, contractionary monetary policy during the boom following the German reunification in 1990 led to rising interest rates, and at the same time firms reported on average an increasingly negative effect of finance on capital expenditures. The correlation between both series is negative: -0.28. Similarly, the lower panel compares `Finance` with a measure of idiosyncratic uncertainty in the West German manufacturing sector, the yearly average of the standard deviation of ex-post forecast errors from Bachmann et al. (2013). As Gilchrist et al. (2010) argue, uncertainty shocks can interact with financial frictions so as to cause an increase in the cost of capital followed by a decline in capital expenditures.[7] The correlation between the uncertainty measure and `Finance`, -0.45, is consistent with that view. Taken together, the evidence in Figure 3 is at least suggestive that the effect of finance on capital expenditures is captured by `Finance`.

The upper-left panel of Figure 4 compares `Sales` and the cyclical component of the volume index of revenues in the German manufacturing sector, obtained from the Federal Statistical Office. The cyclical component is extracted by means of the HP-filter with smoothing parameter $\lambda = 6.25$ for annual data, following Ravn and Uhlig (2002). The correlation between both time series is positive and high: 0.72. In the upper-right panel we plot the HP-filtered ($\lambda = 6.25$) index of new orders in the German manufacturing sector from the Federal Statistical Office. The correlation with the investment determinant index `Sales` is 0.68. The lower-left panel of Figure 4 displays real production in the German manufacturing sector, obtained from the Federal Statistical Office, at business cycle frequencies ($\lambda = 6.25$). Again, the correlation with `Sales` is positive and high: 0.67. The evidence in Figure 4 is consistent with the aggregate investment determinant index `Sales` capturing the effect of sales and sales expectations on capital expenditures in the manufacturing sector.

[6] There does not appear to exist a good longitudinally consistent time series of bank loan interest rates for Germany. The MFI interest rate statistics about euro-denominated loans to non-financial corporations which are resident in the euro area are available from the Bundesbank since 2003. These include loan rates for outstanding amounts and new business, up to 1 million Euro and over 1 million Euro, of German banks with maturity up to one year, between one and five years, or over five years. For the time before 2003, the European Central Bank provides data on national retail interest rates of German banks, broken down by short-term loans to enterprises and medium and long-term loans to enterprises. The correlation between corporate bond yields and the different lending rates is almost always above 0.80.

[7] Other examples of papers that study the link between investment activity and uncertainty through financial frictions are Christiano et al. (2013); Arellano et al. (2012); Chugh (2012); Dorofeenko et al. (2008).

Figure 5 depicts `Macro` and fiscal policy covariate candidates. The relation between `Macro` and corporate tax policy is shown in the top panel. Since the firms in the Ifo Investment Survey are predominantly incorporated entities, which are under corporate tax law, as opposed to single-ownership firms and partnerships, which are subject to personal income taxation, the linearly detrended corporate tax rate is used. Its correlation with `Macro` is small: -0.15. The lower panel plots `Macro` and a measure of real government purchases at business-cycle frequencies, i.e. HP(6.25)-filtered. Government purchases are defined as the sum of intermediate inputs, wage costs, benefits in kind, and gross investment, obtained from German national accounting (*Volkswirtschaftliche Gesamtrechnung, VGR*) data on expenditures in the government sector. The correlation between the two series is essentially zero: 0.01.

In addition, Figure 6 depicts `Macro` and two other covariate candidates. The top panel displays the linearly detrended monetary policy rate. Until 1998 the discount rate set by the Bundesbank was the main instrument for the conduct of monetary policy, followed by the main refinancing operations rate set by the European Central Bank since 1999. The correlation coefficient between both series, 0.22, is small and has an unexpected sign. Increases in the monetary policy rate should depress economic activity through higher refinancing costs and thus if `Macro` captured the monetary policy environment, we should expect a negative correlation with the monetary policy rate. Indeed, in the data the correlation between the monetary policy rate and the investment growth rate, ΔI_t^{FSO}, is, albeit insignificantly so, negative: -0.09.[8] In contrast, the lower panel shows that `Macro` closely follows the cyclical component of real GDP, obtained from German VGR (*Volkswirtschaftliche Gesamtrechnung*) data and extracted by an HP-filter with smoothing parameter $\lambda = 6.25$. The correlation between the two series is 0.66. Taken together, the evidence in Figure 5 and Figure 6 suggests that the aggregate investment determinant index `Macro` probably does not capture fiscal or monetary policy per se, but rather appears to express firms' assessment of the general macroeconomic environment.

[8] The correlation with ΔI_t^{IFO} is -0.25.

A different perspective on the economic content of the aggregate investment determinant indices can be gained through a principal component analysis. In Figure 7 we depict the scree plot of the investment determinant indices' principal components. In cumulative terms, the first two principal components explain roughly 70 percent of the total variation and the first three more than 80 percent. This is consistent with the evidence from Table 1 and suggests that some of the investment determinant indices capture similar economic concepts.

Table 3 reports the pairwise correlations of the investment determinant indices and the aggregate investment growth rate with the principal components of the investment determinant indices. The first column shows that the first principal component is strongly correlated with all of the non-technological investment determinant indices, but not with `Tech`. Notice that this factor is also highly correlated with aggregate investment growth, as shown in the last row of the first column, and thus it can be expected that non-technology shocks play a central role in explaining short-run fluctuations of aggregate investment.

In contrast, the aggregate investment determinant indices' second principal component has a positive, strong correlation with `Tech`: 0.76. The correlation with the non-technological investment determinant indices, however, is small. It is also worth mentioning that the pairwise correlation coefficient between the second principal component and the aggregate investment growth rate is small: 0.05. Thus, it can again be expected that technology shocks will only be a secondary source of the business cycle dynamics in capital expenditures.

The third column of Table 3 shows that the third principal component of the investment determinant indices is correlated with most investment determinant indices, but only very weakly with investment growth. In any event, the fraction of total variance explained by the third principal component is small. Altogether the principal component analysis suggests that there are essentially at most two or three underlying economic phenomena captured by the six aggregate investment determinant indices which explain aggregate investment growth. This insight will matter for the interpretation of our empirical results.

3 Empirical Setup

As has been pointed out, Table 1 shows that some aggregate investment determinant indices are mutually correlated. In order to extract economically meaningful shocks from these investment determinant indices, we must first orthogonalize them, using both economically and statistically plausible identification assumptions. Then we can calculate the contribution of these orthogonal shocks to aggregate investment growth.

3.1 Identification

We start by assuming that innovations to `Tech`, which we interpret as technology shocks, are orthogonal to innovations in the non-technological investment determinant indices. The economic content of this assumption is that technology within a year is determined by engineering efforts or engineering luck, which themselves are not the result of anything happening inside the economic or political sphere in that year. We also implicitly assume that the non-technological investment determinants indeed capture the economic and/or political sphere, and that survey respondents make the same distinction. The principal component analysis on the aggregate investment determinant indices from Section 2.4, which results in a clear separation between technological and non-technological investment determinants, is also consistent with this view. These relatively mild assumptions are sufficient to estimate the relative contributions of technological and non-technological shocks to aggregate investment dynamics.

In order to identify orthogonal shocks within the group of non-technological investment determinant indices, one has to make more and stronger assumptions. We start by motivating our baseline orthogonalization scheme.

The analysis in Section 2.4 shows that (i) `Profit` is very highly correlated with `Sales` and does not seem to capture any cost element, (ii) `Macro` captures most likely the general macroeconomic environment and (iii) `Other` appears to be simply a residual category. Therefore we orthogonalize these three investment determinant indices with respect to `Technology`, `Finance`, and `Sales`. To decide about the orthogonalization between `Finance` and `Sales` for our baseline specification, we assume that aggregate demand can change (presumably, drop) immediately when a shock hits financial markets or the financial intermediation sector.[9] Conversely, when there is an autonomous drop in aggregate demand, we assume that this will affect firms' financial situation not within a year. This is consistent with a view of firms' net worth being a slower-moving state variable.[10] Thus, in the baseline specification we orthogonalize `Sales` with respect to `Finance` and interpret the orthogonalized time series as financial shocks and aggregate demand shocks, respectively. As an alternative we also consider a specification where `Finance` is orthogonalized with respect to `Sales`.

Econometrically, the recursive orthogonalization of the aggregate investment determinant indices can be cast into the following regression equations:

$$\texttt{Tech}_t = \nu_1 + \widehat{\texttt{Tech}}_t \tag{3}$$

$$\texttt{Finance}_t = \nu_2 + \delta_{21}\,\widehat{\texttt{Tech}}_t + \widehat{\texttt{Finance}}_t \tag{4}$$

$$\texttt{Sales}_t = \nu_3 + \delta_{31}\,\widehat{\texttt{Tech}}_t + \delta_{32}\,\widehat{\texttt{Finance}}_t + \widehat{\texttt{Sales}}_t \tag{5}$$

$$\texttt{Profit}_t = \nu_4 + \delta_{41}\,\widehat{\texttt{Tech}}_t + \delta_{42}\,\widehat{\texttt{Finance}}_t + \delta_{43}\,\widehat{\texttt{Sales}}_t + \widehat{\texttt{Profit}}_t \tag{6}$$

$$\texttt{Macro}_t = \nu_5 + \delta_{51}\,\widehat{\texttt{Tech}}_t + \delta_{52}\,\widehat{\texttt{Finance}}_t + \delta_{53}\,\widehat{\texttt{Sales}}_t + \delta_{54}\,\widehat{\texttt{Profit}}_t + \widehat{\texttt{Macro}}_t \tag{7}$$

$$\texttt{Other}_t = \nu_6 + \delta_{61}\,\widehat{\texttt{Tech}}_t + \delta_{62}\,\widehat{\texttt{Finance}}_t + \delta_{63}\,\widehat{\texttt{Sales}}_t + \delta_{64}\,\widehat{\texttt{Profit}}_t + \delta_{65}\,\widehat{\texttt{Macro}}_t + \widehat{\texttt{Other}}_t \tag{8}$$

That is, we start by regressing the aggregate investment determinant index `Tech` on a constant. The residual of this regression, $\widehat{\texttt{Tech}}$, is the orthogonal investment determinant index of technology, our measure of technology shocks. Then we regress `Finance` on a constant

[9] Tables 4 and 5 show the coefficient estimates for Equations (3) to (8) for both the baseline orthogonalization and an alternative orthogonalization, respectively. In Table 4 the coefficient on $\widehat{\texttt{Finance}}$ in the equation of `Sales`, δ_{32}, is significantly positive: 1.7497, which means that negative shocks in financial markets or the financial intermediation sector have a negative impact on how survey respondents view the impact of aggregate demand on capital expenditures.

[10] It is worth noting that in a statistical sense we find some evidence that `Finance` Granger-causes `Sales`, but not vice versa. Also, the dynamic correlogram between the two investment determinants shows that `Finance` leads `Sales` in a statistical sense.

and $\widehat{\texttt{Tech}}$ to obtain the component of $\texttt{Finance}$ orthogonal to $\widehat{\texttt{Tech}}$, $\widehat{\texttt{Finance}}$, our measure of financial shocks. Proceeding recursively in this manner gives the mutually orthogonal versions of the investment determinant indices, denoted by hat-variables.

In Figure 8 we check for serial correlation in the orthogonal investment determinant indices. Economically meaningful shocks should not be serially correlated. Indeed, the serial correlation in the orthogonal investment determinant indices is not significant at the 95 percent level.

3.2 Variance Decomposition

In order to estimate the relative contributions of the orthogonalized shocks to aggregate investment growth, we estimate the following equation by ordinary least squares:[11]

$$\Delta I_t^{FSO} = c + \beta_1 \widehat{\texttt{Tech}_t} + \beta_2 \widehat{\texttt{Finance}}_t + \beta_3 \widehat{\texttt{Sales}_t} + \beta_4 \widehat{\texttt{Profit}}_t + \beta_5 \widehat{\texttt{Macro}}_t + \beta_6 \widehat{\texttt{Other}_t} + u_t \quad (9)$$

where ΔI_t^{FSO} denotes aggregate investment growth obtained from the Federal Statistical Office and c is a constant.

While the magnitude of the $\beta-$coefficients has little economic meaning, we can interpret their signs and the statistical significance level at which they are different from zero. Also, we can compute the contribution of the six regressors to the variance of aggregate investment growth. We exploit the fact that the regressors are mutually orthogonal, and therefore the R^2 of this multivariate regression equals the sum of the R^2 in univariate regressions of ΔI_t^{FSO} on each of the orthogonalized aggregate investment determinant indices. Hence, we can compute the contribution to the overall R^2 for every such orthogonalized variable.

[11]Figure 9 shows that the residuals of this regression are serially uncorrelated. Given the small number of observations in the time dimension we therefore prefer a static specification without lags of investment growth.

4 Results

4.1 Aggregate Evidence

The first column of Table 6 shows the results from estimating Equation (9) with ordinary least squares under the baseline orthogonalization (3) - (8). The overall R^2 is 0.82, which means that more than eighty percent of the total variation in aggregate investment growth can be explained by the investment determinants from the Ifo Investment Survey. $\widehat{\texttt{Tech}}$, $\widehat{\texttt{Finance}}$ and $\widehat{\texttt{Sales}}$ affect the aggregate investment growth rate positively, at the 1% significance level. $\widehat{\texttt{Macro}}$ is marginally significant at the 5% significance level and the other non-technological shocks have insignificant coefficients. This suggests already that $\widehat{\texttt{Tech}}$, $\widehat{\texttt{Finance}}$ and $\widehat{\texttt{Sales}}$ explain the bulk of the fluctuations in aggregate investments growth.

Building on the variance decomposition outlined in Section 3.2, Table 7 reports the relative contributions of the orthogonalized aggregate investment determinant indices to the overall R^2 of 0.82. Column 1 of Panel A documents the results for the baseline orthogonalization, which assumes that `Tech` is orthogonal to shocks in the non-technological investment determinant indices. The orthogonalized investment determinant index of technology accounts for a significant fraction, 19.04%, of fluctuations in aggregate investment growth. Without imposing more assumptions on the empirical model, the remainder is explained by the non-technological shocks, $\widehat{\texttt{Non-Tech}}$. Columns 2-6 of Panel A in Table 7 display the relative contribution of $\widehat{\texttt{Tech}}$ to the R^2 as `Tech` moves gradually to the last position in the orthogonalization scheme.[12] The contribution of $\widehat{\texttt{Tech}}$ decreases from roughly 19 percent to approximately 8 percent. This provides upper and lower bounds for the fraction of aggregate investment growth dynamics that can be explained by technology shocks. Given the parsimony of the assumptions required to compute these bounds, we view this as a rather robust result of our approach.

[12]By construction the total R^2 in Equation (9) remains unaltered as different orthogonalization schemes correspond to different linear combinations of the aggregate investment determinant indices but leave the overall informational content of the explanatory variables unchanged. Similarly, if the relative position of an investment determinant index in the orthogonalization scheme stays the same, the contribution to aggregate investment growth of its orthogonalized version is unaffected.

Imposing the additional orthogonalization assumptions amongst the non-technological aggregate investment determinant indices outlined and motivated in Section 3.1, we can determine the relative contributions of these non-technological investment determinants to short-run fluctuations in aggregate investment growth. Column 1 of Panel B in Table 7 reports their relative contribution to the R^2 of Equation (9) in the baseline orthogonalization. Of course the fraction of fluctuations in aggregate investment growth explained by $\widehat{\texttt{Tech}}$ is unaffected when more structure is imposed on the non-technological investment determinants. The bulk of the variation in aggregate investment growth can now be attributed to $\widehat{\texttt{Finance}}$ (financial shocks) and $\widehat{\texttt{Sales}}$ (aggregate demand shocks), which account for 46.48% and 23.10% of the total R^2, respectively. The relative contributions of $\widehat{\texttt{Profit}}$, $\widehat{\texttt{Macro}}$, and $\widehat{\texttt{Other}}$ to the R^2 are small as suggested by their statistically insignificant or only marginally significant coefficient estimates reported in Column 1 of Table 6.

In the second column of Table 6 we report the regression results of Equation (9) for the alternative orthogonalization, when `Finance` is orthogonalized with respect to `Sales`. Obviously, only the coefficient estimates on $\widehat{\texttt{Finance}}$ and $\widehat{\texttt{Sales}}$ change. While the former's statistical significance decreases, the precision of the latter increases. Thus, it can be expected that $\widehat{\texttt{Finance}}$ will now explain a smaller fraction of aggregate investment growth. Table 8 (in Column 2) confirms this conjecture and shows the relative contribution to the R^2 for the alternative orthogonalization between `Finance` and `Sales`. The relative contribution of $\widehat{\texttt{Sales}}$ to the R^2 increases to 61.08%, the relative contribution of $\widehat{\texttt{Finance}}$ decreases to 8.51%. Our results can be viewed as upper and lower bounds for the importance of financial and aggregate demand shocks, respectively. Financial shocks explain aggregate investment growth with a contribution between 9 percent and 46 percent, aggregate demand shocks with a contribution between 23 percent and 61 percent.

A slightly different angle on our results can be gained from computing counterfactual aggregate investment growth rate series, where we subtract from the fitted investment growth rate series from Equation (9) the contribution of one of the orthogonalized investment determinant indices at a time. Figures 10 and 11 do so for the baseline orthogonalization scheme and the alternative orthogonalization scheme, respectively. They also show the actual investment growth rate series from the Federal Statistical Office together with the fitted investment growth rate series from Equation (9). In neither orthogonalization scheme does the elimination of $\widehat{\texttt{Tech}}$ change the fitted investment growth rate drastically. This means that while technology shocks may explain a significant fraction of the overall time series fluctuations of investment growth, they do not appear to be crucial to understand any one particular historical episode in the German investment cycle.

In contrast, leaving out $\widehat{\texttt{Finance}}$, i.e. financial shocks in our interpretation, in the baseline orthogonalization, misses the beginning of the sample and both the decline and the recovery of investment growth in the early 2000s. Moreover, $\widehat{\texttt{Sales}}$, i.e. aggregate demand shocks in our interpretation, were clearly important for the post-reunification recession in the early 1990s. Unsurprisingly, in the alternative orthogonalization it is $\widehat{\texttt{Sales}}$ that determines almost all of the important cyclical downturns and upswings of the aggregate investment growth rate.

Using on the left-hand side of Equation (9) directly the investment growth rate implied by the Ifo Investment Survey, ΔI_t^{IFO}, instead of the investment growth rate from administrative data, ΔI_t^{FSO}, yields similar results. The upper bound estimate for the relative contribution of $\widehat{\texttt{Tech}}$ towards explaining the time series variance of aggregate investment growth is now 15 percent. Financial shocks explain aggregate investment growth with a contribution between 6 percent and 45 percent, aggregate demand shocks with a contribution between 32 percent and 71 percent, depending on the orthogonalization scheme.

Finally, the results reported in this section are robust to transforming the investment data into real terms and using real aggregate investment growth on the left-hand side of Equation (9).[13] We use the deflator of gross fixed capital formation for the manufacturing sector, obtained from German VGR (*Volkswirtschaftliche Gesamtrechnung*) data, to calculate growth

[13]Given that the survey asks about nominal investment expenditures at the firm-level and, presumably, their determinants, we used as a first pass nominal investment expenditures also for the aggregate. It is reassuring, however, that our results are essentially invariant to deflating.

rates of real investment and re-estimate the empirical model. The R^2 of Equation (9) remains about the same at 0.84, and the precision of the coefficient estimates on $\widehat{\texttt{Tech}}$, $\widehat{\texttt{Finance}}$, and $\widehat{\texttt{Sales}}$ improves slightly. While the coefficient on $\widehat{\texttt{Macro}}$ becomes statistically insignificant, the coefficient estimate on $\widehat{\texttt{Profit}}$ becomes marginally significant. Qualitatively as well as quantitatively, however, their relative contributions to the overall R^2 of the regression remain unchanged.

4.2 Semi-Aggregate Evidence

The results reported in the previous section remain robust in semi-aggregate specifications at the two-digit industry level and at the Laender level. Using the weights defined in Section 2.2, we first compute investment determinant indices by two-digit industry and by geographic region. Specifically, we distinguish eight industries:[14] Chemical Industry, Oil; Plastics, Rubber; Glass, Ceramics; Metals; Machinery; Wood, Paper, Printing; Textiles, Leather; Food, Tobacco. In terms of the regional split we use eight out of the eleven West German Laender: Baden-Württemberg, Bavaria, Hamburg, Hesse, Lower Saxony, North Rhine-Westphalia, Rhineland-Palatinate, and Schleswig-Holstein.[15] For each sector and for each Land, we construct the orthogonalized semi-aggregate investment determinant indices by applying the recursive orthogonalization procedure described in Section 3.1. To estimate the relative contribution of each such orthogonal investment determinant index to the corresponding investment growth rate, we fit the industry-level or regional equivalent of Equation (9) with ordinary least squares, separately for each industry/Land. As the industry-level and regional investment growth rates are only available since 1992 from German VGR data, the sample period gets slightly shorter.[16]

[14] The Ifo Investment Survey records the WZ03 and WZ08 industrial classification codes from 2003 and 2008, respectively, used in the German national accounting system. From these we map the firm-level observations into two-digit industries. We drop data for the Energy and Mining sector because the number of observations in the cross-section of this industry is small.

[15] We drop data from Bremen, Saarland and West Berlin because cross-sections from these Laender are small, just as the Laender themselves.

[16] The results are again robust to using the disaggregated investment growth rates from the IFO Investment Survey, and, thus, slightly longer samples.

Figure 12 displays box-plots of the estimates for the relative contributions of orthogonal shocks to the overall R^2 at the two-digit industry level for the baseline orthogonalization. That is, when $\texttt{Sales}_i$ is orthogonalized with respect to $\texttt{Finance}_i$, where the i subscript indicates an industry. The rightmost box-plot depicts the overall R^2 of the nine industry-level regressions. While the explanatory power of the investment determinant indices constructed from the Ifo Investment Survey slightly decreases at the semi-aggregate level, the R^2 still remains above two third in some sectors. The median of the R^2 across all industries is 0.63.

The leftmost box-plot of Figure 12 shows the relative contributions of $\widehat{\texttt{Tech}}_i$ to the industry-level investment growth rates. Although it is well below 10% for some industries, in others $\widehat{\texttt{Tech}}_i$ still accounts for roughly 20% of the short-run fluctuations in capital expenditure growth. For example, its relative contribution to investment growth in the Machinery industry is 21.55%. By and large, these industry-level results confirm the aggregate evidence from Section 4.1 that technology is important for investment fluctuations, but by no means its most important driver.

Indeed, the finding that $\widehat{\texttt{Finance}}$ and $\widehat{\texttt{Sales}}$ explain most of the short-run fluctuations in investment largely carries over to the industry level. The second and third box-plots of Figure 12 display the contributions of $\widehat{\texttt{Finance}}_i$ and $\widehat{\texttt{Sales}}_i$ to the overall R^2. The industry-level median estimates are 33.68% and 27.66%, respectively. The R^2-contributions for the other orthogonal shocks are small: the median relative contributions to the R^2 for $\widehat{\texttt{Profit}}_i$, $\widehat{\texttt{Macro}}_i$, and $\widehat{\texttt{Other}}_i$ are all below 10%. In the alternative specification, when $\texttt{Finance}_i$ is orthogonalized with respect to $\texttt{Sales}_i$, the relative contribution of $\texttt{Finance}_i$ to the R^2 becomes again smaller and the bulk of the variation in investment growth can be attributed to $\texttt{Sales}_i$. Figure 13 shows their median contributions to the R^2 at the two-digit industry level: 3.14% and 56.68%, respectively.

The Laender results for the baseline and the alternative specification are shown in Figure 14 and Figure 15, respectively. The median overall R^2 across all Laender is 0.58. The median relative contribution of $\widehat{\texttt{Tech}}_i$ to regional investment growth is 4.78%, somewhat lower than the estimate for the aggregate. The results for the non-technological regional investment determinant indices are qualitatively and, to a large extent, quantitatively similar to the results for the aggregate and the industry-level. Notice, however, that even in the baseline specification the median estimate for the relative contribution of $\texttt{Sales}_i$ to investment growth is higher than the corresponding estimate for the relative contribution of $\texttt{Finance}_i$.

In sum, the semi-aggregate evidence presented in this subsection lends support to the finding from aggregate data that technology shocks are a significant, but not the major contributor to short-run investment dynamics. Instead, the largest part of investment fluctuations is explained by a combination of financial and demand shocks.

5 Conclusion

This paper uses a novel approach to address a seminal question in macroeconomics: the sources of aggregate fluctuations, here investment fluctuations. We use survey data about subjective investment determinants to uncover what drives the short-run dynamics of investment in the West German manufacturing sector. We find evidence for technology shocks explaining a significant fraction of the fluctutations of aggregate investment growth. However, the larger part must be attributed to non-technological factors. This is the first of our two principal results, which we consider as very robust, partly because of the parsimony of the assumptions needed to obtain it, partly because of a variety of robustness checks.

We also show that in addition to the contribution of technology shocks, there are only one or two major non-technological drivers of short-run investment dynamics, which we interpret as financial and aggregate demand shocks. Whether the bulk of aggregate investment growth is exclusively driven by aggregate demand shocks or also by financial shocks cannot definitively be decided with our approach. But we can bound the range of their importance: financial shocks explain aggregate investment growth with a contribution between 9 percent and 46 percent, aggregate demand shocks with a contribution between 23 percent and 61 percent. This is our second principal result.

References

Alexopoulos, M. (2011): "Read All about It!! What Happens Following a Technology Shock?" *American Economic Review*, 101, 1144–79.

Arellano, C., Y. Bai, and P. J. Kehoe (2012): "Financial Frictions and Fluctuations in Volatility," Federal Reserve Bank of Minneapolis Research Department Staff Report 466.

Bachmann, R., S. Elstner, and E. Sims (2013): "Uncertainty and Economic Activity: Evidence from Business Survey Data," *American Economic Journal: Macroeconomics*, 5, 217–249.

Basu, S., M. S. Kimball, and J. G. Fernald (2006): "Are Technology Improvements Contractionary?" *American Economic Review*, 96, 1418–1448.

Christiano, L., R. Motto, and M. Rostagno (2013): "Risk Shocks," NBER Working Paper 18682.

Christiano, L. J., M. Eichenbaum, and R. Vigfusson (2003): "What Happens After a Technology Shock?" NBER Working Paper 9819.

Chugh, S. K. (2012): "Firm Risk and Leverage-Based Business Cycles," Mimeo, Boston College.

Dorofeenko, V., G. S. Lee, and K. D. Salyer (2008): "Time-Varying Uncertainty And The Credit Channel," *Bulletin of Economic Research*, 60, 375–403.

Fisher, J. D. M. (2006): "The Dynamic Effects of Neutral and Investment-Specific Technology Shocks," *Journal of Political Economy*, 114, 413–451.

Francis, N. and V. A. Ramey (2005): "Is the technology-driven real business cycle hypothesis dead? Shocks and aggregate fluctuations revisited," *Journal of Monetary Economics*, 52, 1379–1399.

Galí, J. (1999): "Technology, Employment, and the Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations?" *American Economic Review*, 89, 249–271.

Gilchrist, S., J. Sim, and E. Zakrajsek (2010): "Uncertainty, Financial Frictions, and Investment Dynamics," Mimeo, Boston University.

Hall, R. E. (1997): "Macroeconomic Fluctuations and the Allocation of Time," *Journal of Labor Economics*, 15, S223–S250.

King, R. G. and S. T. Rebelo (1999): "Resuscitating Real Business Cycles," in *Handbook of Macroeconomics*, ed. by J. B. Taylor and M. Woodford, Elsevier, vol. 1, 927–1007.

Ravn, M. O. and H. Uhlig (2002): "On Adjusting the Hodrick-Prescott Filter for the Frequency of Observations," *The Review of Economics and Statistics*, 84, 371–376.

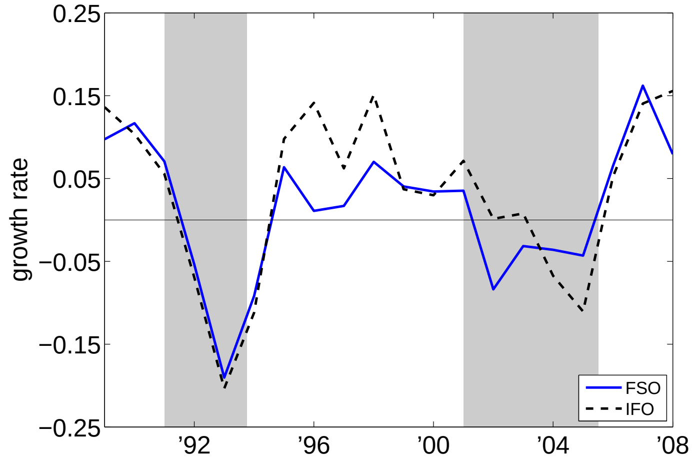
Romer, C. D. and D. H. Romer (2004): "A New Measure of Monetary Shocks: Derivation and Implications," *The American Economic Review*, 94, pp. 1055–1084.

——— (2010): "The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks," *The American Economic Review*, 100, pp. 763–801.

Sachverständigenrat (2009): "Die Zukunft nicht aufs Spiel setzen - Jahresgutachten 2009/10," Sachverständigenrat zur begutachtung der gesamtwirtschaftlichen entwicklung.

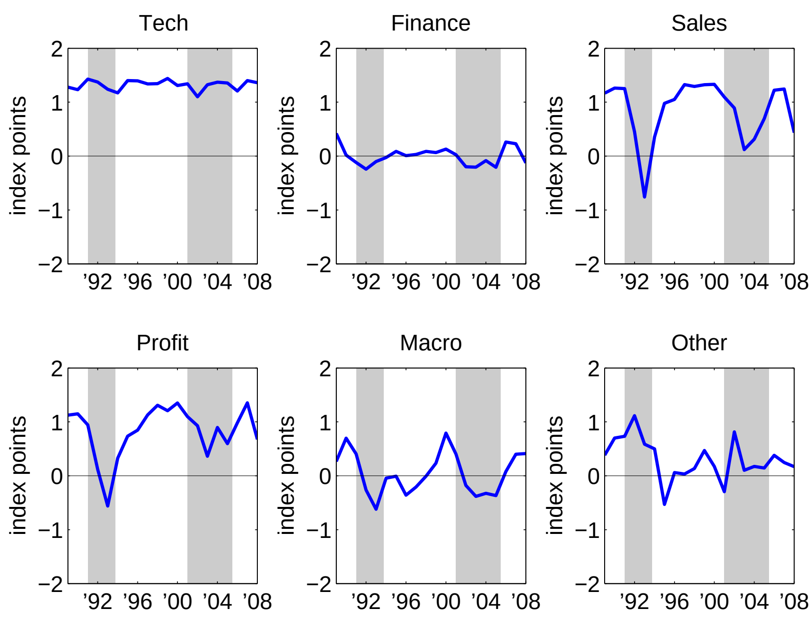
Shea, J. (1999): "What Do Technology Shocks Do?" *NBER Macroeconomics Annual*, 13, 275–322.

Figure 1 – Measures of Aggregate Investment Growth ($\rho = 0.88$)



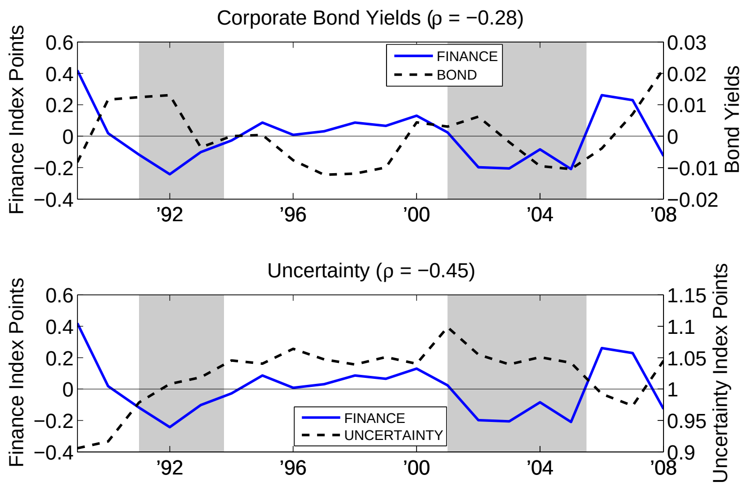
Notes: This figure plots two measures of the aggregate investment growth rate in the West German manufacturing sector. *FSO* is administrative data and obtained from the Federal Statistical Office. *IFO* is the growth rate implied by the Ifo Investment Survey, obtained from aggregating the firm-level responses to **Q1** with weights as described in the text. The correlation coefficient between *FSO* and *IFO*, ρ, is 0.88. The sample period goes from 1989 to 2008. The gray-shaded regions show recessions as dated by the Sachverständigenrat (see Sachverständigenrat, 2009, p. 261): I/1991 - III/1993 and I/2001 - II/2005.

Figure 2 – Aggregate Investment Determinant Indices



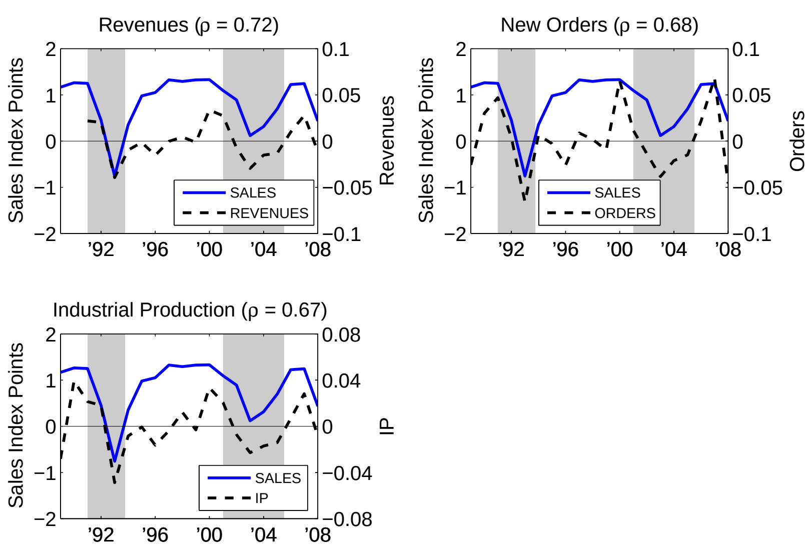
Notes: The panels show the aggregate investment determinant indices `Tech`, `Finance`, `Sales`, `Profit`, `Macro`, and `Other` for the West German manufacturing sector, constructed from aggregating the firm-level responses to **Q2** with weights as described in the text. Index values above zero represent a positive and index values below zero a negative effect on investment activity. The sample period goes from 1989 to 2008. The gray-shaded regions show recessions as dated by the Sachverständigenrat (see Sachverständigenrat, 2009, p. 261): I/1991 - III/1993 and I/2001 - II/2005.

Figure 3 – Investment Determinant Index `Finance` and Covariate Candidates



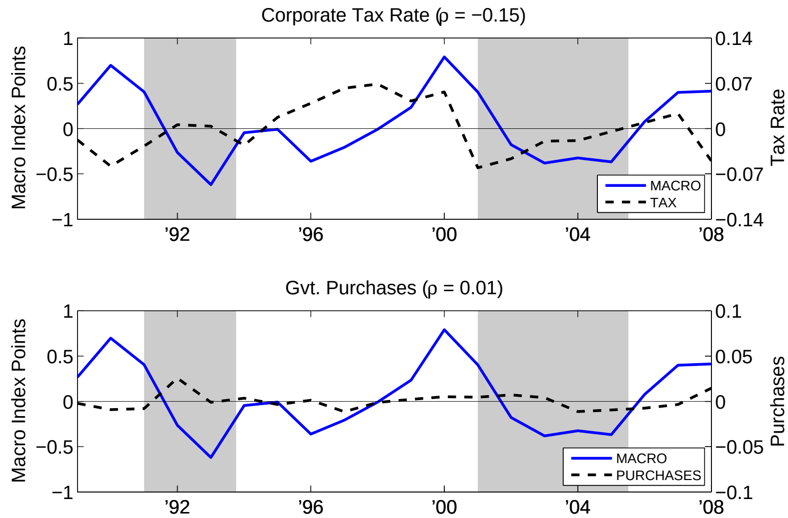
Notes: This figure compares the aggregate investment determinant index `Finance`, based on **Q2**, and two covariate candidates. The top panel plots `Finance` and corporate bond yields. *BOND* is the linearly detrended interest rate on outstanding corporate bonds, obtained from the Bundesbank. The bottom-panel compares `Finance` and a measure of idiosyncratic uncertainty in the West German manufacturing sector. *UNCERTAINTY* is the yearly average of the standard deviation of ex-post forecast errors from Bachmann et al. (2013). The panel titles report the pairwise correlation coefficient between the two time series shown, ρ. The sample period goes from 1989 to 2008. The gray-shaded regions show recessions as dated by the Sachverständigenrat (see Sachverständigenrat, 2009, p. 261): I/1991 - III/1993 and I/2001 - II/2005.

Figure 4 – Investment Determinant Index `Sales` and Covariate Candidates



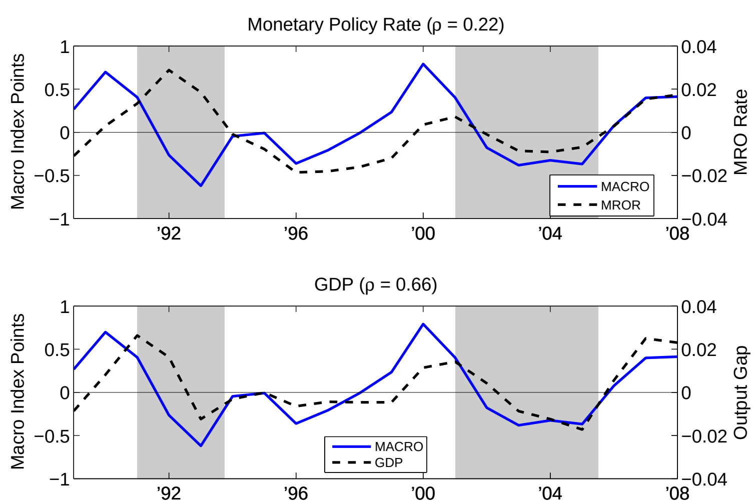
Notes: The top-left panel displays the aggregate investment determinant index `Sales`, based on **Q2**, and revenues. *REVENUES* is the cyclical component of the volume index of revenues in the German manufacturing sector, obtained from the Federal Statistical Office and extracted via the HP-filter ($\lambda = 6.25$) after taking logs. The top-right panel compares `Sales` and new orders. *ORDERS* is the HP-filtered ($\lambda = 6.25$) series of the log of real new orders in the German manufacturing sector, taken from the Federal Statistical Office. The bottom-left panel depicts `Sales` and industrial production. *IP* is the volume index of industrial production in the German manufacturing sector at business cycle frequencies, obtained from the Federal Statistical Office and extracted via the HP-filter ($\lambda = 6.25$) after taking logs. The panel titles report the pairwise correlation coefficient between the two time series shown, ρ. The sample period goes from 1989 to 2008. *REVENUES* is only available since 1991. The gray-shaded regions show recessions as dated by the Sachverständigenrat (see Sachverständigenrat, 2009, p. 261): I/1991 - III/1993 and I/2001 - II/2005.

Figure 5 – Investment Determinant Index `Macro` and Fiscal Policy Covariate Candidates



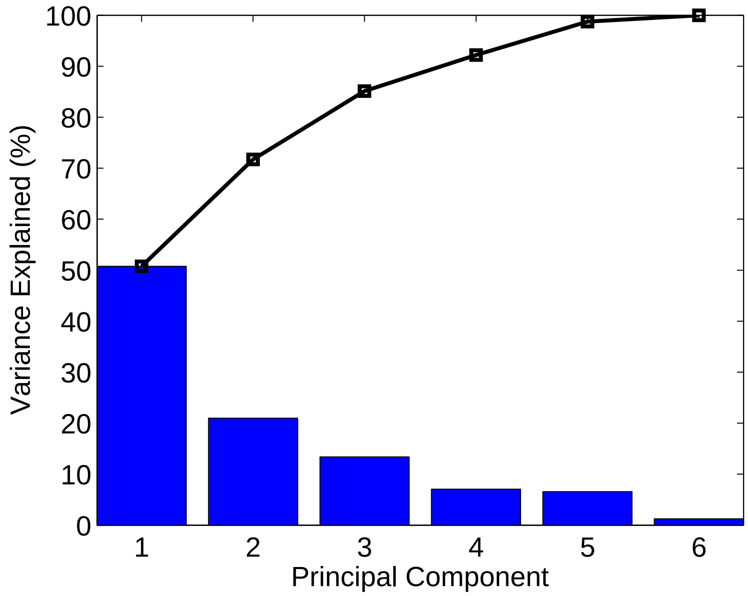
Notes: The top panel compares the aggregate investment determinant index `Macro`, based on **Q2**, and *TAX*, which is the linearly detrended corporate tax rate obtained from the Organization for Economic Co-operation and Development. The lower panel depicts `Macro` and government purchases. *PURCHASES* is the cyclical component of real government purchases (intermediate inputs, wage costs, benefits in kind, and gross investment) from German VGR (*Volkswirtschaftliche Gesamtrechnung*) data and filtered by means of the HP-filter (λ = 6.25) after taking logs. The panel titles report the pairwise correlation coefficient between the two time series shown, ρ. The sample period goes from 1989 to 2008. The gray-shaded regions show recessions as dated by the Sachverständigenrat (see Sachverständigenrat, 2009, p. 261): I/1991 - III/1993 and I/2001 - II/2005.

Figure 6 – Investment Determinant Index `Macro` and Other Covariate Candidates



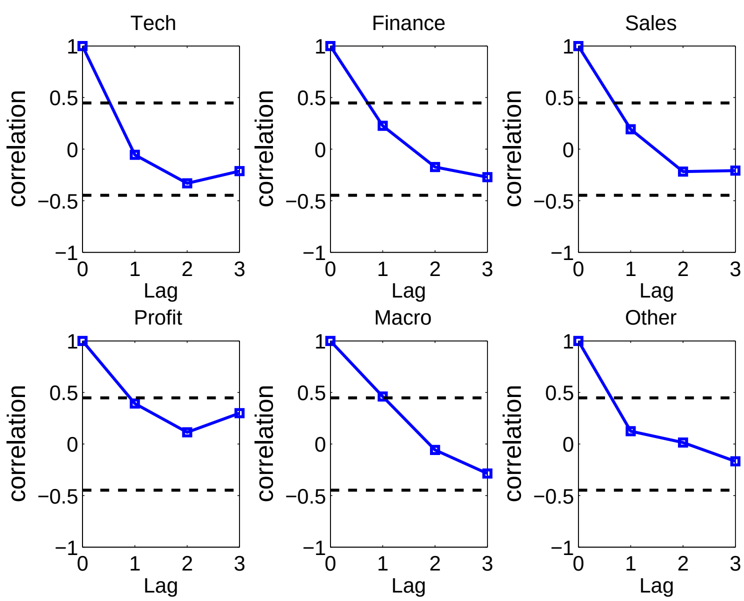
Notes: The top panel compares the aggregate investment determinant index `Macro`, based on **Q2**, and the monetary policy rate. *MROR* (Main Refinancing Operations Rate) is the discount rate set by the Bundesbank until 1998, followed by the main refinancing operations rate set by the European Central Bank since 1999, jointly adjusted for a linear trend. The bottom panel compares `Macro` and the cyclical component of real gross domestic product, taken from German VGR (*Volkswirtschaftliche Gesamtrechnung*) data and extracted via the HP-filter (λ = 6.25) after taking logs. The panel titles report the pairwise correlation coefficient between the two time series shown, ρ. The sample period goes from 1989 to 2008. The gray-shaded regions show recessions as dated by the Sachverständigenrat (see Sachverständigenrat, 2009, p. 261): I/1991 - III/1993 and I/2001 - II/2005.

Figure 7 – Variance Explained by Principal Components of Investment Determinant Indices



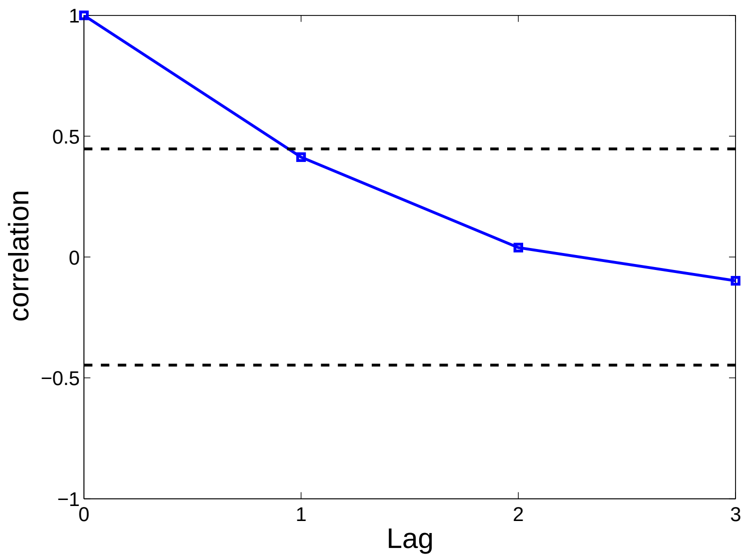
Notes: The bars in this figure display the fraction of total variation explained by each principal component of the aggregate investment determinant indices. The solid black line is the cumulative explained variance.

Figure 8 – Serial Correlation of Orthogonalized Investment Determinants in Baseline Specification



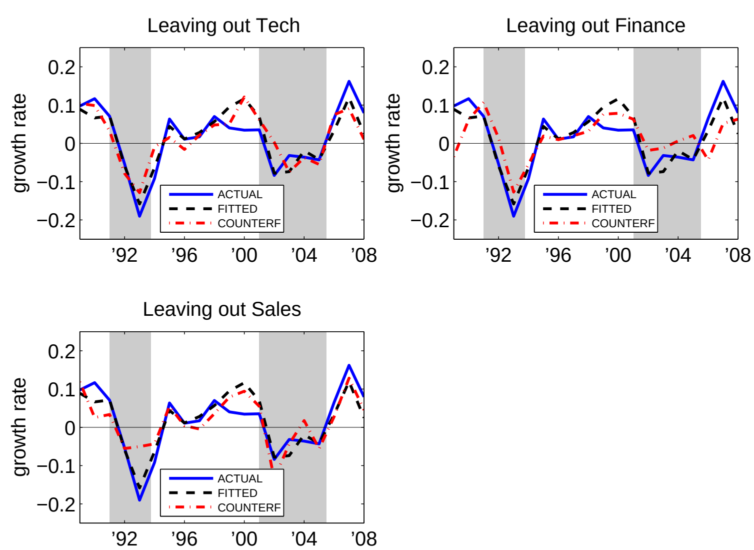
Notes: The panels display the serial correlation, contemporaneous and at three lags, of the orthogonalized aggregate investment determinant indices, $\widehat{\texttt{Tech}}$, $\widehat{\texttt{Finance}}$, $\widehat{\texttt{Sales}}$, $\widehat{\texttt{Profit}}$, $\widehat{\texttt{Macro}}$, and $\widehat{\texttt{Other}}$. The investment determinant indices are based on **Q2** and the orthogonal shocks are recovered as described in the text. The recursive orthogonalization scheme is: `Tech`, `Finance`, `Sales`, `Profit`, `Macro`, `Other`. The dashed lines represent the upper and lower bound of the approximate 95% confidence interval for the correlation coefficient estimate. The sample period goes from 1989 to 2008.

Figure 9 – Serial Correlation of Residuals in the Baseline Specification



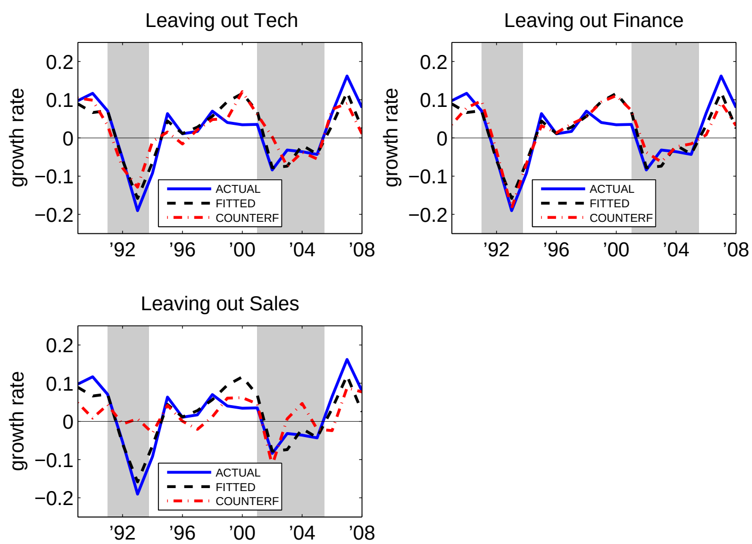
Notes: This figure plots the serial correlation, contemporaneous and at three lags, of the residuals in a regression of aggregate investment growth in the West German manufacturing sector on the orthogonalized aggregate investment determinant indices. The aggregate investment growth rate is obtained from the Federal Statistical Office. The investment determinant indices are based on **Q2** and the orthogonal shocks are recovered as described in the text. The recursive orthogonalization scheme is: `Tech`, `Finance`, `Sales`, `Profit`, `Macro`, `Other`. The dashed lines represent the upper and lower bound of the approximate 95% confidence interval for the correlation coefficient estimate. The sample period goes from 1989 to 2008.

Figure 10 – Fit and Counterfactuals in the Baseline Specification



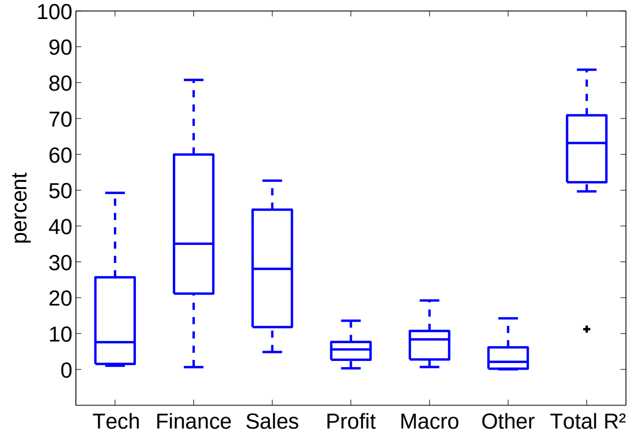
Notes: This figure plots the West German manufacturing investment growth rate obtained from the Federal Statistical Office ($ACTUAL$), the fitted series of the aggregate investment growth rate estimated from Equation (9) ($FITTED$), and, in three different panels, a counterfactual fitted series of the aggregate investment growth rate ($COUNTERF$), where, respectively and separately, the contribution of $\widehat{\texttt{Tech}}$, $\widehat{\texttt{Finance}}$ and $\widehat{\texttt{Sales}}$ to the overall fitted series is eliminated. This figure plots the case of the baseline orthogonalization. The sample period goes from 1989 to 2008. The gray-shaded regions show recessions as dated by the Sachverständigenrat (see Sachverständigenrat, 2009, p. 261): I/1991 - III/1993 and I/2001 - II/2005.

Figure 11 – Fit and Counterfactuals in the Alternative Specification



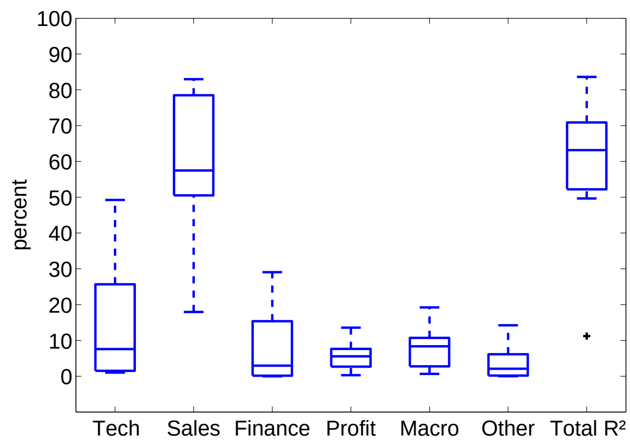
Notes: This figure plots the West German manufacturing investment growth rate obtained from the Federal Statistical Office ($ACTUAL$), the fitted series of the aggregate investment growth rate estimated from Equation (9) ($FITTED$), and, in three different panels, a counterfactual fitted series of the aggregate investment growth rate ($COUNTERF$), where, respectively and separately, the contribution of $\widehat{\texttt{Tech}}$, $\widehat{\texttt{Finance}}$ and $\widehat{\texttt{Sales}}$ to the overall fitted series is eliminated. This figure plots the case of the alternative orthogonalization. The sample period goes from 1989 to 2008. The gray-shaded regions show recessions as dated by the Sachverständigenrat (see Sachverständigenrat, 2009, p. 261): I/1991 - III/1993 and I/2001 - II/2005.

Figure 12 – Relative Contributions of Orthogonalized Shocks to the R^2 in the Baseline Specification at the Two-Digit Industry Level



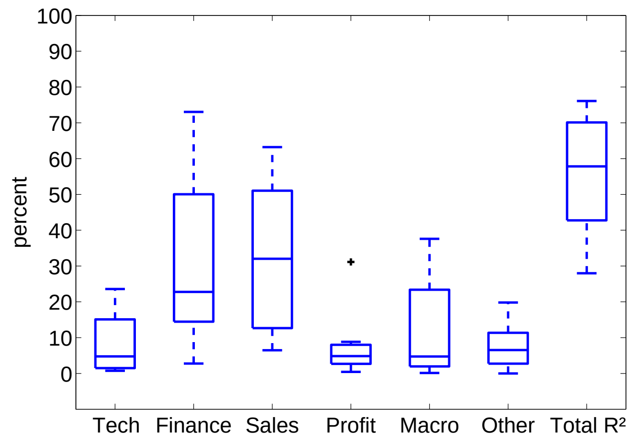
Notes: This figure depicts the box-plots of estimates for the relative contributions of shocks to investment fluctuations at the two-digit manufacturing industry level. The estimates are obtained from a decomposition of the R^2 in regressions of investment growth on the orthogonalized sector-specific investment determinant indices, $\widehat{\texttt{Tech}}_i$, $\widehat{\texttt{Finance}}_i$, $\widehat{\texttt{Sales}}_i$, $\widehat{\texttt{Profit}}_i$, $\widehat{\texttt{Macro}}_i$, and $\widehat{\texttt{Other}}_i$, estimated for eight two-digit industries. The sample period goes from 1992 to 2008. The industry-specific investment growth rates and investment determinant indices are based on German VGR (*Volkswirtschaftliche Gesamtrechnung*) data and **Q2**, respectively. The orthogonal shocks are recovered and the variance decomposition is calculated as described in the text. The recursive orthogonalization scheme is: $\texttt{Tech}_i$, $\texttt{Finance}_i$, $\texttt{Sales}_i$, $\texttt{Profit}_i$, $\texttt{Macro}_i$, $\texttt{Other}_i$. The first six box-plots show the industry-specific relative contributions of orthogonal shocks to the R^2. The final box-plot displays the overall R^2. The ends of the whiskers represent the lowest and highest estimates from the lowest and highest quartile, respectively, within 1.5 times the interquartile range. Outliers are plotted as '+'.

Figure 13 – Relative Contributions of Orthogonalized Shocks to the R^2 in the Alternative Specification at the Two-Digit Industry Industry Level



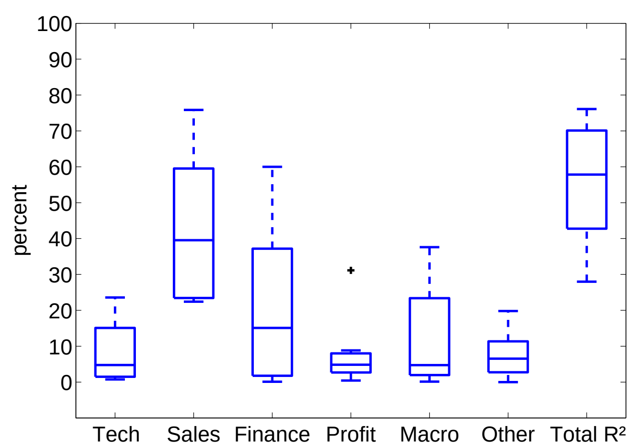
Notes: This figure depicts the box-plots of estimates for the relative contributions of shocks to investment fluctuations at the two-digit manufacturing industry level. The estimates are obtained from a decomposition of the R^2 in regressions of investment growth on the orthogonalized sector-specific investment determinant indices, $\widehat{\texttt{Tech}}_i$, $\widehat{\texttt{Sales}}_i$, $\widehat{\texttt{Finance}}_i$, $\widehat{\texttt{Profit}}_i$, $\widehat{\texttt{Macro}}_i$, and $\widehat{\texttt{Other}}_i$, estimated for eight two-digit industries. The sample period goes from 1992 to 2008. The industry-specific investment growth rates and investment determinant indices are based on German VGR (*Volkswirtschaftliche Gesamtrechnung*) data and **Q2**, respectively. The orthogonal shocks are recovered and the variance decomposition is calculated as described in the text. The recursive orthogonalization scheme is: $\texttt{Tech}_i$, $\texttt{Sales}_i$, $\texttt{Finance}_i$, $\texttt{Profit}_i$, $\texttt{Macro}_i$, $\texttt{Other}_i$. The first six box-plots show the industry-specific relative contributions of orthogonal shocks to the R^2. The final box-plot displays the overall R^2. The ends of the whiskers represent the lowest and highest estimates from the lowest and highest quartile, respectively, within 1.5 times the interquartile range. Outliers are plotted as '+'.

Figure 14 – Relative Contributions of Orthogonalized Shocks to the R^2 in the Baseline Specification at the Laender Level



Notes: This figure depicts the box-plots of estimates for the relative contributions of shocks to manufacturing investment fluctuations at the Laender level. The estimates are obtained from a decomposition of the R^2 in regressions of investment growth on the orthogonalized Laender-specific investment determinant indices, $\widehat{\texttt{Tech}}_i$, $\widehat{\texttt{Finance}}_i$, $\widehat{\texttt{Sales}}_i$, $\widehat{\texttt{Profit}}_i$, $\widehat{\texttt{Macro}}_i$, and $\widehat{\texttt{Other}}_i$, estimated for eight West German Laender. The sample period goes from 1992 to 2008. The Laender-specific investment growth rates and investment determinant indices are based on German VGR (*Volkswirtschaftliche Gesamtrechnung*) data and **Q2**, respectively. The orthogonal shocks are recovered and the variance decomposition is calculated as described in the text. The recursive orthogonalization scheme is: $\texttt{Tech}_i$, $\texttt{Finance}_i$, $\texttt{Sales}_i$, $\texttt{Profit}_i$, $\texttt{Macro}_i$, $\texttt{Other}_i$. The first six box-plots show the Laender-specific relative contributions of orthogonal shocks to the R^2. The final box-plot displays the overall R^2. The ends of the whiskers represent the lowest and highest estimates from the lowest and highest quartile, respectively, within 1.5 times the interquartile range. Outliers are plotted as '+'.

Figure 15 – Relative Contributions of Orthogonalized Shocks to the R^2 in the Alternative Specification at the Laender Level



Notes: This figure depicts the box-plots of estimates for the relative contributions of shocks to manufacturing investment fluctuations at the Laender level. The estimates are obtained from a decomposition of the R^2 in regressions of investment growth on the orthogonalized Laender-specific investment determinant indices, $\widehat{\texttt{Tech}}_i$, $\widehat{\texttt{Sales}}_i$, $\widehat{\texttt{Finance}}_i$, $\widehat{\texttt{Profit}}_i$, $\widehat{\texttt{Macro}}_i$, and $\widehat{\texttt{Other}}_i$, estimated for eight West German Laender. The sample period goes from 1992 to 2008. The Laender-specific investment growth rates and investment determinant indices are based on German VGR (*Volkswirtschaftliche Gesamtrechnung*) data and **Q2**, respectively. The orthogonal shocks are recovered and the variance decomposition is calculated as described in the text. The recursive orthogonalization scheme is: $\texttt{Tech}_i$, $\texttt{Sales}_i$, $\texttt{Finance}_i$, $\texttt{Profit}_i$, $\texttt{Macro}_i$, $\texttt{Other}_i$. The first six box-plots show the Laender-specific relative contributions of orthogonal shocks to the R^2. The final box-plot displays the overall R^2. The ends of the whiskers represent the lowest and highest estimates from the lowest and highest quartile, respectively, within 1.5 times the interquartile range. Outliers are plotted as '+'.

Table 1 – Pairwise Correlations with the Aggregate Investment Determinant Indices

	`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

Notes: Panel A reports the pairwise correlation coefficients between the aggregate investment determinant indices, obtained from aggregating the firm-level responses to **Q2** with weights as described in the text. Panel B shows the pairwise correlations of the aggregate investment determinant indices with the aggregate investment growth rate in the West German manufacturing sector, ΔI_t^{FSO}, obtained from the Federal Statistical Office. Significance at the 1%, 5%, and 10% level is indicated by ***, **, and * , respectively.

Table 2 – Mean of `Tech` Conditional on Investment in Restructuring and Rationalization

Tercile	Mean(`Tech`)
1	1.1869
2	1.4625
3	1.4957

Notes: This table displays the conditional mean of the investment determinant index `Tech`, which is based on **Q2**. The mean uses the weights as described in the text and is conditional on the terciles of a proxy for that fraction of investment undertaken mainly for reasons of technological development. The proxy variable is the sum of the shares of restructuring and rationalization investment, extracted from the Ifo Investment Survey.

Table 3 – 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

Notes: This table shows the pairwise correlations of the aggregate investment determinant indices and the aggregate investment growth in the West German manufacturing sector with the first three principal components of the aggregate investment determinant indices. The aggregate investment growth rate is obtained from the Federal Statistical Office. The investment determinant indices are based on **Q2**. The principal components follow the sign convention that the loading which is largest in modulus has a positive sign. Significance at the 1%, 5%, and 10% level is indicated by ***, **, and * , respectively.

Table 4 – Estimation Results for Equations (3) to (8) in the Baseline Specification

Dependent Variable	Tech	Finance	Sales	Profit	Macro	Other
Constant	1.3205	0.0023	0.8516	0.8286	0.0460	0.3042
	(65.9748)	(0.0577)	(8.1422)	(18.0448)	(0.6324)	(3.6841)
$\widehat{\texttt{Tech}}$		-0.0028	1.3442	1.0827	0.3800	-1.4952
		(-0.0062)	(1.1213)	(2.0571)	(0.4560)	(-1.5798)
$\widehat{\texttt{Finance}}$			1.7497	1.5598	1.0534	-0.6212
			(2.8179)	(5.7215)	(2.4402)	(-1.2671)
$\widehat{\texttt{Sales}}$				0.7482	0.3937	0.0643
				(7.0262)	(2.3351)	(0.3358)
$\widehat{\texttt{Profit}}$					0.3719	-0.4900
					(0.9395)	(-1.0900)
$\widehat{\texttt{Macro}}$						0.2640
						(0.9003)

Notes: This table shows the coefficient estimates in the recursive orthogonalization of the aggregate investment determinant indices for the baseline specification between `Finance` and `Sales`, see Equations (3)-(8). The sample period goes from 1989 to 2008. The aggregate investment determinant indices are based on **Q2**. The recursive orthogonalization scheme is: `Tech`, `Finance`, `Sales`, `Profit`, `Macro`, and `Other`. t-statistics in parentheses.

Table 5 – Estimation Results for Equations (3) to (8) in the Alternative Specification

Dependent Variable	`Tech`	`Sales`	`Finance`	`Profit`	`Macro`	`Other`
Constant	1.3205	0.8516	0.0023	0.8286	0.0460	0.3042
	(65.9748)	(6.9171)	(0.0679)	(18.0448)	(0.6324)	(3.6841)
$\widehat{\texttt{Tech}}$		1.3442	-0.0028	1.0827	0.3800	-1.4952
		(0.9526)	(-0.0073)	(2.0571)	(0.4560)	(-1.5798)
$\widehat{\texttt{Sales}}$			0.1820	0.7938	0.4600	-0.0692
			(2.8179)	(9.0292)	(3.3048)	(-0.4377)
$\widehat{\texttt{Finance}}$				0.2507	0.3645	-0.7337
				(0.7592)	(0.6971)	(-1.2356)
$\widehat{\texttt{Profit}}$					0.3719	-0.4900
					(0.9395)	(-1.0900)
$\widehat{\texttt{Macro}}$						0.2640
						(0.9003)

Notes: This table shows the coefficient estimates in the recursive orthogonalization of the aggregate investment determinant indices for the alternative specification between `Finance` and `Sales`. The recursive orthogonalization scheme is: `Tech`, `Sales`, `Finance`, `Profit`, `Macro`, and `Other`. See the notes to Table 4 for further information.

Table 6 – Regression Results for the Baseline and the Alternative Specification

Dependent Variable	ΔI_t^{FSO}	

Orthogonalization:	`Tech`
	`Finance`
	`Sales`
	`Profit`
	`Macro`
	`Other`
		`Tech`
		`Sales`
		`Finance`
		`Profit`
		`Macro`
		`Other`

$\widehat{\texttt{Tech}}$	0.3669	0.3669
	(3.3382)	(3.3382)
$\widehat{\texttt{Finance}}$	0.2969	0.1538
	(5.2158)	(2.2312)
$\widehat{\texttt{Sales}}$	0.0818	0.1098
	(3.6773)	(5.9790)
$\widehat{\texttt{Profit}}$	0.0662	0.0662
	(1.2679)	(1.2679)
$\widehat{\texttt{Macro}}$	0.0765	0.0765
	(2.2457)	(2.2457)
$\widehat{\texttt{Other}}$	-0.0023	-0.0023
	(-0.0754)	(-0.0754)
Constant	0.0166	0.0166
	(1.7355)	(1.7355)
N	20	20
R^2	0.8183	0.8183

Notes: The table documents the results of regressing the aggregate investment growth rate in the West German manufacturing sector on the orthogonalized aggregate investment determinant indices for the baseline and the alternative orthogonalization between `Finance` and `Sales`. The sample period goes from 1989 to 2008. The aggregate investment growth rate is obtained from the Federal Statistical Office and the investment determinant indices are based on **Q2**. The orthogonal shocks are recovered as described in the text. The recursive orthogonalization scheme is shown above each column. t-statistics in parentheses.

Table 7 – Relative Contributions to the R^2 (in percent) with Different Orthogonalizations of `Tech`

Orthogonalization:	`Tech`
	`Finance`
	`Sales`
	`Profit`
	`Macro`
	`Other`
		`Finance`
		`Tech`
		`Sales`
		`Profit`
		`Macro`
		`Other`
			`Finance`
			`Sales`
			`Tech`
			`Profit`
			`Macro`
			`Other`
				`Finance`
				`Sales`
				`Profit`
				`Tech`
				`Macro`
				`Other`
					`Finance`
					`Sales`
					`Profit`
					`Macro`
					`Tech`
					`Other`
						`Finance`
						`Sales`
						`Profit`
						`Macro`
						`Other`
						`Tech`

Panel A:						
$\widehat{\texttt{Tech}}$	19.04	19.13	8.72	8.37	9.26	7.74
$\widehat{\texttt{Non-Tech}}$	80.96	80.87	91.28	91.63	90.74	92.26
Panel B:						
$\widehat{\texttt{Finance}}$	46.48	46.39	46.39	46.39	46.39	46.39
$\widehat{\texttt{Sales}}$	23.10	23.10	33.51	33.51	33.51	33.51
$\widehat{\texttt{Profit}}$	2.75	2.75	2.75	3.10	3.10	3.10
$\widehat{\texttt{Macro}}$	8.62	8.62	8.62	8.62	7.72	7.72
$\widehat{\texttt{Other}}$	0.01	0.01	0.01	0.01	0.01	1.54
R^2	0.8183					

Notes: This table reports the relative contributions of the orthogonalized aggregate investment determinant indices to aggregate investment growth in the West German manufacturing sector. The estimates are obtained from a decomposition of the R^2 in a regression of investment growth on the orthogonalized investment determinant indices. The sample period goes from 1989 to 2008. The aggregate investment growth rate is obtained from the Federal Statistical Office. The investment determinant indices are based on **Q2**. *Panel A* assumes that `Tech` is orthogonal to shocks in the non-technological investment determinant indices. The recursive orthogonalization scheme is shown above each column.

Table 8 – Relative Contribution to the R^2 (in percent)

Orthogonalization:	`Tech`
	`Finance`
	`Sales`
	`Profit`
	`Macro`
	`Other`
		`Tech`
		`Sales`
		`Finance`
		`Profit`
		`Macro`
		`Other`

$\widehat{\texttt{Tech}}$	19.04	19.04
$\widehat{\texttt{Finance}}$	46.48	8.51
$\widehat{\texttt{Sales}}$	23.10	61.08
$\widehat{\texttt{Profit}}$	2.75	
$\widehat{\texttt{Macro}}$	8.62	
$\widehat{\texttt{Other}}$	0.01	
R^2	0.8183	

Notes: This table reports the relative contributions of the orthogonalized aggregate investment determinant indices to aggregate investment growth in the West German manufacturing sector for the baseline and the alternative orthogonalization between `Finance` and `Sales`. See the notes to Table 7 for further information.

Appendix: Survey Guidelines

The Ifo Investment Survey gives the following guidelines on the firm-level investment determinants to complete **Q2** of the survey questionnaire:

Sales Situation and Expectation To be considered are aspects like the degree of capacity utilization, the expected range of price movements and changes in sales figures, and an assessment of the uncertainty surrounding these expectations.

Finance This counts factors like disposable financial resources, borrowing costs, and interest rate expectations.

Profit Expectation To be considered are factors like the return on investment and the relative attractiveness of fixed assets and financial assets.

Technical Factors This comprises all incentives to invest which come from technical development.

Macro Policy Environment To be considered are aspects such as an assessment of the effects of economic policy, the tax regulations applying to investment, as well as the possibility to outsource production abroad.