DIW Weekly Report

A policy bulletin from the German Institute for Economic Research

31 2019

Economy. Politics. Science.

DIW BERLIN

247 Report by Heike Belitz and Martin Gornig

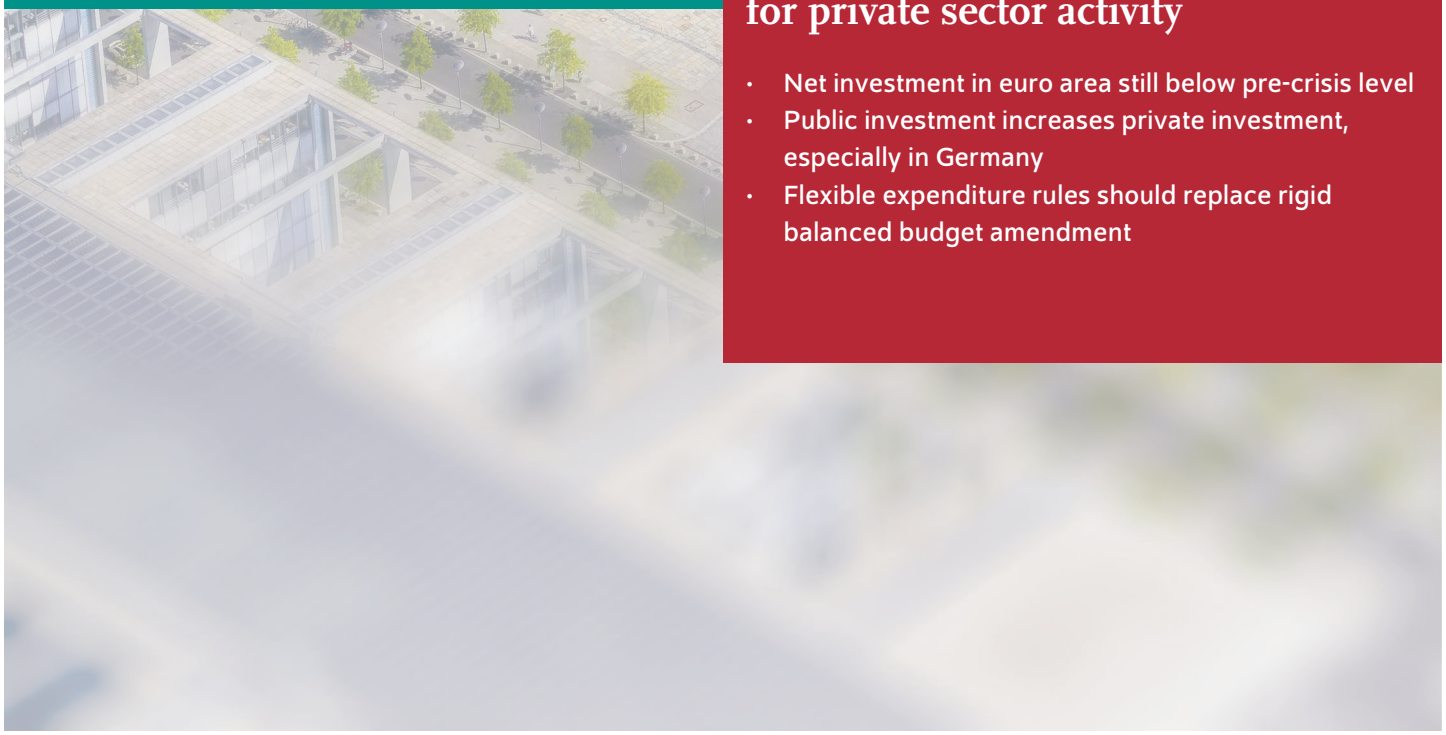
German economy needs to invest more in knowledge capital

- Germany's use of knowledge capital does not compare well to that in other countries
- Moreover, the capital used is not very modern
- The country needs to invest more in knowledge to stay competitive

255 Report by Marius Clemens, Marius Goerge, and Claus Michelsen

Public investment a key prerequisite for private sector activity

- Net investment in euro area still below pre-crisis level
- Public investment increases private investment, especially in Germany
- Flexible expenditure rules should replace rigid balanced budget amendment



LEGAL AND EDITORIAL DETAILS

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www.diw.de
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Volume 9 July 31, 2019

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Sale and distribution
DIW Berlin Leserservice, Postfach 74, 77649 Offenburg
leserservice@diw.de
Phone: +49 1806 14 00 50 25 (20 cents per phone call)

Layout
Roman Wilhelm, DIW Berlin

Cover design
© imageBROKER / Steffen Diemer

Composition
Satz-Rechen-Zentrum Hartmann + Heenemann GmbH & Co. KG, Berlin

ISSN 2568-7697

DIW Weekly Report 31 2019

AT A GLANCE

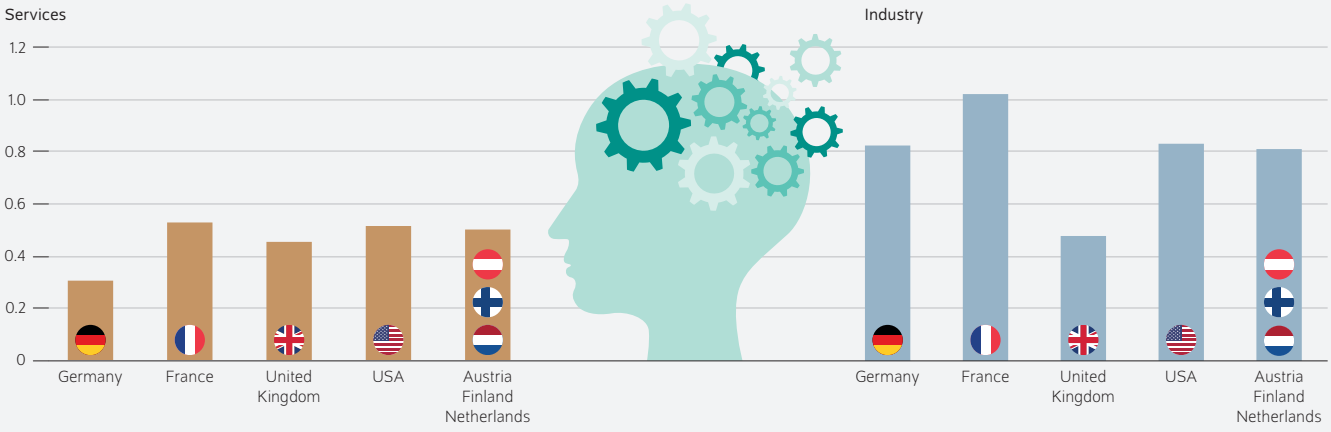
German economy needs to invest more in knowledge capital

By Heike Belitz and Martin Gornig

- Knowledge capital is becoming increasingly important for businesses' international competitiveness
- This Weekly Report analyzes the use of knowledge capital by companies in Germany, the USA, and select European countries
- All types of knowledge capital are taken into account, even those not recorded by national statistics such as financial products and training
- German companies are lagging behind in the services and industrial sectors
- Policies should urgently be reviewed and, in many places, conditions for investment in knowledge capital must be improved

When all components of knowledge capital are taken into account, Germany lags behind the other countries examined

Knowledge capital stock compared to gross value added (capital-output ratio) in 2017



Remark: Austria, Finland and the Netherlands were combined due to similar size and economic structure.
Sources: EU-KLEMS, Eurostat, OECD, own calculations.

FROM THE AUTHORS

"Even when considering only the elements of knowledge capital recorded by national statistics, Germany does not fare very well in terms of use of knowledge capital compared to other countries. When using a broader definition of knowledge capital, the picture is even gloomier. Germany needs to invest much more than it currently does in knowledge,"
— Heike Belitz —

MEDIA

Audio Interview with Martin Gornig (in German)
www.diw.de/mediathek

German economy needs to invest more in knowledge capital

By Heike Belitz and Martin Gornig

ABSTRACT

The efficiency of the German economy is powered by its knowledge-intensive industrial and services sectors. Yet the use of knowledge capital to drive innovation and productivity in Germany is rather low compared to other European countries and the United States. Germany is clearly lagging behind, especially in the services sector. The same applies to the industrial sector, where German businesses are not using knowledge capital to an above-average extent. Moreover, the level of knowledge capital modernity is low in Germany's industrial and services sectors, which jeopardizes the competitiveness of the German economy. The federal government has set a target for increasing R&D expenditure to 3.5 percent of GDP by 2025. In terms of corporate investments in total knowledge capital, this corresponds to an almost 35 billion euro increase in total annual investments. For this target to be achieved, conditions for investing in knowledge capital must be reviewed and improved.

In recent years, the German economy has established a strong competitive position. An important component of this competitiveness is a focus on knowledge-intensive production, which requires a high level of investment activity.

Businesses invest in machinery, devices, vehicles (equipment), and buildings, as well as in the knowledge of what is produced and how it is produced. This is known as knowledge capital.[1] It is made up of different components (Figure 1), including research and development (R&D), software, copyrights, and mineral exploration. These components are recorded as knowledge capital in official statistics under the umbrella term "intellectual property" and are regularly reported in the national accounts. Using these statistics, this Weekly Report examines the period from 1997 to 2017. For the year 2017, we take into account further components of knowledge capital which are not recorded in national accounts, such as advertisements, organizational capital, architecture and engineering design, new financial products, and training.[2]

When companies invest in equipment, buildings, and knowledge, they expect to reap benefits for a number of years. These investments in tangible and intangible assets thus contribute not only to securing businesses' profitability, but also to increasing an economy's production and productivity.[3]

1 There is no conclusive definition for the components of knowledge-based capital. The OECD counts the following elements as a part of knowledge-based capital: software, databases, private sector R&D, mineral exploration, trademarks and copyrights, licenses and artistic originals, new products in the financial sector, new architectural and technical designs, R&D in the social sciences and humanities, marketing and advertising, education and training to develop firm-specific human capital, and organizational capital. See OECD, *Supporting Investment in Knowledge Capital, Growth, and Innovation* (Paris, 2013) (available online, accessed July 11, 2019. This applies to all other online sources in this report unless stated otherwise).

2 Within the scope of several EU-funded research projects, DIW Berlin has been involved in developing estimating approaches for comprehensively quantifying investments in knowledge capital that go beyond the elements recorded in national accounts. The estimations for EU countries and the United States are documented in the INTAN-Invest databank (available online). See Carol Corrado et al., "Intangible investment in the EU and US before and since the Great Recession and its contribution to productivity growth," in *Investment and Investment Finance in Europe*, ed. Atanas Kolev et al. (European Investment Bank, November 2016), Chapter 2.

3 See Jonathan Haskel and Stian Westlake, *Capitalism without capital: the rise of the intangible economy* (Princeton University Press, 2017); Bernd Görzig and Martin Gornig, "Intangibles, Can They Explain the Dispersion in Return Rates?," *The Review of Income and Wealth* 59, no. 4 (2013); Thomas Niebel, Mary O'Mahony, and Marianne Saam, "The Contribution of Intangible Assets to Sectoral Productivity Growth in the EU," *Review of Income and Wealth* 63 (2017): 49-67; for Germany: Heike Belitz, Marie Le Mouel, and Alexander Schiersch, "Company Productivity Increases with More Knowledge-Based Capital," *DIW Weekly Report*, no. 4/5 (2018) (available online).

DOI: https://doi.org/10.18723/diw_dwr:2019-31-1

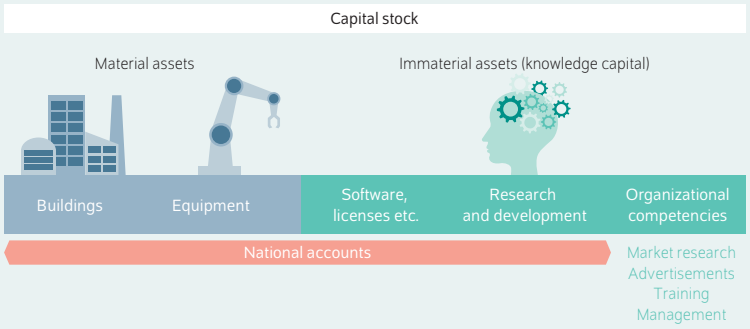
At DIW Berlin, we conducted a study for the Bertelsmann Stiftung to analyze the extent to which industry and market services[4] invest in knowledge capital in Germany, the United States, France, the United Kingdom, the Netherlands, Austria, and Finland.[5] Included are the types of knowledge capital recorded in the national accounts as well as other important components for which internationally comparable data are available.

The significance of the capital used and its change is estimated using the capital-output ratio, which indicates the amount of capital which was available for the production volume achieved (in this case, gross value added). The capital is measured using the existing net fixed assets (see Box).

A low capital-output ratio can indicate the use of capital is particularly efficient. However, empirical research indicates investments in capital positively affect production and productivity.[6]

Figure 1

Material assets/Immaterial assets (knowledge capital)



Source: Authors' own depiction.

National accounts do not record all immaterial assets.

Knowledge capital gaining in importance worldwide

In industry and the market services sector, there are typical combinations of physical capital and knowledge capital recorded in official statistics which can be found in all countries examined.[7] Buildings dominate the assets of service providers while equipment traditionally dominates in industry (see Figure 2). However, knowledge capital is increasingly gaining in significance. The knowledge capital recorded in the national accounts is particularly large compared to the use of real capital (equipment and buildings) in industry. Knowledge capital already has greater significant in France and the United States; in Germany, it is as important as equipment capital.

Following the global economic crisis of 2009, the use of knowledge capital in industry increased its pace of growth in most countries. However, in the United Kingdom, the relative use of knowledge capital in industry declined between 2007 and 2017. In other countries, the growth momentum in industry remained high or even increased. This could be an expression of an intracompany division of labor: large international companies have strengthened the knowledge industry in continental Europe while concentrating on production in the United Kingdom ("extended workbenches").

Germany lost the leading position in the use of knowledge capital in industry it had in the mid-1990s, and the United States had caught up by 2007. In 2017, the relative use of knowledge capital in industry in Germany was on par with that of Austria, the Netherlands, and Finland.[8]

The relative use of knowledge capital in the services sectors has increased even more markedly after beginning at a low level. Between 2007 and 2017, the capital-output ratio grew the most in Germany, followed by France and the group of small EU countries, Austria, the Netherlands, and Finland. In contrast, the development in the United States is more subdued, and the capital-output ratio of the British services sector declined both before and after the economic crisis. This development could be related to the United Kingdom's strong focus on financial services; the knowledge capital components covered by national accounts to date are heavily engineering driven and do not reflect investments in financial innovation.

Overall, Germany and the United Kingdom have the lowest relative use of knowledge capital recorded in the national accounts of all the countries examined. Service providers in the USA and the three smaller EU countries examined here have a significantly higher ratio of knowledge capital to value added, with France taking the lead.

The divergent use of knowledge capital by international standards could be due to contrasting company behavior in individual sectors, but it could also be influenced by the respective weight of more or less knowledge-intensive sub-sectors within industry and the services sector. Using a sectoral decomposition, the differences between the knowledge capital-output ratios (knowledge capital compared to sectoral value added) of Germany and the United States,

4 The term "industry" is used here synonymously with the manufacturing sector, as it is referred to in the official statistics. Market services include trade, transport, hotels and restaurants, information and communication, financial and insurance services, business services as well as arts, entertainment, recreation, and other services.

5 Heike Belitz and Martin Gornig, "Internationaler Vergleich des sektoralen Wissenskapitals," Study commissioned by the Bertelsmann Stiftung (2019) (available online) (in German).

6 See the literature referenced in footnote 3.

7 The EUKLEMS database is used for the international comparison of tangible and intangible investments included in the national accounts and the corresponding capital stocks for the period 1997 to 2015. Kirsten Jäger, *EU KLEMS Growth and Productivity Accounts 2017 release – Description of Methodology and General Notes* (2017) (available online). It was revised to include the most recent data from national statistics and is current up to 2017. See Belitz and Gornig (2019), reference as above.

8 Due to the size of these three economies and their similar structure, they have been grouped together here.

Box

Definitions and concepts

Following production theory, the capital-output ratio is used to assess the significance of the use of capital and its change. It indicates how much capital expenditure was available for the production quantity achieved. Knowledge capital, like other types of capital, is viewed as an input factor which is portrayed relative to the output. From the perspective of a macroeconomic production function, production in a sector corresponds to the gross value added achieved. The use of knowledge capital is measured by the existing net fixed assets.

$$Capital-output\ ratio_{a,i,j,t} = \frac{Net\ fixed\ assets_{a,i,j,t}}{Gross\ value\ added_{i,j,t}}$$

with a representing the type of capital and i the economic sector, j the country, and t the year.

Formally, the capital-output ratio corresponds to the reciprocal value of capital productivity. Indications of particularly high levels of efficiency could be obtained by incorporating quality indicators for the use of capital. One indicator of the quality of knowledge capital use is its level of modernity. Another way used by official statistics to show the degree of modernity of capital stock is to show the ratio between gross and net fixed assets. However, since data on gross fixed assets were only available for a few countries, the degree of modernity is determined differently here. The main idea is that the more the capital stock consists of recent investment years, the more modern it is. Accordingly, gross investments were compared to net fixed assets. The number of investment years included is open. Generally, the longer the service life of the type of investment, the more investment years should be included. This Weekly Report shows the results for the last three investment years.[1]

$$Level\ of\ modernity_{a,i,j,t} = \frac{\sum_{n=0}^{N} Gross\ investment_{a,i,j,k}}{Net\ fixed\ assets_{a,i,j,t}}$$

with a representing the type of capital and i the economic sector, j the country, and t the year.

Furthermore, $N = \{2\}$ and $k = t - n$ apply.

1 Alternative calculations with reference to one or five investment years do not show any other country order. See Belitz and Gornig (2019), reference as above.

France, the United Kingdom, and the three small European countries were analyzed.[9] These differences are mainly due to diverging corporate investment behavior in the respective industrial and services sectors and not structural differences (the relative importance of more or less knowledge-intensive sectors in these countries).

German knowledge capital lacks modernity

When it comes to utilizing knowledge capital in the services and industrial sectors, Germany is far from the top. In fact, in terms of the services sector, Germany and the United Kingdom rank at the bottom. In 2017, knowledge capital use in France and the United States was almost 85 and 30 percent higher than in Germany, respectively. Germany ranked below France and the United States in terms of knowledge capital use in the industrial sector in 2017 as well: in industry, the gap between the capital-output ratios is 30 and 15 percent, respectively.

Germany's current and future position in international competition depend not only on the amount of capital used, but its modernity and quality as well. Our measure of modernity is based on the idea that the higher the share of recent investments in the capital stock, the more modern it is. Accordingly, gross investments were compared to net fixed assets (see Box).

In terms of knowledge capital, Germany lags behind all other countries in modernity (see Figure 3), especially in the services sector. In Germany, the last three investment years account for around 80 percent of capital stock. In contrast, it is between 90 and 100 percent in the United States, United Kingdom, and France, and even over 100 percent on average in Austria, the Netherlands, and Finland.[10]

In industry, too, the degree of modernity in Germany is lower than in other countries. However, the gap between Germany and the United States and the smaller EU countries is significantly smaller than in the services sector. The United Kingdom has by far the smallest but most modern knowledge capital stock in industry.

Germany lags even further behind in terms of extended knowledge capital

Only certain parts of knowledge capital are reflected in the national accounts. Components such as investments in design development, new financial products, advertising, training, and organizational capital are not included.

Estimates have been made here in order to gain an idea of the importance of this knowledge capital for economic performance in the countries examined in 2017. The starting point

9 Belitz and Gornig (2019), reference as above.

10 This means that the capital stock in Germany will be renewed after about roughly three to four years and somewhat earlier in the other countries examined.

Figure 2

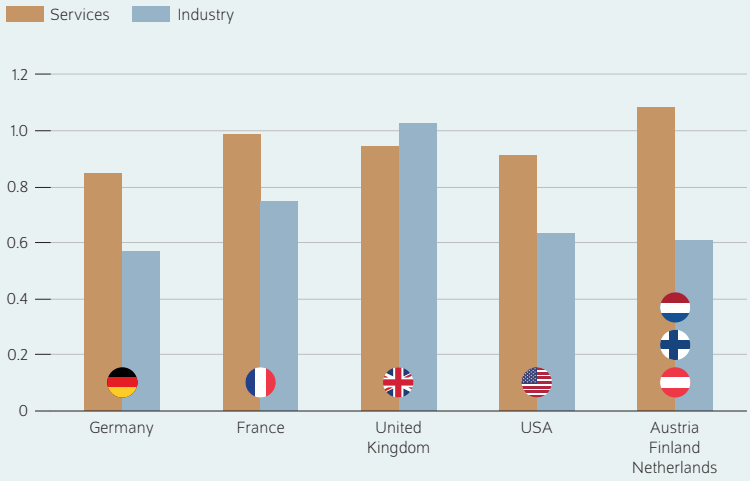
Capital-output ratio for knowledge, equipment, and buildings
Capital stock compared to gross value added, 1997 to 2017, for the services and industrial sectors

Source: EU-KLEMS, Eurostat, OECD, authors' own calculations.

The capital-output ratio for knowledge is increasing in almost all countries.

Figure 3

Level of modernity of the knowledge capital
In 2017, knowledge capital as recorded in the national accounts



Source: EU-KLEMS, Eurostat, OECD, authors' own calculations.

The knowledge capital used by German businesses is less modern than in the other countries examined.

is the INTAN-Invest database,[11] which provides estimates of the level of investments in knowledge capital for the above fields not covered by official statistics up to 2015. When calculating the capital-output ratio of these components in 2017,

- it was assumed that the components not included have similarly short lifespans to those included,[12]
- that the relationship between the recorded and unrecorded investments can be transferred to the relationship between recorded and unrecorded knowledge capital stock, and
- these relationships within the individual sectors did not change between 2015 and 2017.

To compare the expanded knowledge capital to production, the value-added parameter was adjusted to take account of the additional sales production (self-produced plants). In the services sector, Germany is clearly lagging behind in terms of use of extended knowledge capital (including the components not covered by official statistics). Out of all the countries examined, the capital-output radio for the use of knowledge capital was lowest in 2017 in Germany. Use of knowledge capital was two thirds higher in the United States, France, and the smaller EU countries. In the United Kingdom, the relative use of knowledge capital is 50 percent higher than in the German services sector.

In German industry, intangible assets accounted for more than half of the total capital used in 2017, taking into account the knowledge capital not recorded in national accounts (see Figure 4). A good half of this knowledge capital stock is R&D capital. Nevertheless, by international standards, Germany's use of knowledge capital is not above average, even in industry. The capital-output ratio for the use of knowledge capital is similarly high as in the United States and the three smaller euro area countries examined. It is noticeably higher in France.

Conclusion: major efforts required for investment in knowledge capital

Accumulating knowledge capital is becoming increasingly important for the innovativeness, productivity, and competitiveness of modern economies. That makes it all the more alarming that companies in Germany use less knowledge capital in Germany than in other European countries and the United States. Germany is clearly lagging behind, especially in the services sector. The situation is not much better in the industrial sector. At the same time, knowledge capital in Germany in both the industrial and services sectors is not very modern. German companies, especially in the industry, have been very successful but have failed to invest their earnings in new knowledge to secure their future prosperity. The automobile industry is one example. Over the years, it has profited greatly from diesel technologies. At the same time, it has been reluctant to invest in the development of new drive systems and mobility concepts. The low degree of modernity and comparatively low amount of knowledge capital contradict Germany's claim of being one of the world's most technologically advanced economies. R&D expenditure in Germany is expected to account for 3.5 percent of GDP in 2025; currently, it is only around three percent.[13] Assuming that, as in previous years, business R&D expenditure accounts for around two thirds of total expenditure, businesses would have to increase their R&D expenditure from two percent to just under 2.5 percent of GDP.[14] To achieve this goal, they would need to increase their R&D investments by about 0.4 percentage points of GDP—measured according to the GDP in 2018, that would be over 13 billion euros. Investments in further components of knowledge capital must grow in tandem. Annual investment growth would need to be three percent in order to increase overall investments in knowledge capital from the current level of six percent to the target of seven percent by 2025. This amounts to a total of 35 billion euros that companies in Germany would have to spend additionally each year on their knowledge capital.

11 Corrado et al., "Intangible investment in the EU and US."

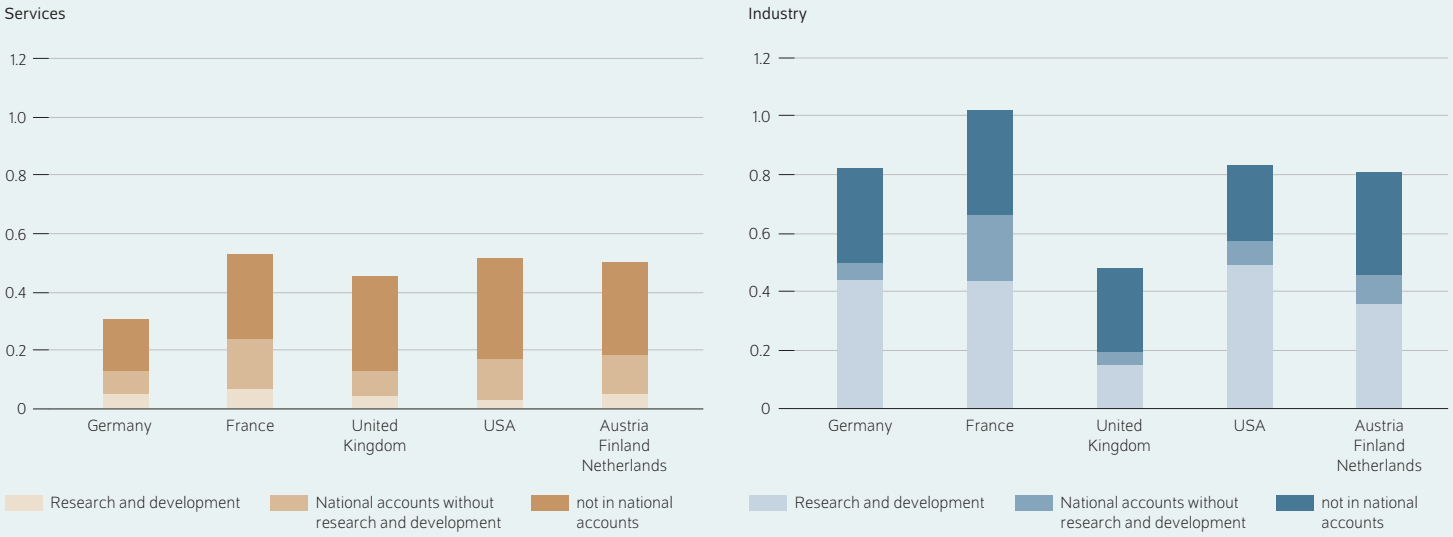
12 Bernd Görzig and Martin Gornig, "The Assessment of Depreciation in the Case of Intangible Assets," SPINTAN Working Paper No. 3 (available online).

13 See Bundesminsterium für Bildung und Forschung, "Zukunft made in Germany, " News Release, March 29, 2017 (available online) (in German).

14 See also: Rainer Frietsch et al., *Schrittweise Erhöhung der FuE-Quote auf bis zu 3,5 des BIP – Instrumente und Auswirkungen auf volkswirtschaftliche Kennzahlen*, Study by Fraunhofer ISI, Prognos, and ZEW, commissioned by the Bundesministerium für Bildung und Forschung, (Karlsruhe: January 2019) (available online) (in German).

Figure 4

Capital-output ratios for knowledge capital in 2017
Knowledge capital as reported in the national accounts and including other elements



Source: EU-KLEMS, Intaninvest, Eurostat, OECD, authors' own calculations.

Under a broader definition of knowledge capital, Germany lags behind all other countries examined in terms of its use of knowledge capital.

In order to achieve this, the conditions in Germany for investing in all types of knowledge capital must be improved. Solely focusing on R&D investments—for which tax incentives are currently being developed—is not enough. Research and development is only one component of knowledge capital, and it can only be effectively efficient in the innovation process together with other components, such as new organizational solutions, training, and software. One starting point could be to promote high-risk innovation projects that require simultaneous investment in different types of knowledge capital. Promoting joint projects, networks, and clusters should especially help support businesses accumulate a broader range of knowledge capital.

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JEL: E22, D24, C23

Keywords: Knowledge capital, intangibles, manufacturing, services

DIW Weekly Report 31 2019

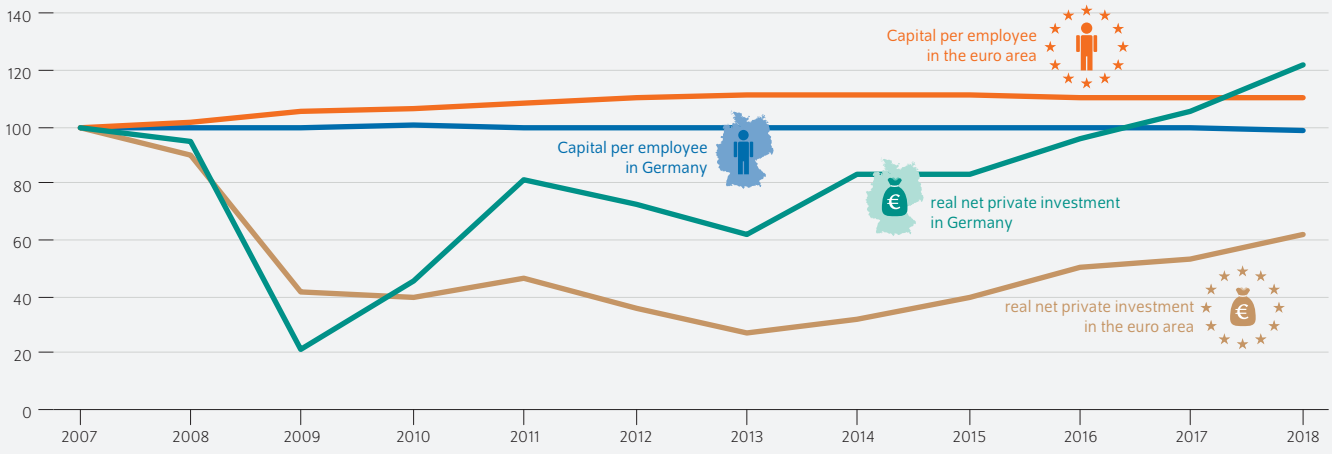
AT A GLANCE

Public investment a key prerequisite for private sector activity

By Marius Clemens, Marius Goerge, and Claus Michelsen

- Net investment in euro area still below pre-crisis level
- Private and public capital intensity plateau in euro area and Germany
- One billion euro additional public investment in the euro area would increase private investment by 1.1 billion euro after five years
- Effect greater in Germany; very strong for investment in construction and infrastructure
- To strengthen public investment, flexible expenditure rules should replace rigid balanced budget amendment

Private net investment increases in Germany more than in the euro area, but private capital intensity stagnates
Change in percentage, 2007 = 100



Sources: Author's own calculation, AMECO database.

FROM THE AUTHORS

"Public investment in education, housing, and environmental protection has in the euro area a strong effect for private sector activities over the medium-term. In Germany, public investment in construction and infrastructure is very effective"

— Marius Clemens —

Public investment a key prerequisite for private sector activity

By Marius Clemens, Marius Goerge, and Claus Michelsen

ABSTRACT

Ten years after the 2008 financial crisis, in the euro area investment is still below the pre-crisis level. Public and private investment growth is so weak that capital per worker (capital intensity) has virtually remained constant. An increase in public investment activity could ultimately stimulate private investment. Estimates for the euro area show that an increase in public investment by one billion euro goes hand in hand with a medium-term increase in private investment of around 1.1 billion euro. In Germany, the effect is somewhat greater. Investment in construction and infrastructure are the most significant drivers. The public sector's widespread reluctance to invest could partially explain the weakness in private investment activity. The public sector should now begin investing more. And the rigid balanced budget amendment (Schuldenbremse) should be replaced by more flexible expenditure rules.

Ten years after the financial and economic crisis of 2008, public and private investment still remain below their pre-crisis level.[1] The investment required to expand and modernize the capital stock and power the economy has been inadequate. This leads to the risk that the economy in the euro area and also in Germany will remain on a low growth trajectory in the medium term.[2]

There are a variety of explanations for reluctance to invest. Directly after the financial crisis, many companies did not have access to credit. When the European debt crisis followed two years later, confidence in the common currency and viability of the common economic area was shaken. Geopolitical crises came next – in Ukraine and Syria, for example – and most recently, significant trade policy uncertainty ranging from an unresolved Brexit to the erratic decisions of the U.S. government. To a great extent, these influences certainly explain private companies' recent reluctance to invest.

Public investment activity was particularly affected by the fact that many states made a major effort to reduce public debt after the crisis. However, in view of the zero interest policy, additional expenditure would have been financed at historically low terms.

The present report examines whether and the extent to which public investment in the euro area in general and Germany in particular have stimulated private investment activity. For the euro area,[3] it examined how public and private investment are mutually dependent on the aggregate level. In addition, different types of investment are examined in detail for Germany. For example, has public construction investment stimulated commercial building activity?

1 Ferdinand Fichtner, Marcel Fratzscher und Martin Gornig, "An Investment Agenda for Europe," *DIW Economic Bulletin* no. 7 (2014) (available online, accessed on 29.07.2019. This applies to all other online sources in this report unless stated otherwise.); Marcel Fratzscher, Martin Gornig und Alexander Schiersch, "Weak Corporate Investment Requires Immediate Action," *DIW Economic Bulletin* no. 15 (2016): 167–171 (available online).

2 See Stefan Bach et al., "More growth through higher investment," *DIW Economic Bulletin*, no. 8 (2013) (available online).

3 The overall study only considers the euro area countries that implemented the euro by 2004. They are: Belgium, Germany, Finland, France, Greece, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal, and Spain.

DOI: https://doi.org/10.18723/diw_dwr:2019-31-2

Figure 1

Real net public and private investment of euro area and selected euro area countries[1]
In billion euros (in constant prices at 2010)

1 The twelve euro area countries that implemented the euro by 2004

Sources: Author's own calculation, AMECO database.

Private and public net investment in euro area are still below the 2007 level, in Germany especially public net investment has increased more in the last years.

Two perspectives on the effect of public investment on the private sector

Whether public investment stimulates private investment (crowding in effect) or suppresses it (crowding out) has been the subject of debate for some time.[4] It is not clear which of the two effects is most common. Those in favor of crowding in argue that public investment improves the investment conditions for the private sector and could stimulate investment activity there. A state-financed expansion of the road network, for example, can simplify and accelerate the transport and trade of goods, which leads to gains in the production process' efficiency and raise private companies' profit expectations in turn. They are willing to invest more when the marginal product or marginal productivity of private capital increases.

In the crowding out effect, on the contrary, an increase in public investment leads to higher user capital costs in the short term because the state demands a large quantity of financial resources. Rising interest rates also make it more expensive for companies to borrow, making investment less profitable and easier to postpone. During upswings or recessions in particular, the crowding out effect can grow stronger if country-specific risk surcharges are raised in reaction to an increase in public debt.

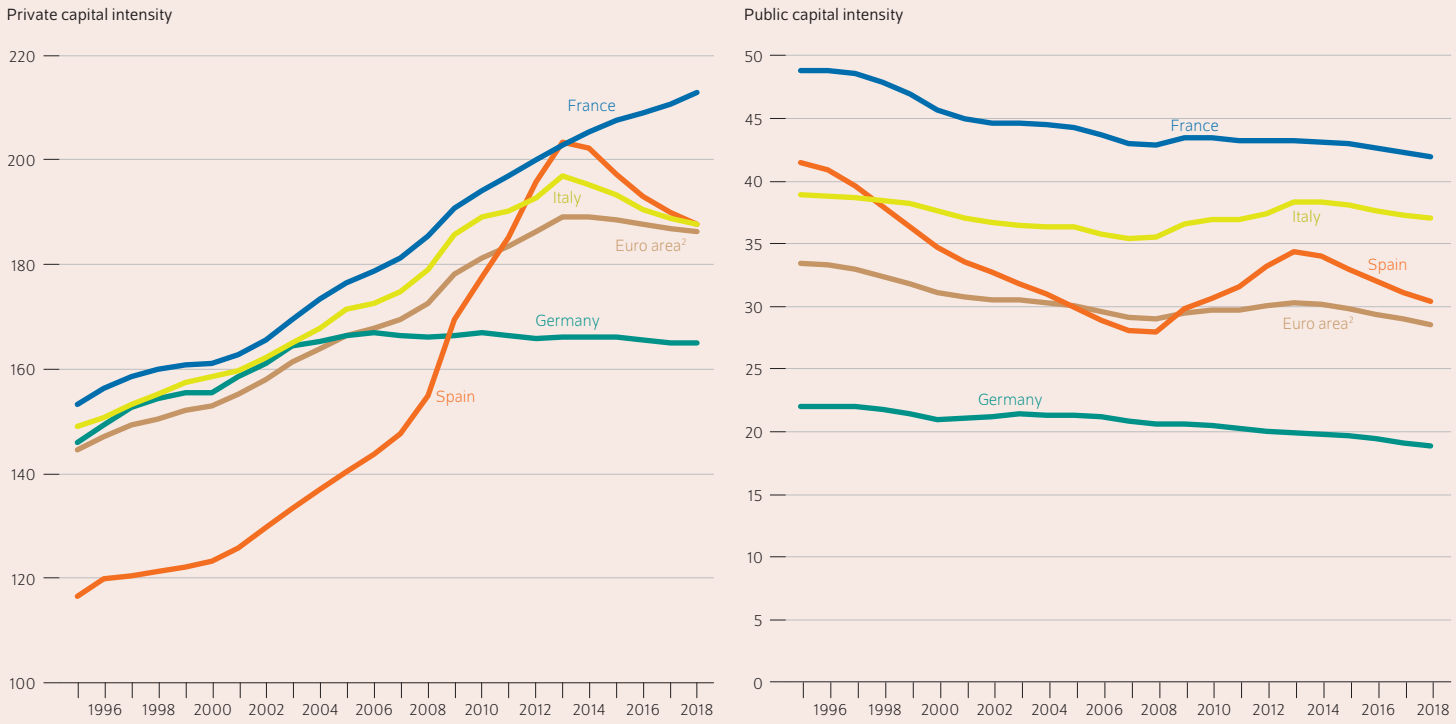
Both financing public investment by borrowing and financing via tax revenue can be harmful to the public sector. Additional public investment leads to a higher expected tax burden for companies in the future, which can also encourage private investment bottlenecks. When interest rates are low, however, this channel is weakened because financing costs remain on a very low level for both the state and companies.

The effect of public investment on private investment demand is not the only unclarity; the direction of causality is also ambiguous. Insufficient private investment can be both the cause and effect of public investment. Conversely, private investment stimulates the growth of GDP, which results in higher tax revenue and therefore, a higher availability of resources for public activity.

4 Marianne Baxter and Robert G. King, "Fiscal policy in general equilibrium," *The American Economic Review*, (1993): 315–334.

Figure 2

Private and public capital intensity in euro area[1] and selected euro area countries
Real private and public gross capital stock[2] per employee in euro



1 The twelve euro area countries that implemented the euro by 2004
2 In constant prices at 2010

Sources: Author's own calculation, AMECO database

Capital endowment per employee in euro area reduces since 2013, in Germany it is a long-term phenomen since 2000.

The empirical literature has not reached a conclusion as to whether crowding in or crowding out is more common. Many studies see a positive effect of public investment on private activities in various countries.[5] Some studies also find in favor of crowding out;[6] but a significant correlation was not established for Germany.[7] However, the studies examined used different methods (SVAR, Panel-SVAR or SVECM models) and their databases.

Public and private investment anemic across Europe since the 2008 crisis

Private and public real net investment in the euro area has still not reached its pre-crisis level (see Figure 1).[8] A probable key reason for this is the generally high level of national debt and the credit constraints this entails. Germany is an exception: public and private net investment have bounced back to a level slightly higher than the pre-crisis values. The comparatively high public investment activity in Germany is due to a resurgence in municipal investment in the places that benefited from increasing tax revenue in the wake of the general economic recovery. However, this only applies to some cities and municipalities because in many regions, the debt burden and high social spending restrict freedom to invest.[9]

5 See David A. Aschauer, "Is public expenditure productive?" *Journal of Monetary Economics*, 23(2) (1989): 177–200; Isabel Argimon, José M. Gonzalez-Paramo, and José M. Roldan, "Evidence of public spending crowding-out from a panel of OECD countries," *Applied Economics*, 29(8) (1997): 1001–1010; Abdul Abidad, Davide Furceri, and Petia Topalova, "The macroeconomic effects of public investment: Evidence from advanced economies," *Journal of Macroeconomics*, 50 (2016): 224-240; António Afonso and Miguel St. Aubyn, "Economic growth, public, and private investment returns in 17 OECD economies," *Portuguese Economic Journal*, 18(1) (2019): 47–65; and Colin Hunt, "The interaction of public and private capital: a study of 20 OECD members," *Applied Economics*, 44 (2012): 739-764; Stefan Mittnik and Thorsten Neumann, "Dynamic effects of public investment: Vector autoregressive evidence from six industrialized countries," *Empirical Economics*, 26(2) (2001): 429–446.

6 Graham M. Voss, "Public and private investment in the United States and Canada," *Economic Modelling*, 19(4) (2002): 641–664; Jérome Creel, Paul Hubert, and Francesco Saraceno, "Une analyse empirique du lien entre investissement public et privé," *Revue de l'OFCE*, (8) (2015): 331-356; and António Afonso and Miguel St. Aubyn, "Economic growth."

7 Tobias Kitlinski, "The robustness of the effects of public investment in infrastructure on private output: Evidence for Germany," *Ruhr Economic Paper*, 560 (2015).

8 In accordance with the AMECO database, net investment is defined as gross investment minus amortization. Therefore, capital stock in gross accruals also contains amortization.

9 See Marcel Fratzscher, Alexander Kriwoluzky, and Claus Michelsen, "Gut investierte Schulden sind eine Entlastung in der Zukunft," *Wirtschaftsdienst* no. 05 (2019): 313–317 (in German only; available online); Martin Gornig und Claus Michelsen, "Kommunale Investitionsschwäche: Engpässe bei Planungs- und Baukapazitäten bremsen Städte und Gemeinden aus: Stärkung von Investitionen in Deutschland," DIW Wochenbericht, no. 11 (2017): 211–219 (in German only, available online); Expertenkommission im Auftrag des Bundesministers für Wirtschaft und Energie, "Stärkung von Investitionen in Deutschland," Abschlussbericht 2015 (in German only, available online).Abschlussbericht 2015 (in German only, available online).

Measured by capital per worker, the growth of capital intensity in the entire euro area shows that less capital has been used since 2013 (see Figure 2). This is primarily due to the weaker dynamic of capital intensity in the private sector. Despite its resurgence after 2013, public capital intensity has been declining for a while. In view of the future challenges the demographic shift and digitalization already pose, capital intensity could be expected to rise more sharply. After all, any structurally-caused labor market bottlenecks could be at least partially compensated for by using capital more intensively: investing in industrial robots, for example. In Germany, capital intensity has been on a plateau since 2006.

The authors' descriptive analysis shows a need for additional investment in the euro area and in particular, in Germany. The largely similar growth of private and public investment in most countries also indicates that higher public investment activity goes hand in hand with higher private investment.

Public and private investment have close ties

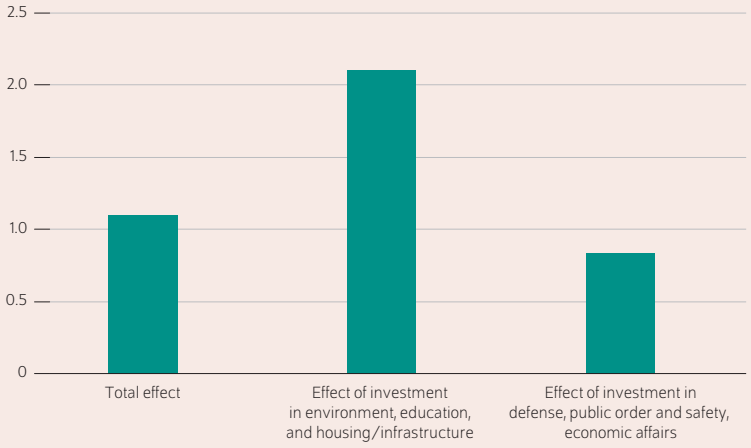
Based on a panel-SVEC model for the euro area, we examined the short- and medium-term effects of public investment on private investment (see box). In addition, we separately modeled the long-term relationship (cointegration) and short-term adjustment between the public and private capital stocks.[10] Further, additional macroeconomic influencing factors such as aggregate demand, the real interest rate, and the national debt level were considered.[11] The estimated overall effect can be interpreted as the average effect of public investment on private investment in the euro area over the short- to medium-term period.[12]

Using this model, we documented a crowding in effect for the entire euro area for the period between 1991 and 2018. An increase in annual public investment of one percent raised private investment by 0.2 percent in the medium term.[13] On average over all countries private investment is five times larger than public investment, such that an increase of public investment of one billion euro goes hand in hand with an increase of 1.1 billion euro of private investment after five years.[14]

Figure 3

Effect of increasing public investments[1] on private investments in euro area

In billion euros, effect after five years



1 Increase by one billion euro

Source: Author's own calculation.

One billion euro of public investment in euro area increases private investment by 1.1 billion euro after 5 years, in areas as education, environmental protection and housing even by 2.1 billion euro.

Additionally, the estimates show that modernization needs[15], such as public investment into education, housing, and protection of the environment, has an even stronger influence on private investment (see Figure 3).

Crowding in effect stronger in Germany

Since the SVEC model used here permits conclusions for the euro area in general but not for each individual country, a SVAR model was also estimated to examine the effect in Germany. It used detailed quarterly data and took specific investment categories into consideration (see box). With it, we were able to document a significant medium-term crowding in effect for public investment in 2017. In Germany, a rise in public investment by one percent went hand in hand with an increase in private investment by 0.27 percent in the first

10 Based on the approach of Christian Dreger and Hans-Eggert Reimers as detailed in their 2014 paper "On the relationship between public and private investment in the euro area," a structural, panel model with vector autoregression and an error correction term was estimated. A panel model was appropriate because the time series for public investment for all countries in the euro area over the period between 1991 and 2018 exist in annual frequency only. Including several countries generated a higher number of observations, for which the model delivered robust results.

11 We assumed that aggregate demand, the real interest rate, and private investment do not have a direct influence on public investment. Further, we assumed that aggregate demand indirectly influences the real interest rate and private investment does not have a direct influence on any of the other variables. As a result of the exceptions, we gave the model an economic structure so that the shock to public investment could be clearly identified.

12 The short-term period consists of the first two years after the shock and the medium term takes five years into account.

13 However, the magnitude of crowding in or potential crowding also depends on the state of the business cycle. The estimate did control for the state of the business cycle, but the effect can be somewhat higher in the first year during a recession, for example, since capacity is not fully utilized. See Abdul Abidad, Davide Furceri, and Petia Topalova, "Macroeconomic effects of public investment."

14 The GDP multiplier effect is not analyzed, but he will be a bit higher, since direct consumption demand effects are not considered. Estimates with a similar methodology by Alan J. Auerbach und Yuriy Gorodnichenko (2012): Measuring the Output Responses to Fiscal Policy, *American Economic Journal*: Economic Policy, 4(2):1–27 show, that in case of public investement increases the medium-term (five years) GDP multiplier effect is around 2.4 in the USA. Tom Krebs und Martin Scheffel, "Lohnende Investitionen," *Perspektiven der Wirtschaftspolitik*, 18(3) (2017): 245–262 show in a calibrated dynamic general equilibrium model for Germany, that the five-year-effect of a permanent increase of public investment by 20 billion euro per year leads to an increase of the private investment-to-gdp ratio between 0.03 and 0.06 percentage points. Considering the real GDP of year 2017 private investment would increase between 19 and 40 billion euro per year.

15 Recent studies for Germany detect a considerable modernization need in housing, environment (climate and energy), knowledge (education and R&D) as well as mobility and infrastructure. See Expertenkommission zur Stärkung von Investitionen in Deutschland, "Stärkung von Investitionen in Deutschland,"; Tom Krebs und Martin Scheffel, "Quantifizierung der gesamtwirtschaftlichen und fiskalischen Effekte ausgewählter Infrastruktur- und Bildungsinvestitionen in Deutschland," Studie im Auftrag des BMWi (2015); DENA, "Integrierte Energiewende–Impulse für die Gestaltung des Energiesystems bis 2050," (2018); Martin Gornig und Claus Michelsen, "Kommunale Investitionsschwäche."

Box

Data and approaches to estimates

Before the relationship between public and private investment is actually estimated, in order to determine the optimal method unit root tests were run followed by cointegration tests. In the case of cointegration, a SVEC panel model (structural vector error correction model) was estimated and otherwise a SVAR model was used (structural vector autoregressive model). Based on impulse-answer functions using Cholesky ordering, the isolated effect of a public investment shock on private investment demand could be mapped.

SVEC panel model for the euro area

The authors estimated the relationship between public and private investment for a panel of euro area countries based on annual data for the period between 1991 and 2017.[1] The database for real public and private investment, real GDP, and the real interest rate, was the European Commission's AMECO database. To map the capital stocks in the public and private sectors, relevant gross investment minus amortization was cumulated. However, only the total net capital stock and not the relevant initial capital stock in the public and private sectors was available for 1990. For this reason, it was presumed that the proportion of public capital equals the ratio of cumulated public net investment to cumulated total net investment and the 1980s were used as the reference period.

SVAR model for Germany

The relationship between public and private investment was examined for Germany based on quarterly data from the period spanning the first quarter of 1991 until the fourth quarter 2018. The basis is the time series of private and public investment on various investment levels of the Federal Statistical Office. They were adjusted for season and converted into real values (2010 prices) to ensure comparability. To increase the robustness of the results, "the standard determinants of investment behavior that underlie many empirical works were included."[2] Companies' sales prospects and financing costs can be approximated using real GDP and real interest rates. The database of the Federal Statistical Office provided the GDP statistics, while the real interest rate as the difference between the long-term (short-term) nominal interest rate and inflation was taken from the Deutsche Bundesbank database. To take the zero interest phase in the euro area that has prevailed since around 2013 into account, a shadow interest rate was also included in the analysis.[3]

1 Based on the approach of Christian Dreger and Hans-Eggert Reimers as detailed in their 2016 paper "Does public investment stimulate private investment? Evidence for the euro area."

2 See Christian Dreger and Hans-Eggert Reimers, "On the relationship," 408; António Afonso and Miguel St. Aubyn, "Economic growth, public, and private investment returns in 17 OECD economies," *Portuguese Economic Journal*, 18(1) (2019): 47–65; and Jérome Creel, Paul Hubert, and Francesco Saraceno, "Une analyse empirique du lien entre investissement public et privé," *Revue de l'OFCE*, (8) (2015): 331–356.

3 See Jing Cynthia Wu and Fan Dora Xia, "Time-Varying Lower Bound of Interest Rates in Europe," *Chicago Booth Research Paper*, no. 17–06 (2017).

five years.[16] In Germany, private investments are seven times larger than public investment on average over time. Thus, an increase of public investment by one billion euro would increase private investment after five years by near two billion euro.[17] Differentiating by individual types of investment showed that in Germany, private investment is strongly stimulated by public construction investment (see Figure 4). In Germany, there was no significant evidence of public investment suppressing private investment.

Conclusions: more flexible expenditure rules will simplify public investment

The present empirical analysis shows that on average in the euro area countries, public investment has a positive effect on private investment activity. Public investment can increase the incentive for additional private investment and as a result, boost growth. Empirical evaluations have shown that investment in education, housing, and environmental protection and in German in particular, investment in construction and infrastructure bring about such crowding in effects.

In Germany, public investment activity was slightly stronger than in the total euro area over the last five years. The empirical results point to a crowding–in between public and private investment in Germany. However, the development of public and private investment was still too low, such that e.g. capital per worker remain constant over time. But in order to modernize Germany and make it sustainable for future developments, the public authority is requested to invest still more into public infrastructure and construction.

Accordingly, we call upon the public sector in Germany to increase its investment in construction and infrastructure in order to modernize it from the ground up. Although the recent medium-term financial budget plans already go in the right direction[18], recent development has shown that backlog can arise even additional financial sources are available. Insufficient capacities, missing competencies at public construction and planning authorities, and the high degree of capacity utilization within the construction sector are the

16 The lower 95-percent confidence interval gives a value at 0.24, the upper 95-percent confidence interval values of 0.4 percent.

17 After ten years one additional publicly invested billon euro would increase private investment by closely three billion euro, however the effect is not statistically significant in the long run.

18 Until 2023, additional funds of 159 billion euro should be invested.

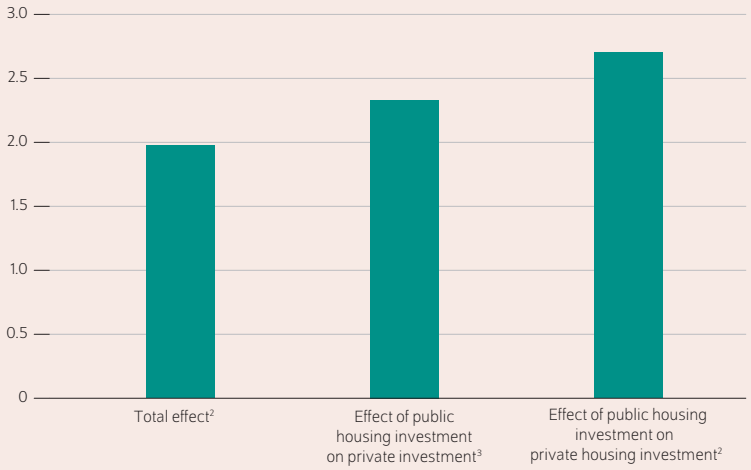
reasons mentioned by state and municipality authorities. Here, it is necessary to establish appropriate instruments to not only remove bottlenecks, but also to support municipalities more intensively by providing an easy and less bureaucratic access to financial sources of the federal government. The German balanced budget amendment has become a too-stiff corset to permit the state to react to the coming economic challenges. For the benefit of stronger public investment activity, which would also stimulate private activity, more flexible expenditure rules should be implemented. A prerequisite for stronger investment activity would be the ability to raise public expenditure by a maximum of the nominal potential growth rate on an annual basis.[19]

19 See Marcel Fratzscher, Alexander Kriwoluzky, and Claus Michelsen, "Neue Fiskalregeln für Europa," *DIW Wochenbericht*, no. 18 (2019): 310–311 (in German; available online).

Figure 4

Effect of increasing public investments[1] on private investments in Germany

In billion euros, effect after five years



1 Increase by one billion euro
2 significant at the 95 percent confidence interval
3 significant at the 90 percent confidence interval

Source: Author's own calculation.

If Germany increases its investment in construction and infrastructure it will have a strong effect on private investment.

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JEL: E22, E62, H54

Keywords: Investment, crowding in, public finance