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HOW DOES CORPORATE TAXATION AFFECT BUSINESS INVESTMENT? EVIDENCE FROM AGGREGATE AND FIRM-LEVEL DATA

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ABSTRACT/RÉSUMÉ

How does corporate taxation affect business investment? Evidence from aggregate and firm-level data

Business investment in OECD countries has remained weak, in particular since the 2008 global financial crisis. At the same time, the cost of capital has significantly and steadily decreased over the last thirty years, reflecting a fall in both interest rates and corporate tax rates. This raises the question of whether business investment still responds to the cost of capital and thus whether corporate tax policy can support investment. This paper analyses trends in business investment and in the cost of capital in OECD countries over the past three decades. Then, it investigates empirically the sensitivity of business investment to corporate taxation, and how this sensitivity varies across firm, investment and tax-design characteristics. Panel regressions at the firm and industry levels confirm that business investment rates are negatively related to corporate taxation, measured by country-level forward-looking effective tax rates. However, the tax sensitivity of business investment has fallen significantly since the global financial crisis. It also differs significantly across firms, assets, and corporate tax design characteristics. Overall, the estimation results suggest that a nuanced and granular approach to corporate tax policy, accounting for heterogeneity in tax sensitivity, is needed to support investment effectively. The paper discusses possible policy options, including the reduction of non-profit taxes, the use of targeted corporate income tax instruments, and the use of more generous capital allowances where they may induce strong investment responses.

JEL classification: D22 ; D24 ; E22 ; E62 ; H25 ; H32.

Keywords: investment, corporate taxation, capital allowances, non-profit taxes, fiscal policy.

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Comment la fiscalité des entreprises affecte-t-elle l'investissement des entreprises ? Analyse sur données agrégées et au niveau des entreprises

L'investissement des entreprises dans les pays de l'OCDE est resté faible en particulier depuis la crise financière mondiale de 2008. En parallèle, le coût du capital a considérablement et régulièrement diminué au cours des trente dernières années, reflétant une baisse à la fois des taux d'intérêt et des taux d'imposition des sociétés. Cela soulève la question de savoir si l'investissement des entreprises réagit toujours au coût du capital et donc si la politique fiscale des entreprises peut soutenir l'investissement. Ce papier analyse les tendances de l'investissement des entreprises et du coût du capital dans les pays de l'OCDE au cours des trois dernières décennies. Il étudie ensuite de manière empirique la sensibilité de l'investissement à la fiscalité des entreprises, et comment cette sensibilité varie selon les caractéristiques de l'entreprise, le type d'investissement et les paramètres de l'impôt. Des régressions de panel au niveau des entreprises et des industries confirment que les taux d'investissement des entreprises sont négativement liés à l'imposition des sociétés, mesurée par les taux d'imposition effectifs prospectifs au niveau des pays. Cependant, la sensibilité fiscale des investissements des entreprises a considérablement diminué depuis la crise financière mondiale. Elle diffère également significativement selon les entreprises, les actifs et les paramètres de la fiscalité des entreprises. Dans l'ensemble, les résultats des estimations suggèrent qu'une approche nuancée et granulaire de la politique fiscale des entreprises, tenant compte de l'hétérogénéité de la sensibilité fiscale, est nécessaire afin de soutenir efficacement l'investissement. Le document examine plusieurs options politiques possibles, y compris la réduction des impôts sur les entreprises non basés sur le profit, l'utilisation d'instruments ciblés de l'impôt sur les sociétés, et l'utilisation de déductions pour amortissement plus généreuses, lorsque celles-ci peuvent induire de fortes réactions d'investissement.

Classification JEL: D22 ; D24 ; E22 ; E62 ; H25 ; H32.

Mots-clés : investissement, fiscalité des entreprises, déductions pour amortissement, impôts de production, politique fiscale.

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How does corporate taxation affect business investment? Evidence from aggregate and firm-level data

By Tibor Hanappi, Valentine Millot and Sébastien Turban[1]

1. Introduction and main findings

Investment has been weak in OECD countries since the global financial crisis (GFC), weighing on productivity growth and living standards (Ollivaud, Guillemette and Turner, 2016[1]; OECD, 2021[2]). Public policy should therefore consider various levers which could help support business investment. The cost of capital has usually been considered as one of the key determinants of investment (Feld and Heckemeyer, 2011[3]; Vartia, 2008[4]; Schwellnus and Arnold, 2008[5]). Government policy can affect the cost of capital through the corporate tax system or the taxation of capital more generally. However, investment decisions can also be influenced by the level of current and anticipated future demand, access to financing and liquidity constraints, economic and policy uncertainty, and market regulation.

Recent trends at the aggregate level in OECD countries point to some diverging trends between business investment and the cost of capital. The cost of capital has steadily fallen over the past three decades, reflecting both the secular decline in global interest rates and cuts in statutory corporate tax rates. However, business investment rates have not increased, and real investment has barely caught up with its trend prevailing before the GFC.[2] This suggests that the desired level of investment (i.e. investment demand by firms for a given cost of capital) has fallen because of other factors (Rachel and Smith, 2015[6]). This could also reflect a declining sensitivity of firms' investment to the cost of capital, raising questions about the extent to which corporate taxation changes stimulate business investment.

These questions are particularly crucial in the current global economic environment, characterised by rising interest rates (and thus a rising cost of capital), high economic and political uncertainty, and strong

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[2] These observations at the aggregate level are in line with evidence showing that the effective minimum ex ante rate of return on corporate investment which is considered viable by companies (the so-called hurdle rates) have been relatively sticky despite fluctuations in the cost of finance (Sharpe and Suarez, 2015[82]; OECD, 2017[81]; Gormsen and Huber, 2022[80]).

demands for fiscal support to vulnerable households and businesses. Recent tax policy reforms implemented in some large, advanced economies suggest that governments still count on corporate tax measures to support investment and economic growth.[3] Understanding how firms are likely to react to different tax reforms and which tax instruments are likely to be the most effective in supporting growth and minimising the cost to public finances is key to informing these policy choices.

Recent empirical literature shows that the sensitivity of firm investment to corporate tax rates tends to be heterogeneous across different types of firms, depending for example on age and sector (Schwellnus and Arnold, 2008[5]; Fuest, Peichl and Siegloch, 2018[7]; Federici and Parisi, 2015[8]); investment financing structure and liquidity constraints (Zwick and Mahon, 2017[9]); market power (Kopp et al., 2019[10]); tax planning possibilities (Sorbe and Johansson, 2017[11]); and profitability (Millot et al., 2020[12]). This calls for a more nuanced assessment of the implications of corporate taxation on investment and growth, taking into account heterogeneity in investment responses.

Against this background, this paper aims to further the understanding of the linkages between tax and investment. It contributes to the empirical literature by analysing the relationship between corporate tax changes and business investment over the past decades, relating these results to observations on aggregate investment trends at the macro level. For this purpose, it brings together up-to-date country and industry-level data from national accounts, firm-level data from Orbis, and detailed data on the cost of capital and its tax components. A second contribution of this paper is to analyse how the tax sensitivity of investment differs across a wide range of firm and investment characteristics. Finally, contrary to previous empirical studies, which look either at the impact of a specific tax measure or synthetic indicators of the overall corporate taxation level, this paper tries to disentangle different parameters of the corporate tax system in a coherent framework to analyse potential impacts of different tax designs.

The results from empirical analysis in this paper call for a more nuanced and granular approach to corporate tax policy. Beyond headline statutory tax rates, a variety of measures can be considered to support investment effectively, accounting for heterogeneities in tax sensitivity. The paper discusses *pros* and *cons* of possible policy options, in particular measures affecting the tax base rather than the tax rate, for example through capital allowances, and measures targeted at specific kinds of investment.

The paper is organised as follows. Section 2 looks at trends in investment and the cost of capital and shows that business investment has been subdued in the past 30 years while the cost of capital has fallen steadily. Section 3 presents econometric estimations showing that aggregate and firm-level investment is still significantly affected by taxation although this sensitivity has diminished since the GFC. In addition, it illustrates important heterogeneity of tax sensitivity across firms, assets and corporate tax designs over time. Finally, Section 4 discusses policy implications of those findings and highlights some considerations for policymakers in using corporate tax policy design to support investment. The main conclusions of the paper are summarised in Box 1.

[3] For example, the UK government introduced the super-deduction tax incentive on business investment in 2021, through which companies can claim 130% capital allowances on plant and machinery investments. In the US, the Tax Cut and Jobs Act in 2017 introduced several changes to business tax, including permanently lowering the corporate income tax rate. In Italy, the government implemented enhanced capital allowances to support investments in digital technologies in 2017 (the so-called “hyper-depreciation”). The French government gradually decreased the statutory corporate tax rate between 2017 and 2022.

Box 1. Summary of the main findings and conclusions

- Business investment is a key determinant of productivity and long-term economic growth. While corporate tax systems have usually been considered as an effective policy lever to support investment, a granular empirical analysis is needed to understand how firms are likely to react to different tax reforms, and which tax instruments are likely to be the most effective in supporting investment.

Business investment has been sluggish since the GFC while the cost of capital has declined

- Real gross investment has barely caught up with the pre-GFC trend and has been generally lacklustre.
- Aggregate investment trends at the macro level are almost entirely driven by within-sector changes and not by the growing importance of sectors with low investment rates (i.e. between-sector changes).
- The cost of capital has declined significantly over the past 20 years. It has mostly been driven by the fall in interest rates. However, corporate taxation has also played a role in reducing the cost of capital.
- Investment is highly concentrated among a small number of large firms, usually belonging to multinational groups.
- Investment trends have been heterogeneous across firms. While investment slowed in most firms after the GFC, investment by large firms and young firms has been more robust than investment by small firms and old firms.

The tax sensitivity of investment has weakened since the GFC, but it is heterogeneous across various dimensions

- Estimates at the industry and at the firm level confirm the findings of past OECD analyses which showed that business investment responds negatively to increases in corporate taxation. However, the tax sensitivity of investment appears to have fallen after the GFC.
- Tax sensitivity of investment differs across asset types. Investment in buildings tends to be less sensitive to corporate taxation at the intensive margin than investment in machinery and equipment or intellectual property products.
- Tax sensitivity is also found to differ across firms. After the GFC, large firms, firms that are part of multinational groups, firms that have a large proportion of intangibles in their total fixed assets, and firms that are highly profitable have all become less sensitive to taxation compared with other firms. The tax sensitivity of old firms has also decreased over time compared with young firms.
- The response of investment to changes in effective tax rates (ETRs) depends on tax instruments:
    - Increases in effective taxation delivered through non-profit taxes (i.e. business taxes levied on other bases than corporate income, such as real estate or corporate wealth) have a stronger negative impact on business investment than corporate income tax (CIT).
    - Changes in the CIT statutory tax rate (STR) and in capital allowances are associated with different investment responses. These differences depend on the initial level of STR and allowances. The higher the initial STR and the higher the allowances, the less stimulative a marginal rate cut is than an equivalent increase in allowances.

Policy makers could explore possibilities to account for heterogeneity in tax sensitivity to support investment effectively via CIT policies

- Potential options include:
  - Eliminating or reducing non-profit taxes on domestic and international businesses. These taxes are likely to generate larger adverse effects on investment than taxes on profits.
  - Limiting cuts in the headline STR. Such cuts are relatively costly compared with other policies, as they lower the ETRs of all firms regardless of their tax sensitivity. In addition, even high STRs, combined with more generous capital allowances, are likely to be less distortive as the CIT would then weigh more on economic rents.
  - Considering the use of targeted CIT instruments to support specific investments, provided that a coherent policy rationale and a strong institutional framework exist. Differences in ETRs across assets and firms can be justified when there are positive externalities (which may occur, for example, with respect to knowledge spillovers and innovation). However, decisions to implement targeted measures should also account for costs of the induced distortions and potentially increased compliance costs and administrative burden for taxpayers and tax authorities. In addition, targeted support should consider whether the impact of any incentives would be affected by the Global Minimum Tax.
  - Making use of more generous capital allowances to reduce ETRs where they are expected to induce strong investment responses. Such policies would likely be less affected by the Global Minimum Tax under the Global Anti-Base Erosion (GloBE) Rules due to the deduction of a fraction of the value of assets and payroll from the base of the minimum tax, and the fact that the GloBE Rules are designed to avoid imposing additional Top-up Tax as a result of timing differences (e.g. due to accelerated depreciation or immediate expensing).

2. Business investment has been subdued after the GFC while the cost of capital has steadily fallen

Private investment has been relatively weak since the GFC. Previous studies have shown that after the GFC, total investment fell abruptly and has failed to recover completely in most economies (OECD, 2015[13]). This partly reflected an important reduction in residential investment by households. However, corporate investment also declined relative to GDP and has not reverted to its pre-crisis level (IMF, 2015[14]).[4] Before the crisis, corporations' net investment was relatively flat in Europe. In contrast, it was volatile in the United States; investment had declined with the burst of the dot-com bubble in the early 2000s and then subsequently recovered (Döttling, Gutierrez Gallardo and Philippon, 2017[15]).

Those subdued trends have translated into a significant reduction in the contribution of capital per worker to GDP per capita growth over the past 20 years, with a large drop during the GFC and a modest catch-up thereafter (Ollivaud, Guillemette and Turner, 2016[1]). Meanwhile, there has been a secular, global downward trend in interest rates and the cost of borrowing of corporations (Boone et al., 2022[16]).

[4] Business (or corporate) investment at the macroeconomic level is measured in this paper using national accounts data by activity classified in the International Standard Industrial Classification of All Economic Activities (ISIC), focusing on business sectors excluding real estate (Annex A). National accounts also provide non-financial accounts by sectors, including nominal investment data for the non-financial and financial corporation sectors. Those accounts have the benefit of wider country coverage, but the investment data are usually not provided in volume, cannot be decomposed by industry and broken down by asset types. Figure A A.1 in Annex A shows that the two measures of business investment are similar for countries where both data are available.

This section first highlights that aggregate business investment has been subdued in recent years relative to pre-crisis levels in most countries and most sectors (Subsection 2.1.) and that the cost of capital – including corporate tax measures – has trended downwards (Subsection 2.2.). It then provides some descriptive analyses of between-firm heterogeneity in investment trends (Subsection 2.3.).

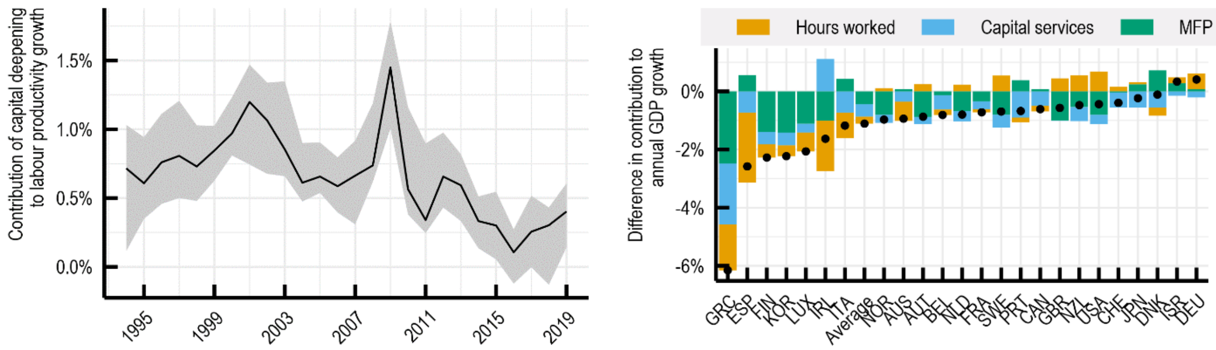
2.1. Post-GFC investment has remained below pre-crisis trends in most countries and most sectors

The contribution of investment to economic growth has fallen in the OECD since the GFC. GDP growth can be decomposed into contributions from labour inputs (typically hours worked), capital inputs (the services provided by the capital stock) and the efficiency of their use (multifactor productivity or MFP). In turn, growth in GDP per hour worked can be decomposed into the contribution of capital deepening (capital services per hour worked) and MFP. These decompositions suggest that the contribution of capital deepening to labour productivity growth has approximately halved on average in OECD countries between the pre-GFC and the post-GFC periods (Figure 1, Panel A). The slowdown in capital services growth has contributed as much as the MFP slowdown to the reduction in GDP growth between the two periods (Figure 1 Panel B).[5] These trends are likely explained significantly by a slowdown in business investment, which represents the most important share of aggregate productive investment in the economy.

Figure 1. The contribution of capital to economic growth has fallen after the GFC

A. Median and interquartile range for the contribution of capital deepening to productivity growth in OECD countries

B. Decomposition of contribution to GDP growth, difference between 2010-2019 and 2000-2007 annual rates



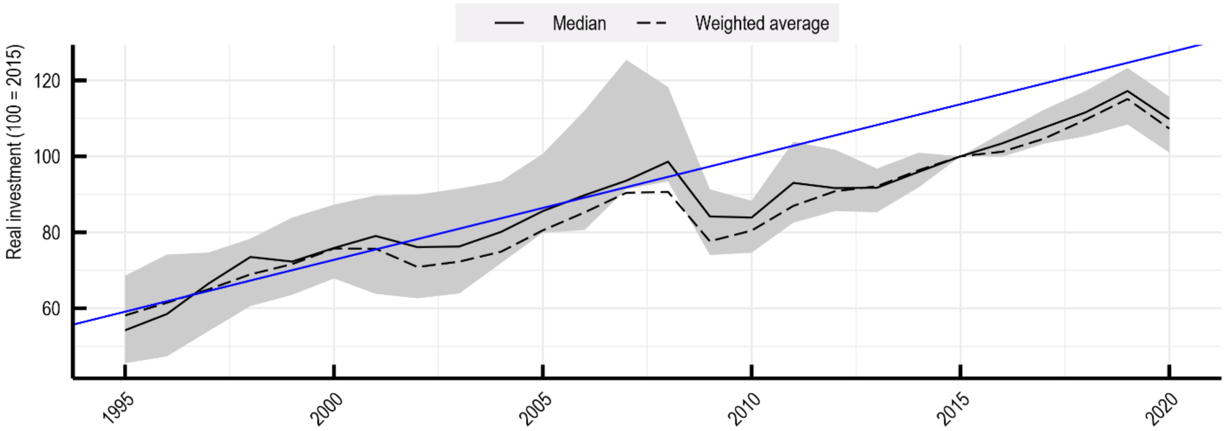
Note: GDP growth can be decomposed into the growth of multifactor productivity (MFP), capital services, and hours worked. In turn, labour productivity growth can be decomposed into the growth of MFP and that of capital services per hour worked (OECD, 2021[17]).Capital input in the OECD Productivity Statistics Database is derived from the perpetual inventory method using common assumptions for all countries for eight types of non-residential fixed assets (Schreyer, Bignon and Dupont, 2003[18]). In Panel A, the black line represents the median for the countries covered and the shaded area indicates the interquartile range. In Panel B, the black dot represents the difference in average GDP growth between 2010-2019 and 2000-2007 in a given country. Those averages can be decomposed in average contributions of each component.
Source: OECD Productivity Statistics Database; and authors' calculations.

Real gross business investment has barely caught up with the pre-GFC trend, even though it had recovered its pre-GFC level in the median OECD country by 2015 (Figure 2). Real investment has been relatively more robust in recent years (and before the COVID-19 crisis) in most countries, but growth rates have tended to be lower everywhere than before 2007. However, average trends mask important cross-country heterogeneity, in particular given sizeable pre-crisis booms in some economies. Investment has remained below its pre-GFC trend in most countries, but it has caught up in some, while it was still

[5] The contribution of capital to productivity here is based on the growth in the volume of capital services, which combines not only changes in the stock but also the "quality" of the capital stock. In the OECD Productivity Statistics Database, this measure of quality is approximated by considering the changes in the structure of the capital stock by asset types, which each have different marginal productivities (OECD, 2021[17]).

even below pre-GFC levels before the COVID-19 crisis for several other economies.[6] The growth rate of real investment after 2012 has been below its pre-2007 trend for four-fifths of countries with available data (Annex A, Figure A A.2). The relative investment weakness post-GFC does not seem to be accounted for by slower depreciation of assets, a fall in relative prices of capital goods, the increasing importance of intangibles, and reduced corporate profits (Annex B).

Figure 2. Real gross business investment in the OECD has barely caught up its pre-crisis trend



Note: The weighted average of growth rates is computed for OECD countries with available data (see Annex A for more details on the coverage), with investment in USD in 2015 as weights. The shaded area represents the interquartile range. The blue line corresponds to the extension of the 1995-2007 trend after 2007 for median real investment.
Source: National accounts; and authors' calculations.

Declining aggregate investment rates could reflect a reallocation of economic activity from investment-intensive sectors (like manufacturing) towards sectors with lower investment levels (like services). The impact of this reallocation could potentially be significant for two reasons. First, the share of low-investment-intensity sectors has grown over the past three decades, mirroring the decline in the share of manufacturing. Second, investment rates in the industries with declining shares are on average three times larger than in some services and in construction (Figure 3, Panel A). However, notwithstanding the sectoral differences in the level of investment rates, investment rates have actually fallen in most business activities (Figure 3, Panel B).[7]

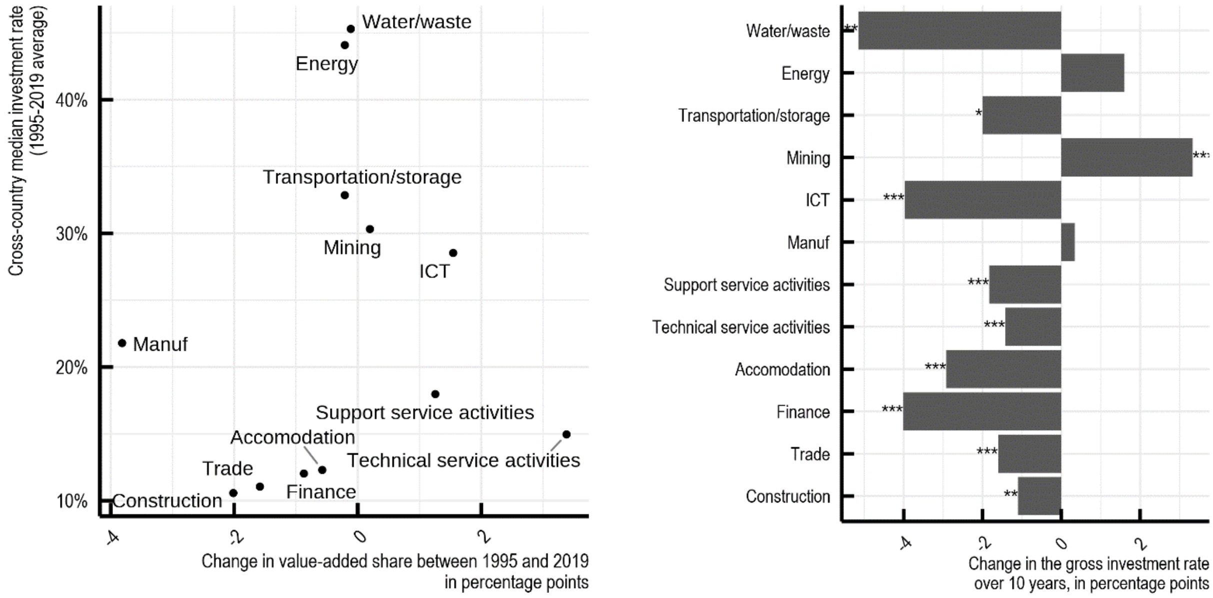
[6] The right counterfactual for this exercise is not obvious as, for example, it is possible that the investment growth pre-GFC was too high. However, as shown below, the relative levels before and after the GFC can be contrasted with the steady downward trend in the cost of capital. In addition, the decline in the contribution of capital to GDP growth after the GFC coincided with an increase in the number of hours worked in most OECD countries, and this increase would have called for additional capital for a given capital-to-labour ratio (OECD, 2021[2]).

[7] This is in line with the findings for the United States (Alexander and Eberly, 2018[64]). The investment trends also hold when using a more detailed list of ISIC Rev. 4 sectors to distinguish industries within the manufacturing sector, though few countries report the disaggregated data.

Figure 3. The share of low-investment activities in the economy has increased and investment rates have fallen in most activities

A. The value-added share of industries with high investment rates has fallen

B. Investment rates have trended downwards in most industries

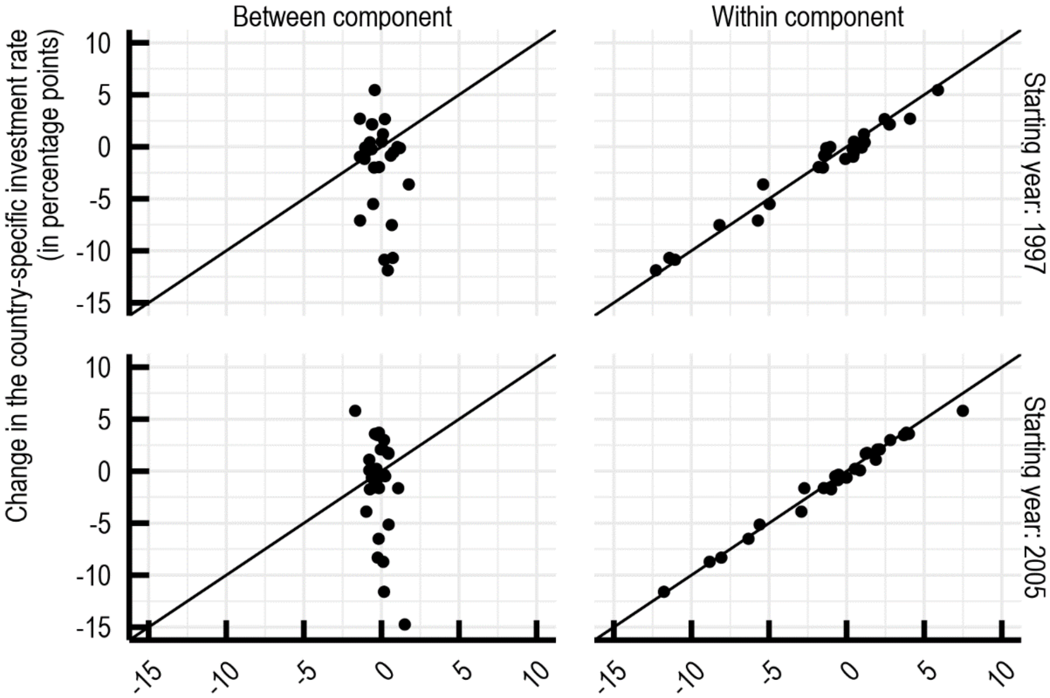


Note: In Panel A, the 1995-2019 average for investment rates (measured by fixed capital formation over value-added) is calculated using the median investment rate by activity across all countries and each year in the sample; the value-added share of each sector in economy-wide value-added is computed as a weighted-average across countries. In Panel B, the graph plots the coefficient β_s of the regression $i^{sector}_{country,time} = \alpha^s_c + \beta^s \cdot t + \epsilon^s_{c,t}$ for each sector s, multiplied by 10. Significance levels with standard errors clustered by year: ***: 0.1%; **: 1%; *: 5%. Sectors are sorted by the median investment rate as measured in Panel A.
Source: National accounts; and authors' calculations.

The fact that investment rates appear to have fallen in most industries suggests that the reallocation of activity towards sectors with low investment rates cannot fully explain the investment slowdown. This is confirmed by a shift-share analysis which decomposes the change in aggregate investment rates over time into a "between" component, measuring the role of the reallocation of value-added between industries, and a "within" component, measuring the role of changing investment rates within industries.[8] The decomposition suggests that changes in the structure of the economy have had only a minimal impact on the trajectory of investment in the past 25 years in all countries. In contrast, changes in investment rates within sectors explain almost entirely the change in aggregate business investment rates (Figure 4).

[8] The investment intensity in the total economy can be expressed as a weighted average of sectoral investment intensities: $I/Y = \sum_s \omega_s \cdot i_s$, where $\omega_s = Y_s/Y$ is the share of sector s in total value-added and i_s is the investment rate in sector s. Defining the average share of value added between the two periods as $\overline{\omega_i}$ and the average investment rate similarly as $\overline{i_i}$, the change in investment rate can be decomposed as $(I/Y)_1 - (I/Y)_0 = \sum_s \overline{\omega_s} \cdot \Delta i_s + \sum_i \overline{i_s} \cdot \Delta \omega_s$ (Autor and Salomons, 2018[74]).

Figure 4. Changes in aggregate investment were mostly driven by within-sector changes



Note: The graph shows, on the y-axis, the change in the business investment rate between 1997 and 2019 in the top row and between 2005 and 2019 in the bottom row; except for New Zealand and Canada where the latest year is respectively 2017 and 2018 because of data availability. The x-axis represents the contribution to this aggregate change of the between-industry component (left column) and within-industry component (right column) in percentage points. The between component keeps investment rates at its average level and considers the impact of changing value-added shares by industry. The within component keeps value-added shares at their average level and considers the impact of changing investment rates by industry. The black line is the 45-degree line (y=x).
Source: National accounts; and authors' calculations.

2.2. The falling cost of capital has supported business investment

A higher cost of capital affects investment negatively, all else being equal (Frank and Shen, 2016[19]; Kim, 2020[20]; Carluccio, Mazet-Sonilhac and Mésonnier, 2021[21]). However, while investment has been subdued in recent years, the main determinants of the cost of capital, i.e. real interest rates and statutory corporate tax rates, have trended downwards (Figure 5). On average in the OECD, statutory corporate tax rates have fallen from 32.3% to 23.1% over the past 20 years, while long-run real sovereign interest rates have fallen from 5.6% to zero over the past 30 years.[9] As a consequence, the fall in the cost of capital in OECD countries (as measured by the required pre-tax return on investment to break even after corporate taxation), of around 6 percentage points, is mainly explained by the drop in interest rates (Figure 6).[10]

The combination of this pronounced fall in the cost of capital and subdued investment levels suggests two non-exclusive possibilities. First, the elasticity of investment to the cost of capital could have fallen. Indeed,

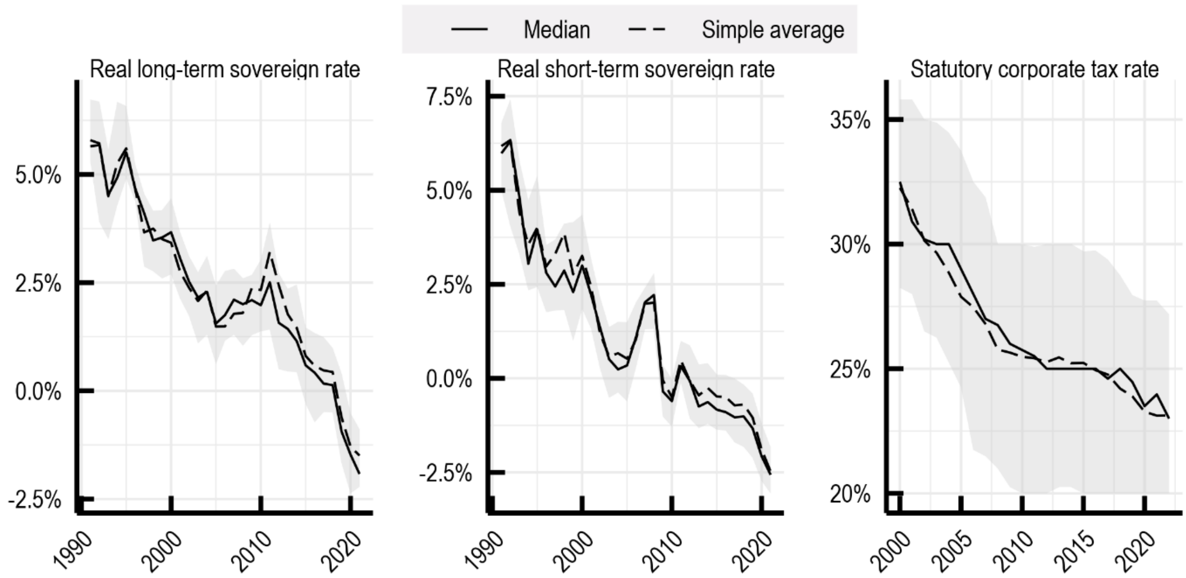
[9] The average real rate was 0.0% in 2019. As can be seen in Figure 5, during the COVID-19 crisis, real rates fell steeply because of the large increase in inflation.

[10] The measure of the cost of capital uses the formulas from Hanappi (2018[27]) based on the standard model of investment behaviour developed by Hall and Jorgenson (1967[30]). The model considers the required return on the marginal investment allowing a firm to break even, given macroeconomic (e.g. inflation, interest rates) and tax (e.g. statutory corporate tax rate, fiscal depreciation schedule) parameters. In this theoretical framework with decreasing marginal returns on capital and perfect competition, the marginal cost should then determine the optimal level of a firm's capital stock.

if one were to apply typical elasticities as usually found in the literature, investment volumes could be around 50% higher now than when the cost of capital started falling.[11] The second possibility is that investment has fallen because of other factors and that this fall has been somewhat compensated by the fall in the cost of capital. The reduction in desired investment for a given level of the cost of capital, without a commensurate reduction in the level of desired savings, would then explain a reduction in the interest rate required to match savings and investment.

A detailed analysis of the main factors contributing to subdued investment rates is beyond the scope of this paper, but the literature suggests several key factors. In the early post-GFC period, the trajectory of investment was commonly viewed to be consistent with the trajectory of GDP, suggesting that the main driver of the investment slowdown was simply the fall in demand (IMF, 2015[14]; Lewis et al., 2014[22]; Barkbu et al., 2015[23]; Bussière, Ferrara and Milovich, 2015[24]; Ollivaud, Guillemette and Turner, 2016[1]). Uncertainty likely played a role for some countries too, although some uncertainty measures had started normalising without a parallel recovery in investment (Lewis et al., 2014[22]).[12] In addition, subdued investment can only be partially explained by the cyclical slump in the aftermath of the GFC, as the post-crisis slowdown has continued a pre-crisis pattern of subdued investment in the United States (Crouzet and Eberly, 2019[25]; Farhi and Gourio, 2018[26]) and globally (Rachel and Smith, 2015[6]).

Figure 5. Real interest rates and statutory tax rates have fallen in the OECD over the past 30 years



Note: The statutory tax rate is the combined corporate tax rate. Real rates are nominal rates deflated by the GDP deflator. The nominal short-term rate is the 3-month interbank interest rate, and the long-term rate is the yield on 10-year government bonds. Shaded areas correspond to the interquartile range.
Source: OECD Main Economic Indicators; OECD Corporate tax statistics; and authors' calculations.

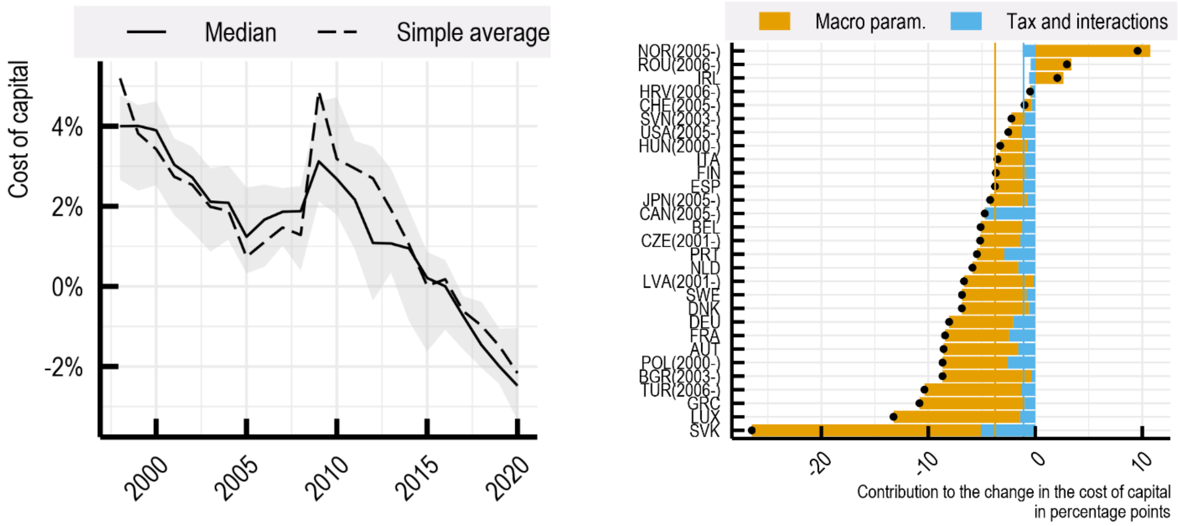
[11] For example, Rachel and Summers (2019[41]) suggest using an elasticity of -0.5, based on a review of the literature in the early 2000s (including Ellis and Price (2003[76]), Gilchrist and Zakrajsek (2007[68]), Guiso et al. (2002[78])). In the typical neo-classical model with a CES production function of labour and capital, the elasticity of the capital stock (or investment) to the cost of capital corresponds to the (negative of the) elasticity of substitution between the two factors of production (Gilchrist and Zakrajsek, 2007[68]). A recent meta-analysis suggests that this elasticity is around 0.3 (Gechert et al., 2022[69]).

[12] Uncertainty was usually measured by the Economic Policy Uncertainty index (Baker, Bloom and Davis, 2016[65]), or stock market volatility indicators like VIX, or measures of forecasts' dispersion.

Figure 6. The cost of capital has fallen over the past 20 years mostly due to declining interest rates

A. Evolution of the cost of capital in the OECD

B. Decomposition of changes in the cost of capital between 1998 and 2020, percentage points



Note: The cost of capital is computed based on the formulas from Hanappi (2018[27]), the fiscal parameters from Spengel et al. (2020[28]), long-term sovereign interest rates and changes in the GDP deflator as a proxy for inflation. The cost of capital is computed as the rate of return on a marginal investment required for an investor to break even after tax. Trends and changes are robust to replacing sovereign bond yields with a stable premium for corporations, but not the levels of the cost of capital. Panel A: The shaded area corresponds to the interquartile range. Panel B: Yearly changes in the cost of capital are decomposed between changes due to macroeconomic parameters and changes due to taxation, and summed over the period 1998-2020, except for countries where the initial year is specified in the label. See Annex C for details of the decomposition. Vertical lines represent the medians of each component.
Source: Authors' calculations.

2.3. Investment has been subdued in most sectors but there is important heterogeneity between firms within sectors

Country and industry-level investment rates, discussed in previous sub-sections, effectively aggregate firm-level investment rates with appropriate weights and are likely to reflect investment of the biggest firms. Thus, they cannot shed light on differences in levels and trends of investment across firm types. Certain firm characteristics can influence a firm's investment behaviour. They typically include cash flows, profitability and the firm-specific cost of capital (Frank and Shen, 2016[19]; Carluccio, Mazet-Sonilhac and Mésonnier, 2021[21]), financial constraints (Kalemli-Özcan, Laeven and Moreno, 2022[29]), and the share of intangible capital (Crouzet and Eberly, 2019[25]). This section analyses differences in investment trends across several of these firm characteristics based on firm-level data from Orbis (Annex D). This dataset contains information on investment rates – measured as investment relative to previous-year fixed assets – and relevant firm-level characteristics from their financial accounts.[13]

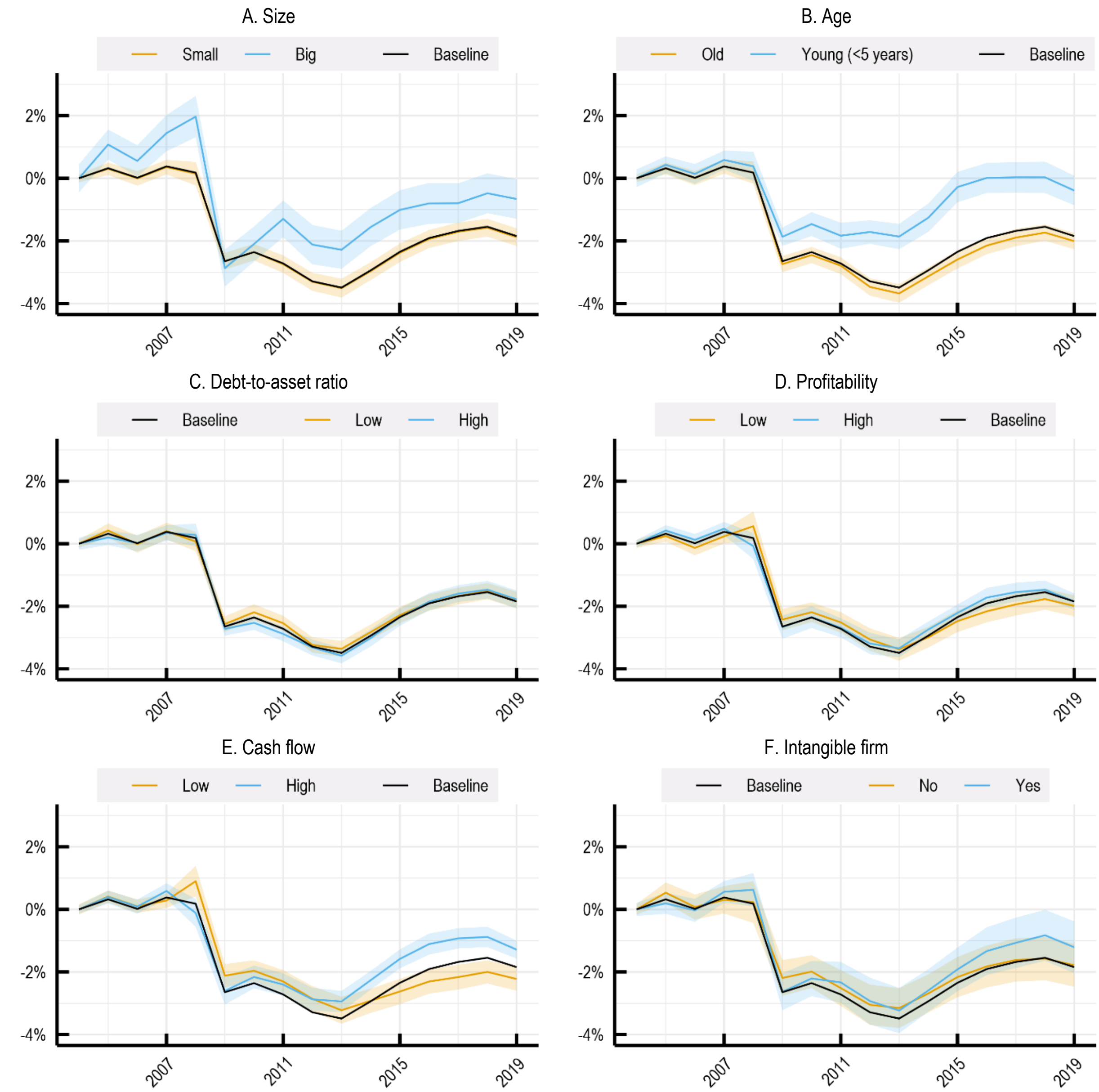
In order to assess the heterogeneity of investment trends according to selected characteristics, investment rates are regressed on country*industry fixed effects and time fixed effects interacted with a binarised version of each firm-level characteristic.[14] This admittedly simple exercise suggests that the investment slowdown has been widely shared across most of the firms, although young (less than five years old) and to a lower extent liquid firms (with a ratio of cash-flow to assets above the sample median) have displayed more robust investment, while large firms (with more than 250 employees) have almost reached their 2004 level again but not their pre-crisis peak (Figure 7).

[13] Annex D describes the differences in investment measures between Orbis and the national accounts.

[14] For example, the sample is split between high-leverage and low-leverage firms depending on where the firm stands relative to the median ratio of debt-like liabilities to total assets.

Figure 7. The investment performance of large and young firms has been stronger relative to small and old firms since the GFC

Firm-level average investment rate trends (normalised to 0 in 2004) by firm characteristics



Note: The coefficients that are plotted are the estimated time fixed effects of the regression of the firm-level investment rate i_t^f (investment divided by the previous-year capital stock for firm *f* at time *t*) on country (c)*industry(i) fixed effects $\gamma_{c(f),i(f)}$ (industries at the 2-digit NACE level) and time fixed effects δ_t interacted with firms' characteristics: $i_t^f = \gamma_{c(f),i(f)} + \beta_1 \cdot 1(f \in g_1) + \beta_2 \cdot 1(f \in g_2) + \boldsymbol{\eta_t^1} \cdot 1(f \in g_1) \cdot \delta_t + \boldsymbol{\eta_t^2} \cdot 1(f \in g_2) \cdot \delta_t + \epsilon_{f,t}$. Standard errors are clustered by country*industry. Firms are split in two groups g_1 and g_2 according to a given characteristic. Big firms are firms with more than 250 employees; young firms are firms incorporated since less than 5 years; firms with high profitability/debt-to-asset/cash flow ratios are firms above the sample median respectively for the ratio of profit before tax to turnover, current and non-current liabilities to total assets, and cash flow to total assets; "intangible firms" are firms which report strictly positive intangibles in Orbis (which is roughly half of the sample). The time fixed effects are normalised to the value in 2004. The black line corresponds to the time fixed effect over the full sample of firms without interactions.
Source: Orbis; and authors' calculations.

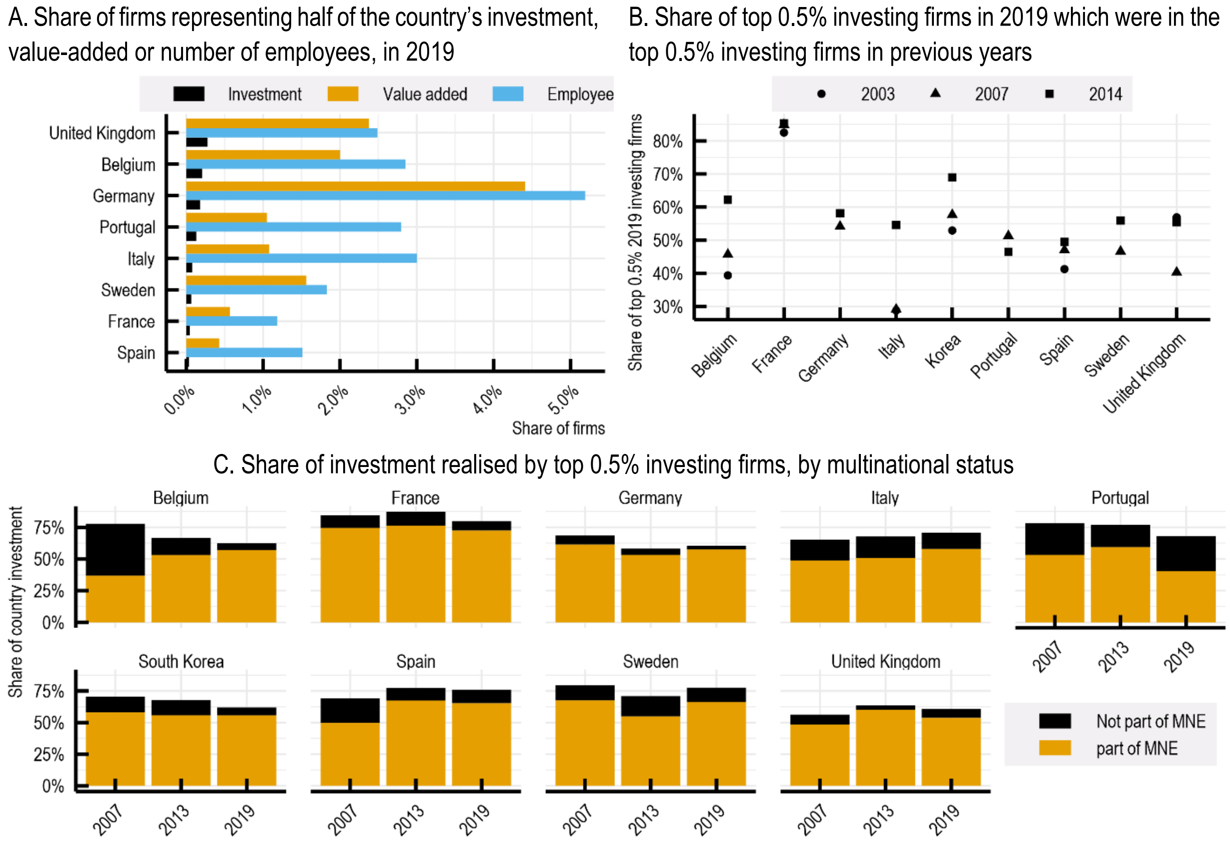
The behaviour of the largest firms is important for understanding national investment trends, because business capital formation appears to be highly concentrated among a few firms. In the Orbis database, for countries with good coverage for unconsolidated accounts, the concentration of investment appears relatively stable over time and substantially higher than the concentration of value-added or employment (Figure 8, Panel A and C).[15] The composition of firms with the highest investment appears to be relatively stable over time. Among the top 0.5% of companies by investment size in 2019, around half of them were in this group 15 years earlier (Figure 8, Panel B). Those firms are usually subsidiaries of multinational groups (Figure 8, Panel C).[16]

The trends described above suggest that investment has been relatively subdued in the past decade in most business sectors, despite the very favourable evolution of the cost of capital. Those aggregate trends may cast some doubt on the possibility to stimulate investment by reducing the cost of capital via the corporate tax system. However, aggregate trends are also likely to reflect mainly the behaviour of the largest firms, which are responsible for the bulk of investment and fail to account for heterogeneity among smaller firms. Thus, the effectiveness of tax policy in stimulating firm investment is ultimately an empirical question. Thus, the next section analyses the response of investment to the tax component of the cost of capital, and how the response can vary across the different instruments of corporate taxation and across different types of firms.

[15] Orbis provides data on taxes paid whose coverage is not as good as for the other variables, but measures of concentration on the available data and using the same metric as in Figure 8 (Panel A) suggests that the concentration of taxes paid (and also profits) is in between the concentration of investment and the concentration of value-added in the countries considered.

[16] This analysis has been replicated on consolidated accounts to assess the concentration of global investment, which yields similar patterns to these based on unconsolidated accounts. Investment at the global level appears to be highly concentrated in multinational groups headquartered in a few countries and the composition of the group of firms with the highest investment display a similar stability as in unconsolidated accounts.

Figure 8. Investment is highly concentrated among subsidiaries of multinational firms



Note: Panel A: Firms are sorted by decreasing amount of investment (respectively value-added and number of employees), and concentration is assessed by the share of firms needed to reach 50% of investment (respectively value-added and number of employees) in the full Orbis sample for each country. Panel B: The firms in the top 0.5% of investment levels in 2019 are followed in previous years, and the persistence of the group's composition is assessed by considering the share of those firms in the top 0.5% in previous years (because some firms are not present in earlier years, this is computed as the share *within remaining firms*). Panel C: The height of the bar corresponds to the share of a country's investment represented by the top 0.5% investing firms. Those firms are then distinguished by whether they are subsidiaries of multinational enterprises (MNEs). MNEs are identified based on ownership links in Orbis (see Annex D for more details).
Source: Orbis database; and authors' calculations.

3. The sensitivity of investment to corporate taxation differs across firms, assets and tax policy design

Corporate income taxes tend to have a negative effect on business investment, although taxes are not the only determinant of investment. Higher corporate income taxes, by reducing the after-tax returns on investment, can lead firms to forgo, downscale or relocate some investment projects (Sorbe and Johansson, 2017[11]; Feld and Heckemeyer, 2011[3]). However, the sensitivity of firm investment to corporate tax rates is found to be heterogeneous across different types of firms. This sensitivity depends for example on firm characteristics such as size, age and sector (Schwellnus and Arnold, 2008[5]; Fuest, Peichl and Siegloch, 2018[7]; Federici and Parisi, 2015[8]); investment financing structure and liquidity constraints (Zwick and Mahon, 2017[9]); market structure, in particular market power (Kopp et al., 2019[10]); tax planning possibilities (Sorbe and Johansson, 2017[11]); and profitability (Millot et al., 2020[12]).

This section aims to explore the extent to which investment at the industry and firm levels responds to changes in corporate taxation. It also analyses whether this response has changed after the GFC, reflecting the disconnection in aggregate trends discussed in the previous section. Finally, it explores how tax sensitivity differs across firms, assets and tax parameters in order to help disentangle the potential effects of various specific measures and inform corporate tax policy reform design.

3.1. Baseline empirical framework to analyse the tax sensitivity of investment and its evolution

The empirical framework to explore the link between corporate taxation and business investment follows the same approach as in Sorbe and Johansson (2017[11]) and Millot et al. (2020[12]). This approach consists of estimating an equation derived from a neo-classical investment model where investment depends on the cost of capital (Hall and Jorgenson, 1967[30]) or one of its key components – corporate tax rates.[17] The equation is estimated for investment rates both at the aggregate (industry) level and at the firm level.

The effect of the corporate tax system is assessed using country-specific ETRs. As detailed in Annex E, ETRs capture the effect of not only statutory corporate tax rates but also of fiscal depreciation rules and other tax deductions. The analysis uses forward-looking ETRs, i.e. a synthetic tax policy indicator calculated on the basis of a hypothetical investment project (OECD, 2022[31]; Hanappi, 2018[27]).[18] In contrast to backward-looking ETRs (capturing the taxes actually paid by companies in the past), forward-looking measures are likely to better reflect investment incentives of the corporate tax system at a given point in time. They are also exogenous to investment, as they are computed based on hypothetical investment projects rather than based on taxes actually paid (which can partially reflect past investment decisions).

In principle, two versions of forward-looking ETRs can be used in estimations: marginal ETRs (EMTRs) and average ETRs (EATRs). The EMTR measures the extent to which taxation affects the cost of capital, i.e. the pre-tax rate of return on capital required to generate zero post-tax economic profit. It corresponds to the case of a marginal project that delivers just enough profit to break even. The EATR, in contrast, reflects the average tax paid by a firm on an investment project earning positive economic profits. Both rates can be relevant for investment decisions. EMTRs are more relevant for the intensive margin (e.g. to analyse how taxes affect the incentive to expand existing investments and the size of new investments), whereas EATRs are more relevant for the extensive margin (i.e. to analyse the effect on discrete investment decisions) (OECD, 2022[31]; Devereux and Griffith, 2003[32]). In the firm-level estimations, only EMTRs are used since it is not possible to observe entry and exit of firms in Orbis and thus the extensive margin. In the industry-level regressions, both EMTRs and EATRs are used.

The estimated equation at the industry-asset level is given by:

$$i_{a,c,i,t} = \alpha \cdot i_{a,c,i,t-1} + \beta \cdot EMTR_{a,c,t-1} + \gamma \cdot VAgrowth_{c,i,t-1} + \sum_{a,c,i} \delta_{a,c,i} + \sum_{a,i,t} \delta_{a,i,t} + \epsilon_{a,c,i,t} \qquad \textbf{(1a)}$$

where $i_{a,c,i,t}$ is the investment rate of industry *i* in asset type *a* (machinery and equipment; construction; or IPP) in country *c*, and in year *t*. The investment rate is defined as the ratio of gross fixed capital formation

[17] Following Sorbe and Johansson (2017[11]), the effect of financing costs (another component of the overall cost of capital) is not included in the baseline specification, but it is included as a control variable for robustness checks, using country-level real long-term interest rates on government bonds as a proxy for industry-level or firm-level financing costs.

[18] The formulas that are used for those ETRs are the same as those used in Section 2.2. and Figure 6. However, in contrast to Section 2.2, the macroeconomic parameters included in the formula (in particular the rate of inflation and the interest rate) are fixed and do not correspond to the realised values. This is because the goal of the estimation is to isolate the change in the forward-looking effective tax rates which are driven by taxation choices only. See the discussion below and Annex E for more details on the EMTR data.

in year *t* to the stock of fixed assets at the end of year *t-1*. $EMTR_{a,c,t-1}$ is the EMTR specific to asset *a* in country *c* and in year *t-1*. $VAgrowth_{c,i,t-1}$ is value-added growth at the country-industry level, in nominal terms, used as a control for demand factors. Finally, $\delta_{a,c,i}$ and $\delta_{a,i,t}$ are asset-country-industry and asset-industry-time fixed effects, controlling for all industry-asset-specific characteristics within countries and time-asset-specific characteristics within industries influencing investment rates.[19] This implies in particular that the econometric identification of the EMTR effect relies on the time variation of investment and EMTR within country-industry-assets and not on variation between country-industry-assets.

The same equation is also estimated at the industry level for the overall investment rate but without differentiating asset types, using a composite EMTR indicator which puts equal weights on all types of assets:

$$i_{c,i,t} = \alpha \cdot i_{c,i,t-1} + \beta \cdot EMTR_{c,t-1}^{composite} + \gamma \cdot VAgrowth_{c,i,t-1} + \sum_{c,i} \delta_{c,i} + \sum_{i,t} \delta_{i,t} + \epsilon_{c,i,t} \quad \textbf{(1b)}$$

In addition, the sensitivity of business investment to corporate taxation is also estimated at the firm level, using a similar approach:

$$i_{f,t} = \beta \cdot EMTR_{c,t-1}^{composite} + \gamma \cdot VAgrowth_{c,i,t-1} + \sum_{f} \delta_{f} + \sum_{i,t} \delta_{i,t} + \epsilon_{f,t} \quad \textbf{(1c)}$$

where $i_{f,t}$ is the investment rate of firm *f* operating in country *c*, in industry *i* and in year *t*. Investment is measured as the change in fixed assets (including both tangible fixed assets and intangible fixed assets) between year *t* and *t-1*, corrected for depreciation (both at book value). The investment rate is then defined as the ratio of investment in year *t* and fixed assets at the end of year *t-1*. $EMTR_{c,t-1}^{composite}$ corresponds to the composite forward-looking EMTR in country *c* and year *t-1*. δ_f and $\delta_{i,t}$ are firm and industry-time fixed effects, controlling for all firm-specific and time-specific (within each industry) characteristics influencing investment rates.[20] The identification of the EMTR effect on investment therefore relies on within firm variation. According to findings in the literature, the average effect of EMTRs on business investment (β), is expected to be negative both at the industry and firm levels (in both cases, β is identified by the changes in EMTR within countries over time).

Baseline equations at the industry and firm levels are also used to check if the tax sensitivity of investment changed after the GFC. This is done by interacting the EMTR with a dummy variable taking value 0 before 2009 and 1 after, rendering the following equation at the industry level:

$$i_{c,i,t}^{a} = \alpha \cdot i_{c,i,t-1}^{a} + \beta_1 \cdot EMTR_{c,t-1}^{a} + \beta_2 \cdot EMTR_{c,t-1}^{a} \cdot \mathbb{1}_{\{year \geq 2009\}} + \gamma \cdot VAgrowth_{c,i,t-1} + \sum_{a,c,i} \delta_{a,c,i} + \sum_{a,i,t} \delta_{a,i,t} + \epsilon_{a,c,i,t} \quad \textbf{(2)}$$

[19] Nickell (1981[66]) shows that including both fixed effects and the lagged dependent variable in ordinary least squares estimations can produce inconsistent estimates, although this bias diminishes when the estimation period is long. The estimation period at the industry and industry-asset levels covers 23 years which has been considered in previous studies as probably large enough to avoid the Nickell critique (Vartia, 2008[4]). As a robustness check, the equation is also estimated without including the lagged investment rate in the right-hand side variables, and the results are not substantially changed with this specification.

[20] Contrary to the industry-level estimation, the estimated equation at the firm level does not include the lagged dependent variable. This is because the observation period is shorter than in the industry-level sample, reflecting limitations in the coverage of available firm-level data (the firm-level sample covers 17 years in total, but most firms are observed only for a shorter period). Results would therefore be more likely to be affected by the Nickell bias if the lagged dependent variable was included.

A similar equation is estimated at the firm level. In this framework, if β_2 is for example estimated as positive and significantly different from zero, this would mean that the sensitivity of business investment to effective taxation has decreased, i.e. has become less negative, after the GFC.

The regressions rely on data from national accounts for the estimations at the industry level and Orbis for the estimations at the firm level. Forward-looking ETR indicators were built for the purpose of this analysis following the OECD methodology (OECD, 2022[31]; Hanappi, 2018[27]), itself derived from the theoretical model developed by Devereux and Griffith (2003[32]), and relying on publicly available information on country-specific corporate tax parameters including from (Spengel et al., 2020[28]) as well as other sources such as International Bureau of Fiscal Documentation (IBFD) and Ernst and Young. The final industry-level sample contains 27,687 industry-asset-year observations (10,137 industry-year observations) spanning 23 years (1999-2021), 27 countries and 27 industries. The final firm-level sample contains nearly 13 million firm-year observations. It covers firms in 25 (mostly European) countries, which are observed over up to 17 years (2003-2019). Additional details on the data sources, coverage and cleaning procedures, and basic descriptive statistics are in Annex E.

EMTR indicators are sensitive to the tax provisions included in the calculations. In particular, tax provisions to reduce the debt-equity bias, such as the Allowance for Corporate Equity (ACE),[21] tend to affect the EMTRs significantly. Their modelling differs across sources. Thus, some robustness checks in the analysis are run on the sample excluding countries having implemented an ACE system during the sample period (Austria, Belgium, Croatia, Cyprus, Italy, Latvia, Lithuania, Malta, Poland, Portugal and Türkiye).

3.2. Business investment is sensitive to corporate tax, but its sensitivity has decreased over time

The results from the baseline equations confirm the negative link between investment and the EMTRs (Table 1). These results are consistent across estimations at the industry level, at the industry-asset level and at the firm level, with an EMTR coefficient ranging from -0.02 to -0.05. At the industry level, a 5-percentage point increase in the EMTR (corresponding to about half of the average standard deviation in the sample) is associated, on average across industries, with a decrease in investment by 1.6% in the long term (about 0.8% in the short term).[22] This estimate is lower in magnitude than previous estimates at the industry level, for instance by Sorbe and Johansson (2017[11]) who used the same approach but a shorter sample (2000-2010). This difference could be explained by the fall in the sensitivity over time.[23] The tax sensitivity of investment has indeed significantly decreased after the GFC as shown by the positive and statistically significant coefficient of the time-dummy interacted variable across all specifications (Table 1, columns 2, 6 and 10).

Industry-level investment is also sensitive to taxation on the extensive margin, with the EATR estimated coefficient on the whole period being significant and negative (Table 1, columns 3 and 7).[24] This sensitivity is significantly weaker in the most recent period of the sample (Table 1, columns 4 and 8).

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[21] An ACE system aims at equating the treatment of debt-financed and equity-financed investment by allowing the deduction of a notional interest rate on equity to match the deduction of interest payments on debt.

[22] A 5-percentage point increase in the EMTR is associated with a lower investment rate by 5 × 0.0208 = 0.104 percentage point in the short term and $5 \times (0.0208/1 - 0.512) = 0.213$ percentage point in the long term. Given an average investment rate of 13% in the sample, this corresponds to lower investment by 0.213/13=1.6% in the long term.

[23] Sorbe and Johansson (2017[11]) also estimate firm-level equations, although the results are not directly comparable as their sample is restricted to firms belonging to multinational groups only.

[24] The comparison between EMTR and EATR coefficients needs to take into account the different scale of each indicator. In particular, one standard deviation corresponds to a change of 10 pp in EMTR and 6 pp in EATR.

The above results are robust to several alternative specifications. They include:

- controlling for the country-specific long-term real sovereign interest rate, as a proxy for industry or firm-level financing costs, the other main component of the cost of capital;
- dropping one country at a time from the sample;
- dropping all countries with the ACE system from the sample;
- for the industry and industry-asset level regressions, dropping the lagged dependent variable from right-hand side variables (footnote 19);
- for the firm-level regressions, dropping observations with negative investment rates and investment rates above 50%;[25]
- for the firm-level regressions, keeping observations with at least eight years of observations in the sample (instead of five).

Several factors could explain the decline in tax sensitivity of investment over time. A first explanation could be related to other factors affecting investment which are not taken into account in the model. Economic uncertainty has, for example, increased substantially following the GFC, probably dampening investment decisions for all firms. Tightened access to finance, particularly to bank loans, after the GFC is also likely to have played a role, as well as increasing market concentration. Part of these effects may be captured by the fixed effects, in particular changes in the overall economic environment affecting all firms (captured through industry*year fixed effects). However, these factors could still influence the results if not all firms are equally affected. Some structural factors may also play a role, such as the changing weight of certain types of firms or certain types of assets in overall investment, given that the sensitivity to corporate taxation is likely to be heterogenous.

[25] This cleaning is stricter than the one used in baseline firm-level regressions, which drops observations below the 10th or above the 90th percentile the investment rate distribution, i.e. investment rates below -9% and above 200%. For industry-level baseline regressions, the sample excludes negative investment rates and investment rates above 50%.

Table 1. Baseline results of investment regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Industry-level				Industry-asset level				Firm-level	
Investment rate$_{t-1}$	0.512***	0.509***	0.513***	0.510***	0.438***	0.437***	0.440***	0.439***		
	(0.0232)	(0.0231)	(0.0233)	(0.0237)	(0.0139)	(0.0139)	(0.0142)	(0.0143)		
EMTR$_{c,t-1}$	-0.0208**	-0.0367***			-0.0335***	-0.0405***			-0.0493***	-0.174***
	(0.0105)	(0.0129)			(0.00776)	(0.00863)			(0.0138)	(0.0206)
EMTR$_{c,t-1}$ X $1_{\{t\geq2009\}}$		0.0335***				0.0198***				0.155***
		(0.00910)				(0.00672)				(0.0192)
EATR$_{c,t-1}$			-0.0345	-0.0786**			-0.0365*	-0.0818***		
			(0.0242)	(0.0306)			(0.0218)	(0.0265)		
EATR$_{c,t-1}$ X $1_{\{t\geq2009\}}$				0.0802***				0.0810***		
				(0.0262)				(0.0218)		
Value added growth$_{i,c,t-1}$	0.0229***	0.0224***	0.0230***	0.0215***	0.0128**	0.0124**	0.0129**	0.0113**	0.0721***	0.0631***
	(0.00630)	(0.00625)	(0.00635)	(0.00630)	(0.00512)	(0.00509)	(0.00516)	(0.00514)	(0.0109)	(0.0105)
Country*industry FE	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO
Industry*year FE	YES	YES	YES	YES	NO	NO	NO	NO	YES	YES
Country*industry*asset FE	NO	NO	NO	NO	YES	YES	YES	YES	NO	NO
Industry*asset*year FE	NO	NO	NO	NO	YES	YES	YES	YES	NO	NO
Firm FE	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES
Observations	10,137	10,137	10,137	10,137	27,687	27,687	27,687	27,687	12,866,542	12,866,542
R-squared	0.852	0.853	0.852	0.853	0.885	0.885	0.885	0.885	0.278	0.279

Note: The estimated equations in Columns 1, 5 and 9 correspond to Equation (1b), (1a), (1c), respectively, where the dependent variable is the investment rate at the industry, industry-asset or firm-level. The estimated equation in Columns 6 corresponds to Equation (2). OLS estimates. Robust standard errors clustered at country*year level are presented in parentheses. *** indicates statistical significance at the 1% level, ** at the 5% level, * at the 10% level.

Source: OECD National Accounts; Orbis; Spengel et al. (2020[28]) http://hdl.handle.net/10419/231440; and authors" calculations.

3.3. How does tax sensitivity differ across asset types?

3.3.1. Empirical framework

The sensitivity of investment to the cost of capital, and specific tax parameters, is likely to differ across various types of assets. For example, investment in buildings and intangibles has been found to be more reactive to changes in dividend taxation than investment in machinery and equipment (Bilicka, Guceri and Koumanakos, 2022[33]).[26] To test the heterogeneity of tax sensitivity across asset types, the baseline industry-level equation is estimated separately for three types of assets:

$$i_{c,i,t}^{a} = \alpha \cdot i_{c,i,t-1}^{a} + \beta \cdot EMTR_{c,t-1}^{a} + \gamma \cdot VAgrowth_{c,i,t-1} + \sum_{c,i} \delta_{c,i} + \sum_{i,t} \delta_{i,t} + \epsilon_{c,i,t} \quad (3)$$

where $i_{c,i,t}^{a}$ is the investment rate in year *t* of industry *i* in country *c,* in three asset types (machinery and equipment; construction; and IPP), following the national accounts definitions, and $EMTR_{c,t-1}^{a}$ is the asset-specific EMTR in country *c* in year *t-1.* The EMTR is also interacted with a dummy variable indicating whether the investment takes place before or after 2009, to investigate differences in the sensitivity of investment over time.

3.3.2. Results

The results of the asset-specific estimations at the industry-level show that investments tend to react differently to changes in corporate taxation depending on the asset type. Investment in buildings is found to be less sensitive to its EMTR on the whole sample than investment in machinery and equipment and in IPP (both the short-run and long-run sensitivities are around 1.5 times smaller in absolute terms; Table 2).[27] In contrast, investment in buildings is found to be more sensitive to the EATR than investment in the two other asset types (for which the estimated coefficients are not significant). This suggests that investment in buildings is more sensitive to taxation at the extensive margin, which could relate to the fact that these types of investment are particularly lumpy compared to other types of investment. Results also show that sensitivity has decreased after the GFC for buildings, and machinery and equipment.

[26] This study finds that firms tend to invest more in land and buildings and in intangibles following an increase in dividend taxation. In the case of investment in land and buildings, which tend to be less productive than investment in other asset types, this could be a sign that firms are investing in assets that will allow them to avoid paying dividend taxes and will help them keep money within the firm.

[27] Results regarding investment in IPP should be taken with caution due to measurement issues. In particular, the measure of IPP in National Accounts covers all IPP assets, including internally developed products, whereas the ETR indicator for IPP is based on tax provisions applying only to externally acquired assets.

Table 2. Investment regression results: Heterogeneity across assets

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Buildings				Machinery and Equipment				IPP			
Investment rate$_{t-1}$	0.403***	0.397***	0.403***	0.400***	0.450***	0.448***	0.454***	0.449***	0.442***	0.442***	0.443***	0.443***
	(0.0275)	(0.0274)	(0.0276)	(0.0278)	(0.0186)	(0.0186)	(0.0193)	(0.0196)	(0.0198)	(0.0198)	(0.0199)	(0.0198)
EMTR$_{c,t-1}$	-0.0245**	-0.0413***			-0.0360***	-0.0527***			-0.0353***	-0.0349***		
	(0.00979)	(0.0104)			(0.0115)	(0.0146)			(0.0129)	(0.0127)		
EMTR$_{c,t-1}$ X $1_{\{t\geq 2009\}}$		0.0338***				0.0363**				-0.00431		
		(0.00733)				(0.0142)				(0.0131)		
EATR$_{c,t-1}$			-0.0405**	-0.0728***			-0.0515	-0.139***			-0.0144	-0.0246
			(0.0200)	(0.0238)			(0.0386)	(0.0459)			(0.0417)	(0.0532)
EATR$_{c,t-1}$ X $1_{\{t\geq 2009\}}$				0.0647***				0.138***				0.0186
				(0.0215)				(0.0350)				(0.0430)
Value added growth$_{i,c,t-1}$	0.0150***	0.0134**	0.0155***	0.0140**	0.0207**	0.0195**	0.0206**	0.0177**	-0.0006	-0.0007	-0.0009	-0.001
	(0.00573)	(0.00571)	(0.00572)	(0.00573)	(0.00884)	(0.00873)	(0.00892)	(0.00886)	(0.0109)	(0.0109)	(0.0109)	(0.0109)
Country*industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry*year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	10,001	10,001	10,001	10,001	9,885	9,885	9,885	9,885	7,801	7,801	7,801	7,801
R-squared	0.651	0.653	0.651	0.652	0.734	0.735	0.734	0.735	0.731	0.731	0.730	0.730

Note: The estimated equations in columns 1, 5 and 9 correspond to Equation (3), where the dependent variable is the industry-level investment rate in buildings, machinery and equipment, and IPP, respectively. OLS estimates. Robust standard errors clustered at country*year level are presented in parentheses. *** indicates statistical significance at the 1% level, ** at the 5% level, * at the 10% level.
Source: OECD National Accounts; Orbis; Spengel et al. (2020[28]) http://hdl.handle.net/10419/231440; and authors' calculations.

3.4. How does tax sensitivity differ across firms?

3.4.1. Empirical framework

The sensitivity of investment is also likely to differ across different types of firms. In line with the literature, the following regressions test whether the tax sensitivity of investment varies across a wide range of firm characteristics and over time. The between-firm heterogeneity in investment sensitivity is assessed by estimating coefficients β_1, β_2, β_3 and β_4 in a fixed-effect regression of the form:

$$i_{f,t} = \beta_1 \cdot EMTR_{c,t-1}^{composite} + \beta_2 \cdot EMTR_{c,t-1}^{composite} \cdot \mathbb{1}_{\{year\geq 2009\}} + \beta_3 \cdot EMTR_{c,t-1}^{composite} \cdot \mathbb{1}_{\{X_f=1\}} + \beta_4 \cdot EMTR_{c,t-1}^{composite} \cdot \mathbb{1}_{\{X_f=1\}} \cdot \mathbb{1}_{\{year\geq 2009\}} + \gamma \cdot VAgrowth_{c,i,t-1} + \sum_f \delta_f + \sum_{i,t} \delta_{i,t} + \epsilon_{f,t} \quad (4)$$

where X_f refers to various firm characteristics that might affect the tax sensitivity of investment, such as: firm size, multinational status, intangible intensity,[28] profitability and age.[29] This specification makes it possible to simultaneously investigate how tax sensitivity differs depending on specific firm characteristics, and how this difference has evolved between the pre-GFC and post-GFC periods.

3.4.2. Results

Results suggest that the tax sensitivity of investment varies over time depending on firm type. Large firms (i.e. with more than 250 employees on average over the total sample), firms that are part of multinational groups, firms that have a large proportion of intangibles in their total fixed assets (more than 10%), and firms that are highly profitable (i.e. with a ratio of profit before tax to operating turnover over 10%) have all become less sensitive to taxation compared with other firms after 2009 (Table 3, columns 1 to 4). However, there is no significant difference between firms in the pre-GFC period. The double interaction between the EMTR and the firm characteristics and the post GFC-dummies is positive and significant. The tax sensitivity of old firms (firms that are more than five years old on average over the whole sample) is also found to have weakened over time compared with young firms, although young firms were less sensitive to tax than old firms before 2009 (Table 3, column 5).[30]

The fact that large, multinational, intangible-intensive and profitable firms tend to be less affected by changes in corporate taxation than other firms could be explained by several factors. The characteristics mentioned above generally relate to what the recent literature has characterised as “superstar firms”, i.e. highly productive and innovative firms, which often rely intensively on intangible assets. These firms typically operate globally and increasingly dominate certain product markets, especially in digitalised industries and industries characterised by winner-takes-all or winner-takes-most dynamics (Calligaris, Criscuolo and

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28 Intangible intensity is measured according to the share of intangible assets in total fixed assets of firms, based on the Orbis data. This is an imperfect proxy of intangible intensity as intangible assets in Orbis cover only assets acquired externally, and not those that are developed internally.

29 Some of these variables tend to be positively correlated, for example most large firms are also part of a multinational group (Table A E.3 in Annex E).

30 Pre-GFC results on age and size are consistent with Schwellnus and Arnold (2008[5]), who find that the corporate tax sensitivity of investment is similar for small and large firms, but tends to be more negative for old firms than for young firms.

Marcolin, 2018[34]; Bajgar et al., 2019[35]; Gutiérrez and Philippon, 2019[36]; Autor et al., 2017[37]). For different reasons, these firms may react differently from other firms to changes in corporate taxation (Millot et al., 2020[12]). First, they may have a dominant position in the market, acquired thanks to past investments, and might be reluctant to reduce future investment as this might threaten their position. In the case of highly profitable firms with significant market power, taxes tend to be levied on monopoly rents rather than on normal returns to capital. This may induce smaller investment response to taxation, as suggested by recent evidence about reactions of US firms to the Tax Cuts and Jobs Act (Kopp et al., 2019[10]). Such firms might also have ample financial resources and easy access to multiple different sources of finance, which makes them less credit constrained and thus less sensitive to a potential increase in taxation.[31] Finally, in the case of multinational firms, tax planning incentives and the ability to shift profits (in particular through the strategic location of intangible assets)[32] could also make them less sensitive to local taxation than domestic firms (Sorbe and Johansson, 2017[11]). Indeed, the difference in tax sensitivity tends to be stronger between large multinational enterprises (MNEs) and other firms than between large domestic firms and other firms (Table 3, column 6 and 7). This is indicative of profit shifting playing a role.

[31] Regressions looking at tax sensitivity depending on various liquidity ratios (cash flow to fixed assets, cash and cash equivalent to fixed assets, cash flow to total assets and cash flow to current liabilities) were also tested. However, the results were inconclusive. This tends to be consistent with Figure 7 (Panel C), showing no significant difference in the firm investment trends depending on their debt-to-asset ratio.

[32] For example, de Mooij and Liu (2020[67]) find that introducing transfer pricing rules has a less negative effect on investment for firms with a relatively high share of intangibles.

Table 3. Investment regression results: Heterogeneity across firms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Value added growth$_{i,c,t-1}$	0.0644***	0.0634***	0.0630***	0.0632***	0.0632***	0.0644***	0.0644***
	(0.0106)	(0.0105)	(0.0104)	(0.0105)	(0.0105)	(0.0106)	(0.0106)
EMTR$_{c,t-1}$	-0.172***	-0.168***	-0.176***	-0.173***	-0.178***	-0.172***	-0.173***
	(0.0205)	(0.0203)	(0.0241)	(0.0208)	(0.0212)	(0.0205)	(0.0204)
EMTR$_{c,t-1}$ X $1_{\{t\geq 2009\}}$	0.151***	0.146***	0.148***	0.153***	0.155***	0.152***	0.153***
	(0.0190)	(0.0189)	(0.0226)	(0.0193)	(0.0193)	(0.0191)	(0.0191)
EMTR$_{c,t-1}$ X $1_{\{Size\ group=Large\}}$	0.00869						
	(0.0320)						
EMTR$_{c,t-1}$ X $1_{\{Size\ group=Large\}}$ X $1_{\{t\geq 2009\}}$	0.0342*						
	(0.0188)						
EMTR$_{c,t-1}$ X $1_{\{MNE=1\}}$		-0.0240					
		(0.0235)					
EMTR$_{c,t-1}$ X $1_{\{MNE=1\}}$ X $1_{\{t\geq 2009\}}$		0.0560***					
		(0.0162)					
EMTR$_{c,t-1}$ X $1_{\{Intangible\ intensity>10\%\}}$			0.0180				
			(0.0220)				
EMTR$_{c,t-1}$ X $1_{\{Intangible\ intensity>10\%\}}$ X $1_{\{t\geq 2009\}}$			0.0215*				
			(0.0123)				
EMTR$_{c,t-1}$ X $1_{\{Profitability=10\%\}}$				-0.00545			
				(0.0128)			
EMTR$_{c,t-1}$ X $1_{\{Profitability=10\%\}}$ X $1_{\{t\geq 2009\}}$				0.0166**			
				(0.00783)			
EMTR$_{c,t-1}$ X $1_{\{Age\ group=Young\}}$					0.143***		
					(0.0530)		
EMTR$_{c,t-1}$ X $1_{\{Age\ group=Young\}}$ X $1_{\{t\geq 2009\}}$					-0.0934**		
					(0.0414)		
EMTR$_{c,t-1}$ X $1_{\{Large\ MNE=1\}}$						0.0101	
						(0.0360)	
EMTR$_{c,t-1}$ X $1_{\{Large\ MNE=1\}}$ X $1_{\{t\geq 2009\}}$						0.0399**	
						(0.0201)	
EMTR$_{c,t-1}$ X $1_{\{Large\ Domestic=1\}}$							0.00939
							(0.0308)
EMTR$_{c,t-1}$ X $1_{\{Large\ Domestic=1\}}$ X $1_{\{t\geq 2009\}}$							0.0190
							(0.0188)
Industry*year FE	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES
Observations	12,764,428	12,866,542	12,865,636	12,824,237	12,854,744	12,764,428	12,764,428
R-squared	0.278	0.279	0.279	0.279	0.279	0.278	0.278

Note: The estimated equations correspond to Equation (4), where the dependent variable is the investment rate at the firm level, measured as the change in fixed assets corrected for depreciation (both measured at book value) divided by lagged fixed assets. Size group=Large refers to firms with more than 250 employees on average in the total sample. MNE=1 refers to firms belonging to multinational groups, according to Orbis ownership links data in 2019. Intangible intensity refers to the firm's average ratio of acquired intangible assets to total fixed assets over the sample period. Profitability refers to the firm's average ratio of profits before tax to operating turnover over the sample period. Age group=Young refers to firms that are five years old or younger on average over the total sample. Large MNE=1 (resp. Large Domestic=1) refers to firms that belong (respectively do not belong) to a multinational group in 2019 and that have more than 250 employees on average over the sample period. OLS estimates. Robust standard errors clustered at country*year level are presented in parentheses. *** indicates statistical significance at the 1% level, ** at the 5% level, * at the 10% level.

Source: OECD National Accounts; Orbis; Spengel et al. (2020[43]); and authors' calculations.

3.5. Does sensitivity to effective tax rates depend on the corporate tax design?

3.5.1. Empirical framework

The ETR indicators used to study the tax sensitivity of investment in the previous subsections are affected not only by STRs but also by various other tax provisions. They include, among others, capital allowances that affect firms' effective tax liabilities through the taxable income base.[33] ETRs, which determine total tax liabilities of a firm, can be affected by changes in the tax base or the tax rate. The reaction of firms to changes in these two components can be different. A recent study argues that changes in annual investment allowances should have a stronger impact on UK firms' investment than changes in the statutory corporate tax rate (Adam, Delestre and Nair, 2022[38]).[34] In theory, STRs should have a small impact on firms' marginal investments since, by definition, those investments have low profitability. However, they will affect the tax revenue from economic rents, which also matter for investment decisions (Barro and Furman, 2018[39]). As a consequence, the STR will still matter for the overall level and location of business investment.

This final part of the analysis aims to disentangle the effect of different CIT design choices on investment, and, in particular, the effect of changes in the tax rate versus changes in the tax base. It aims to simulate the effect on investment rates of a change in the statutory corporate tax rate and an equivalent change in allowances. Ideally, the equivalence between the two types of measures would need to be defined referring to a tax-revenue-neutral reform to identify the effect of a pure structural change in corporate tax design on economic activity. Since tax revenue cannot be observed in the empirical framework described above, the proposed approach simply considers reforms that induce the same change in EMTRs. However, such an approach does not account for several effects:

- The proposed proxy focuses on the effective tax rate on a theoretical marginal investment, i.e. an investment which delivers no economic profit after taxation. The impact on revenue may be different depending on the profitability of the investment. Higher STRs are likely to generate more revenues for more profitable investment, while the revenue effect of allowances would be unchanged. Hence, the increase in allowances that would be equivalent to a given STR cut in terms of tax revenue would actually be higher across the full population of firms than what is assumed in the EMTR-neutral setting.
- The simplified assumption ignores dynamic and general equilibrium effects, like the fact that additional revenue may arise if the reform leads to higher investment and growth. The EMTR focuses on the intensive margin, while the tax rate also matters for the extensive margin. High rates might discourage new investment projects in a country (in particular for large MNEs), which could also affect tax revenue. Consequently, the increase in allowances that would be equivalent to a given STR cut in terms of tax

[33] Capital allowances relate to fiscal depreciation rules. Jurisdiction-specific tax codes provide capital allowances to reflect the decrease in asset value over time. If capital allowances are more (respectively less) generous relative to economic depreciation, fiscal depreciation is accelerated (respectively decelerated). Other measures affecting the tax base include deductions of interest payments or notional interest deductions on equity through ACE systems (OECD, 2022[31]).

[34] One complex issue in this context, which is discussed below, is to define and compare "equivalent" changes in tax rates and tax bases.

revenue might be higher than what is assumed in the EMTR-neutral setting which would thus tend to offset the first effect.[35]

Two different approaches are used to test if changes in the statutory corporate tax rate and in parameters affecting the tax base have different effects on the tax sensitivity of investment. The first approach involves simply replacing the EMTR indicator by the STR and a parameter representing the tax base (the two main components of the EMTR) in the firm-level baseline equation discussed above, as well as their interaction:

$$i_{f,t} = \beta_1 \cdot STR_{c,t-1} + \beta_2 \cdot (1-Z)_{c,t-1} + \beta_3 \cdot STR_{c,t-1} * (1-Z)_{c,t-1} + \gamma \cdot VAgrowth_{c,i,t-1} + \sum_f \delta_f + \sum_{i,t} \delta_{i,t} + \epsilon_{f,t} \quad (5)$$

where STR is the statutory corporate tax rate, and Z is the net present value of depreciation allowances used in calculating the EMTR ($1-Z$ is therefore a proxy for the tax base, decreasing with the level allowances).[36] After estimating the three β coefficients, they can be used to simulate the overall effect of a rate change versus an equivalent (EMTR-neutral) change in allowances on firm-level investment rates. Due to the presence of the interaction term, this effect will depend on the initial level of the rate and allowances considered. For example, capital allowances are likely to have a larger impact when the STR is high.

The second approach decomposes the overall EMTR indicator used in the baseline analysis to disentangle the contribution of different parameters and their respective effects on firm investment rates. The methodology used for the decomposition of the EMTR indicator is explained in detail in Annex C. The country-level EMTR for each year is decomposed between four components accounting for the effect of: (i) the statutory rate ($\widehat{STR}$ *component*), (ii) depreciation allowances ($\hat{Z}$ *component*)[37], (iii) the presence or not and the specific design of an ACE system ($\widehat{ACE}$ *component*), and (iv) the presence or not and the specific design of non-profit taxes[38] ($\widehat{NPT}$ *component*) affecting corporations, plus a residual component accounting for the interaction effect between all the parameters. The following equation is then estimated:

$$i_{f,t} = \beta_1 \cdot \widehat{STR}_{c,t-1} + \beta_2 \cdot \hat{Z}_{c,t-1} + \beta_3 \cdot \widehat{ACE}_{c,t-1} + \beta_4 \cdot \widehat{NPT}_{c,t-1} + \gamma \cdot VAgrowth_{c,i,t-1} + \sum_f \delta_f + \sum_{i,t} \delta_{i,t} + \epsilon_{f,t} \quad (6)$$

As in the first approach, the overall effect of a rate change versus an equivalent (e.g. EMTR-neutral) change in allowances on firm-level investment rates is then simulated based on the estimated β coefficients. Given that ACE systems tend to have a significant effect on the decomposition (Annex E, Figure A E.1), this regression is run both on the full sample of countries and on the sample excluding countries that have implemented an ACE system.[39]

[35] Overall, these effects will generally increase with the share of rents in total profit.

[36] The net present value of depreciation allowances is asset specific. The *Z* parameter is computed as the average allowances across the three different asset types.

[37] The $\hat{Z}$ component measures the contribution of allowances to the level of EMTR, it is therefore decreasing with the level of Z, as the base parameter $(1-Z)$ in the first approach.

[38] Non-profit taxes correspond here to taxes levied on real estate and/or corporate wealth (Hanappi, 2018[27]). See Spengel et al. (2020[28]) for more details on which non-profit taxes are covered for each country.

[39] The regressions on the two samples yield similar results in terms of the signs of the coefficients, however the size of the coefficients tends to differ. Given uncertainties in the calculations of the ACE component in the EMTR decomposition, the simulation favours the results based on the sample excluding countries with the ACE system.

Finally, in order to study differences between non-profit taxes and corporate income taxes, the following equation, derived from the baseline firm-level equation, is estimated:

$$i_{f,t} = \beta_1 \cdot EMTR_{c,t-1} + \beta_2 \cdot EMTR_{c,t-1}^{NPT=0} + \gamma \cdot VAgrowth_{c,i,t-1} + \sum_f \delta_f + \sum_{i,t} \delta_{i,t} + \epsilon_{f,t} \quad (7)$$

where $EMTR_{c,t-1}$ is the overall EMTR indicator, including the effect of non-profit taxes applicable in year *t-1* in country c, and $EMTR_{c,t-1}^{NPT=0}$ is the EMTR resulting from the same CIT parameters but in the absence of non-profit taxes. If β_1 is negative and β_2 is positive, non-profit taxes have a more negative effect on investment than the CIT parameters.

3.5.2. Results

The coefficients of the regressions that disentangle the respective roles of the tax rates and allowances are difficult to interpret (Table 4, columns 2, 4 and 5). This is due to the interaction between the rate and base parameters, which affects overall tax liabilities and in turn investment. However, the estimated coefficients can be used to simulate the investment response to a STR cut and the equivalent (EMTR-neutral) increase in allowances. Using the coefficients estimated in Equation (5), a 5-percentage point cut in the STR from the average level of the STR and allowances is found to increase the investment rate by 0.07 percentage point. With the EMTR-equivalent increase in capital allowances, the effect is more than ten times larger, increasing investment by 0.75 percentage point (Figure 9, Panel A). Similar results are obtained when using coefficients from Equation (6), based on the components of the EMTR decomposition. At the median level of STR and allowances in the sample, a marginal decrease in the statutory tax rate while keeping the EMTR constant results in a lower investment level than a marginal increase in allowances (Figure 9, Panel B).

Several factors could explain the finding that investment is more sensitive to the base than to the rate. One explanation may be that rate changes could affect economic rents rather than the normal return on investment, implying reduced behavioural responses to rate changes. Another reason is that tax rates tend to be more volatile than base parameters, which might also downplay behavioural responses to rate changes as these might be perceived as transitory.[40] Finally, allowances and rate changes are likely to affect different types of firms. In particular, changes in rates may have a bigger impact on highly profitable firms, which tend to be less sensitive to taxation according to results shown in Table 3. Thus, base changes could be better targeted towards tax-sensitive firms.

However, the result on the relative effect of an STR change compared to a change in allowances depends on the initial level of STR and allowances considered. For example, with high EMTRs, a rate cut is found to have a stronger impact on investment than an equivalent increase in allowances.[41] In general, the higher the initial STR level and the lower the level of EMTR, the less beneficial a rate cut is found to be compared with an equivalent increase in allowances (Figure 9, Panel B).[42]

[40] On average over the countries covered in the sample, STRs have changed 4.1 times between 2005 and 2020, versus 4.9 times for capital allowances.

[41] For example, in a country like Spain, which has a relatively low EMTR (6% in 2020, close to the first quartile the sample used for Figure 9, Panel B) and a STR of 25%, a marginal rate cut would be less beneficial for investment than an equivalent increase in allowances. The reverse would apply to Finland, which has a relatively high EMTR (16% in 2020, above the third quartile) and relatively low STR (20%).

[42] At very high STR and allowances levels, an increase in STRs may also be beneficial to investment as it can result in a lower EMTR level by increasing the value of interest deductions.

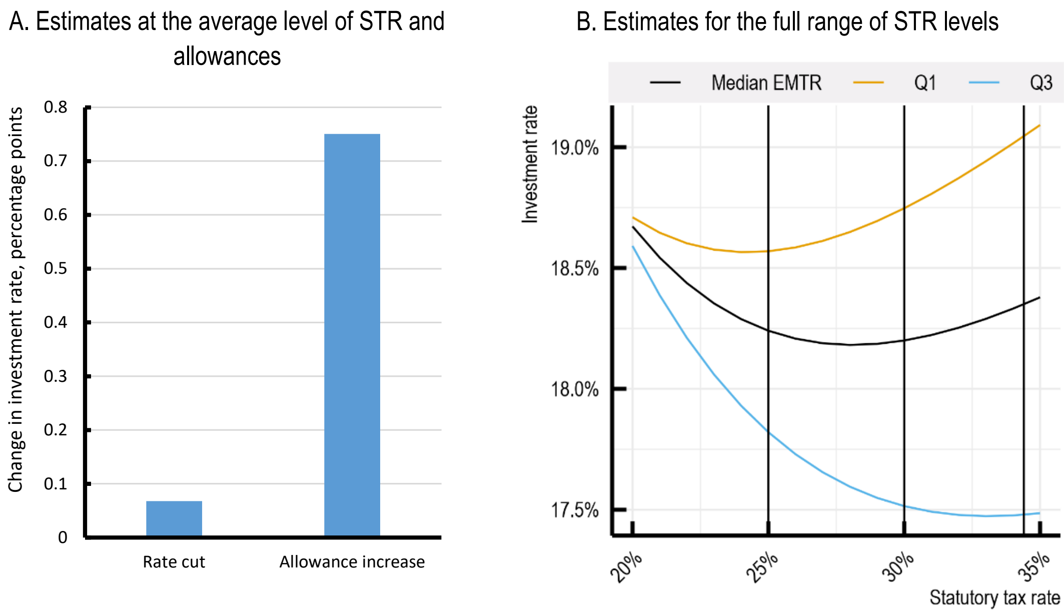
Finally, the results tend to show that non-profit taxes have a more negative impact on investment rates than other components of the EMTR (Table 4, column 3). This result is consistent with earlier findings from the literature arguing that non-profit taxes tend to have more distortive effects than taxes based on profits (Martin and Trannoy, 2019[40]).

Table 4. Investment regression results: Heterogeneity across corporate tax parameters

	(1)	(2)	(3)	(4)	(5)
	Full sample				No ACE sample
Value added growth$_{i,c,t-1}$	0.0722***	0.0764***	0.0683***	0.0700***	0.0777***
	(0.0109)	(0.0110)	(0.0110)	(0.0108)	(0.0105)
EMTR$_{c,t-1}$	-0.0491***		-0.306***		
	(0.0138)		(0.0478)		
STR$_{c,t-1}$		0.423**			
		(0.192)			
(1-Z)$_{c,t-1}$		0.288*			
		(0.149)			
STR$_{c,t-1}$ X (1-Z)$_{c,t-1}$		-1.347**			
		(0.554)			
EMTR_NPT0$_{c,t-1}$			0.269***		
			(0.0466)		
STR component$_{c,t-1}$				-0.278*	-0.440***
				(0.156)	(0.142)
Z component$_{c,t-1}$				-0.0858	-0.142**
				(0.0560)	(0.0568)
ACE component$_{c,t-1}$				0.0461	
				(0.0327)	
NPT component$_{c,t-1}$				-0.236***	-0.156***
				(0.0503)	(0.0529)
Residual component$_{c,t-1}$				-0.177***	-0.576***
				(0.0653)	(0.101)
Industry*year FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES
Observations	12,869,037	12,869,037	12,869,037	12,869,037	8,533,303
R-squared	0.278	0.278	0.279	0.279	0.282

Note: The dependent variable in all columns is the investment rate at the firm level, measured as the change in fixed assets corrected for depreciation (both measured at book value) divided by lagged fixed assets. The estimated equation in column 2 corresponds to Equation (5), where the STR corresponds to the lagged corporate statutory tax rate and Z corresponds to the net present value of capital allowances (averaged across three asset types). The estimated equation in column 3 corresponds to Equation (7), where EMTR_NPT0 corresponds to the EMTR with all corporate income tax parameters unchanged except non-profit taxes which are set to 0. The estimated equation in the last two columns corresponds to Equation (6), where STR, Z, ACE, NPT and Residual components refer to an EMTR decomposition disentangling the effect of the STR, depreciation allowances, the presence or not and the specific design of an ACE system, and the presence or not and the specific design of non-profit taxes, as detailed in Annex C. This regression is run both on the full sample of countries (column 4) or on the sample excluding countries that have implemented an ACE system (column 5). OLS estimates. Robust standard errors clustered at country*year level are presented in parentheses. *** indicates statistical significance at the 1% level, ** at the 5% level, * at the 10% level.
Source: OECD National Accounts; Orbis; and Spengel et al. (2020[28]); and authors' calculations.

Figure 9. Investment rate response to a statutory CIT rate change or the equivalent change in allowances



Note: Panel A: The graph plots the estimated increase in investment rates following a 5-percentage point cut in the STR or the equivalent (EMTR-constant) increase in allowances, based on Equation (5) estimates (Table 4, column 2). The effect is estimated at the average level of STR and allowances in the sample, under a scenario without an ACE system and non-profit taxes. Considering different initial values of STR or allowances would yield different results. Panel B: The graph plots the estimated level of investment rate for a range of CIT rate-allowances pairs corresponding to the same EMTR level, based on Equation (6) estimates (Table 4, column 5), around a reference level of 18.2% (average investment rate in the sample considered) at the median EMTR and STR. Given the important impact that ACE parameters have in the EMTR decomposition, the results of the estimation based on the sample excluding countries with ACE system is preferred for this simulation exercise. Vertical lines correspond to the quartiles of the STR in the relevant sample. Likewise, the EMTR quantiles are defined over the relevant sample. The figure can be read as follows: for countries at the median EMTR level in the sample (black line) and with a STR of 30%, the results suggest that moving to a STR of 35%, while keeping the same EMTR (i.e. compensating the STR increase with an increase in allowances), would result in a higher rate of investment. On the contrary, for countries at the median EMTR level and with a STR of 20%, the results suggest that moving to a STR of 25%, while keeping the same EMTR, would result in a lower rate of investment.
Source: Orbis; OECD National Accounts; Spengel et al. (2020[28]); and authors' calculations.

4. Policy discussion

Supporting business investment is a key priority for governments to sustain long-term growth. Policies to support business investment will also be central in allowing countries to tackle long-term challenges, such as climate change or the digital transformation, which will require significant investment both from public and private sources.[43] Strengthening investment would also be important if the structural forces behind "secular stagnation", leading to persistently low demand, were to come back after inflation and interest rates have normalised (Rachel and Summers, 2019[41]).

[43] For instance, European countries will need to invest EUR 340 billion (2.3% of GDP) a year in energy systems and related infrastructure to meet their 55% emission reduction target by 2030, of which more than half is likely to be financed from private sources (EIB, 2021[75]). The digital transformation of economies also requires substantial private investment, including in communications infrastructures, technologies, and knowledge-based capital (OECD, 2020[72]; Sorbe et al., 2019[71]).

Corporate tax policy has often been considered as one of the key levers through which governments may influence investment.[44] Past studies focusing on the implications of the CIT system for investment have argued that lower effective taxation (via lower rates, higher allowances and other measures) reduces investment costs, which in turn increases investment and growth (Schwellnus and Arnold, 2008[5]; Vartia, 2008[4]). For this reason, many studies (including past OECD papers and reports) have supported a shift away from corporate and personal income taxes towards consumption and property taxes (OECD, 2010[42]; Johansson et al., 2008[43]; Cournède, Fournier and Hoeller, 2018[44]). However, the assessment of corporate taxation and investment linkages is evolving. Recent studies as well as this paper, seek to provide a more nuanced assessment of the impact of corporate tax on investment and growth.

- First, the results in this paper align with an expanding literature showing that there is significant heterogeneity in firms' investment responses to corporate taxation (Federici and Parisi, 2015[8]; Sorbe and Johansson, 2017[11]; Zwick and Mahon, 2017[9]; Fuest, Peichl and Siegloch, 2018[7]; Millot et al., 2020[12]; Hanappi and Whyman, forthcoming[45]). After the GFC, large firms, firms that are part of multinational groups, firms that have a large proportion of intangibles in their total fixed assets, and firms that are highly profitable have become less sensitive to taxation compared with other firms. The tax sensitivity of old firms has also decreased over time compared with young firms.
- Second, this paper points to a decline in the tax sensitivity of investment after the GFC for many firms. This finding suggests that changes in corporate taxation that result in higher ETRs reduce investment less now than before the GFC.
- Third, this paper also highlights significant heterogeneity in tax responses to different CIT parameters, in particular between the statutory CIT rate and the CIT base, as discussed further below.

Recent international tax developments may influence the effects of corporate tax policies. Over recent decades, trade and financial globalisation have increased international tax competition, and have contributed to sizeable tax revenue losses due to profit shifting (OECD, 2015[46]; Clausing, 2011[47]). However, multilateral co-operation on international tax matters will limit the scope for such competition. Potential revenue gains from policy strategies to attract shifted profits are being reduced as a result of progress in the adoption of the 15 Actions under the OECD/G20 Base Erosion and Profit Shifting (BEPS) project. In addition, the agreement to implement a Global Minimum Corporate Tax under the Two Pillar Solution to Address the Tax Challenges of the Digital Economy will further reduce profit-shifting and place multilaterally agreed limits on tax competition in the form of a 15% minimum effective tax rate on large MNE groups (OECD, 2021[48]). Still, certain provisions (e.g. the Substance-Based Income Exclusion and the treatment of accelerated depreciation and R&D expenses) will allow governments to continue to seek to attract MNE investment through their CIT policies (OECD, 2021[48]).

The findings presented in this paper suggest that stimulating investment through the corporate tax system, especially through statutory tax rate reductions, may be less effective than previously assessed. CIT cuts, even sizeable ones, may have little effect in terms of aggregate investment and economic growth, while they might adversely affect public finances which are already under pressure (Guillemette and Turner, 2021[49]). At the same time, the evidence suggests that investment responses of certain types of firms to taxation remain strong. The

[44] Other policy areas are also likely to play a role in supporting investment, including stimulating aggregate demand through macroeconomic policies, reducing policy-related uncertainty, enhancing the functioning of financial markets, product and labour markets and environmental regulations, or public investment in infrastructure (Égert, 2021[70]; OECD, 2015[13]).

findings of this paper highlight three dimensions of heterogeneity in tax sensitivities that appear particularly relevant from a CIT policy perspective: variation in (i) the responsiveness of investment with respect to different types of business taxes; (ii) the responsiveness of different taxpayers; and (iii) the responsiveness to changes in statutory CIT rate and the CIT base.

4.1. Sensitivity to different kinds of business taxes

The taxation of corporations should target business income or profits and limit business taxes levied on a base other than profit, which can be highly distortive. Although business taxes on bases other than profit generally represent a moderate share of total taxes paid by businesses compared to CIT, their number and importance tend to vary across countries (Martin and Trannoy, 2019[40]). In theory, taxes on bases other than profit are expected to weaken the link between investment decisions and a firm's profitability. In practice, the results presented above provide evidence that they have a stronger negative effect on investment compared with income-based taxes (Subsection 3.5.). Thus, non-profit taxes are likely to reduce the level of investment for a given firm. Moreover, taxation based on inputs may induce distortions which can contribute to a misallocation of factors of production that can in turn affect the aggregate productivity of the economy. While not being the focus of this paper, the latter effect could be macroeconomically relevant. Recent literature has suggested that the misallocation of the factors of production has contributed to half of the fall in total factor productivity in the United States and Europe in recent years (Baqaee and Farhi, 2019[50]; ECB, 2021[51]).

4.2. Sensitivity of different firms

Governments could enhance revenue-raising from CIT and support investment by targeting policies towards more responsive firms or types of investment where there is evidence of positive externalities.

The behavioural response to taxation of large multinational firms responsible for most of business investment appears to have weakened, while other firms tend to be more responsive (Section 3.4.). Investment allowances that are capped at an absolute amount can ensure that tax benefits reach smaller and relatively more responsive firms. Such preferences could be justified in order to address some market failures such as difficulties in accessing finance for small firms.

Similarly, where investments are expected to have particularly strong positive externalities, e.g. in terms of knowledge spillovers, targeted ETR reductions can be provided through accelerated or bonus depreciation, or full expensing operating directly at the asset level, where policy makers choose to use the CIT system for this purpose.[45]

Nevertheless, targeted measures pose several risks, including higher complexity and compliance costs as well as distortions to firm behaviour and the possibility of windfall gains for firms benefiting from generous incentives. Targeted measures can increase the misallocation of capital and provide opportunities for tax planning, and if poorly designed, can result in redundant incentives. For instance, firms may reshape corporate structures to keep firms under certain size thresholds or to make the most of tax incentives on certain types of assets. Low

[45] Examples of such policies already exist across OECD countries, for example with R&D tax incentives (González Cabral, Appelt and Hanappi, 2021[77]). Specific allowances can also be used to foster investment with a positive environmental impact. The United States for example has a longstanding tradition of using corporate tax credits to encourage investment in renewable energy production, such as wind and solar, while the Netherlands has an Environment Investment Allowance for investment in technologies aiming to encourage the low-carbon transition (OECD, 2020[73]).

CIT rates on small firms can result in labour income being re-characterised as capital income (Smith et al., 2019[52]; Cooper et al., 2016[53]). Overly complex tax incentive schemes, or those that are poorly targeted (e.g. those that are not targeted at more responsive firms or where there are externalities) can moreover reduce transparency, which can lead to wasteful incentives or windfall gains.[46] To avoid such outcomes, countries should introduce such targeted measures only in the presence of a strong institutional framework, in addition to supporting administrative capacity in order to identify relevant firms precisely and monitor heterogeneous tax implementation, including through tax expenditure reporting.

4.3. Sensitivity to base and rate measures

Measures to lower the EMTRs of tax-sensitive firms may be more effective in supporting investment if they are implemented through allowances rather than STR reductions. Tax sensitive firms may be less mobile and thus more sensitive to the intensive margin rather than the extensive margin (Adam, Delestre and Nair, 2022[38]). This would imply that they are more sensitive to allowances, which are independent of profitability and tend to affect investment decisions at the intensive margin, compared to the STR, which plays a bigger role at the extensive margin. In practice, the empirical evidence presented in Section 3.5. suggests that base measures can be more effective in increasing investment compared to STR cuts, especially at low EMTR levels.

In most OECD countries, capital allowances are currently following economic depreciation at the asset level quite closely (OECD, 2022[31]). Providing more acceleration, bonus depreciation or full expensing of certain investments could be an attractive policy option to increase investment effectively, while minimising the government's cost per additional unit of business investment. Accelerated depreciation or even full expensing of tangible capital assets are likely to be less affected by the Global Minimum Tax due to the deduction of a fraction of the value of assets and payroll from the base of the minimum tax (the Substance Based Income Exclusion) and the fact that the GloBE Rules are designed to avoid imposing additional top-up tax as a result of differences in the timing of taxes paid (OECD, 2022[54]).

In some cases, the use of targeted allowance measures could potentially be financed by modestly higher STRs, depending on country-specific economic conditions such as the reliance on foreign direct investment (FDI) in total investment and the existing STR. Higher STRs, combined with more generous capital allowances, are likely to reduce distortions as the CIT would be largely levied on economic rents.[47] The main concern with such an approach is that it could reduce a country's competitiveness in attracting FDI relative to its peers, and therefore have a negative impact on aggregate investment. However, the reduced sensitivity to tax and the recently agreed multilateral limitations on the race to the bottom on CIT rates as a result of the international corporate tax reform may attenuate this concern (Hebous and Keen, 2022[55]), although in the individual country case, this will likely also depend on the existing STR. Such an approach may allow countries to safeguard their current levels of revenue, while attracting additional investments. Of course, in addition to taxation, countries' attractiveness to foreign investment is crucially driven by a range of non-tax factors and the evidence suggests that responsiveness to tax at both margins is likely to have declined after the GFC, especially for the largest firms accounting for most investment.

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[46] These issues can be particularly relevant for developing countries (Celani, Dressler and Hanappi, 2022[79]).

[47] However, the aim of such policy is not to tackle economic rents per se, which are more likely to be addressed through competition policies.

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Annex A. Business investment in national accounts

There are two main sources of business investment data in national accounts:

- First, the national accounts by sectors directly provide data on gross fixed capital formation (GFCF) of non-financial and financial corporations. The advantage of using these data is an explicit focus on the corporate sector. The disadvantage is that several details are lacking. For instance, there is no deflator available by sector, and different types of economic activities and assets cannot be easily distinguished.
- Second, the national accounts provide data on capital formation and value-added by activity, using the International Standard Industrial Classification of All Economic Activities (ISIC) rev4 classification (Table A A.1). Business activities are commonly defined as all sectors excluding agriculture, forestry and fishing (sector A) and sectors that are more likely to be public (sectors O though U), including education and social work activities for example. In this paper, we also exclude the real estate sector (L) as its investment corresponds mostly to investment in dwellings by households (this is also the sector where the value-added generated by imputed rents is classified). The data by business activities have advantages related to data availability for investment deflators, value-added by activity and different types of assets, facilitating detailed sector-specific analyses of investment.

Table A A.1. Broad structure of the ISIC of all economic activities and business sectors

Section	Divisions	Description
A	01–03	Agriculture, forestry and fishing
B	05–09	Mining and quarrying
C	10–33	Manufacturing
D	35	Electricity, gas, steam and air conditioning supply
E	36–39	Water supply; sewerage, waste management and remediation activities
F	41–43	Construction
G	45–47	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	49–53	Transportation and storage
I	55–56	Accommodation and food service activities
J	58–63	Information and communication
K	64–66	Financial and insurance activities
L	68	Real estate activities
M	69–75	Professional, scientific and technical activities
N	77–82	Administrative and support service activities
O	84	Public administration and defence; compulsory social security
P	85	Education
Q	86–88	Human health and social work activities
R	90–93	Arts, entertainment and recreation
S	94–96	Other service activities
T	97–98	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
U	99	Activities of extraterritorial organizations and bodies

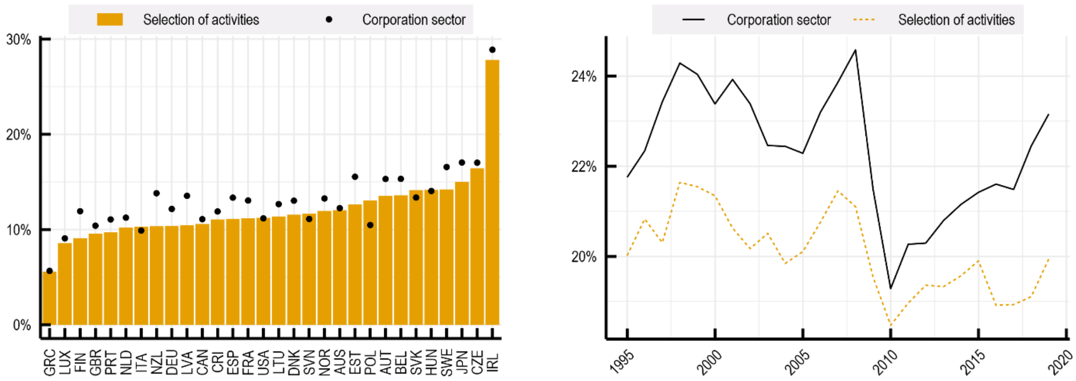
Note: ISIC stands for international standard industry classification. Business sectors highlighted in yellow.
Source: United Nations Statistical Division (2008[56]).

In recent years, the two measures were close to each other in the OECD countries (Figure A A.1, Panel A). They followed the same trend since 1995 based on the median investment to gross-value-added ratio for the OECD countries (Figure A A.1, Panel B). Business investment based on the ISIC rev4 classification is the favoured measure in this paper, unless otherwise specified. This is motivated by its various advantages and only small differences with the other measure.

Figure A A.1. Business investment can be measured in two main ways in national accounts

A. Business investment to GDP ratio, 2014-19 average

B. Median business investment to gross value added



Note: In Panel A, countries are sorted according to the gross investment rate by the selection of activities. In Panel B, the lines refer to the medians across the OECD countries with available data. The selection of activities corresponds to investment in sectors B through N excluding the real estate sector (L) according to the ISIC rev. 4 classification in national accounts.
Source: National accounts; and authors' calculations.

The drawback of using the data by activity in national accounts is that the country coverage for investment is slightly narrower than in national accounts by sectors. Table A A.2 shows the country and time coverage of the investment data. Most European countries and the United provide data for the 12 activities selected as business activities. Data are unavailable for water supply; sewerage, waste management and remediation activities (sector E) in Australia, Canada and New Zealand; for that sector and for administrative and support service activities (sector N) in Japan; and for mining and quarrying (sector B) and electricity, gas, steam and air conditioning supply (sector D) in Israel. Those countries are kept in the sample for the purpose of the analysis of aggregate data, while the remaining OECD countries are excluded. For the countries selected, data are typically available at least since 1995 and up to 2020.

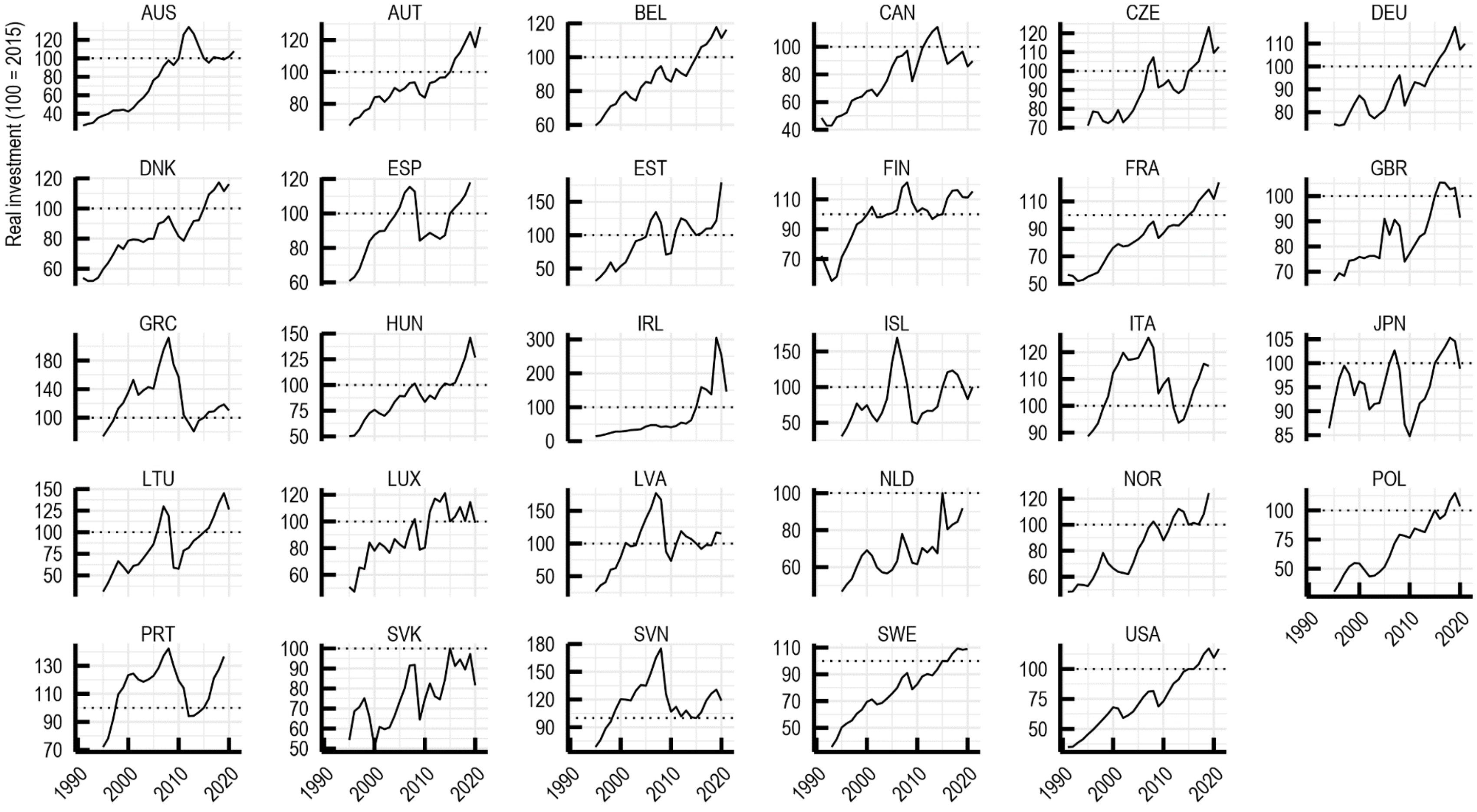
Table A A.2. Coverage of investment data by activity in national accounts

ISO3 country code	Number of business activities with investment data	Time coverage
AUS	11	1980-2021
AUT	12	1995-2021
BEL	12	1995-2020
CAN	11	1980-2020
CHL	2	2018-2020
CRI	12	2012-2016
CZE	12	1995-2021
DEU	12	1995-2021
DNK	12	1980-2019
ESP	12	1995-2019
EST	12	1995-2020
FIN	12	1980-2021
FRA	12	1980-2020
GBR	12	1995-2020
GRC	12	1995-2020
HUN	12	1995-2020
IRL	12	1995-2021
ISL	12	1995-2021
ISR	10	2006-2020
ITA	12	1995-2019
JPN	10	1980-2020
LTU	12	1995-2020
LUX	12	1995-2020
LVA	12	1995-2020
MEX	6	1993-2019
NLD	12	1995-2019
NOR	12	1980-2019
NZL	11	1980-2017
POL	12	1995-2020
PRT	12	1995-2019
SVK	12	1995-2020
SVN	12	1995-2020
SWE	12	1993-2020
USA	12	1980-2021

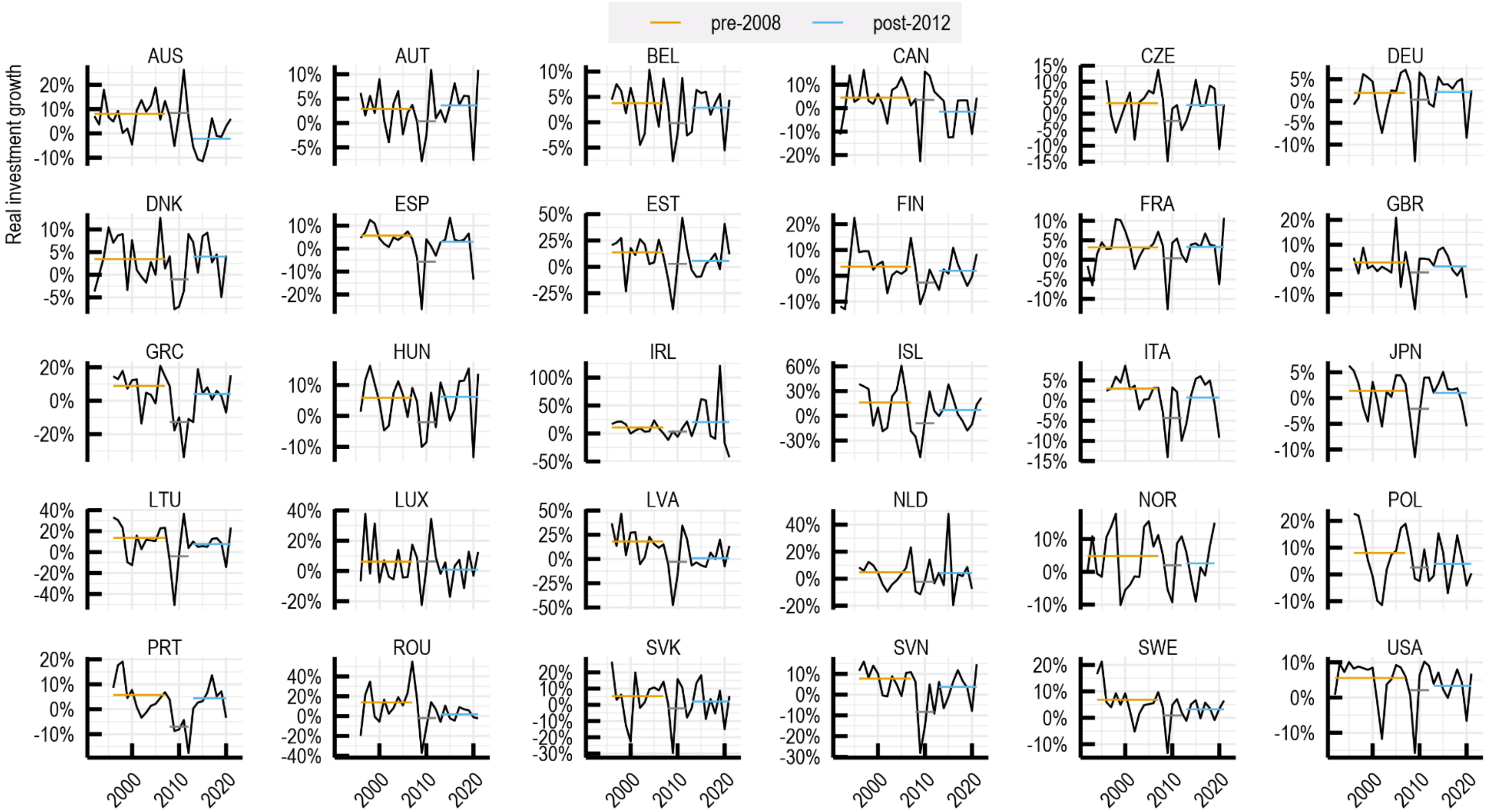
Note: Investment data refer to gross fixed capital formation. OECD countries with no data available are not listed in the table. Time coverage refers to the range of years for which the investment data are available for the number of industries shown in the second column. Business activities refer to activities B through N, excluding L, in the ISIC Rev. 4 classification – which amounts to 12 activities.
Source: National accounts.

Figure A A.2. Real business investment in the OECD

A. Real investment, index 2015=100



B. Real investment growth, per cent

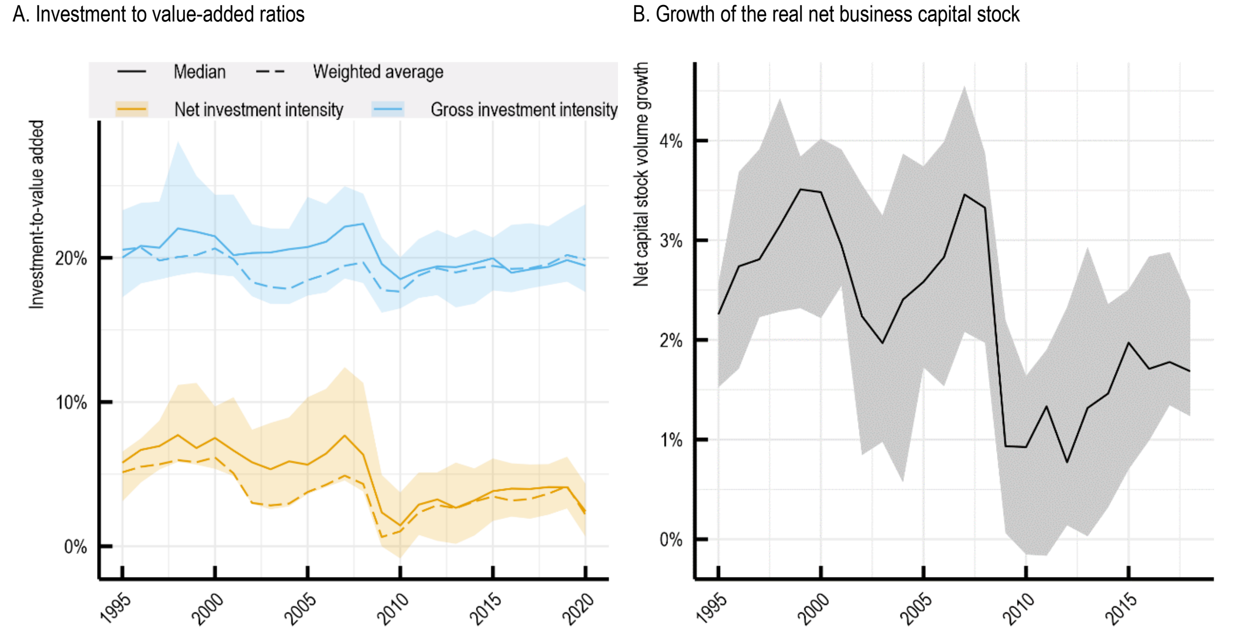


Note: Panel A: Real gross fixed capital formation in business activities. Panel B: Period averages taken over years before 2008 (excluded) and after 2012 (excluded). Growth of the capital stock net of depreciation, in volume.
Source: National accounts; and authors' calculations.

Annex B. Considering potential explanations for subdued investment

The subdued gross investment trends are not explained by a slower depreciation of assets. Ratios of both net and gross investment to value added (measured in net and gross terms, respectively) are below their pre-crisis levels in the OECD (Figure A B.1, Panel A). However, the recovery of the net investment rate has been slightly slower than for gross investment. This could stem from the rise of depreciation rates, which is plausible due to the expanding intangible economy.[48]

Figure A B.1. Net and gross investment have been lacklustre and the growth of the real net capital stock has fallen since the GFC



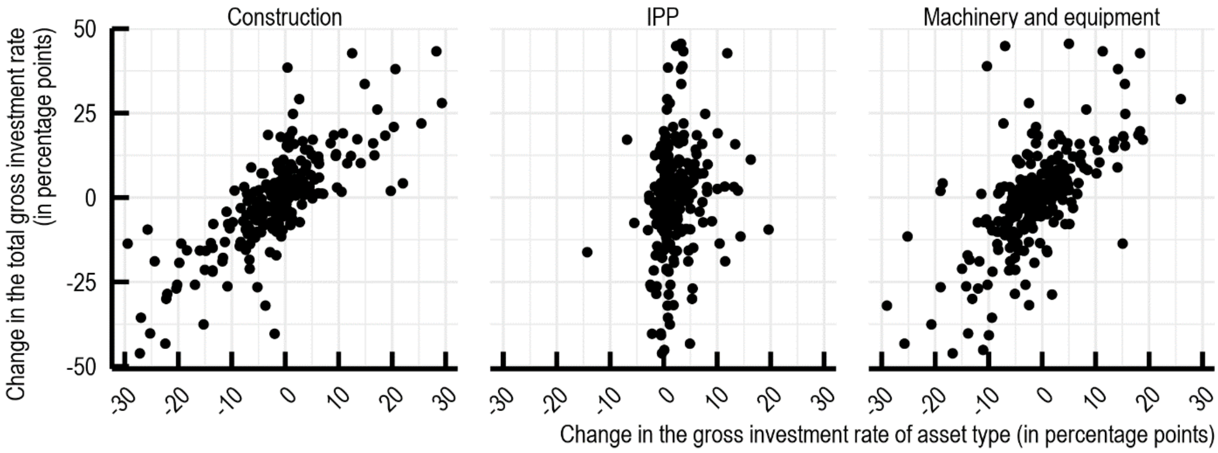
Note: Panel A: The graph presents the cross-country distribution of business investment intensity. The blue items indicate the ratio of gross fixed capital formation over gross value-added; the yellow items show the ratio of net fixed capital formation over net value-added. Medians and averages are calculated for OECD countries with available data. The weighted average is weighted by gross or net value-added. The shaded areas represent the interquartile range over OECD countries with available data. Panel B: Growth rate of the net business capital stock, in volume. The black line is the median over OECD countries with available data in the STAN Database, i.e. OECD members excluding Australia, Canada, Chile, Colombia, Costa Rica, Ireland, Latvia, Switzerland and Türkiye. The shaded area represents the interquartile range.
Source: National accounts, STructural ANalysis (STAN) Database; and authors' calculations.

A fall in the price of capital goods relative to value-added has not contributed to the recent decline in investment ratios either. Recent evidence suggests that prices of capital and value added have displayed similar trends since the 2000s (IMF, 2014[57]). More generally, trends in the price of capital cannot explain lacklustre trends in real investment as shown above. Combining the effect of prices and depreciation trends suggest that the growth rate of the net capital stock in volume has not recovered its pre-GFC level in the OECD (Figure A B.1, Panel B).

[48] In the United States, depreciation rates for IPP and equipment have steadily increased since 1970 (WGEM Team on Investment, 2018[63]).

The increasing importance of intangibles complicates the measurement of investment, but measurement issues of intangibles do not seem to explain aggregate investment trends either. An investment fall in intangible-intensive firms or sectors could stem from measurement issues because some intangible assets are not included in national accounts (Corrado et al., 2017[58]).[49] Since the mid-1990s, changes in investment rates by business industries are strongly correlated with changes in investment rates for tangible assets in those industries, while there is no correlation with the changes in intangible investment rates (Figure A B.2). Inclusion of intangible investment by country and industry to account for assets not included in national accounts, such as advertising and marketing (as done by Corrado et al. (2017[58])), increases investment levels but does not affect general investment trends in the OECD (Figure A B.3).[50]

Figure A B.2. Aggregate changes in business investment are more closely linked to changes in tangible assets



Note: The graph shows the change in the aggregate investment rate by country*industry against the change in the investment rate for the three types of assets in national accounts: construction, machinery and equipment, and IPP. Data covers 26 OECD countries (all European OECD countries except Sweden, Switzerland and Türkiye; Japan and New Zealand), for the years 1995-2019 except for the United Kingdom (1998-2015), New Zealand (1995-2017) and Denmark (1995-2018).
Source: National accounts; and authors' calculations.

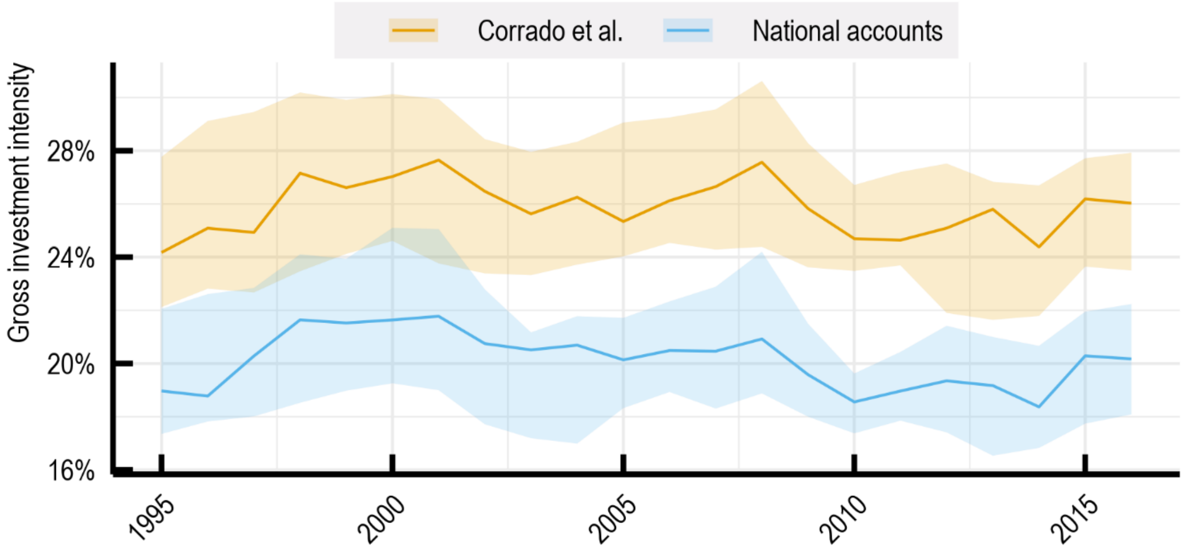
Business investment is also low given the actual level of businesses' profits and assets (measured by the net stock of fixed assets in the previous year).[51] In particular, for the median OECD country, the investment ratios after the GFC are usually all below the lowest pre-GFC point (Figure A B.4).

[49] The increasing importance of intangibles could also explain an investment slowdown if intangible assets support increasing market power, for example because intangible assets are non-rival and favour economies of scale. Market power would create a positive wedge between the marginal product of capital and the actual cost of capital (Crouzet and Eberly, 2019[25]).

[50] Increasing investment in intangibles for a given sector also implies an increase in the value-added of the sector.

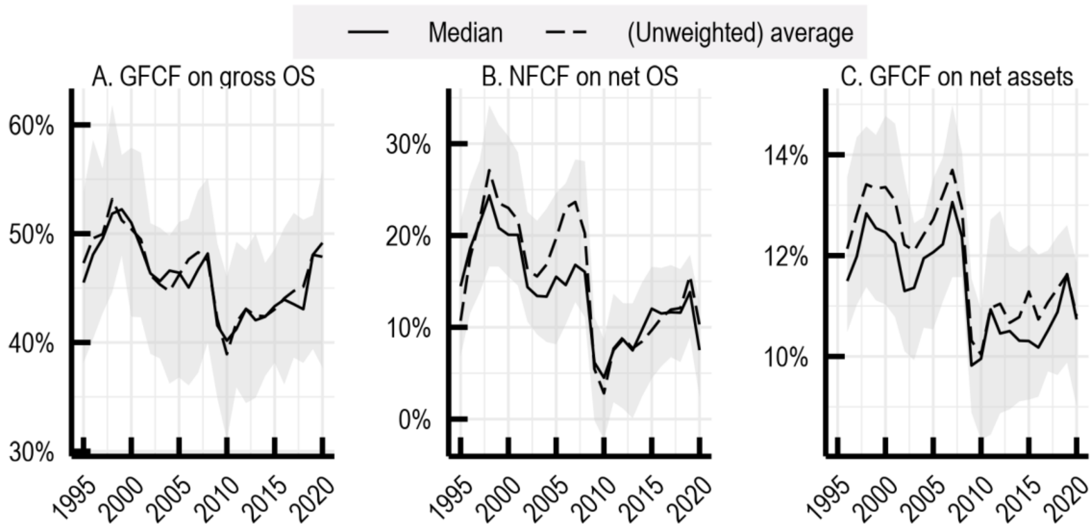
[51] In theory, various structural factors could explain a divergence between business value-added, profits and capital stock such as trends in depreciation or market power. Fahri and Gourio (2018[26]) provide a relatively simple neo-classical model illustrating potential determinants of the different investment ratios. For example, the investment-to-capital stock ratio, in the long run, should be sufficient to maintain the level of the capital stock relative to the size of the economy, and will thus depend particularly on the depreciation rate and the economic growth rate (in addition to the price of capital). On the other hand, the target level for the capital stock as a fraction of income (and thus the ratio of investment to value-added), in a neoclassical model, will be determined by other structural factors. They include the rental cost of capital and a potential mark-up due to market power and the technology which can eventually determine factor income shares. In that context, profits in the denominator are an intermediate measure: they reflect a return on capital and the share of income which is not allocated to labour compensation.

Figure A B.3. Incorporating additional intangible assets into national accounts data does not fully explain subdued investment after the GFC



Note: The yellow items consider the ratio of investment to value-added including the additional intangibles defined in Corrado et al. (2017[58]), for a set of 16 European countries: Austria, Belgium, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, the Netherlands, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, and the United Kingdom. The blue items consider investment intensity according to the national accounts data for the same sample of countries. The thick lines are the cross-country medians, shaded areas are the interquartile ranges.
Source: Corrado et al. (2017[58]): *Intangible investment in the EU and US before and since the Great Recession and its contribution to productivity growth*; and authors' calculations.

Figure A B.4. Post-GFC ratios of investment to profits and assets have also been subdued relative to pre-GFC levels



Note: The graph displays the distribution of the ratio of gross fixed capital formation (GFCF) to gross operating surplus (OS) (Panel A) and to net fixed assets in the previous year (Panel C), and the ratio of net fixed capital formation (NFCF) to net OS (Panel B) in the business sector, among OECD countries with available data. Shaded areas represent the interquartile range.
Source: National Accounts; and authors' calculations.

Annex C. Decomposition of the cost of capital and the effective tax rates

This annex explains the decomposition of the cost of capital, that is used to identify the main drivers over the past decades (Section 2.2. and Annex E), and the decomposition of the effective tax rate, that is used to disentangle channels through which it impacts investment (Section 3.5.).

Decomposition of the cost of capital

The cost of capital, $T(\boldsymbol{\phi_t})$, following Hanappi (2018[27]), is defined by asset type (three assets) and source of financing (equity and debt). Its formula is based on time-varying macroeconomic (interest and inflation rates) and tax parameters (including the statutory tax rate and the net present value of depreciation allowances) – denoted by $\boldsymbol{\phi_t}$.

Because those parameters interact with each other, it is impossible to compute an exact additive decomposition of the cost of capital. For example, depreciation allowances or interest deductions are more valuable for firms subject to higher statutory tax rates. Considering the case where the statutory tax rate τ_t and the net present value of allowances Z_t are the only relevant parameters, the change in the cost of capital between two periods can be decomposed into three components related to: the change in the tax rate, the change in the allowances and an interaction term. The latter reflects the fact that the impact of allowances on the cost of capital depends on the statutory tax rate.

$$
\begin{aligned}
\boldsymbol{\Delta T_t} &= T(\tau_t, Z_t) - T(\tau_0, Z_0) \\
&= \underbrace{[T(\tau_t, Z_0) - T(\tau_0, Z_0)]}_{Tax\ rate\ effect} + \underbrace{[T(\tau_0, Z_t) - T(\tau_0, Z_0)]}_{Tax\ base\ effect} \\
&+ \underbrace{\left[\left(T(\tau_t, Z_t) - T(\tau_t, Z_0)\right) - \left(T(\tau_0, Z_t) - T(\tau_0, Z_0)\right)\right]}_{Interaction\ term}
\end{aligned}
$$

The above decomposition can be used more generally to assess the role of falling interest rates and inflation in driving changes in the cost of capital by looking at their contribution to $\boldsymbol{\Delta T_t}$ when holding the fiscal parameters constant at their previous-year values. As shown in the main text, falling nominal interest rates have been by far the main driver of the decline in the cost of capital for all countries (Figure 6).

Decomposing the level of effective tax rates to disentangle the channels through which they impact investment

Decomposing the EMTR in order to test the impact of different tax parameters on investment is complex because the estimation (e.g. equation (1a)) requires a decomposition of the EMTR *in levels*. However, it is possible to adapt the decomposition above and consider variations in EMTRs around a *reference value*. Formally, if $\mathrm{T}(\boldsymbol{\phi}_\mathbf{t})$ is the EMTR evaluated at the tax parameters $\boldsymbol{\phi}_\mathbf{t}$, one can decompose the difference between $\mathrm{T}(\boldsymbol{\phi}_\mathbf{t})$ and a given $\mathrm{T}(\boldsymbol{\phi}_\mathbf{0})$ between the variation induced by each single parameter (super-indexed by i) of $\boldsymbol{\phi}_\mathbf{t}$ and $\boldsymbol{\phi}_\mathbf{0}$, along with an interaction term.

$$T(\boldsymbol{\phi_t}) - T(\boldsymbol{\phi_0}) = \sum_i \left[T\left(\phi_t^i, \phi_0^{-i}\right) - T\left(\phi_0^i, \phi_0^{-i}\right)\right] + \Delta_t$$

The baseline regression of firms' investment rates on the EMTR and firm fixed effects can be rewritten as (omitting other independent variables):

$$i_t^f = \beta \cdot T(\tau_t, Z_t, \lambda_t) + \delta_f + \epsilon_{t,f}$$

with τ_t, Z_t, λ_t respectively the statutory tax rates, the net present value of allowances, and the other tax parameters.

Given the above, the EMTR can be decomposed as

$$T(\tau_t, Z_t, \lambda_t) = T(\tau_0, Z_0, \lambda_0) + x^{\tau}(\tau_t) + x^{Z}(Z_t) + x_t^{\lambda}(\lambda_t) + x_t^{X}(\tau_t, Z_t, \lambda_t)$$

where $x^{i} = T\left(\phi_t^i, \phi_0^{-i}\right) - T\left(\phi_0^i, \phi_0^{-i}\right)$.

The estimation of the regression yields a formula for average investment:

$$i^f(\tau, Z, \lambda) = \hat{\beta}^{\tau} x^{\tau}(\tau) + \hat{\beta}^{Z} x^{Z}(Z) + \hat{\beta}^{\lambda} x^{\lambda}(\lambda) + \hat{\beta}^{X} x^{X}(\tau, Z, \lambda) + \text{constant}$$

Evaluated at $\lambda = \lambda_0$, $x^{\lambda}(\lambda) = 0$ and investment becomes a function of the tax rate and the level of allowances:

$$i^f(\tau, Z) = \hat{\beta}^{\tau} x^{\tau}(\tau) + \hat{\beta}^{Z} x^{Z}(Z) + \hat{\beta}^{X} x^{X}(\tau, Z) + \text{constant}$$

Likewise, the EMTR under those assumptions is a function of the two parameters. Given a level of EMTR $\overline{T}$, one can define the function $Z(\tau|\overline{T})$ satisfying $T(\tau, Z(\tau|\overline{T})) = \overline{T}$. Eventually, in an EMTR-neutral tax reform, investment becomes a function of the statutory tax rate:

$$i^f(\tau, Z) = i^f(\tau, Z(\tau|\overline{T})) + \text{constant} = G(\tau) + \text{constant}$$

An EMTR-neutral tax reform which increases the statutory tax rates and compensates by raising allowances would be beneficial to investment if $G'(\tau) > 0$.

Annex D. Description of the Orbis data

Coverage

Orbis, provided by Bureau Van Dijk, is the largest cross-country firm-level database for economic and financial research. It contains financial information from firms' balance sheets and income statements both at the consolidated and unconsolidated accounts level, as well as information on ownership links between firms.

The sample of countries covered in the analysis is driven by the availability of data on fixed assets and depreciation in the cleaned dataset. The time coverage of the Orbis vintage used in this study varies across firms and countries, with a maximum of 30 years (1990-2019). The sample is restricted to all non-agriculture, non-financial business industries (i.e. all industries excluding NACE Revision 2 codes below 5, above 82, and between 64 and 66). The number of firms varies widely across countries (Table A D.1).

The analysis on investment trends in Section 2. relies on a limited sample of countries and years where Orbis has a good coverage compared to the aggregate data from national accounts and to official micro-data, relying on the coverage assessment from Bajgar et al. (2020[59]): Belgium, France, Germany (from 2006), Italy, Korea, Portugal (from 2006), Spain, Sweden (from 2004) and the United Kingdom.

The sample used for the tax sensitivity analysis in Section 3. is restricted by the availability of data on marginal effective tax rates at the country level, and value-added growth at the country-industry level. It covers the following countries: Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Latvia, Luxembourg, Malta, the Netherlands, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Türkiye and the United Kingdom (see Annex E for more details on the sample used for the tax sensitivity analysis).

Table A D.1. Number of observations with non-missing investment variable, by country and year

	AUT	AUS	BEL	CZE	DEU	DNK	EST	ESP	FIN	FRA	GBR	GRC	HUN
2000	70	0	31,426	4,377	1,026	2,012	8,562	171,793	17,704	151,064	33,566	8,485	511
2001	64	0	29,690	4,649	1,001	6,273	8,402	208,499	18,858	160,085	32,755	9,408	86
2002	62	0	14,845	6,901	1,511	6,289	8,275	278,794	20,933	175,474	32,474	10,388	288
2003	10	1	14,783	14,966	2,445	8,695	9,554	314,984	26,656	204,369	31,764	11,793	264
2004	8	13	14,772	20,992	3,256	9,602	10,699	332,011	32,454	252,921	29,840	12,170	127
2005	26	52	14,416	29,295	4,521	9,563	11,504	357,922	35,428	259,183	27,934	12,411	377
2006	36	430	13,973	34,926	8,934	8,591	12,261	378,473	36,456	220,064	26,937	12,607	1,606
2007	77	488	16,698	42,617	13,296	8,110	13,545	389,347	33,539	214,215	26,398	12,604	5,000
2008	94	524	26,463	34,394	15,286	6,946	15,201	353,240	25,122	196,976	25,864	12,246	13,565
2009	106	574	25,710	33,757	16,051	5,857	14,181	398,942	23,443	191,196	26,308	12,031	15,045
2010	66	582	24,889	36,025	16,744	4,981	15,060	391,857	24,546	201,090	30,506	13,369	76,249
2011	116	559	24,839	30,502	17,830	4,024	19,450	378,294	26,384	175,017	30,962	13,817	60,664
2012	216	279	25,003	30,380	18,918	3,122	21,019	365,023	32,051	128,653	30,946	13,606	83,549
2013	352	620	22,668	28,550	19,402	2,972	22,624	348,909	33,039	122,496	30,990	13,382	130,061
2014	677	2,517	21,545	26,608	13,961	2,837	24,044	348,660	34,488	132,753	31,602	13,078	136,931
2015	1,405	3,013	20,771	26,624	13,610	2,633	25,625	351,571	33,388	114,458	31,678	13,700	145,490
2016	2,603	3,101	18,698	24,572	13,692	2,607	26,651	361,827	30,087	87,310	33,960	13,835	143,276
2017	2,890	3,152	17,885	28,696	14,527	3,240	27,292	371,652	31,607	75,815	36,353	14,681	141,099
2018	3,092	3,495	17,206	29,454	14,999	3,272	27,789	381,185	36,412	64,447	35,759	16,030	139,310
2019	3,096	2,778	16,500	26,695	15,959	3,372	28,441	379,519	38,650	55,702	35,260	15,810	139,889

	IRL	ITA	JPN	KOR	LUX	LVA	NLD	POL	PRT	SVK	SVN	SWE
2000	1	99,725	875	824	75	19	924	3,744	524	206	338	84,171
2001	0	110,560	3,844	6,024	63	51	921	5,548	489	439	1,104	88,544
2002	0	129,425	5,708	27,490	7	70	1,168	7,717	357	857	1,183	93,739
2003	0	157,727	33,077	45,148	1	82	1,746	9,555	40	1,740	3,346	99,107
2004	0	55,868	41,238	48,496	4	107	1,788	11,923	61	2,672	6,775	103,004
2005	5	73,440	44,537	44,258	3	142	1,820	10,573	44	4,463	7,899	107,535
2006	207	86,623	48,853	43,140	1	180	1,790	12,153	183	12,467	8,240	109,468
2007	1,205	161,085	52,143	45,913	15	215	1,749	15,433	185,470	17,873	9,329	112,940
2008	1,939	180,976	53,986	51,942	164	205	1,487	20,961	188,446	16,707	8,980	115,777
2009	2,083	218,395	53,060	59,498	293	207	1,318	26,613	186,428	20,204	8,655	118,886
2010	2,085	166,155	44,261	63,965	508	445	1,277	15,434	180,261	34,287	10,311	120,150
2011	2,158	187,609	31,186	56,171	556	1,472	1,331	10,665	173,062	11,713	37,859	120,526
2012	2,172	399,444	32,565	58,119	641	1,483	1,662	7,438	166,533	11,521	35,111	122,342
2013	2,227	411,560	28,926	65,225	644	1,608	1,339	8,898	164,306	35,616	33,414	123,738
2014	2,362	414,025	22,814	62,701	654	1,636	1,097	5,926	165,712	8,284	35,911	125,791
2015	2,554	428,883	11,028	53,385	222	1,686	778	6,209	167,932	6,946	36,479	128,583
2016	2,756	441,581	8,876	42,407	54	1,731	592	2,269	171,073	24,463	37,422	130,240
2017	3,508	450,204	8,873	37,710	21	1,661	383	13,999	173,586	33,263	38,711	129,812
2018	3,910	447,937	8,626	40,328	10	1,597	350	47,057	175,798	44,611	40,130	129,314
2019	3,920	451,434	7,935	37,666	8	1,549	333	49,266	176,738	46,888	41,731	130,694

Note: Investment is measured as the annual change in fixed assets (including both tangible and intangible assets) over one year, plus depreciation (both at book value). Sample restricted to non-agriculture and non-financial business industries.
Source: Orbis; and authors' calculations.

Data filtering and cleaning

As discussed in Andrews et al. (2016), Bailin Rivares et al. (2019[60]) and Gal et al. (2019[61]), the Orbis data are cleaned and benchmarked using a number of common procedures. They include keeping accounts that refer to entire calendar years, using harmonised consolidation level of accounts, dropping observations with missing information on key variables as well as outliers identified as extreme changes or ratios. Additional cleaning steps were applied for the purpose of the analysis in this paper, focusing more specifically on investment measures (see more details on the construction of investment measure in the variable definition section below).

Variable definitions

The main firm-level variables used for the analysis are the following:

- *Tangible fixed assets*: balance sheet item from Orbis, corresponding to "All tangible assets such as buildings, machinery, etc.", measured at book value.
- *Intangible fixed assets*: balance sheet item from Orbis, corresponding to all intangible assets built through "formation expenses, research expenses, goodwill, development expenses and all other expenses with a long-term effect", measured at book value. Unlike other accounting approaches for intangible assets, e.g. in national accounts, this item only covers acquired intangible assets and not the ones that are developed internally by firms.
- *Investment (gross),* is constructed from the Orbis data as the annual change in fixed assets (including both tangible and intangible assets), plus depreciation (both at book value). This measure is divided by the stock of fixed assets in *t-1* to calculate *investment rate*. Investment rates at the entity-level are built using nominal values originally reported in euros in the Orbis database converted back to local currency to avoid exchange rate movements affecting the measure. Extreme values of investment rates are excluded (below the 10th or above the 90th percentile, by country).
- *Size* is a categorical variable based on the number of employees (balance sheet item in Orbis), e.g. SMEs (less than 250 employees) versus large firms (250+ employees).
- *Sector* corresponds to the primary activity of a company, using the NACE Revision 2 classification at the 4-digit level.
- *Profitability* is measured as a ratio of profit and loss before tax to operating revenue.
- *MNE status*: multinational groups were identified using Orbis ownership links data for the year 2019. Entities in Orbis are assigned to corporate groups based on their Global Ultimate Owner (GUO), using a 50% ownership threshold, and considering GUOs of corporate nature (i.e. industrial companies, banks, financial companies, insurance companies, or financial companies) to avoid, for example, assigning to the same group two independent firms owned by the same individual or government entity. In turn, MNE groups are defined as corporate groups having entities in at least two jurisdictions. The corporate group structure considered in the analysis is based on ownership links data from 2019, as the coverage of ownership links data is significantly lower for earlier years. The multinational status considered in the analysis is therefore fixed and ignores changes that might occur in the corporate group structure over the sample period.

Comparability between Orbis and national accounts data

The approach to measuring firm-level investment used in this paper is based on the change in fixed assets adding depreciation and thus it is conceptually equivalent to the GFCF measure in national accounts. The latter is defined as the net acquisition of produced fixed assets (i.e. net meaning after a deduction of sales of fixed assets). Fixed assets in Orbis are measured at book value and do not include revaluation effects. Netting for depreciation implies that the investment measure corresponds only to the new fixed assets created or bought by the firm in year *t*, as both fixed assets and depreciation are measured at book value and thus consistent with each other in the Orbis database. Nevertheless, several differences exist with the national accounts measure of GFCF. One major difference stems from the coverage of intangible fixed assets. The Orbis database only covers intangible assets acquired externally, whereas national accounts also include some intangible assets developed in house.

The other major source of discrepancy between Orbis and the national accounts data relates to the incomplete coverage of firms in Orbis. Although Orbis contains information on a very large number of firms, including private firms, the coverage varies across countries and is rarely comparable to the number of firms covered, for example, in business registers (Bajgar et al., 2020[59]). This limited coverage, as well as differences in variable definitions and data cleaning, imply that it is not always possible to reproduce and match macro trends based on firm-level data (Bajgar et al., 2019[62]).

Annex E. Tax sensitivity regressions: data sources and descriptive statistics

Industry-level data

Industry-level data are taken from the OECD Annual National Accounts database (accessed in October 2022). The database contains information on investment for different types of fixed assets in 34 OECD countries and for different industries (at the 1 or 2-digit level of the NACE Rev. 2 classification). For this paper, three main types of assets are used: construction; machinery and equipment; and IPP.[52] The investment rate at the industry level is computed as gross fixed capital formation, divided by the lagged value of fixed assets, both in nominal terms.

Value-added growth at the industry level, included as a control variable both in industry and firm-level regressions as a proxy for demand effects, is measured as the growth rate of gross value added, in real terms.

Following Sorbe and Johansson (2017[11]), extreme values of the investment rate (negative or above 50%) or of value-added growth (annual growth below -30% or above 30%) are excluded from the sample, as they are likely to result from exceptional events or series breaks.

Agriculture (industries with NACE Rev. 2 codes 1 to 4), finance and insurance activities (NACE Rev. 2 codes 64 to 66), real estate (NACE Rev. 2 code 68), and public services (NACE Rev. 2 codes above 82) are excluded from the sample.

Firm-level data

The firm-level analysis relies on data from Orbis, which are used to build firm-level investment rates and to extract the following firm characteristics: size, multinational status, intangible intensity, profitability and age (see more details on the database coverage, variable definitions and cleaning in Annex D).

Like for the industry-level data, the sample covers all non-agriculture, non-financial and non-real estate business industries. The time coverage of the Orbis database used in this study (2021 vintage) varies across firms and countries, with a maximum 30-year history (1990-2019). The analysis is restricted to the years 2003-2019, which are better covered for most countries. The sample is restricted to firms with at least five years of observations.[53]

Forward-looking effective tax rates

Forward-looking ETRs indicators were built for the purpose of this analysis following the OECD methodology (OECD, 2022[31]; Hanappi, 2018[27]), using publicly available country-specific corporate tax

[52] The remaining component of aggregate investment, investment in biological resources was dropped as it represents a negligible share of overall investment in most countries, and no EMTR is available for this type of asset.

[53] Most of the firms are not in the database for all years, due mainly to variation in Orbis coverage.

parameters information, primarily from the International Bureau of Fiscal Documentation (IBFD) and the Leibniz Centre for European Economic Research (ZEW) (Spengel et al., 2020[28]).[54] The data have been compiled for 35 countries over the 1998-2021 period.

The methodology builds on the theoretical model developed by Devereux and Griffith (2003[32]). EMTR indicators are directly derived from measures of the cost of capital, which is defined as the pre-tax rate of return on an investment which is required to generate zero post-tax economic profits, depending on fiscal and macroeconomic parameters. Contrary to the cost of capital indicators used in Section 2.2, the ETR indicators used for estimations consider fixed macroeconomic parameters in order to focus only on the role of taxation on investment.

It is possible to decompose the main drivers of the yearly changes in EMTRs in the past 20 years (Annex C) focusing on the impact of various fiscal parameters. Over this period, EMTRs have fallen in around two third of the countries and their variations have been mostly driven by changes in statutory tax rates and in depreciation allowances (Figure A E.1). For some countries, the implementation of an Allowance for Corporate Equity (ACE) system has contributed to a significant drop in the level of the EMTR by reducing the cost of capital for equity-financed investment.[55]

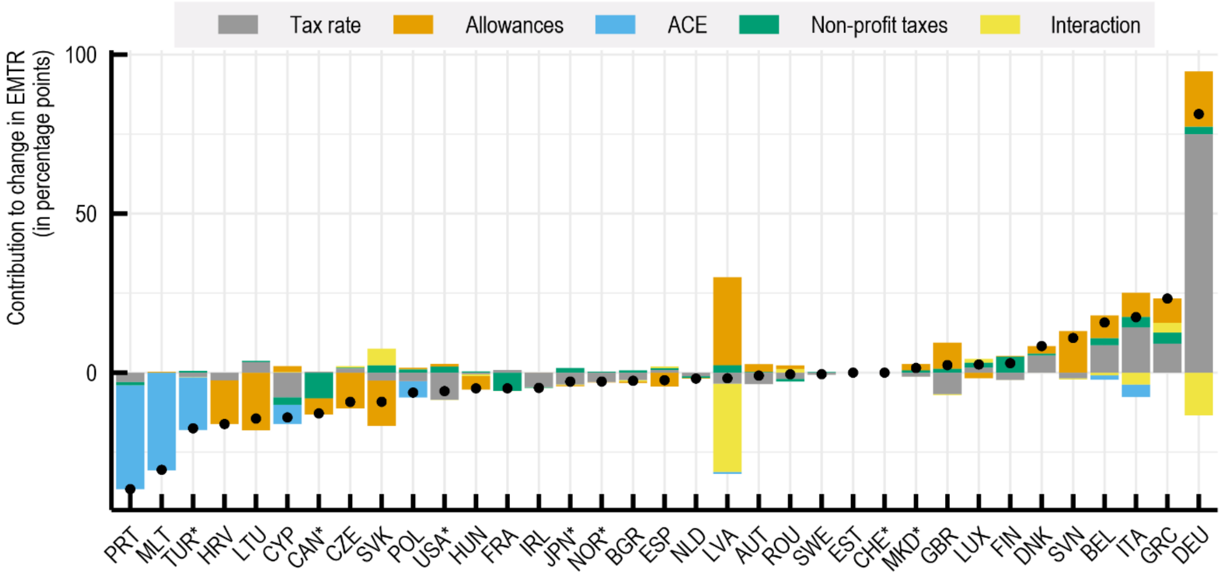
In order to test the respective effects on investment of the different fiscal parameters composing the EMTR (i.e. to estimate equation (6)), another decomposition was used, consisting of decomposing the difference between the actual EMTR – evaluated at the actual value of the fiscal parameters – and an EMTR evaluated at reference values for the same parameters (Annex C). Each element of the decomposition thus corresponds to the variation around the reference EMTR due to adjusting a single parameter around its own reference value. However, the elements of the decomposition may not be individually interpretable for policy reforms since the impact of a change in a given parameter evaluated when the other parameters are set at their reference value may differ from its impact when evaluated at a country's actual tax parameters.[56]

[54] OECD forward looking Effective Tax Rates indicators, calculated based on information provided by country representatives are also available from the *OECD Corporate Tax Statistics* database, but only with a five-year history (2017-2021).

[55] The countries that have put in place an ACE system (at least for several years in the analysed sample) are: Austria, Belgium, Croatia, Cyprus, Italy, Latvia, Lithuania, Malta, Poland, Portugal and Türkiye.

[56] An extreme example would be to consider a case of a statutory tax rate set at zero. In this situation, adjusting allowances has no impact on the EMTR.

Figure A E.1. Past changes in EMTRs are typically driven by statutory tax rates and depreciation allowances



Note: Changes in EMTR between 1998 and 2020 except for countries labelled with stars (where the start is in 2005). The black dot corresponds to the total (sum of the five components). Because the EMTR is not a simple additive function of the various parameters (for example, increasing statutory tax rates make allowances more valuable), the sum of the impact of changes in a single parameter do not sum to the total change in the EMTR which is reflected in the interaction term. See Annex C for details on the decomposition. The large change observed in Germany is due to the relatively high statutory tax rate at the beginning of the period (the combined statutory corporate tax rate in 2000 was 51.6%). This implies a low cost of capital for debt-financed investment via the deductibility of interests and a highly negative EMTR.
Source: Authors' calculations based on Spengel et al. (2020[28]).

Final samples

Given all data constraints, the final industry-level unbalanced panel contains 27,687 industry-asset-year observations (10,137 industry-year observations), covering 23 years (1999-2021), 27 countries and 27 industries.[57]

The final firm-level sample covers firms in 25 countries, mostly in Europe, and contains nearly 13 million firm-year observations.[58] The number of observations is relatively stable over time, although it is lower at the beginning and at the end of the sample (Table A E.1). Basic statistics on the main variables of interest for the final sample are presented in Table A E.2.

57 The 27 countries covered are: Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, the United Kingdom and the United States.

58 The 25 countries covered are: Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Latvia, Luxembourg, Malta, the Netherlands, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Türkiye and the United Kingdom.

Table A E.1. Number of observations in the final samples

	Industry-level	Industry-asset level	Firm-level
1999	351	931	-
2000	356	953	-
2001	350	934	-
2002	432	1,141	-
2003	439	1,191	431,075
2004	438	1,193	446,562
2005	430	1,163	489,851
2006	483	1,301	545,107
2007	485	1,301	707,352
2008	487	1,313	719,852
2009	491	1,337	794,889
2010	472	1,303	802,802
2011	473	1,318	815,125
2012	490	1,376	928,574
2013	496	1,379	955,617
2014	512	1,426	945,622
2015	512	1,428	930,435
2016	511	1,419	887,647
2017	514	1,423	861,405
2018	515	1,423	826,324
2019	515	1,399	778,303
2020	369	999	-
2021	16	36	-

Source: OECD National Accounts; Orbis; Spengel et al. (2020[28]); and authors' calculations.

Table A E.2. Basic statistics on the final samples

		Number of observations	Mean	Standard deviation	Minimum	Maximum
Industry level	Investment rate	10,137	13%	7%	0%	50%
	EMTR (lagged)	10,137	11%	10%	-69%	34%
	Industry VA growth rate (lagged)	10,137	2%	8%	-30%	30%
Industry-asset level	Investment rate	27,687	16%	12%	0%	50%
	EMTR (lagged)	27,687	11%	15%	-139%	49%
	Industry VA growth rate (lagged)	27,687	2%	8%	-30%	30%
Firm-level	Investment rate	12,866,542	19%	27%	-9%	202%
	EMTR (lagged)	12,866,542	8%	9%	-25%	30%
	Industry VA growth rate (lagged)	12,866,542	1%	5%	-30%	30%

Source: OECD National Accounts; Orbis; Spengel et al. (2020[28]); and authors' calculations.

Table A E.3. Distribution of firm-level characteristics in the firm-level sample

	Size group= Large	MNE=1	Intangible intensity>10%	Profitability≥10%	Age group= Young
Size group=Large	2.26%				
MNE=1	1.49%	9.50%			
Intangible intensity>10%	0.62%	2.83%	24.36%		
Profitability≥10%	0.32%	1.69%	2.13%	11.77%	
Age group=Young	0.02%	0.15%	1.20%	0.44%	3.64%

Note: The table shows the share of observations in the final sample by firm characteristic. For example, 2.26% of observations correspond to large firms, and 1.49% correspond to large and multinational firms (so 65%, i.e. 1.49/ 2.26 of large firms belong to MNE groups). The sample for this table is restricted to observations with non-missing information for all firm-characteristics, i.e. 12,704,048 firm-year observations.
Source: OECD National Accounts; Orbis; Spengel et al. (2020[28]); and authors' calculations.