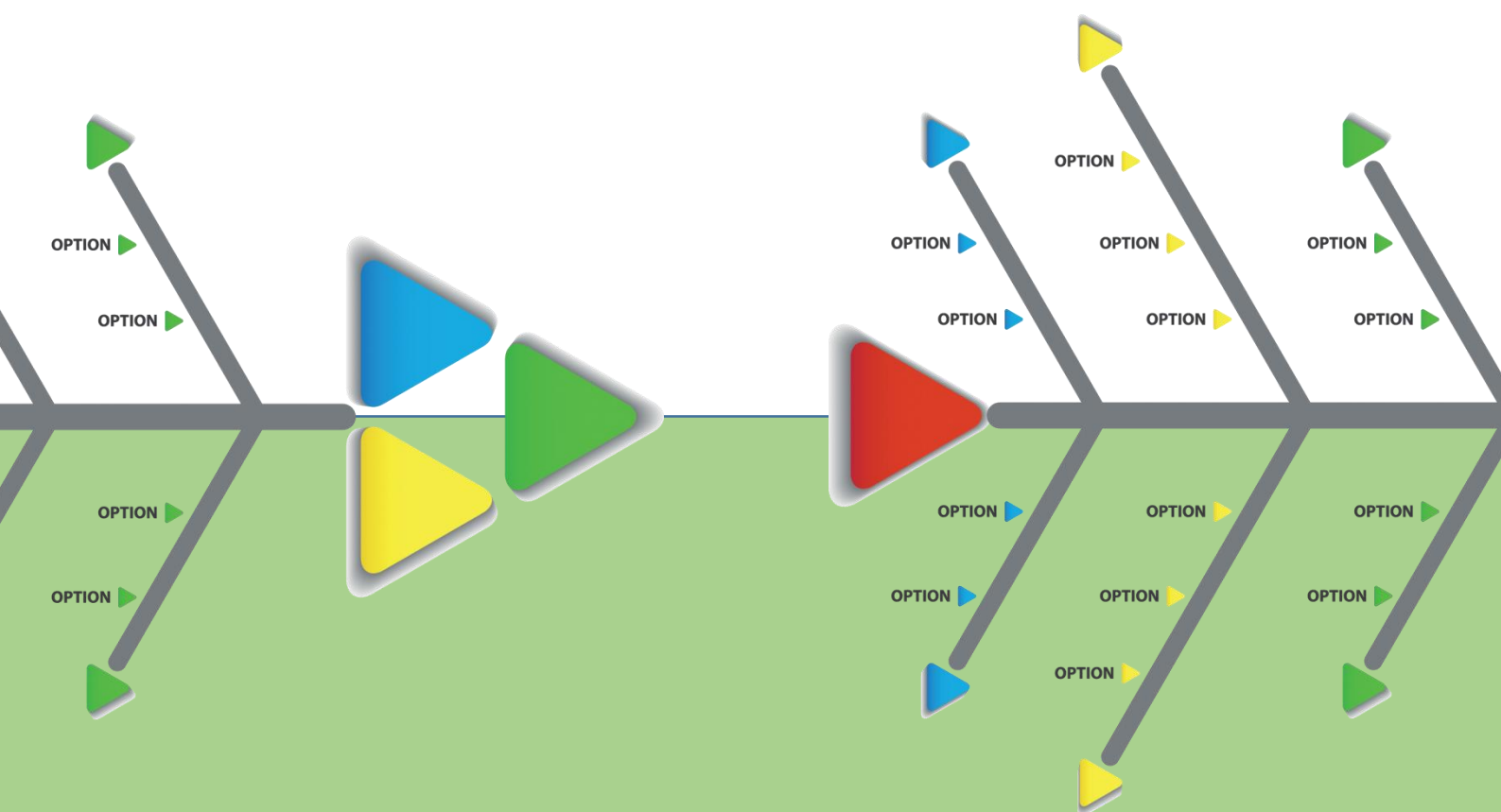


## JRC POLICY BRIEF

# Disentangling the processes of firm growth and R&D investment



# Disentangling the processes of firm growth and R&D investment

## Headlines

Sales growth kick-starts the growth process, having large effects on subsequent growth of capital expenditures, R&D investment, employment and operating profits.

Policy interventions designed to boost business R&D investment should seek to remove the obstacles to firm growth, because it is sales growth that drives R&D investment.

If Europe is to have 'smart growth' whereby firm growth occurs alongside investments in R&D and innovation, there is a key role of demand.

## 1. Causal relations and policy<sup>1</sup>

To boost its global innovation performance, Europe needs growing firms that invest in R&D.

Understanding the determinants of R&D investment decisions is notoriously tricky, both for econometricians, R&D managers and policy makers. Jack Goldman, a former vice-president for research at Xerox admits that even putting a number on R&D investment is "precisely what most of us who are committed to industrial basic research find most difficult to do."

Policy interventions cannot be based on mere statistical associations or

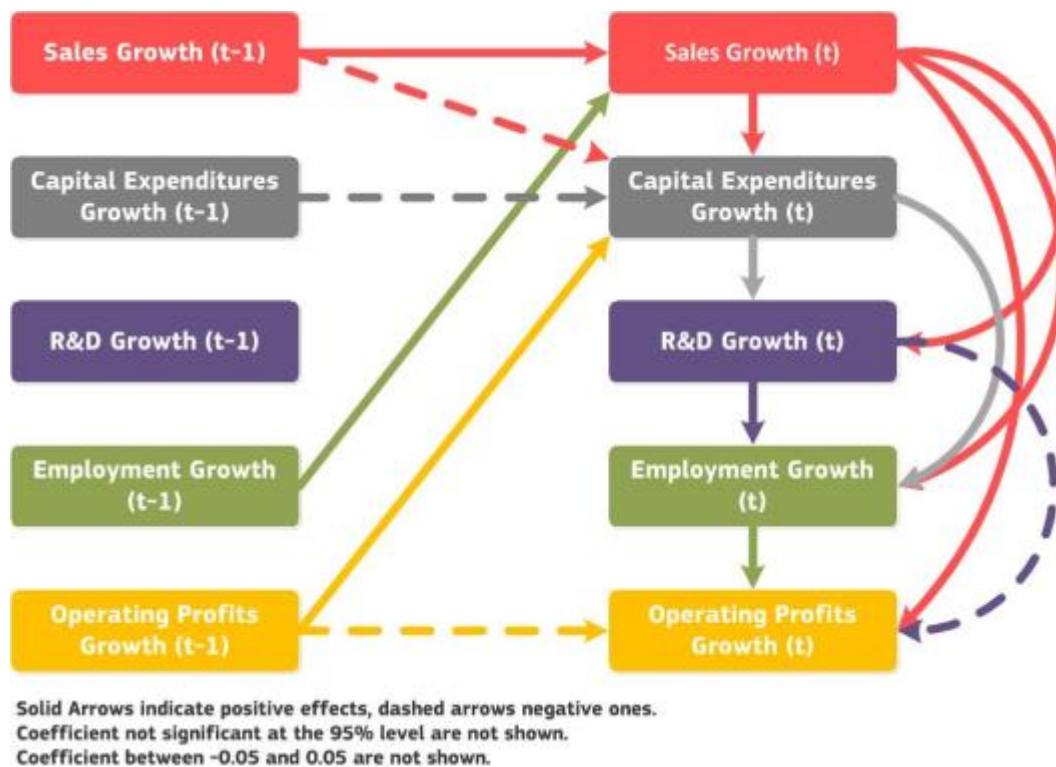
partial correlations between variables, but require an understanding of the causal relations underlying the system (Pearl, 2009).

Research into R&D investment and industrial dynamics generally produces estimates of associations rather than causal effects, because it is difficult to set up laboratory experiments involving firms, and some designs for obtaining causal estimates from observational data (e.g. instrumental variables, regression discontinuity design) are difficult to apply to data on industrial dynamics.

Getting a grasp on the causal relations between these variables will allow us to have a targeted intervention on one variable that will propagate throughout the growing firm to have the intended effects on the outcome variable of choice (in our case, R&D investments).

Recent research at the JRC has tried to disentangle the causal relations between companies' R&D investments, sales, capital expenditures, employment growth and profits. Results indicate that sales growth is the kick-starter of the growth process, having large effects on subsequent growth of capital expenditures, R&D investment, employment and operating profits. Sales growth emerges as the key stimulus for R&D investment. This is consistent with the hypothesis that firms invest in R&D as a fixed proportion of sales. Instead the growth of operating profits seems to have little effect on subsequent R&D investment.

<sup>1</sup> The document is based on the JRC Technical Report: "Who's doing who? Growth of sales, employment, assets, profits and R&D entangled in a curious five-way love triangle", Coad A. and Grassano N., JRC98745.



## 2. Results and policy implications

The figure above provides an overview of the results of our analysis.

Sales growth is the *primis motor* of the growth process. Increases in sales lead to increases in R&D budgets. In this way, growing firms behave as if they seek to maintain a roughly constant R&D / sales ratio as they grow. Firms may stick to a certain R&D / Sales ratio as a rule of thumb in the face of fundamental uncertainty about what the optimal level of R&D is (Thompson, 1999).

Firms may benchmark themselves against rivals in terms of mimicking their R&D / sales ratios. Alternatively, it could be that there is pressure from sector-level investors to ensure that firms in the same sector have similar R&D intensities (defined as R&D / Sales ratios).

Sales growth has large positive effects on R&D investment and on the other variables – growth of employment, capital expenditures, and profits – if we consider growth in the same year. Also, it has large positive lagged effects on capital expenditure and sales growth. Policy interventions

### Box 1: Methodology and data

We apply a new technique, imported from the Machine Learning community (Computer Science), in order to gain new insights into the co-evolution of key variables in the growth process of innovative firms, and in particular to estimate the causal relations between these variables.

The data used in the analysis come from the 2014 edition of the EU Industrial R&D Investment Scoreboard. We build an unbalanced panel dataset of 2871 firms, pulling together all the firms included in the world top 2500 R&D investors and the extra firms included in the EU top 1000 R&D investors list.

We computed the yearly growth rates for the variables of interest by taking log-differences. Variables are pre-processed to remove the possible confounding effects of control variables, such as age, firm size, and sector.

To recover the causal relationships between the 5 main variables, we used the VAR-LINGAM method. Causal inference is data-driven rather than relying on theoretical priors.

designed to boost R&D investment should therefore seek to remove the obstacles to firm growth, because it is sales growth that drives R&D investment.

Capital Expenditures<sup>2</sup> are observed to boost R&D – they provide new opportunities for R&D as the firm invests and scales up by spending on new capital goods and investments.

<sup>2</sup> Capital expenditure is defined as the «expenditure used by a company to acquire or upgrade physical assets such as equipment, property, industrial buildings. In accounts capital expenditure is added to an asset account (i.e. capitalised), thus increasing the asset's base. It is disclosed in accounts as additions to tangible fixed assets.»(European Commission, 2014, pg.88)

Growth of capital expenditures also creates jobs, because new machines are installed in conjunction with the hiring of new employees. These effects are observed within-the-period, although growth of capital expenditures has no major effect on any other variable when considering lagged effects.

New R&D investments have an instantaneous effect on job creation as new employees are hired to fill R&D positions. However, there is an additional effect, because R&D expenditures reveal new market opportunities that are exploited by expanding the workforce. World Bank research has shown that innovative firms grow by hiring many non-skilled employees too (Dutz et al., 2011), as firms build on innovative new opportunities that have repercussions on other firm departments, affecting firm growth more generally.

It may come as a surprise to some that the growth of profits does not appear to be a major driver of R&D investment. Our results show no direct instantaneous effect of profits growth on R&D expenditures. There is a lagged effect, but it is relatively small in magnitude and only on capital expenditure and operating profit of the following time period.

*In sum, the empirical evidence that either liquidity or profitability are conducive to innovative effort appears slim.*

Kamien and Schwartz  
(1975, page 26)

*Since Schumpeter, economists have argued that internal finance should be an important determinant of R&D expenditures ... almost without exception; previous empirical studies have not found evidence of such a relationship.*

Himmelberg and Petersen  
(1994, page 38).

## Box 2: R&D as a fixed percentage of sales

«You have a product. The product is selling. That gives you a certain stream of revenue. You can take that stream of revenue and put some of it into R&D for the next round. Some of it has to be reserved for manufacturing, some of it for profits.

Now, if you are on an upward swing and your product is succeeding, you have a flow back of money to invest in R&D; and if it isn't, you don't. And in my experience, and the experience of many other people, oddly enough, R&D is determined, more or less, as a percent of sales. It is not an independent variable. Let me say once more. R&D is often a fixed percent of sales. Now I exaggerate to make my point. Ten percent is a very reasonable sort of number in a high-tech industry... It may be that, in the correlation, which has often been remarked on, between R&D spending and industrial success, it is the industrial success which causes the R&D spending, not the other way around.»

Ralph Gomory, former senior vice-president of IBM and former member of the US President's Council of Advisers on Science and Technology. Gomory (1992, p392), cited in Thompson (1999 p323), emphasis added.)

Our results call for a nuanced interpretation of the traditional Schumpeterian perspective that emphasizes that it is oligopolies of large and profitable firms that are the drivers of industrial innovation. It is the 'large' nature of these oligopolistic firms, rather than their 'profitable' nature, that seems to be driving their R&D investment. Instead of being reinvested in R&D, profits are probably siphoned off and distributed to investors.

The finding that profits has little impact on R&D investment is what we would expect if the new technological opportunities currently available are unrelated to how profitably a firm has exploited past opportunities.

## Conclusions

Our analysis has highlighted the key role of sales growth, rather than profits growth, in stimulating R&D growth. Investment in R&D is not driven by rational calculation, but the

'animal spirits' of innovation, perhaps tinted with over-optimism, or perhaps restrained by conservative risk-aversion, whereby industrialists put aside their elaborate forecasts and use their gut feelings, and their need for achievement, to channel large amount of funds into new R&D projects.

If Europe is to have 'smart growth' whereby firm growth occurs alongside investments in R&D and innovation, there is a key role of demand (see also Stiglitz, 2015 on the key role of demand).

One possible channel to boost sales growth (and hence R&D growth and employment growth) is to encourage firms to boost their sales through increased exporting activity. Another possible channel is through the use of procurement policy to generate sales for innovative firms with growth ambitions (e.g. Rolfstam, 2013). Also improving framework conditions, for example by reducing the level of product market regulations (e.g. Ciriaci et al., 2016), can act as a trigger for sales growth

Note however there is heterogeneity across firms. Not all firms grow in the same way. Some might have different growth processes. Nevertheless, our robustness analysis shows that in the vast majority of cases, sales growth comes first.

Another final consideration is that there may be heterogeneity across sectors (e.g. do pharmaceutical firms grow in the same way as automobiles?). We have not investigated this in depth, because to focus on individual sectors would mean having a reduced number of observations in our dataset.

We leave for future research these investigations of how heterogeneities in subsamples and possible exceptional cases may belie the broader

relationships observed at the aggregate level.

### Box 3: Case study - Patent box as a misguided policy

It is not necessary to guarantee high profits to firms as a prerequisite for investment in innovation. A recent JRC evaluation of the 'Patent Box' innovation policy (Alstadsæter et al., 2015) has shown that it was ineffective in stimulating innovation (although it is often seen as if it was only a policy for tax competition rather than stimulating innovation (Griffith et al., 2010)). To the extent that patent box was genuinely formulated as a policy to stimulate subsequent innovation, the causal arguments in favour of patent box were: firms innovate → firms file patents → the tax regime increases profits from patents → these profits are reinvested into innovation.

However, our results cast doubt on the link between higher profits and subsequent reinvestment into innovation (R&D). Instead, profits occur at the end of the growth process and are not reinvested to any great extent. To paraphrase the evolutionary economist Giovanni Dosi, it would be better to consider that the profits of innovative firms are spent on champagne and caviar rather than being reinvested into risky long-term innovation projects.

Our results show that it is primarily sales growth that drives investment in R&D. Policies that aim to boost R&D investment by firms would be better off in targeting how firms can first increase their sales volume.

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