

WP/18/161

IMF Working Paper

Investment Slowdown in Denmark: Diagnosis and Policy Options

by Tigran Poghosyan

IMF Working Papers describe research in progress by the author(s) and are published to elicit comments and to encourage debate. The views expressed in IMF Working Papers are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

I N T E R N A T I O N A L M O N E T A R Y F U N D

IMF Working Paper

European Department

Investment Slowdown in Denmark: Diagnosis and Policy Options

Prepared by Tigran Poghosyan¹

Authorized for distribution by Miguel Segoviano

July 2018

***IMF Working Papers* describe research in progress by the author(s) and are published to elicit comments and to encourage debate.** The views expressed in IMF Working Papers are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

Abstract

Total investment in Denmark has experienced a sharp slowdown following the global financial crisis. This slowdown has coincided with a decline in labor productivity and expansion of the current account surplus. This paper presents stylized facts summarizing the investment slowdown followed by an empirical analysis identifying its drivers. The results suggest that the decline in output has contributed to investment slowdown, consistent with predictions of the accelerator model. However, other factors, including high leverage and structural rigidities in product markets, also played a role.

JEL Classification Numbers: E22, O43.

Keywords: investment, accelerator model, leverage, structural reforms.

Author's E-Mail Address: tpoghosyan@imf.org

¹In addition to the IMF's Denmark team, I would like to thank Jaebin Ahn, Aqib Aslam, Romain Duval, Davide Furceri, Rasmus Mose Jensen, Aiko Mineshima, Pau Rabanal, and seminar participants at the IMF's European Department and Denmark's Nationalbank for helpful comments and suggestions. The usual disclaimer applies.

Contents	Page
I. Introduction.....	3
II. Investment Dynamics in Denmark: Stylized Facts.....	4
III. Determinants of Investment Slowdown.....	5
IV. Empirical Analysis: The Accelerator Model.....	7
V. Diving Deeper: The Role of Leverage and Product Market Reforms.....	9
VI. Conclusions.....	13
 FIGURES	
1. Dynamics of Gross Fixed Capital Formation (GFCF).....	15
2. Implications of the Investment Slowdown: Drop in Labor Productivity Growth.....	16
4. GFCG/GDP Ratio: Comparison of Denmark with EU Peers.....	18
5. Components Driving the Decline in GFCF.....	19
6. Quality of Infrastructure and Public Capital Spending.....	20
7. Decomposition of Investment Decline (2007–16).....	21
8. Output Dynamics in Denmark.....	22
9. Investment Constraints in Denmark: Evidence from a Firm Survey.....	23
10. Leverage in Various Sectors.....	24
11. Product Market Regulation.....	25
12. Residuals from the Baseline Accelerator Model: Denmark.....	26
13. Residuals from the Baseline Accelerator Model: Denmark.....	27
14. Residuals from the augmented.....	28
15. Leverage and Investment-to-GDP Ratio: Historical Comparison of Denmark and Other Advanced Economies.....	29
16. Leverage and Long-run Investment Growth: Estimating the Tipping-point.....	30
17. Cumulative Impact of Product Market Reforms on Investment.....	31
18. Cumulative Impact of Product Market Reforms on Investment: Difference-in-difference Approach.....	32
19. PMR in Network and Retail Sectors (2013): Comparison of Denmark with OECD EU Peers.....	33
 TABLES	
1. Estimation Results: Baseline Accelerator Model for Denmark.....	34
2. Estimation Results: Augmented Accelerator Model for a Panel of OECD.....	35
 ANNEXES	
Shift-Share Analysis of Investment Dynamics.....	39
The Accelerator Model.....	40
 References.....	 36

I. INTRODUCTION

Total investment in Denmark has fallen rapidly after the global financial crisis (GFC). Real gross fixed capital formation (GFCF) has dropped by 20 percent over 2007–10 (Figure 1, left panel). From 2010 onward, investment recovery was not sufficiently strong to compensate for the losses incurred during the GFC, resulting in a downward level shift in GFCF. As a share of GDP, investment has declined by 5.4 percent during 2007–10 and now remains about 3 percent of GDP lower relative to its pre-crisis level (Figure 1, right panel). This decline, albeit from a historically high pre-crisis level, has slowed down capital accumulation.

The post-GFC investment weakness has important macroeconomic implications. It brings about two macro-critical issues:

- *Drop in labor productivity growth.* Using the standard production function, labor productivity can be defined as: $\frac{Y}{L} = A \left(\frac{K}{L}\right)^\alpha$, where Y is the real output, K is the stock of capital, L is the labor input, A is the total factor productivity, and α is a constant measuring the share of capital in total output. This formula suggests that reduction in capital-to-labor ratio driven by weak investment has a direct adverse effect on labor productivity.² Figure 2, left panel, illustrates this relationship in Denmark. As expected, the rapid decline in investment following the GFC was associated with a slowdown in labor productivity growth from close to 2 percent in 2010 to close to 0 percent in 2016³, suppressed by the slowdown of contributions from the capital-to-labor ratio from 0.7 percent in 2010 to -0.3 percent in 2016 (Figure 2, right panel).
- *Surge in the current account surplus.* Following the national accounts identity, the current account surplus can be defined as the difference between aggregate savings and investment ($CAB = S - I$). In Denmark, both aggregate savings and investment have declined in the aftermath of the GFC. However, starting from 2010 savings have recovered and surpassed their pre-crisis peak in 2016, while investment recovery was sluggish. Hence, the increase in the current account surplus from less than 2 percent of GDP in 2007 to 8 percent of GDP in 2016 was largely driven by the slowdown in investment-to-GDP ratio following the GFC.

The purpose of this paper is to analyze the determinants of investment slowdown and identify policies to boost investment. Section B provides stylized facts on investment dynamics in Denmark. Section C reviews the determinants of investment slowdown discussed in the literature and illustrates the Danish data. Section D presents empirical analysis using the baseline and augmented versions of the accelerator model. Section E focuses on the role of

² From the capital dynamics equation: $K_t = I_t + \delta * K_{t-1}$, where I denotes investment and δ denotes the depreciation rate. Hence, a slowdown in I would directly translate into lower K .

³ Using output-to-hours worked ratio shows a smaller deceleration in labor productivity growth: from 1.1 percent in 2010 to 0.4 percent in 2016.

leverage and product market reforms as drivers of investment. The last section concludes with policy recommendations.

II. INVESTMENT DYNAMICS IN DENMARK: STYLIZED FACTS

Many advanced economies have experienced investment slowdown after the GFC, but the decline in Denmark has been particularly pronounced. Figure 4, left panel, presents the dynamics of *nominal* GFCF-to-GDP ratio in Denmark and EU peers over 2000–16 period. Total investment in Denmark has peaked at 24 percent of GDP before the crisis and dropped to 18 percent of GDP in 2010. This decline, albeit from a historically high pre-crisis level, has been the most rapid in comparison to EU peers. Moreover, despite the gradual recovery, the post-GFC investment ratio in Denmark remains low in comparison to peers. Some commentators have argued that the decline in nominal GFCF-to-GDP ratio could be partly explained by the decline of investment prices relative to the overall prices in the economy. Therefore, in Figure 4, right panel, we show the dynamics of *real* GFCF-to-GDP ratio, which accounts for changes in relative investment prices. The decline in real GFCF-to-GDP ratio in Denmark is not as pronounced as that of the nominal ratio, supporting the conjecture of decline in relative prices. Nevertheless, the decline in the Danish real investment ratio is still more rapid compared to the peers and its post-GFC levels are still among the lowest.

Decomposition of the decline into components shows that it was broad-based across asset classes and was mainly driven by the private sector. Figure 5, left panel, shows the decomposition of the cumulative decline relative to 2007 by asset classes. Almost all asset classes have seen a decline in the post-GFC period, with the notable exception of investment in intellectual property products. Figure 5, right panel, shows the breakdown of the decline by institutional sectors. The results suggest that the decline was mainly driven by the private sector, while public sector has expanded offsetting part of the decline. The expansion in public capital spending was supported by the countercyclical measures implemented by the government following the GFC.

There is some scope to increase aggregate investment through further expansion in public capital spending, but it is limited. In the latest survey conducted by the World Economic Forum, Denmark's infrastructure quality is ranked 12th best in the world (Figure 6, left panel). When comparing with EU-peers, Denmark's infrastructure quality is somewhere in the middle. While there is some scope to boost public infrastructure further to improve connectivity across Denmark's geographically scattered urban areas, it is limited as Denmark's government spending on capital is already one of the highest among EU peers (Figure 6, right panel).

The decline in investment was mainly driven by weak investment dynamics within individual sectors. We conduct a shift-share analysis of GFCF-to-GVA ratio over 2007–16 to explore the drivers of the post-GFC investment slowdown at the sectoral level (see Annex 1). This methodology allows decomposing the change in GFCF-to-GVA ratio into *within-factors* (decline of investment in individual sectors) and *between- (or structural shift) factors* (increase

in the share of low-investment sectors in the total output). The decomposition suggests that within-factors have dominated and the role of structural shifts was negligible (Figure 7, left panel).⁴ Moreover, in several sectors, such as mining, manufacturing, electricity, transport, and financial, the post-GFC GFCF-to-GVA ratio has increased by 1.4 percent in total, but this increase was more than offset by the decline in other sectors (Figure 7, right panel).

III. DETERMINANTS OF INVESTMENT SLOWDOWN

There is a vast empirical literature on the determinants of investment. The recent IMF contributions include Barkbu and others (2015) and WEO (2015), which analyze the slowdown of investment in AEs. EC and ECB also addressed this issue in recent reports (ECB 2016; EC 2017).

A widely popular conceptual framework underlying the empirical analysis is the accelerator model. The accelerator model postulates that dynamics of investment should be explained by changes in output (see Annex 2).⁵ The recent IMF analysis provides evidence in support of the accelerator model. For instance, IMF (2015) finds that economic weakness has been the overriding factor holding back private investment worldwide in recent years. Barkbu and others (2015) echo this finding and show that output dynamics explained part of the investment weakness in euro area countries, particularly before the European sovereign debt crisis. ECB (2016) and EC (2017) also find evidence supporting the pronounced role played by output. Figure 8 shows that there was a downward shift in gross value added in Denmark following the crisis, which likely contributed to the investment slowdown.

However, most studies find that output alone is not sufficient to explain investment and call for studying the impact of additional factors. Several impediments to investment have been put forward in the literature:

- *Debt overhang.* GFC led to an increase in private leverage. This in turn reduced the ability of private firms—especially small- and medium-sized ones—to raise funding for investment projects (Kuchler 2015). Empirical evidence suggests that highly indebted firms appear to be less responsive to demand fluctuations (IMF 2016a).
- *Uncertainty.* Uncertainty about future economic conditions and expected profits can be a drag for investment plans, because of the lumpy and irreversible nature of investment projects. Increased uncertainty can lead to a postponement of investment plans in anticipation for more desirable risk-return prospects (IMF 2015; Barkbu and others 2015; Busetti and others 2016).

⁴ A similar picture emerges when doing a shift-share analysis for the 2008–16 period.

⁵ Other models include the Tobin's Q, the neoclassical model, and various formulations of the Euler's equation (see Oliner and others 1995 for a survey).

- *Financial constraints.* GFC reduced the value of collaterals (equity, real estate), making it more difficult for firms to obtain loans from banks for investment purposes. Firms with financial constraints face difficulties expanding investment because of the lack of funding resources and irrespective of their business perspectives (IMF 2015; Barkbu and others 2015).
- *Weak competition.* Greater market concentration and reduced competition—due to technological progress, regulatory bottlenecks, barriers to entry, or common ownership—reduce incentives for investment (Danish Ministry of Business and Growth 2014; Guiterrez and Philippon 2016).
- *Tax burden.* The taxation regime has important implications for the return on investment projects, which has ramifications for investment behavior. The effective tax rates are affected not only by the statutory tax rates, but also by the tax base (e.g., asset specific depreciation allowances, investment tax credits, interest deductibility, among others). This was explicitly recognized in the report on growth and competitiveness prepared by the Danish government (Danish Ministry of Business and Growth 2014).
- *Stringent product and labor market regulations.* More stringent product and labor market regulations can create barriers for investment by imposing constraints on the ability of firms to realize profits. For instance, product market regulations can create impediments for entry and exit, reducing competition and dis-incentivizing innovation. Similarly, rigid market regulations could lead to shortages of qualified labor force. Empirical evidence for OECD countries provides support to the negative association between product and labor market regulations and investment (Egert 2017). Moreover, the relationship seems to be asymmetric, with tightening of the regulations having a stronger impact on investment compared to the relaxation.
- *Intangible assets.* In the modern world, the composition of capital in advanced economies shifted more toward intangibles, such as human capital (education and training), R&D expenditure, market development, and organizational and managerial efficiency. The latter are more difficult to quantify/measure using the current statistical definitions, which could lead to underestimation of private investment. Moreover, due to their specific nature, their association with output developments may not be as close as that of tangible assets (Thum-Thysen and others 2017). IMF (2017a) analyses intangible investment in Denmark using firm-level data.

Uncertainty and capacity constraints are important impediments to investment in Denmark. The recent firm survey by EIB shows that most firms have identified skilled labor shortages and uncertainty about the future as major impediments to investment by firms (Figure 9, left

panel).⁶ It is also notable that capacity constraints are mentioned as one of the largest in Denmark (Figure 9, right panel), indicating a scope for expansion in investment demand by firms once the obstacles have been removed.

High and growing leverage could also explain the weakness in investment. Figure 10 shows that leverage in Denmark has been on the rise since 2001 in all sectors, except general government. Leverage picked up around 2010 and started declining since then, but remains elevated. Largest leverage buildup was observed in the private non-financial sector. IMF (2017a) shows that more highly leveraged firms had lower tangible investment in Denmark.

Product market regulation (PMR) in Denmark is relatively less restrictive compared to OECD countries, but there is scope for improvement. OECD surveys conducted in 5-year intervals over 1998–2013 rank Denmark quite favorably relative to OECD countries in terms of restrictiveness of PMR (Figure 11). Moreover, Denmark’s ranking has gradually improved over this period. Nevertheless, as identified by Copenhagen Economics (2013a, 2013b, 2013c) and IMF (2016c), there is scope for further deregulation in certain sectors, notably the electricity, gas, retail, and rail sectors.

IV. EMPIRICAL ANALYSIS: THE ACCELERATOR MODEL

We use the accelerator model to disentangle the role of output and non-output drivers of investment slowdown. Following the two-step accelerator approach (see, e.g., Barkbu and others 2015; WEO 2015; EC 2017), we start by estimating the baseline accelerator model. This model allows to assess whether the dynamics of investment could be explained by changes in output. If the decline in investment was deeper than what is explained by the changes in output, then the benchmark accelerator model is augmented by additional explanatory factors discussed above in the second step.

A. Baseline accelerator model

The baseline accelerator model suggests that the post-GFC weakness in GFCF cannot be fully explained by the output movements. As discussed above, both GFCF and GDP have dropped following the GFC, raising the question of whether the decline in GFCF is solely a result of weaker economic environment. Table 1 shows estimation results of the baseline accelerator model using 12 quarterly lags of output, like in IMF (2015). Most coefficients of the lagged output variables, as well as the sum of 12 coefficients, are significant, supporting the baseline accelerator hypothesis of the importance of output for investment dynamics. The residual from the baseline accelerator model displayed in Figure 13, left panel, shows that part of the GFCF movements cannot be explained by the output dynamics. Specifically, the residual has been persistently negative following the GFC, suggesting that GFCF has fallen beyond the

⁶ The uncertainty is most likely related to international developments rather than domestic factors.

level explained by weaker output. More recently, the residual converged to zero, suggesting that GFCF has converged to the level explained by the output dynamics. Nevertheless, one would have expected much stronger investment in the most recent period given ultra-low borrowing costs.⁷

The decline in Danish GFCF beyond the level explained by output movements has been one of the most pronounced among EU peers. In addition to Denmark, we run the baseline accelerator model for 9 EU countries.⁸ Figure 12, right panel, displays the residuals from these regressions. The results suggest that the unexplained (negative) component of the GFCF has been particularly pronounced in Denmark in the immediate aftermath of the GFC. It is also notable that Denmark had highest positive residuals in the pre-GFC period, corroborating the previous claim that the investment slowdown started from the historically high pre-GFC levels. In more recent periods, the residual for Denmark has converged to zero, while residuals in some EU peers have become even more negative.

The decline in the GFCF of individual sectors and investment categories in Denmark cannot be fully explained by the output movements either. We run the baseline accelerator model for GFCFs in 13 sectors⁹ and 10 GFCF categories¹⁰ in Denmark. For the sectoral regressions, we use sector-specific GVAs, while for the category-specific regressions we use aggregate GVA. Figure 14, left panel, shows that the residual turns negative post-GFC and remains negative through 2016 in most sectors. A notable exception is the “financial and insurance activities” sector, for which the residual is positive and large. Figure 13, right panel, shows a similar picture for the GFCF categories. The residual turns negative for many GFCF categories in the post-GFC period. There is a positive spike in the “communications equipment” category in 2014–15.

B. Augmented accelerator model

Inclusion of additional controls in the augmented accelerator model improves the fit after the GFC. Figure 14 shows that the persistence of negative residuals following GFC disappears once additional controls for leverage, price markups, product market reforms, and economic

⁷ Denmark’s 2018 AIV Selected Issues Chapter “Danish Households, Asset Prices, and Interest Rate Shocks”.

⁸ Following the classification in the latest EIB report (EIB 2017), we compare Denmark with the following EU peers: Austria, Belgium, Finland, France, Germany, Luxembourg, the Netherlands, Sweden, and the United Kingdom.

⁹ The sectors are: (1) agriculture, forestry, and fishing, (2) mining and quarrying, (3) manufacturing, (4) electricity, gas, and water supply, (5) construction, (6) wholesale and retail trade, repair of motor vehicles and motorcycles, (7) transportation and storage, (8) accommodation and food service activities, (9) information and communication, (10) financial and insurance activities, (11) real estate activities, (12) professional, scientific, technical, administrative and support service activities, and (13) community social and personal services (see [EUKLEMS](#) for further information).

¹⁰ The categories are: (1) computing equipment, (2) communications equipment, (3) computer software and databases, (4) transport equipment, (5) other machinery and equipment, (6) total non-residential investment, (7) residential structures, (8) cultivated assets, (9) research and development, and (10) other intellectual property products (IPP) (see [EUKLEMS](#) for further information).

policy uncertainty are included. This implies that in addition to output, other factors have played a role in driving investment down following the crisis. Identifying these impediments and focusing policies on removing them is thus warranted.

Panel regressions for OECD countries confirm the importance of leverage, competitiveness, and policy uncertainty variables for investment dynamics. Table 2 shows estimation results from the augmented accelerator model for a panel of OECD countries. Estimations for an annual data with 3 lags of output (equivalent of 12 quarterly lags used in the baseline specification) confirm the significance of lagged output. In addition:

- Non-financial corporate leverage has a negative and significant effect on investment, confirming that elevated leverage is another drag holding back investment (Kuchler 2015; IMF 2017a).
- The level of competitiveness, proxied by the price markup, also has a significant negative effect. This confirms that low level of competition adversely affects investment (Copenhagen Economics 2013a, 2013b, 2013c).
- Policy uncertainty, proxied by the level of uncertainty in the EU, also has a negative and significant effect. This is not surprising given the openness of the Danish economy.
- The impact of the product markets reform variable is insignificant, which could be driven by low variability of this extrapolated 5-year interval variable. Another reason could be that product market reforms tend to be responsive to developments in the real sector (including investment), which can lead to a reverse causality. In the next section, we explore the role of product market reforms in greater detail using the narrative database.

V. DIVING DEEPER: THE ROLE OF LEVERAGE AND PRODUCT MARKET REFORMS

We use two empirical methodologies to provide further evidence on the importance of leverage and product market reforms for investment. First, we employ the methodology of Gaspar and others (2016) to estimate a tipping point in leverage beyond which advanced economies have experienced a major slowdown in investment growth.¹¹ The analysis is performed using long time series on investment and leverage for the period 1870–2013. Second, we use the local projections methodology to analyze the impact of product market reforms on investment. Product market reforms are identified using the narrative methodology (IMF 2016b). We also use the difference-in-difference approach of Rajan and Zingales (1998) to explore mechanisms through which product market reforms affect investment.

¹¹ I would like to thank Philippe Wingender for sharing his codes.

A. Leverage and investment

High leverage is an impediment to investment. The augmented accelerator analysis suggests that leverage has negative impact on investment. This result corroborates firm level evidence on the negative association between leverage and investment (Kuchler 2015; IMF 2017a). In this section, we use long historical series on leverage and investment to assess a tipping point of leverage beyond which advanced economies have experience a major slowdown in long-run investment growth. We start by analyzing the historical dynamics of leverage and investment-to-GDP ratio¹² in Denmark and other advanced economies using the macrofinancial history database put together by Jorda and others (2017) for 17 advanced economies for the period 1870–2013.¹³ As shown in Figure 15, left panel, Denmark has historically been one of the most leveraged advanced economies. At the outset of the crisis, Denmark’s leverage reached historical peak of about 210 percent of GDP. In the meantime, investment-to-GDP ratio in Denmark has not matched the high levels of leverage (Figure 15, right panel). Since 1970s, investment-to-GDP ratio has been relatively low—one of the lowest among advanced economies. As discussed above, it dropped rapidly following the GFC and remains at the bottom of the distribution across advanced economies.

Regression discontinuity analysis suggests that long-run investment growth declines rapidly once leverage exceeds 87.8 percent of GDP. Following Gaspar and others (2016), we adopt a two-step regression discontinuity framework. First, we assess the impact of leverage on 15-year real investment growth, which we allow to vary discontinuously at the unique unknown threshold value γ .¹⁴ We also include long term interest rates (current and lagged) and country fixed effects as controls. The level of γ that maximizes the R-squared of the regressions is the tipping point, which is estimated at 87.8 percent (Figure 16, left panel). Second, we illustrate graphically the investment effect of crossing the tipping point of leverage. Figure 16, right panel, presents: (i) average 15-year real investment growth within bins equal to 1 percent of leverage, (ii) predicted values from a local linear regression with bandwidth of 3, and (iii) predicted values from a global fourth-order polynomial regression that includes leverage fully interacted with the threshold variable as a dependent variable. The picture shows clearly that investment growth drops rapidly and even becomes negative from the 87.8 percent discontinuity point onward. Given that Denmark’s leverage level is currently above 200 percent of GDP, this analysis indicates that it is an impediment to long-run investment growth.

¹² Ideally, we would have preferred to use different components of investment and leverage (corporate sector, households, etc.). However, such a breakdown is not available in the macrofinancial history database.

¹³ The database is available at: <http://www.macrohistory.net/>. 17 countries included in the sample are: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK, and the US.

¹⁴ Following Gaspar and others (2016), we exclude outliers of leverage (below 5th and above 95th percentiles).

B. Product market reforms and investment

Product market reforms can boost investment. IMF (2016b) shows that product and labor market reforms raise long-term output by boosting productivity and employment, which in turn can encourage more investment especially by firms that are not constrained by high leverage. We provide evidence on the impact of PMR on investment using data for total economy and individual sectors using a methodology similar to that adopted for analyzing output in IMF (2016b) and IMF (2017b). Intuitively, if product market reforms boost output, they should also boost investment to support the expansion in output. Product market reforms can affect investment in several ways, including through lowering markups, reducing costs of capital adjustment, and affecting the ownership structure (Alesina and others 2005). We use three empirical specifications to analyze the relationship between product market reforms and investment.

Model 1: Country-level reforms and aggregate investment. The empirical specification takes the following form:

$$ri_{c,t+h} - ri_{c,t-1} = \alpha_c + \gamma_t + \beta_h R_{c,t} + \theta_h X_{c,t} + \varepsilon_{c,t}$$

where $ri_{c,t+h}$ is the log of real investment in country c and period t . The model is estimated for yearly horizons $h=0, 1, \dots, 5$. α_c are the country fixed effects included to take account of country-specific differences in average investment growth rates, γ_t are time fixed effects included to take account of global shocks affecting the global business cycle and investment, R is a binary variable indicating the occurrence of a product market reform, and X is the set of control variables, including lagged aggregate investment growth, lagged recession dummies defined as growth below -3 percent (following IMF 2017b). The latter are included to control for a possible correlation between cyclical developments, aggregate investment dynamics and reforms (IMF 2016b). The main coefficient of interest is β_h , which indicates the cumulative response of the log of aggregate real investment in period $t+h$ to product market reforms implemented in period t relative to a no reform baseline.

Figure 17, left panel, presents the results from model 1. Product market reforms have a statistically significant impact on investment in the medium-term. This complements the earlier positive results on the impact of reforms on output. On the 5th year following from the reform, real investment is 4.5 percentage points higher relative to where it would have been if the reform did not take place.

Model 2: Country-level reforms and sectoral investment. The empirical specification takes the following form:

$$ri_{c,s,t+h} - ri_{c,s,t-1} = \alpha_{c,s} + \gamma_{st} + \beta_h R_{c,t} + \theta_h X_{c,s,t} + \varepsilon_{c,s,t}$$

where $ri_{c,s,t+h}$ is the log of real investment country c , sector s , and period t . The model is estimated for yearly horizons $h=0, 1, \dots, 5$. $\alpha_{c,s}$ are the country-sector fixed effects included to take account of sector-specific differences in average investment growth rates within individual countries, γ_{st} are sector-time fixed effects included to take account of global shocks

affecting the sector-specific business cycle and investment, R is a binary variable indicating the occurrence of a product market reform, and X is the set of control variables, including lagged sectoral investment growth, lagged recession dummies defined as growth below -3 percent (following IMF 2017b). The latter are included to control for a possible correlation between cyclical developments, sectoral investment dynamics and reforms (IMF 2016b). The main coefficient of interest is β_h , which indicates the cumulative response of the log of sectoral real investment in period $t+h$ to product market reforms implemented in period t relative to a no reform baseline.

Figure 17, right panel, presents the results from model 2. It shows that product market reforms have a statistically significant impact on investment at the sectoral level in the medium-term. Real investment in an average sector gains about 4 percentage points relative to the no-reform baseline. This average effect can mask substantial heterogeneity across sectors with different exposures to product market regulation.

Model 3: Country-level reforms and sectoral investment accounting for sectoral exposure (difference-in-difference estimator). Following Rajan and Zingales (1998), the empirical specification takes the following form:

$$ri_{c,s,t+h} - ri_{c,s,t-1} = \alpha_{c,s} + \gamma_{s,t} + \beta_h(Exp_s * R_{c,t}) + \theta_h X_{c,s,t} + \varepsilon_{c,s,t}$$

where the main difference from the previous specification is that the reform dummies are multiplied by the term Exp_s . The latter is the sector-specific “natural” turnover rate (the sum of firm entry and exit rates), which is taken from the U.S. Bureau of Labor Statistics (Andrews and Cingano 2014).¹⁵ Sectors with relatively higher “natural” turnover rates are expected to be more bound by product market regulations compared to sectors with relatively lower “natural” turnover rate. Hence, the coefficient β_h represents the cumulative difference-in-difference effect of the impact of reforms on investment in higher “natural” exposure sectors relative to lower “natural” exposure sectors in period $t+h$. In the empirical analysis, we estimate the investment gain from reforms between a sector with a relatively high “natural” turnover rate (at the 75th percentile of the cross-sector distribution of turnover rates in the U.S.) and a sector with a relatively low “natural” turnover rate (at the 25th percentile of the cross-sector distribution of turnover rates in the U.S.).

Figure 18 presents the results from model 3. It shows that product market reforms tend to increase investment in sectors that have higher propensity of turnover relative to those with a lower propensity. At the 5th year following the reform, the cumulative investment gain is about 0.8 percent. These results confirm the positive effects obtained in the previous analysis.

Further deregulation of network and retail sectors can help boost investment in Denmark. As shown in the empirical analysis above, PMR has a strong impact on investment, while

¹⁵ A similar exercise for labor market reforms and employment was performed by Duval and others (2017).

Denmark's standing in the OECD's overall PMR indicator is above OECD average. To explore areas where Denmark can make further progress in deregulating product markets we looked at the components of the product market reform index in 2013—the latest year of the OECD survey. Figure 19 shows that there is scope to improve Denmark's PMR standing in network sectors (electricity, rail, telecom, postal, and gas) relation to OECD EU frontier in areas of entry barriers, public ownership, vertical integration, and market structure. Similar picture emerges when looking at the retail sector, in areas of licenses/permits needed, regulation of large outlets, protection of existing firms, regulation of opening hours, and price controls.

VI. CONCLUSIONS

The post-GFC weakness in Denmark's aggregate investment cannot be fully explained by the output slowdown. The baseline accelerator model confirms that output slowdown played a role, but post-GFC investment has fallen beyond the level explained by output movements in most of the post-GFC period. Most recently, investment converged to the level explained by output movements, but one would have expected much stronger investment given the record low interest rates. The augmented accelerator model suggests that additional factors, such as high leverage, weak competition, and elevated policy uncertainty, also had a significant impact. Panel regressions using a panel of advanced economies show that reduction in leverage and product market reforms can boost investment in the medium term.

Well-designed policies are needed to boost private investment. Policy actions should target the following areas:

- *Reduce debt-bias.* Leverage has increased at the outset of the crisis and despite recent declines remains elevated. Tax policy measures aimed at reducing “debt-bias” would reduce the vulnerabilities of the private sector to shocks and would promote additional investment.¹⁶
- *Enhance competition.* As mentioned in Copenhagen Economics (2013a, 2013b, 2013c) and IMF (2016c), regulations could be eased further in some sectors. The gap from OECD EU countries is particularly high in regulations pertaining to network and retail sectors. The breakdown of the OECD index suggests further scope for deregulation in areas of public ownership, vertical integration, and market structure. For the retail sector, regulation in Denmark is most restrictive in areas of licensing, large outlets, protection of existing firms, shop opening hours, and price controls. For instance, the call from the Productivity Commission to liberalize the Planning Act to allow the construction of hypermarkets that combine supermarkets and department stores seems warranted.

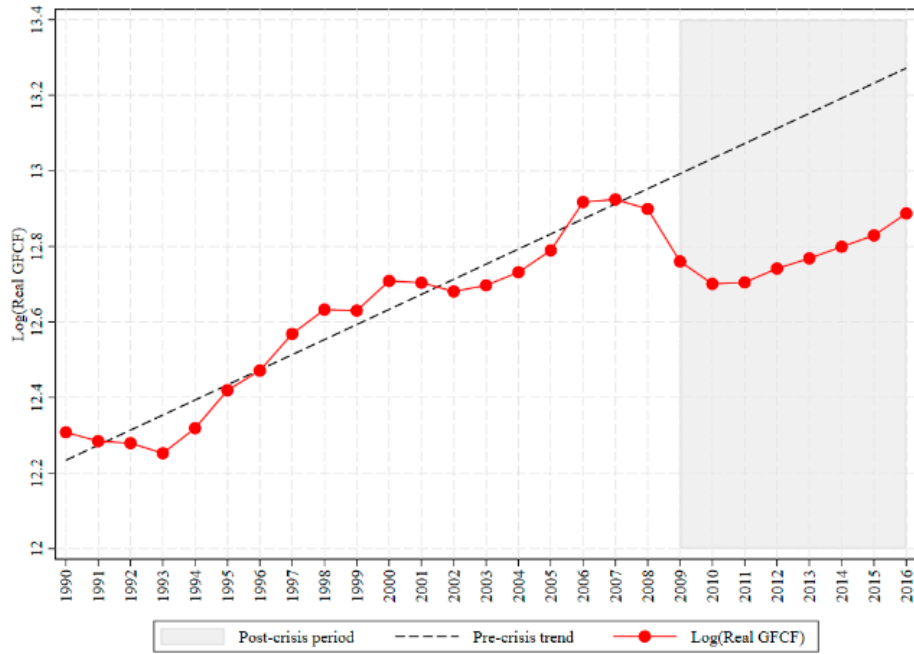
Higher investment would help address two macro-critical issues. First, higher investment would increase capital-labor ratio and boost labor productivity, which in turn would lead to

¹⁶ See Denmark's 2018 AIV Selected Issues Chapter “Capital Income Tax Reform Options in Denmark” for details of tax policy measures.

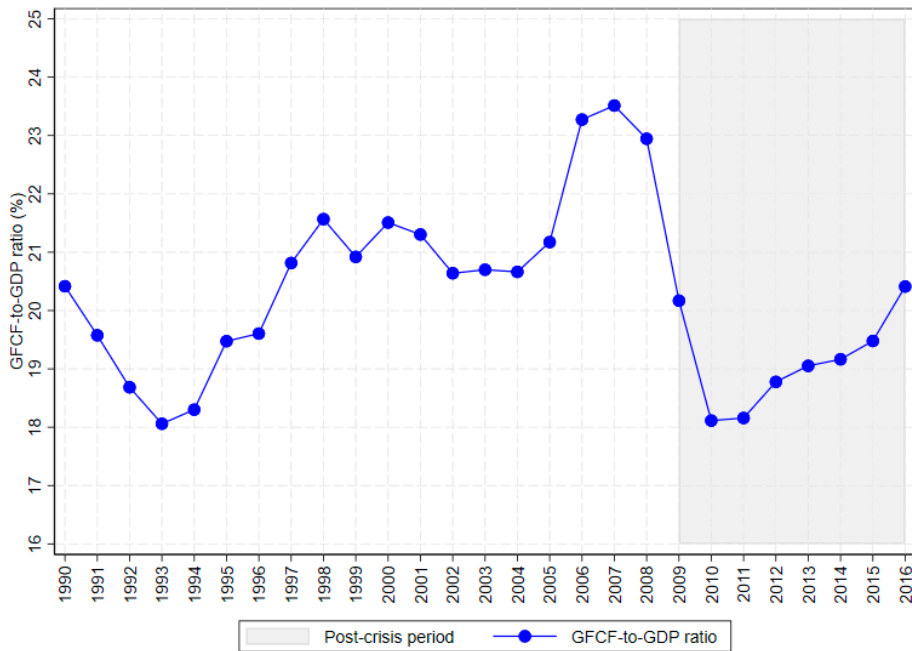
higher output and economic prosperity. Counterfactual simulations suggest that 2 percentage points higher annual real investment over the 2018-22 period would result in 0.7 percent higher real output relative to the baseline in 2022. Second, higher investment supported by PMR reforms would help reduce current account surplus. This is clear from the national accounts identity, but is also supported by theoretical and empirical studies. For instance, Cacciatore and others (2016) develop a New Keynesian model which shows that PMR reforms would increase firm entry and boost investment, which in turn would reduce current account balance. In addition, Culiuc and Kyobe (2017) use local projections methodology to show that PMR reforms in advanced economies have a negative short-term effect on the current account balance.

Figure 1. Dynamics of Gross Fixed Capital Formation (GFCF)

Real GFCF has declined by 20 percent between 2007–10, resulting in a downward level shift.



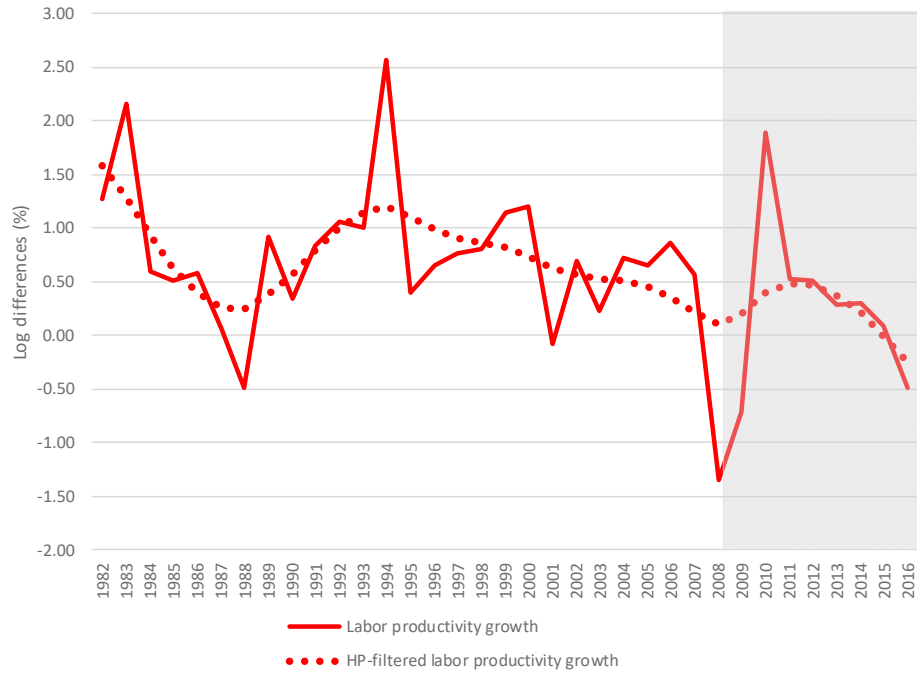
As a share of GDP, GFCF declined by 5.4 percent from peak to trough between 2007–10.



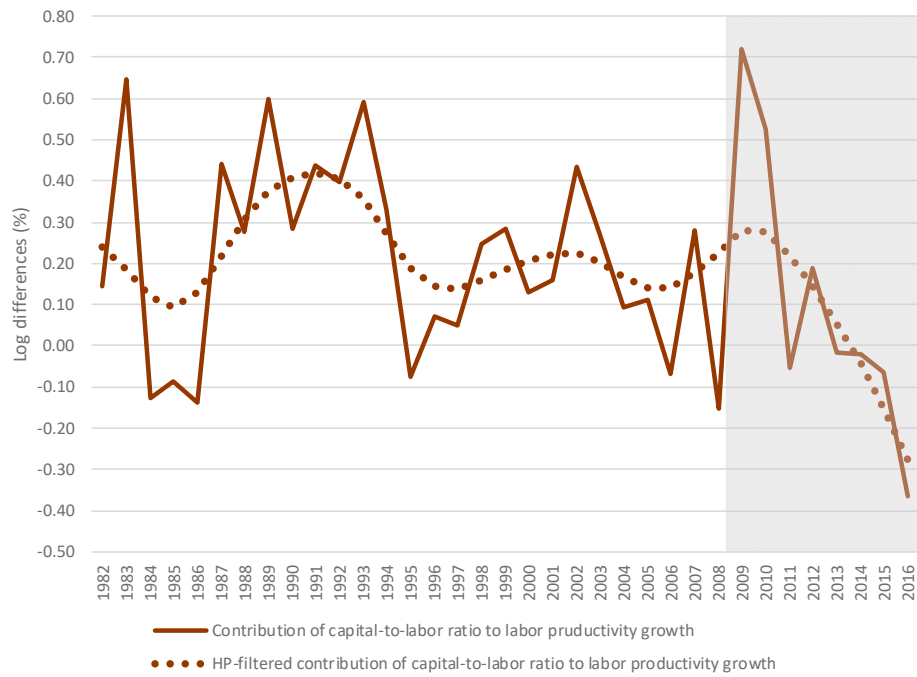
Source: Eurostat and IMF Staff calculations.

**Figure 2. Implications of the Investment Slowdown:
Drop in Labor Productivity Growth**

The decline in GFCF-to-GDP ratio was associated with a slowdown in labor productivity growth...



... suppressed by a slowdown of contributions from the capital-to-labor ratio.

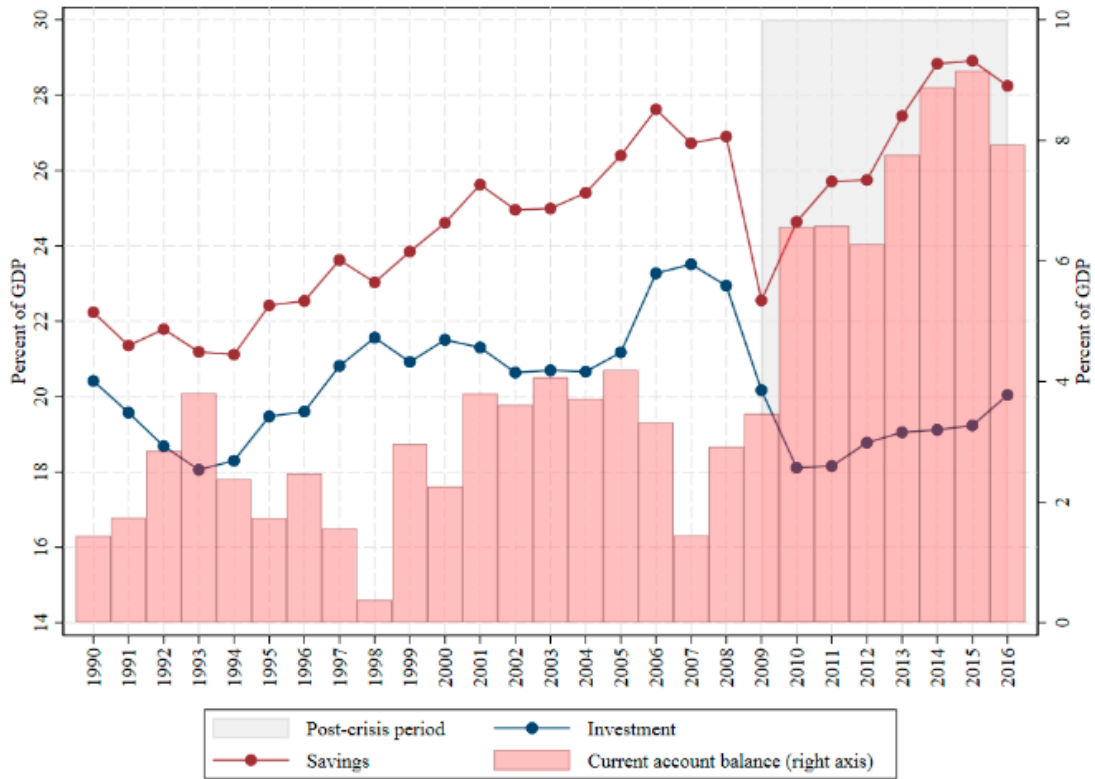


Source: Eurostat and IMF Staff calculations

Note: Labor productivity is defined as the ratio of real GDP and employment.

Figure 3. Implications of the Investment Slowdown: Surge in the Current Account Surplus

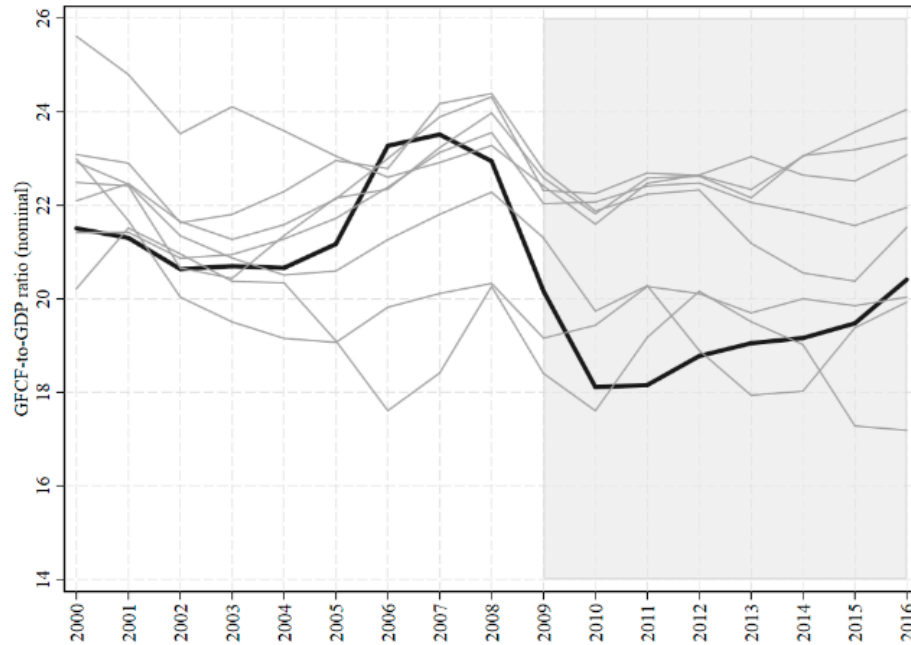
The expansion in the current account surplus between 2007–16 was largely driven by weaker investment.



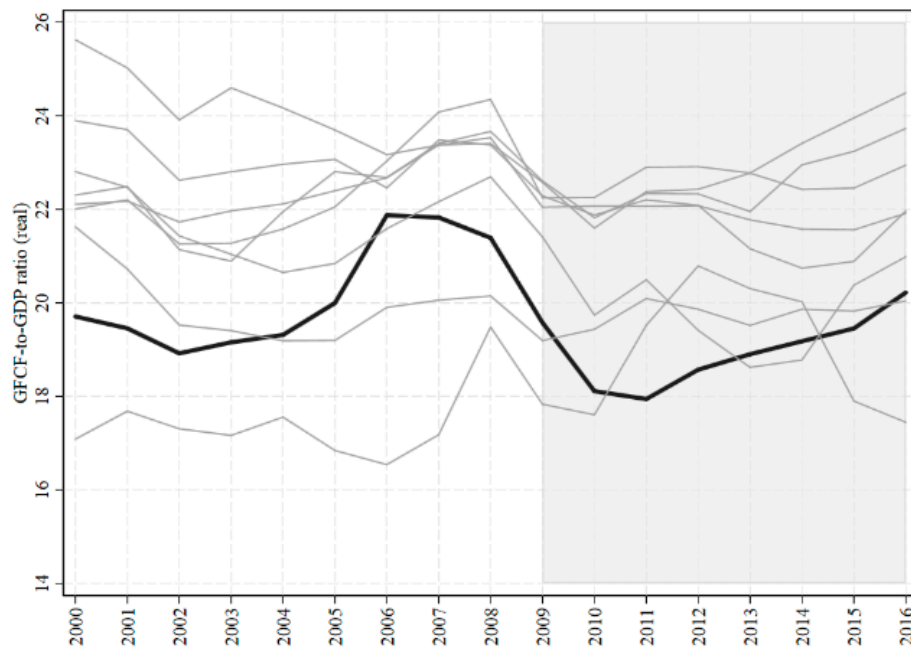
Source: Eurostat and IMF Staff calculations.

Figure 4. GFCG/GDP Ratio: Comparison of Denmark with EU Peers

Nominal GFCF/GDP ratio: the decline in Denmark is pronounced and stands out relative to EU peers, also in terms of low post-GFC levels.



Real GFCF/GDP ratio: the decline in Denmark is not as pronounced as for the nominal ratio, but still stands out relative to EU peers.

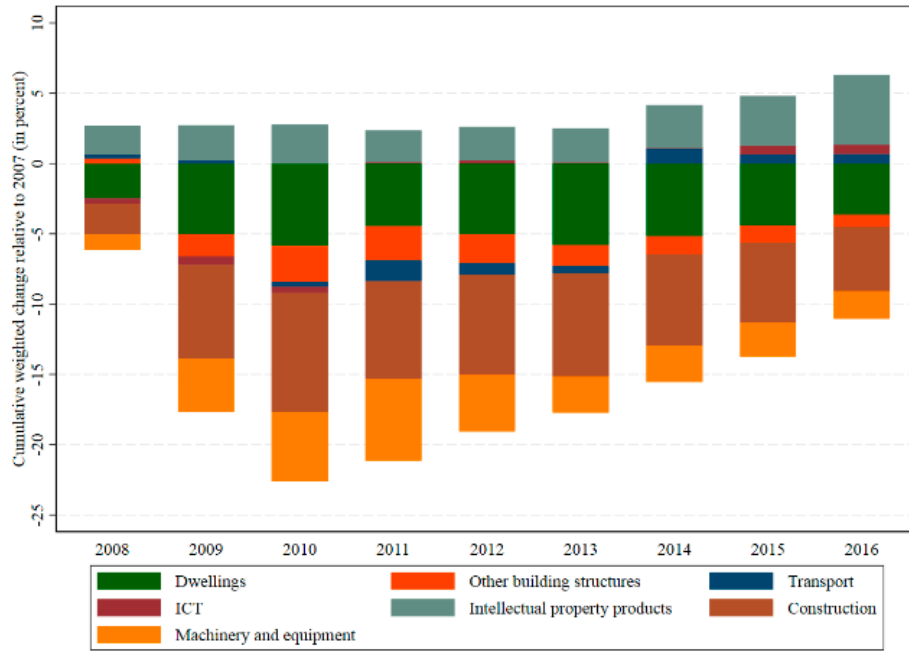


Source: Eurostat and IMF Staff calculations.

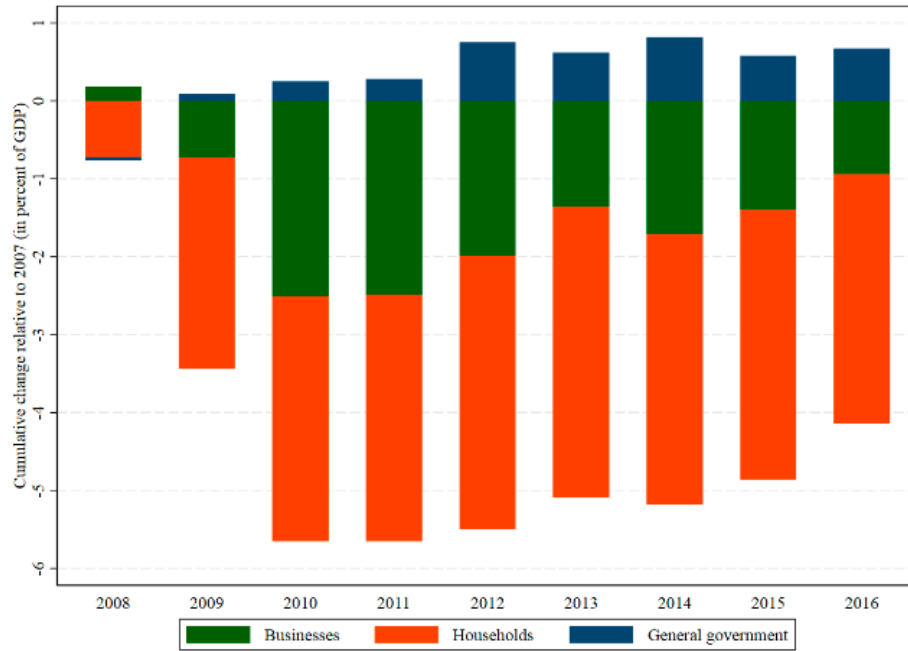
Note: Boldfaced line represents Denmark. EU peers are Austria, Belgium, Finland, France, Germany, Luxembourg, the Netherlands, and Sweden.

Figure 5. Components Driving the Decline in GFCF

By asset classes: the decline was broad-based, except for investment in intellectual property products.



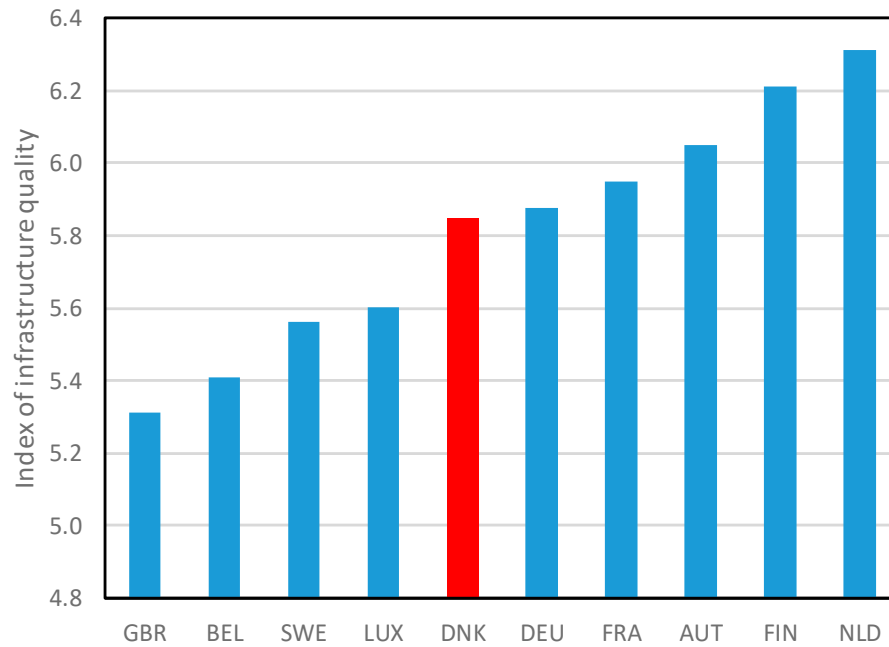
By institutional sectors: the decline was mainly driven by the private sector, while public investment expanded.



Source: Eurostat and IMF Staff calculations.

Figure 6. Quality of Infrastructure and Public Capital Spending

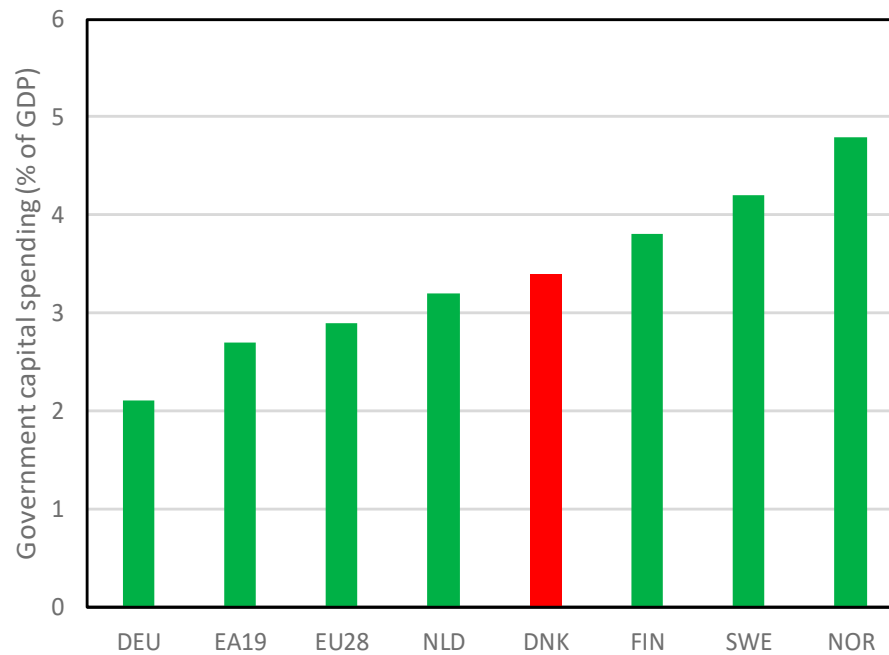
Denmark's infrastructure quality is ranked 12th best in the world, but in comparison to EU peers it is in the middle.



Source: World Economic Forum report (2015–16).

Note: 1=lowest quality, 7=highest quality.

Public capital spending-to-GDP ratio in Denmark is one of the highest among EU peers.

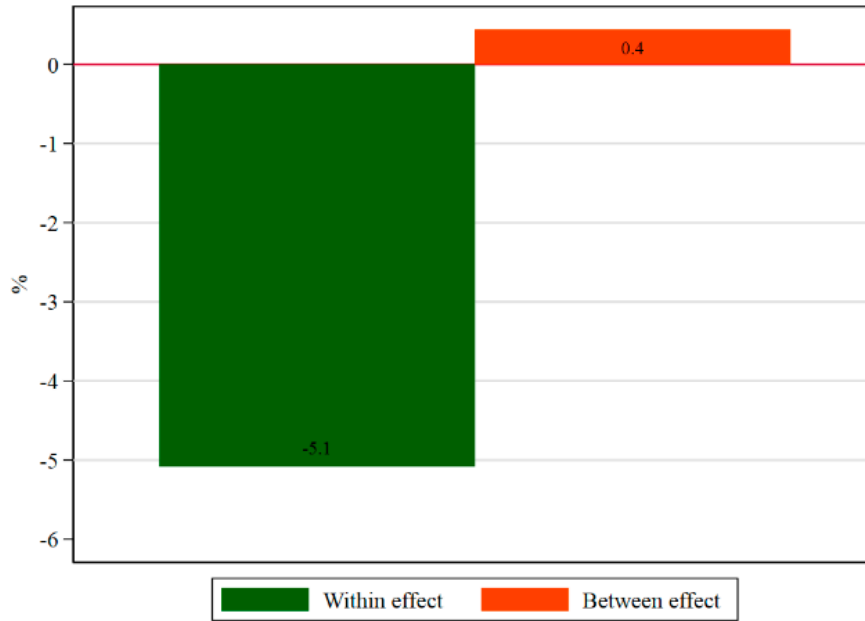


Source: OECD and IMF Staff calculations.

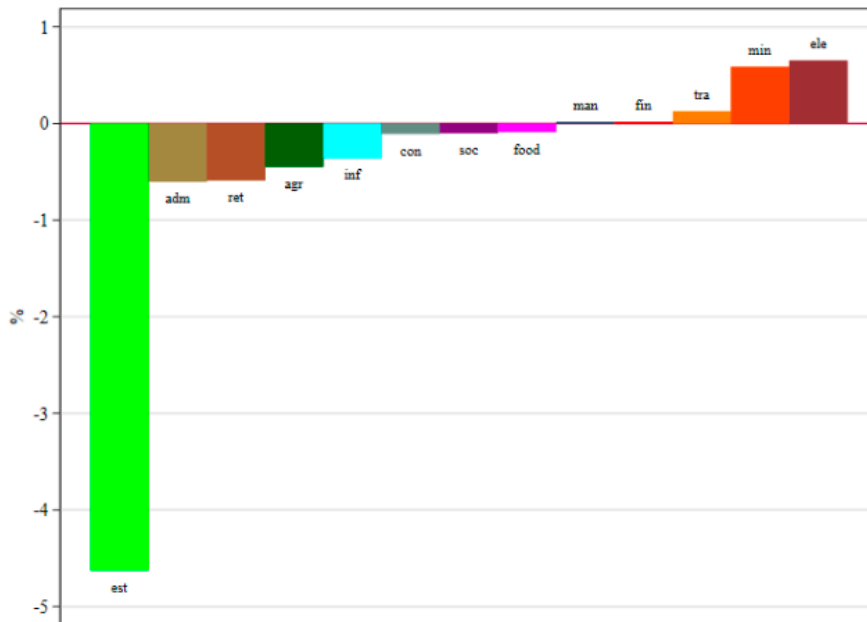
Note: Reported are the data for 2016.

Figure 7. Decomposition of Investment Decline (2007–16)

The decline in GFCF-to-GVA ratio of 4.7 percent over 2017–16 was mainly driven by within factors (5.1 percent).



The increase in GFCF-to-GVA ratio in some sectors was more than offset by the decline in other sectors.



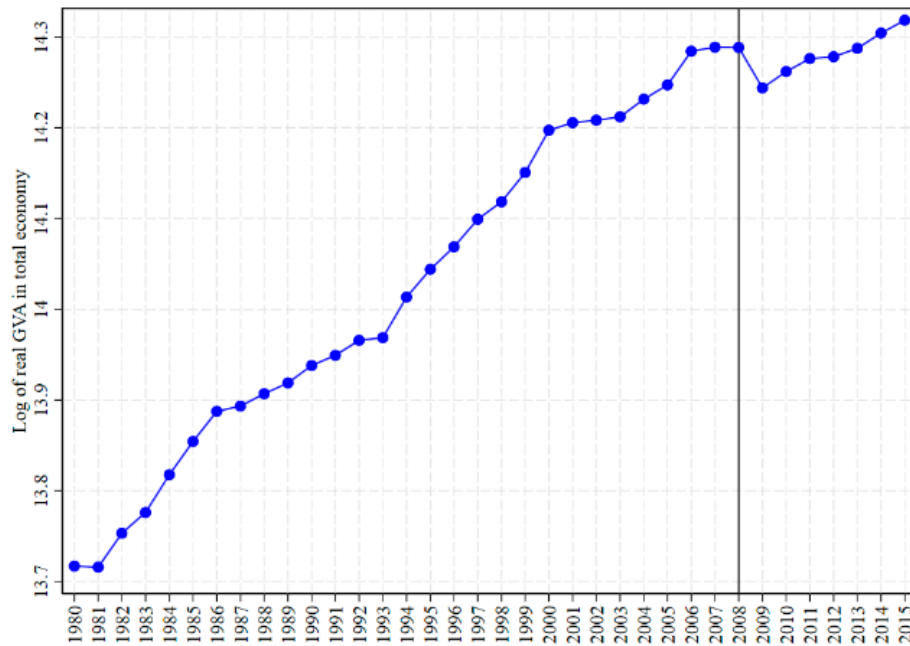
Source: EUKLEMS and IMF Staff calculations.

Note: sectoral abbreviations are as follows:

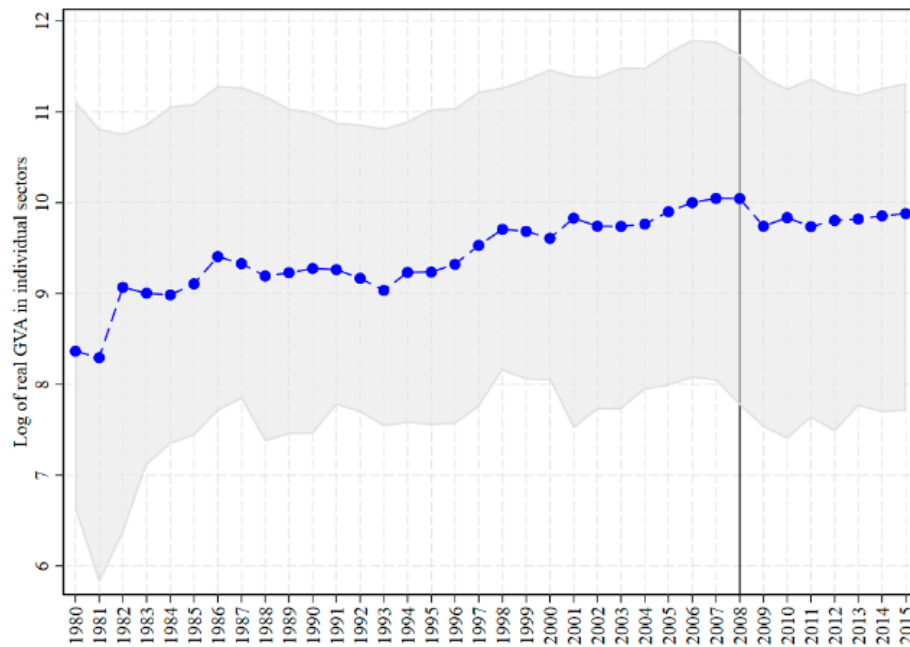
agr=agriculture, forestry, and fishing; min=mining and quarrying; man=manufacturing; ele=electricity, gas, and water supply; con=construction; ret=wholesale and retail trade, repair of motor vehicles and motorcycles; tra=transportation and storage; food=accommodation and food service activities; inf=information and communication; fin=financial and insurance activities; est=real estate activities; adm=professional, scientific, technical, administrative and support service activities; soc=community social and personal services.

Figure 8. Output Dynamics in Denmark

Aggregate gross value added (GVA) has shown a downward shift following the crisis...



... with a similar downward shift observed in individual sectors.

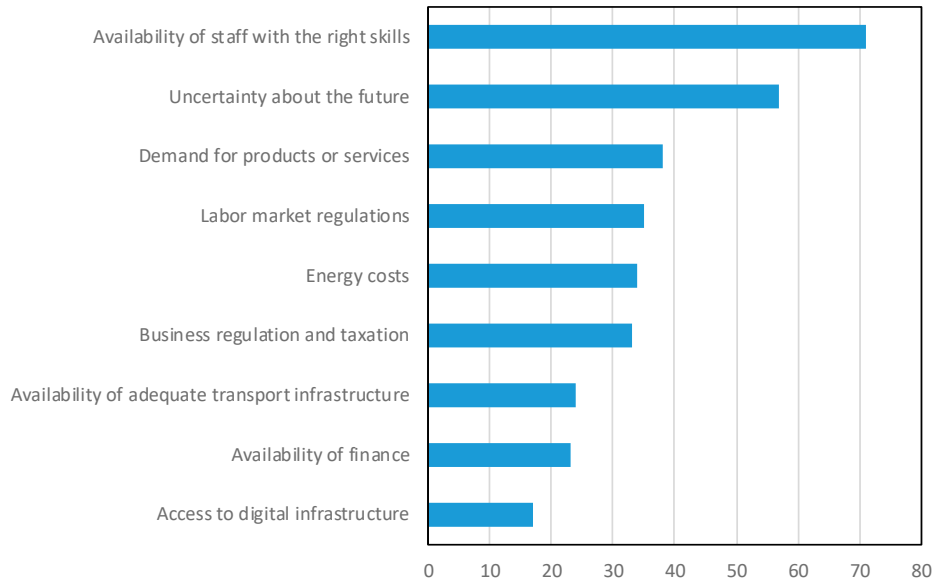


Source: EUKLEMS and IMF staff calculations.

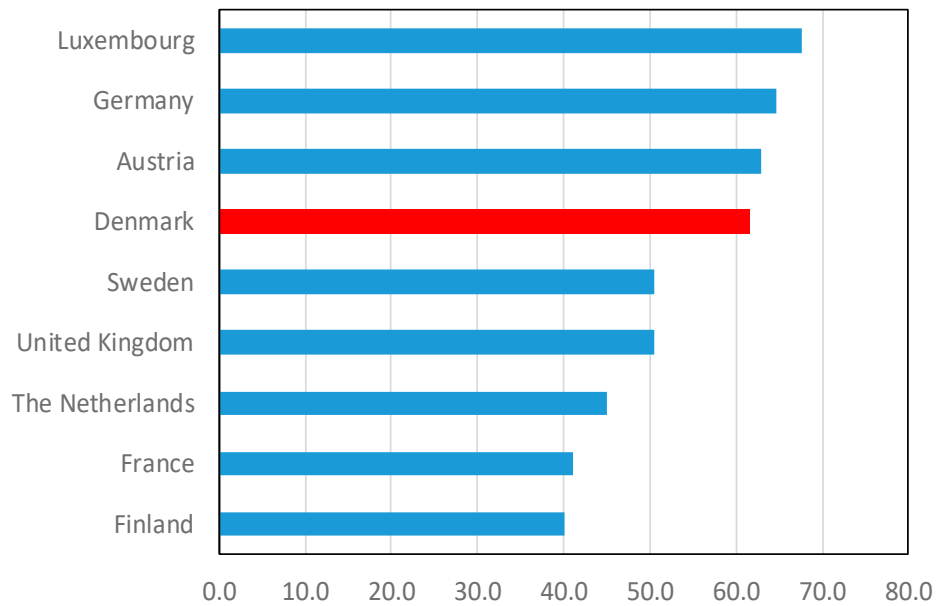
Note: The vertical line represents the start of the GFC. Reported is the minimum-maximum range across sectors (grey area) and median across sectors (blue line).

Figure 9. Investment Constraints in Denmark: Evidence from a Firm Survey

Skilled labor shortages and uncertainty are the largest investment constraints in Denmark.



Capacity constraints in Denmark rank high among EU peers.

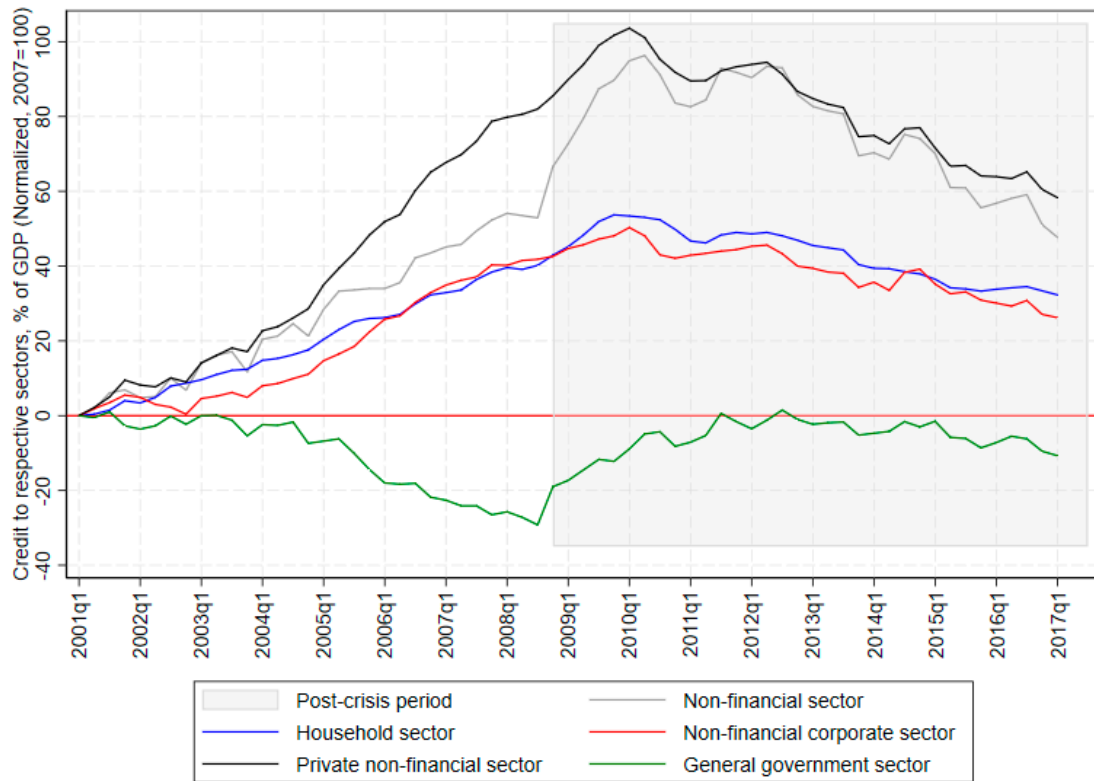


Source: EIB – EIBIS 2017 survey.

Note: Reported is the share of firms responding positively.

Figure 10. Leverage in Various Sectors

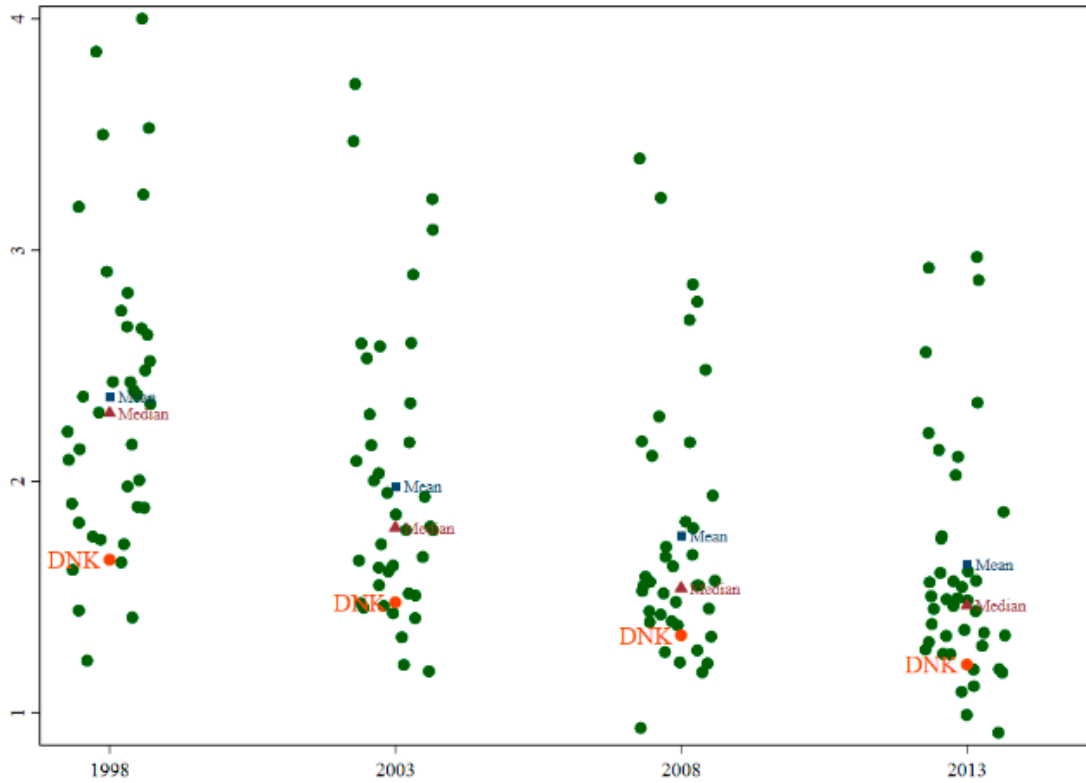
Leverage in Denmark has seen a sizeable expansion since 2001 in all sectors, except general government.



Source: BIS and IMF Staff calculations.

Figure 11. Product Market Regulation: Denmark versus OECD Countries

PMR in Denmark are relatively less restrictive compared to OECD, but there is scope for further improvement.

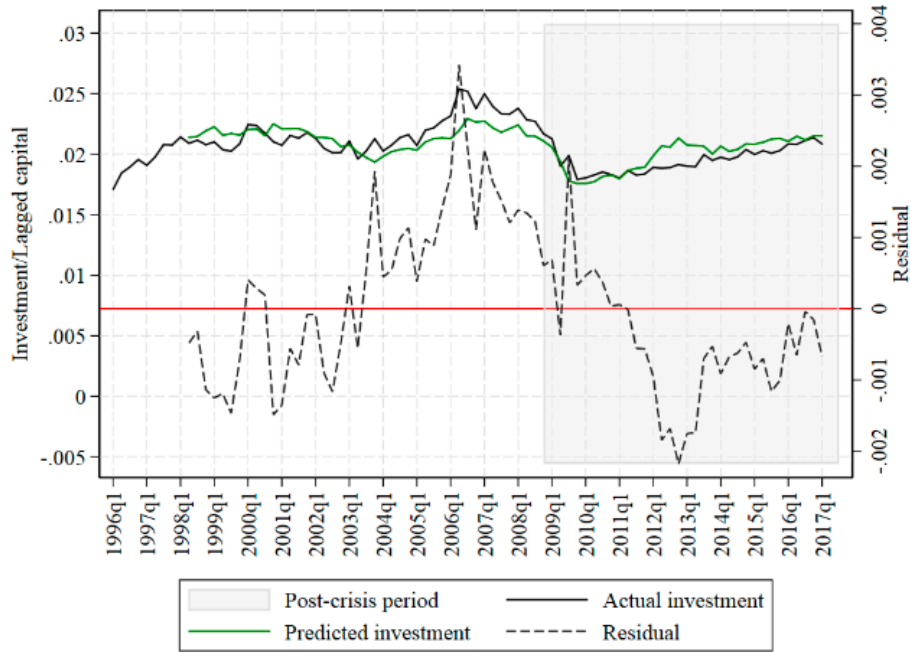


Source: OECD.

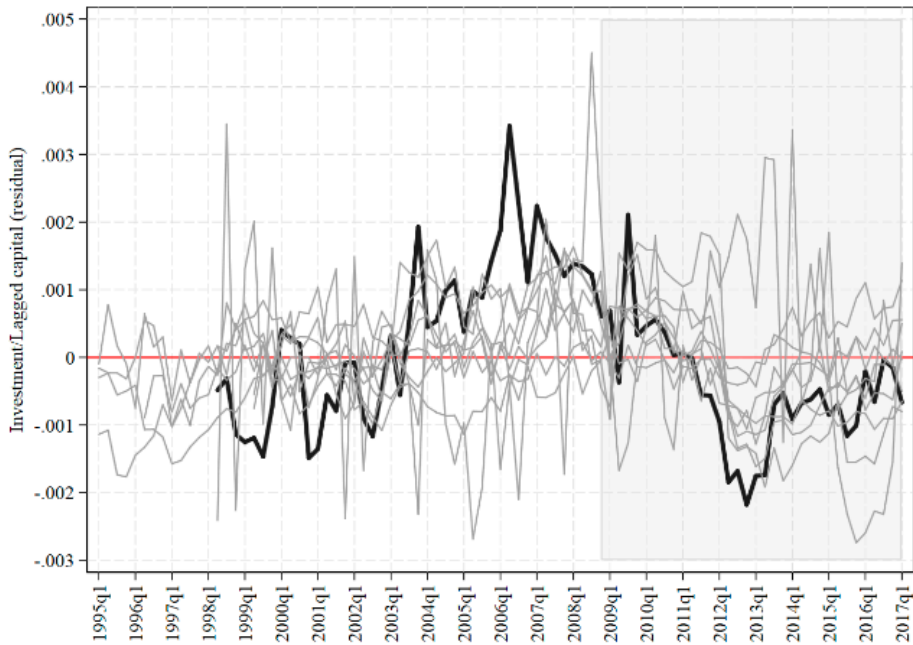
Note: Product market regulation (PMR) index is ranging between 0 (least restrictive) and 6 (most restrictive).

Figure 12. Residuals from the Baseline Accelerator Model

GFCF in Denmark has fallen short of the level explained by output movements in most of the post-GFC period.



The unexplained decline of GFCF in Denmark was more pronounced relative to that of EU peers.

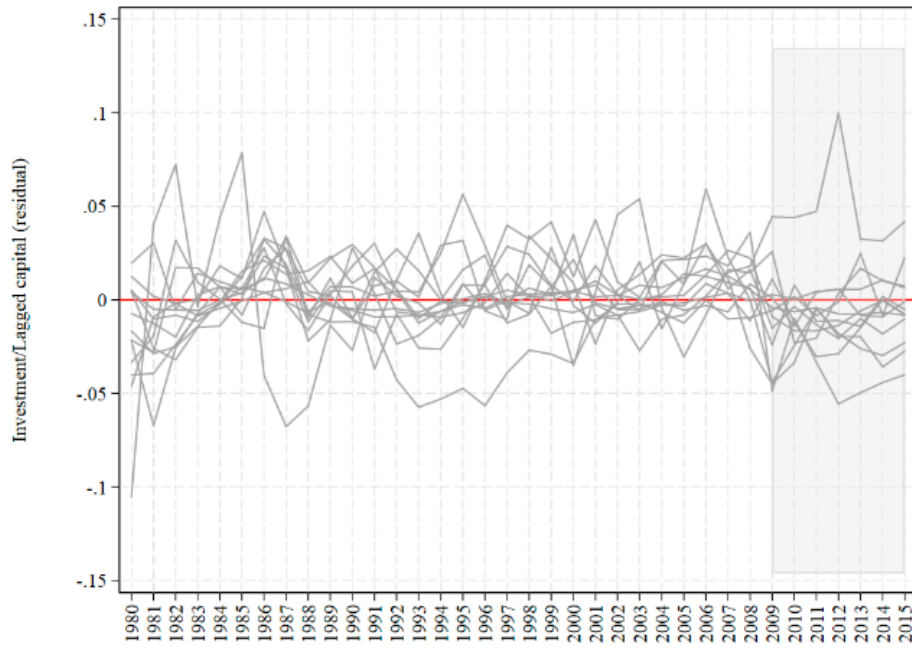


Source: EUKLEMS and IMF Staff calculations.

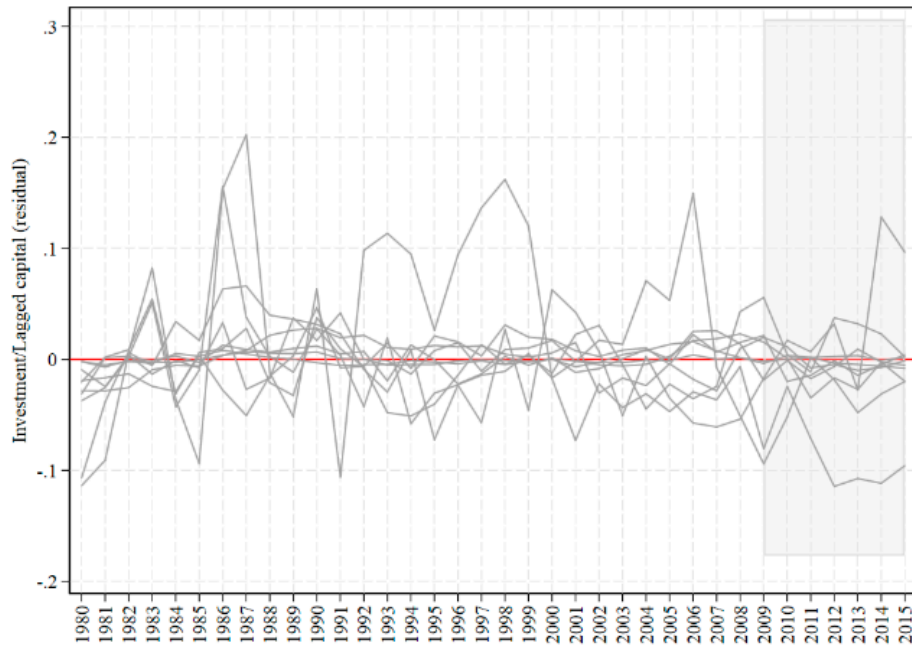
Note: The boldfaced line represents Denmark. Grey lines represent 9 peers: Austria, Belgium, Finland, France, Germany, Luxembourg, Netherlands, Sweden, and the UK.

Figure 13. Residuals from the Baseline Accelerator Model: By Sectors and Categories

GFCF by 13 sectors.



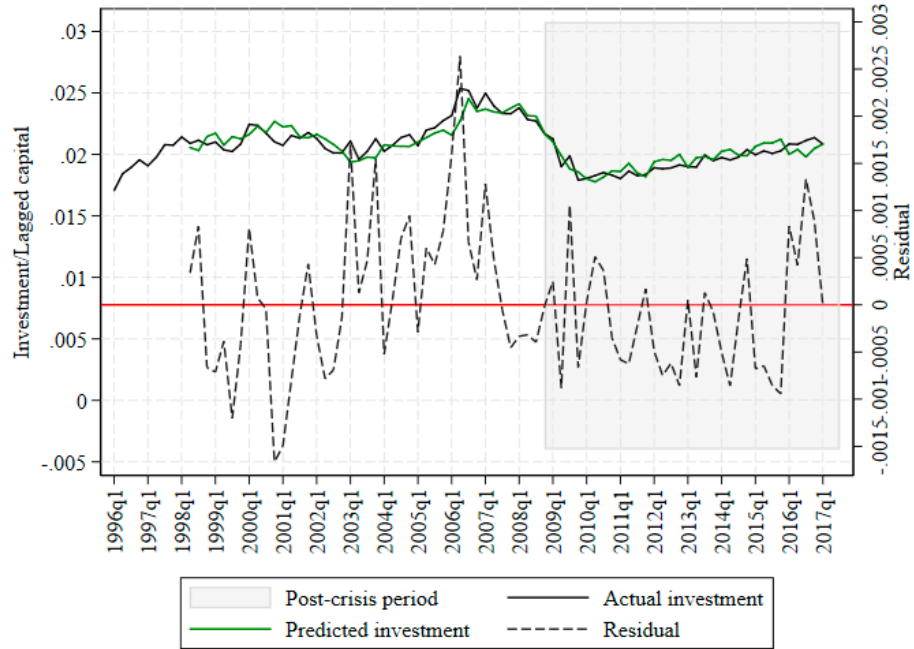
GFCF by 10 investment categories.



Source: EUKLEMS and IMF Staff calculations.

Figure 14. Residuals from the Augmented Accelerator Model

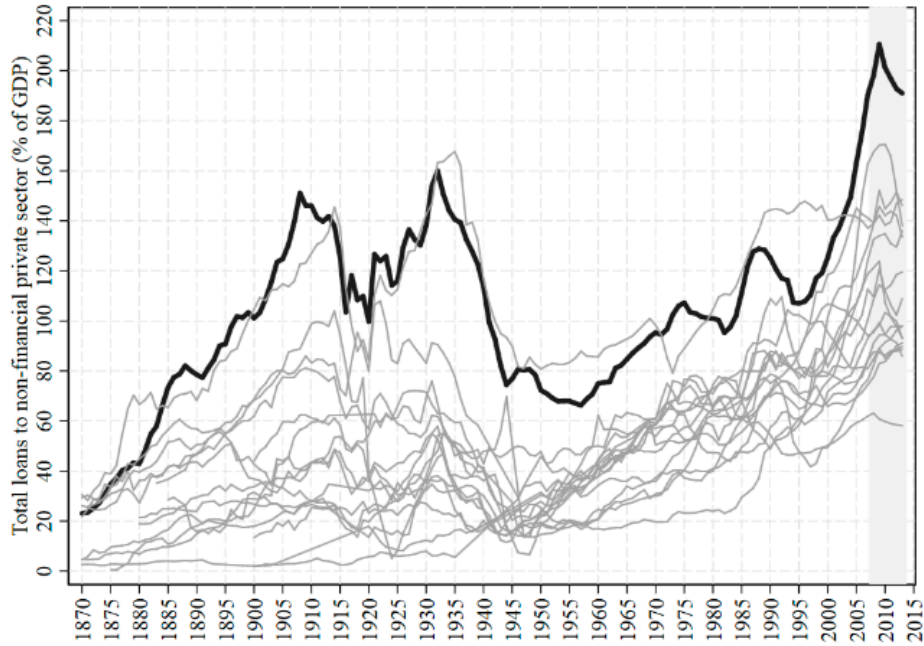
Inclusion of additional controls removes the persistence of negative residuals following the GFC.



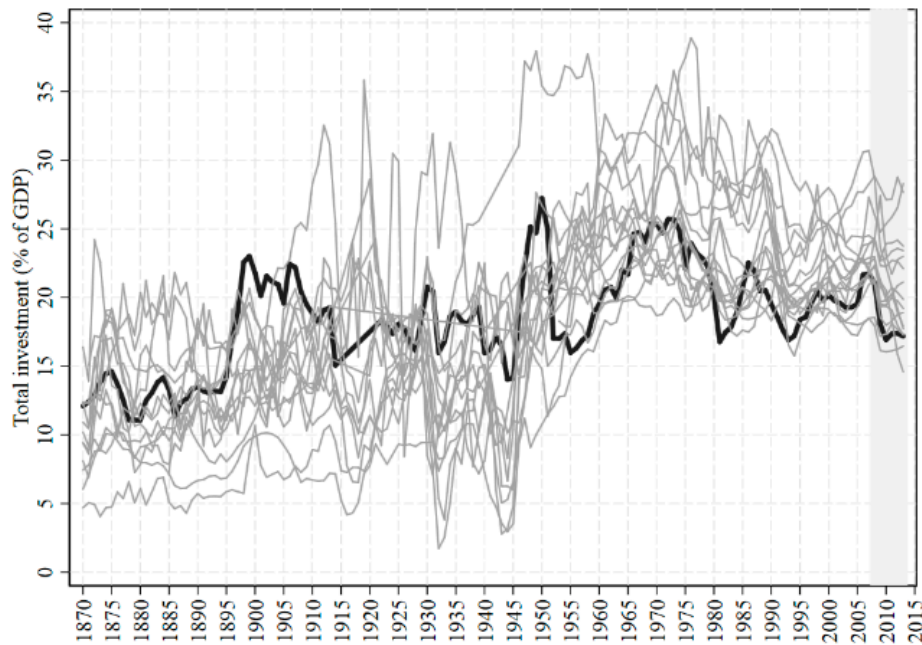
Source: Eurostat and IMF Staff calculations.

**Figure 15. Leverage and Investment-to-GDP Ratio:
Historical Comparison of Denmark and Other Advanced Economies**

Denmark has historically been one of the most leveraged advanced economies...



... but investment-to-GDP ratio has lagged that of other advanced economies, especially more recently.

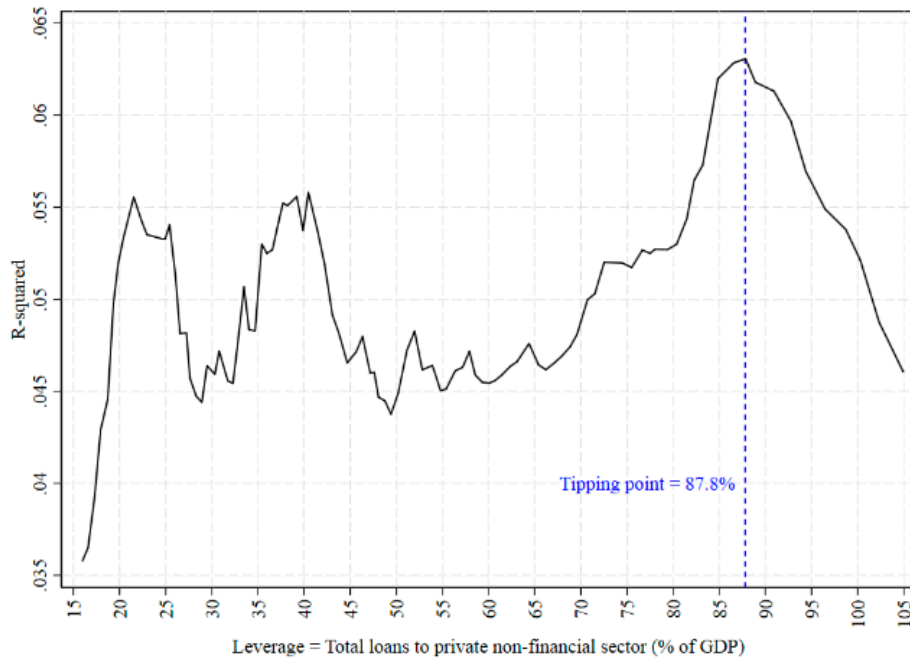


Source: Macrofinancial history database, Jorda and others (2017).

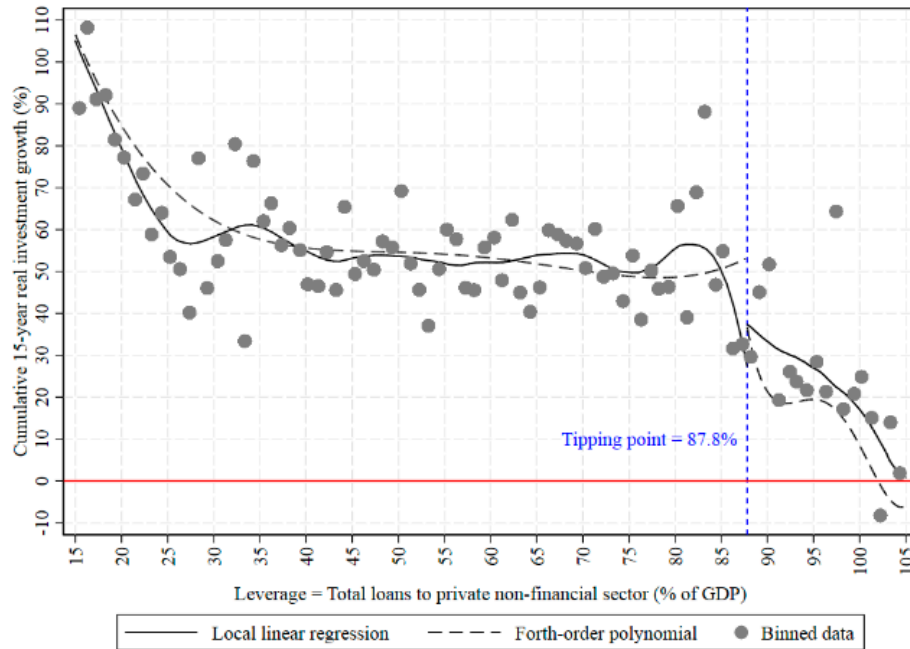
Note: Reported are series from 17 advanced economies. The boldfaced line represents Denmark

Figure 16. Leverage and Long-run Investment Growth: Estimating the Tipping-point

Leverage tipping point.



Impact on 15-year real investment growth.

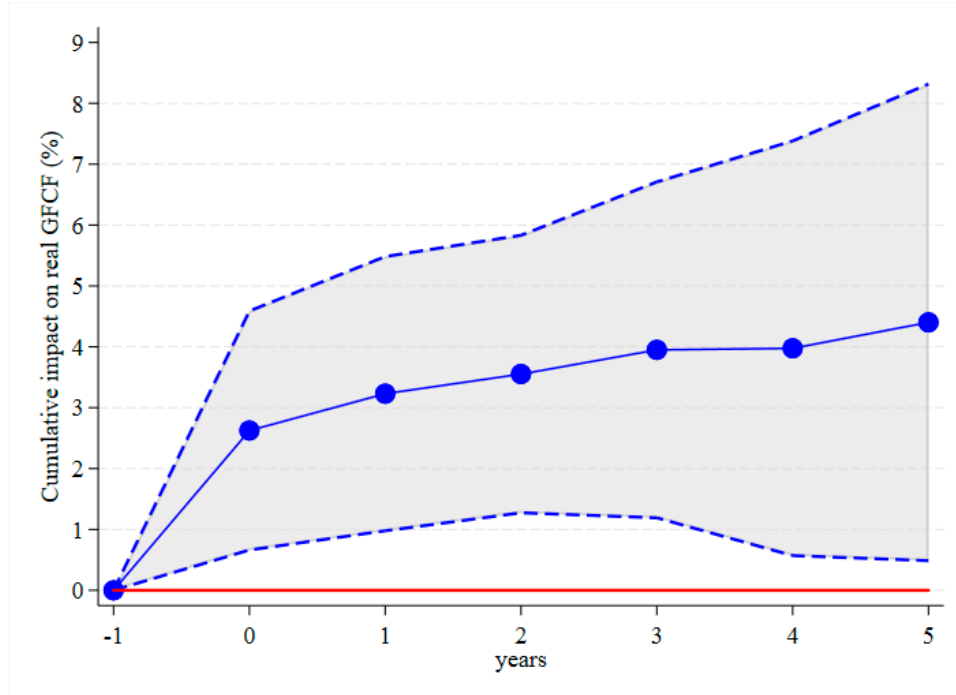


Source: Macrofinancial history database, Jorda and others (2017), and IMF Staff calculations.

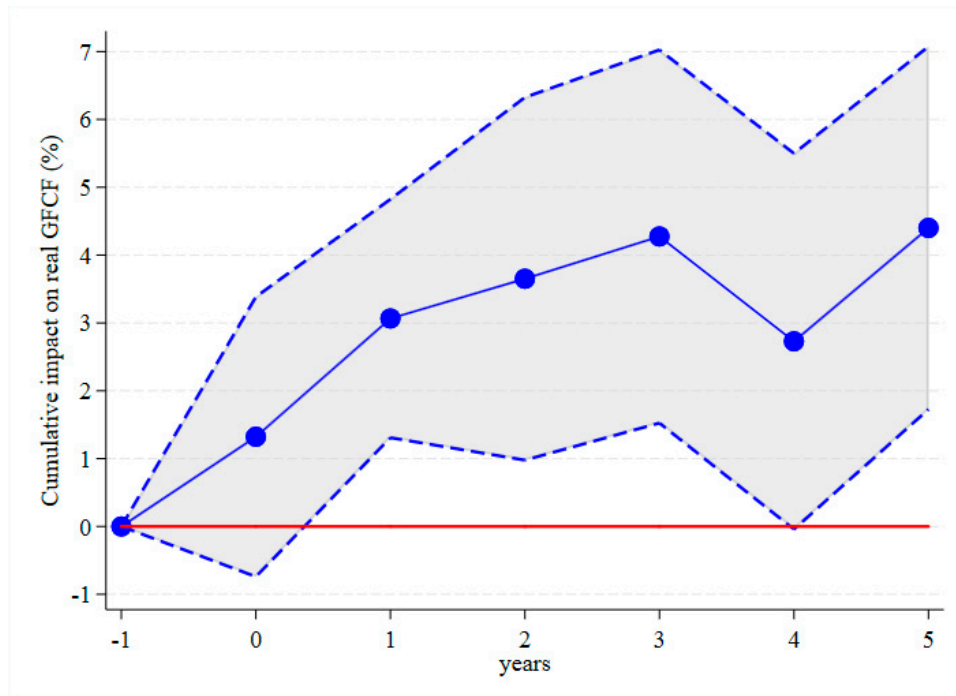
Note: Gaspar and others (2016) provide details of the estimation methodology.

Figure 17. Cumulative Impact of Product Market Reforms on Investment

Model 1: Country-level reforms and aggregate investment.



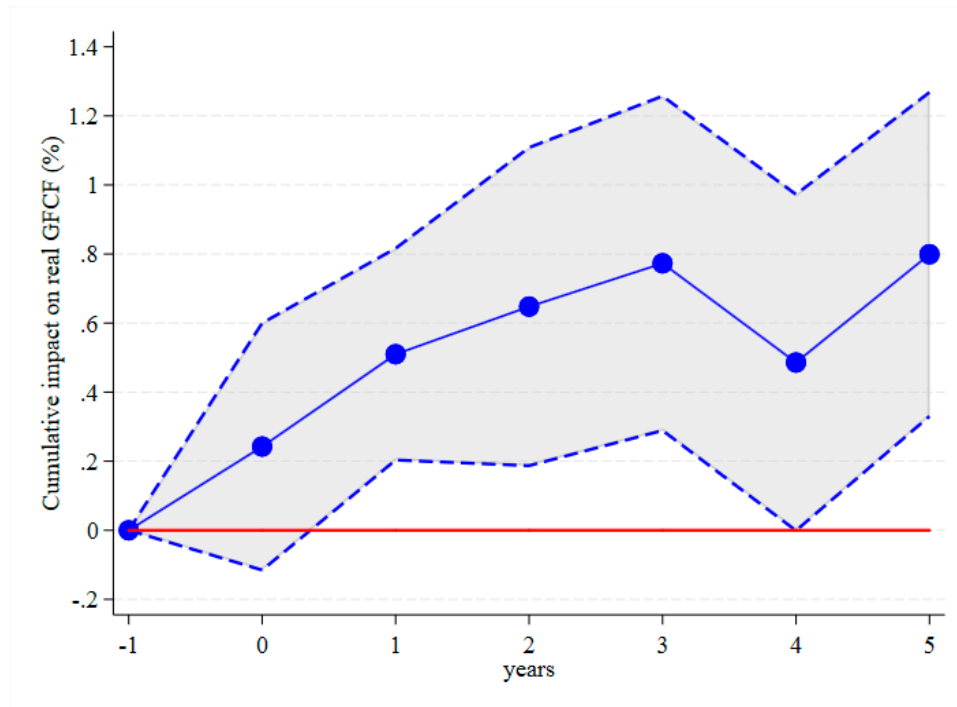
Model 2: Country-level reforms and sectoral investment.



Source: EUKLEMS, Duval and others (2018), and IMF Staff calculations.

Figure 18. Cumulative Impact of Product Market Reforms on Investment: Difference-in-Difference Approach

Model 3: Country-level reforms and sectoral investment accounting for sectoral exposure (difference-in-difference estimator).

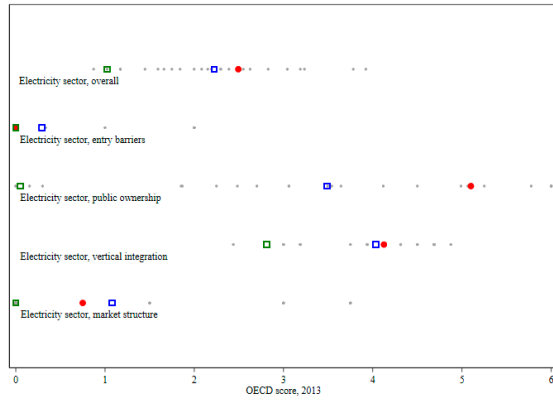


Source: EUKLEMS, Duval and others (2018), and IMF Staff calculations.

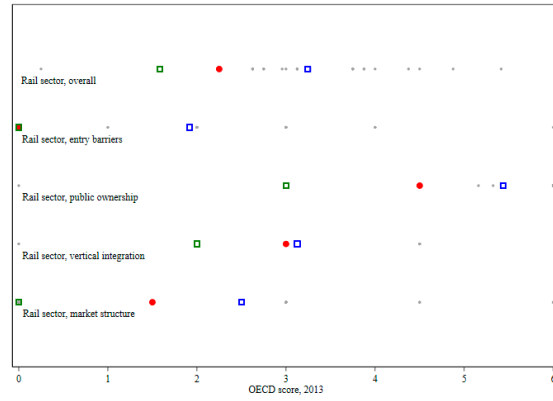
Note: Solid line denotes the differential investment effect of reform between a sector with a high “natural” turnover rate (at the 75th percentile of the U.S. distribution) and a sector with a low natural layoff rate (at the 25th percentile of the U.S. distribution). Dotted lines indicate 90 percent confidence interval based on standard errors clustered at country-sector level.

**Figure 19. PMR in Network and Retail Sectors (2013):
Comparison of Denmark with OECD EU Peers**

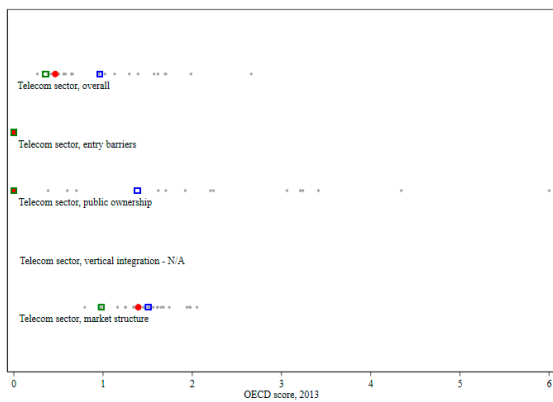
Electricity sector



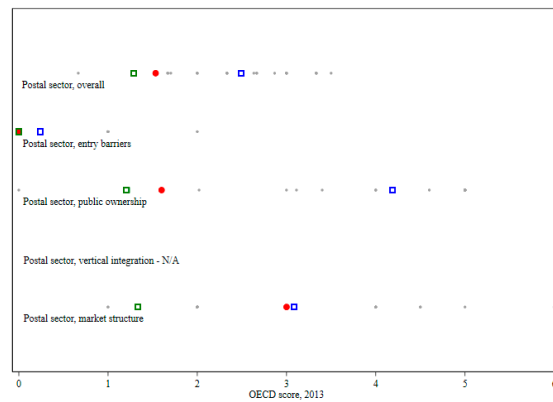
Rail sector



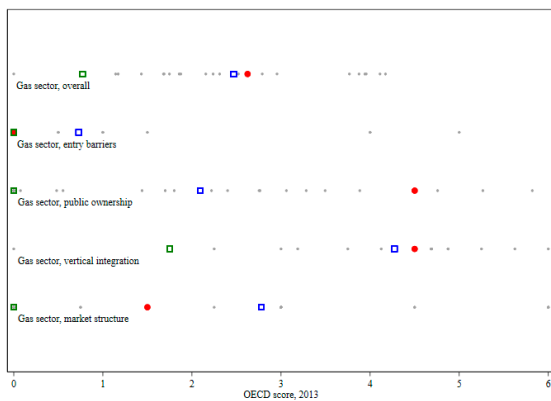
Telecom sector



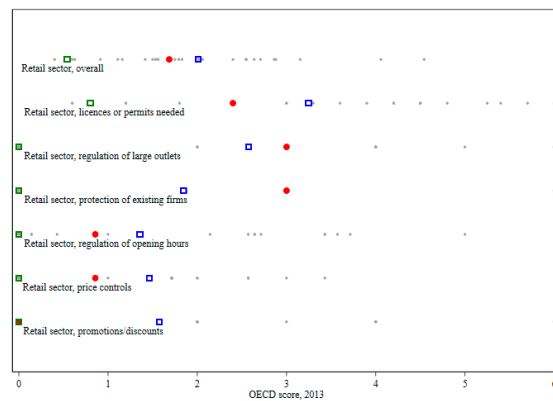
Postal sector



Gas sector



Retail sector



Source: OECD and IMF Staff calculations.

Note: Grey dots represent OECD EU countries, ● represents Denmark, □ represents OECD EU countries' average, and ◻ represents OECD EU countries' frontier (measured as the average of top three OECD EU countries).

Table 1. Estimation Results: Baseline Accelerator Model for Denmark

	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}	α	δ
Coefficient	0.22	0.25**	0.33**	0.45***	0.27*	0.41***	0.47***	0.24**	0.36**	0.27*	0.46***	0.29*	-14.76	0.02***
Standard error	(0.21)	(0.12)	(0.16)	(0.17)	(0.14)	(0.12)	(0.12)	(0.11)	(0.17)	(0.14)	(0.16)	(0.17)	(14.92)	(0.00)
Observations	76													
R-squared	0.476													
Sum of β s	1.475													
Standard error (sum of β s)	0.625													
t-stat (sum of β s)	2.360													

Source: Eurostat and IMF Staff calculations.

Note: Estimations are performed using the Newey-West estimator on quarterly data for the 1998–2016 period. *, **, and *** denote significance at 10, 5, and 1 percent confidence level, respectively.

Table 2. Estimation Results: Augmented Accelerator Model for a Panel of OECD Countries

	β_1	β_2	β_3	Leverage (non-financial corporations)	Change in PMR index	Markup indicator	Uncertainty index (EU-level)	α
Coefficient	0.57***	0.21***	0.36***	-43.71*	27.28	-2.10**	-0.04**	-2,881.51**
Standard error	(0.07)	(0.03)	(0.06)	(23.48)	(15.93)	(0.95)	(0.01)	(1,319.04)
Observations	283							
R-squared	0.87							
Sum of β s	1.720							
Standard error (sum of β s)	0.194							
t-stat (sum of β s)	8.849							

Source: Eurostat and IMF Staff calculations.

Note: Estimations are performed using the fixed effects estimator on annual data for OECD countries over the 1999–2016 period. *Leverage* is measured as credit to non-financial corporations as a share of GDP (source: BIS). *PMR index* is the OECD's index of product market regulations for 1998, 2003, 2008, and 2013, with interpolated values for the years in between (source: OECD and IMF Staff calculations). *Markup indicator* is the price markup measured as (gross output-intermediate inputs-labor inputs)/gross output (source: EUKLEMS and IMF Staff calculations). *Uncertainty index* is European-policy related measure of economic uncertainty (source: <http://www.policyuncertainty.com/>).

*, **, and *** denote significance at 10, 5, and 1 percent confidence level, respectively.

REFERENCES

- Alesina, A, Ardagna, S, Nicoletti, G, and F. Schiantarelli, 2005, “Regulation and Investment,” *Journal of the European Economic Association*, 3 (4): pp. 791–825.
- Andrews, D, and F. Cingano, 2014, “Public Policy and Resource Allocation: Evidence from Firms in OECD Countries,” *Economic Policy*, 29 (78): pp. 253–96.
- Barkbu, B, Berkmen, P., Lukyantsau, P., Saksonovs, S., and H. Schoelermann, 2015, “Investment in the Euro Area: Why Has It Been Weak,” IMF Working Paper 15/32, International Monetary Fund, Washington.
- Busetti, F, Giordano, C. and G. Zevi, 2016, “The Drivers of Italy’s Investment Slump During the Double Recession,” *Italian Economic Journal*, 2: pp. 143–65.
- Cacciatore, M, Duval, R., Fiori, G, and F. Ghironi, 2016, “Market Reforms in the Time of Imbalance,” *Journal of Economic Dynamics & Control*, 72: pp. 69–93.
- Copenhagen Economics, 2013a, “Regulation and Productivity in the Private Service Sectors,” background report prepared for the Danish Productivity Commission.
- , 2013b, “Productivity Gains in Danish Network Industries,” background report prepared for the Danish Productivity Commission.
- , 2013c, “Barriers to Productivity Growth in the Retail Sector,” background report prepared for the Danish Productivity Commission.
- Culiuc, A, and A. Kyobe, 2017, “Structural Reforms and External Rebalancing,” IMF Working Paper 17/182, International Monetary Fund, Washington.
- Danish Ministry of Business and Growth, 2014, “Report on Growth and Competitiveness,” available at www.konkurrenceevne.dk.
- Djankov, S, Ganser, T, McLiesh, C, Ramalho, R, and A. Shleifer, 2010, “The Effect of Corporate Taxes on Investment and Entrepreneurship,” *American Economic Journal: Macroeconomics*, 2: pp. 31–64.
- Duval, R, Furceri, D, and J. Jalles, 2017, “Job Protection Regulation in Good and Bad Times,” IMF Working Paper 17/277, International Monetary Fund, Washington.
- Duval, R, Furceri, D, B. Hu, Jalles, J, and H. Nguyen, 2018, “A Narrative Database of Major Labor and Product Market Reforms in Advanced Economies,” IMF Working Paper 18/19, International Monetary Fund, Washington.
- Egert, B, 2017, "Regulation, Institutions and Aggregate Investment: New Evidence from OECD Countries," OECD Economics Department Working Papers No. 1392.

European Central Bank (ECB) (2016), "Business Investment Developments in the Euro Area Since the Crisis," Economic Bulletin No. 7.

European Commission (EC) (2017), "Investment in the EU Member States: An Analysis of Drivers and Barriers," Institutional Paper 062.

European Investment Bank (EIB) (2017), "Investment and Investment Finance in Europe: From Recovery to Sustainable Growth," Annual Investment Report 2017/2018.

Gaspar, V, Jaramillo, L, and P. Wingender, 2016, "Tax Capacity and Growth: Is there a Tipping Point?" IMF Working Paper 16/234, International Monetary Fund, Washington.

Gutierrez G, and T. Philippon, 2016, "Investment-Less Growth: An Empirical Investigation," CEPR Discussion Paper 11673.

International Monetary Fund (IMF) (2015), "Private Investment: What's the Holdup?" *World Economic Outlook*, April, Chapter 4, pp. 111–43.

———, (2016a), "Investment, Firm Size, and the Corporate Debt Burden: A Firm-Level Analysis of the Euro Area," IMF Country Report No. 16/220.

———, (2016b), "Time for a Supply-Side Boost? Macroeconomic Effects of Labor and Product Market Reforms," *World Economic Outlook*, April, Chapter 3, pp. 101–42.

———, (2016c), "Product Market Reform and Firm Productivity in Denmark," IMF Country Report No. 16/185.

———, (2017a), "Dynamics of Firm Investment in Denmark: Role of Leverage, Demand, and Knowledge Intensity," IMF Country Report No. 17/159.

———, (IMF) (2017b), "Can Structural Reforms Foster Real Convergence in the Euro Area?" IMF Country Report No. 17/236.

Jorda, O, Schularick, M, and Taylor, A, 2017, "Macrofinancial History and the New Business Cycle Facts," in NBER Macroeconomics Annual, volume 31, edited by M. Eichenbaum and J. Parker. Chicago: University of Chicago Press.

Jorgenson, D, and Siebert, C, 1968, "A Comparison of Alternative Theories of Corporate Investment Behavior," *American Economic Review*, 58: pp. 681–712.

Kuchler, A, 2015, "Firm Leverage and Investment During the Crisis," Danmarks Nationalbank Working Paper No. 96, Danmarks Nationalbank, Copenhagen.

Oliner, S, Rudebusch, G, and Sichel, D, 1995, "New and Old Models of Business Investment: A Comparison of Forecasting Performance," *Journal of Money, Credit, and Banking*, 27 (3): pp. 806–26.

Rajan, R, and Zingales, L, 1998, “Financial Dependence and Growth,” *American Economic Review*, 88 (3): pp. 559–86.

Thum-Thysen, A, Voigt, P, Bilbao-Osorio, B, Maier, C, and Ognyanova, D, 2017, “Unlocking Investment in Intangible Assets,” European Economy Discussion Papers No. 047.

Annex I. Shift-Share Analysis of Investment Dynamics

This annex describes the methodology used for performing a shift-share analysis of the investment-to-output ratio dynamics.

Each sector can contribute to the investment-to-output ratio dynamics in two ways: by changes in investment within the sector (within-effect) and by changes in the share of the sector in aggregate output (between-effect, or structural shift). To decompose the contributions into within- and between- effects, we follow the shift-share methodology (see Busetti and others 2016 and EC 2017, among others).

The simplest way to illustrate the approach is to consider a one country, two-sector ($i=[1, 2]$), and two-period ($t=[0, T]$) model. Let Y_i denote output in sector i , INV_i denote investment, and superscripts 0 and T denote the beginning and the end of the period, respectively.

The aggregate investment-to-output ratio (I) at time T can be written as:

$$I^T = \frac{INV^T}{Y^T} * 100 = \frac{INV_1^T + INV_2^T}{Y^T} * 100 = \frac{INV_1^T}{Y_1^T} \frac{Y_1^T}{Y^T} * 100 + \frac{INV_2^T}{Y_2^T} \frac{Y_2^T}{Y^T} * 100 = I_1^T S_1^T + I_2^T S_2^T \quad (1.1)$$

where S_i denotes share of sector i output in total output. The difference in investment ratios at time 0 and T can be written as:

$$I^T - I^0 = (I_2^T - I_2^0)S_2^T + (I_1^T - I_1^0)S_1^T + (S_2^T - S_2^0)I_2^0 + (S_1^T - S_1^0)I_1^0 \quad (1.2)$$

or alternatively as:

$$I^T - I^0 = (I_2^T - I_2^0)S_2^0 + (I_1^T - I_1^0)S_1^0 + (S_2^T - S_2^0)I_2^T + (S_1^T - S_1^0)I_1^T \quad (1.3)$$

To make the decomposition invariant to a particular base, one could use period averages as weights by combining (1.2) and (1.3):

$$I^T - I^0 = (I_2^T - I_2^0)\bar{S}_2 + (I_1^T - I_1^0)\bar{S}_1 + (S_2^T - S_2^0)\bar{I}_2 + (S_1^T - S_1^0)\bar{I}_1 \quad (1.4)$$

where bars indicate the arithmetic average over period $[0, T]$.

In a multi-sector setting, expression (1.4) can be written as:

$$I^T - I^0 = \underbrace{\sum_{i=1}^N (I_i^T - I_i^0) \bar{S}_i}_{\text{within-effect}} + \underbrace{\sum_{i=1}^N (S_i^T - S_i^0) \bar{I}_i}_{\text{between-effect}} \quad (1.5)$$

where N is the number of sectors. This breakdown could be used to gauge the magnitude of within- and between-effects.

Annex II. The Accelerator Model

Following IMF (2015) and EC (2017), we adopt the accelerator model to model investment. Investment in time t and country i (I_{it}) is a function of a desired stock of capital (K_{it}^*), its lags (up to N periods) to account for inertia in the adjustment of the capital stock to its desired level, and the capital depreciation rate (δ_i)¹⁷:

$$I_{it} = \alpha_i + \sum_{j=0}^N \lambda_j \Delta K_{it-j}^* + \delta_i K_{it-1} \quad (2.1)$$

The accelerator model postulates proportional relationship between changes in desired stock of capital and changes in output:

$$\Delta K_{it}^* = c \Delta Y_{it} \quad (2.2)$$

Plugging in (2.2) into (2.1), dividing both sides by K_{it-1} , and lagging the output by one year to alleviate the endogeneity issues yields the following baseline empirical specification:

$$\frac{I_{it}}{K_{it-1}} = \delta_i + \frac{\alpha_i}{K_{it-1}} + \sum_{n=1}^N \beta_j \frac{\Delta Y_{it-n}}{K_{it-1}} + \varepsilon_{it} \quad (2.3)$$

where α_i is the country-specific fixed effect and ε_{it} is the i.i.d. error.

Baseline regression (2.3) allows modeling the dynamics of investment based purely on output developments. The residual of this regressions would indicate whether the investment slowdown following the GFC can be largely explained by sluggish output developments. If that is not the case, then the baseline model can be augmented to include additional determinants of investment:

$$\frac{I_{it}}{K_{it-1}} = \delta_i + \frac{\alpha_i}{K_{it-1}} + \sum_{n=1}^N \beta_n \frac{\Delta Y_{it-n}}{K_{it-1}} + \sum_{k=1}^K \gamma_k P_{it} + \varepsilon_{it} \quad (2.4)$$

where P denotes additional factors driving investment, including those affected by policies. The significance of γ_s would help judging their importance in explaining the investment slowdown following the GFC.

The model is estimated using fixed effects panel estimator with standard errors corrected for autocorrelation, heteroskedasticity, and intra-group correlation. In some specifications, the regressions are run for a panel of sectors within countries (sector-specific fixed effects regressions) or for individual countries/sectors (time series regressions).

¹⁷ See Jorgenson and Siebert (1968) for a theoretical derivation of the accelerator model and Oliner and others (1995) for an empirical specification based on the theory.