Corporate Innovation and Resilience in the Euro Area

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Abstract

This paper provides evidence on whether innovation enhanced the resilience of publicly traded companies in the euro area during the COVID–19 pandemic. Using financial statements and stock prices of around 1,200 companies observed from the first week of 2019 to the last week of 2021, I find that companies reporting research and development expenses before the crisis induced by the pandemic were less likely to incur a loss due to its impact as well as recovered faster if having incurred a loss. In addition, I examine whether institutions and government policies played a role in fostering resilience. I find that the impact of innovation on resilience is greater in countries that had lower effective corporate tax rates during the pandemic and extended existing tax incentives to mitigate its impact.

Keywords: crisis; innovation; institutions; resilience; taxation
JEL codes: D02; E32; H25; M21; O31

*This paper was conceived in December 2023 and developed mostly while I was a visiting researcher at the Leibniz Center for European Economic Research (ZEW) in Mannheim, Germany (February–June 2024). I would like to thank Professor Hanna Hottenrott, head of the Economics of Innovation and Industrial Dynamics research unit at ZEW, for the invitation and a productive research stay at the institute. In addition, I benefited from discussions with Dr. Annalisa Tassi, a visiting researcher affiliated with the Corporate Taxation and Public Finance research unit at the same institute, as well as doctoral students with double affiliations with the University of Mannheim and ZEW: Hannah Gundert, Julia Spix, Stefan Weck, and Sophia Wickel. I thank them all and acknowledge that any errors are my own. Financial support for this research was provided by the Italian Ministry of University and Research in the form of a doctoral scholarship at the University of Padua, and data were accessed through an institutional subscription provided by the Department of Economics and Management of the same university. I thank Antonio Trabucco for his technical support. Replication codes are available upon request. Please address correspondence to either 33 Via del Santo, 35123 Padua, Italy (postal) or gayane.shakhmuradyan@studenti.unipd.it (email).

1 Introduction

The question of what fosters resilience, i.e., the ability of economic agents to withstand and rebound from crises, is of both academic and policy relevance. Interest in resilience within the field of economics arose largely in the aftermath of the global financial crisis (Acemoglu, Ozdaglar, and Tahbaz–Salehi 2015), and it has recently revived due to the COVID–19 pandemic (Brunnermeier 2024; Copestake, Estefania–Flores, and Furceri 2024; Pagano, Wagner, and Zechner 2023). In particular, scholars have studied supply chain resilience due to disruptions in global supply chains caused by the pandemic (Acemoglu and Tahbaz–Salehi 2025; Grossman, Helpman, and Sabal 2024; Grossman, Helpman, and Lhuillier 2023). [1] Less but growing attention has been devoted to inherent firm–level characteristics that contribute to resilience, such as corporate structure, culture, and governance (Aghion et al. 2021; Ding et al. 2021; Li et al. 2021).

In this paper, I address two interrelated research questions: *Does innovation enhance corporate resilience?* and *Does political economy—defined as institutions and government policies implemented during crises—affect corporate resilience?* These are important questions to address given the uncertainty and volatility associated with the current business environment, as well as the aim of governments to design cost–effective measures supporting businesses affected by economic crises. Based on the endogenous growth theory (Aghion and Howitt 1992; Arrow 1962; Grossman and Helpman 1990, 1991, 1994; Romer 1986, 1990, 1994; Schumpeter 1942), I hypothesize that companies allocating greater resources to innovation, i.e., those reporting research and development (R&D) expenses, are more resilient. Specifically, I conceive of resilience as *crisis impact resistance* and *crisis recovery speed*, arguing that innovation enhances resilience in two ways: first, it makes companies less likely to incur a loss due to a crisis, and second, it enables faster recovery for those companies that incur a loss. Furthermore, drawing on the literature on institutions as

[1] Notably, the National Bureau of Economic Research hosted two conferences on the resilience of supply chains in the Spring and Fall of 2024, featuring 14 papers in total, and it has a current call for funding research in the area, implemented in cooperation with the Department of Homeland Security and Texas A&M University. See National Bureau of Economic Research (2024a, 2024b, 2024c) for further details.

a source of economic growth (Acemoglu, Johnson, and Robinson 2005; Hall and Jones 1999; North 1990), law and finance (La Porta et al. 1998), and tax policy and investment (Bloom, Griffith, and Van Reenen 2002; Hall and Jorgenson 1967; Hassett and Hubbard 2002; Zwick and Mahon 2017), I hypothesize that institutions and government policies matter for corporate resilience: the observed impact of innovation on resilience is greater in countries that provide a more favorable environment for business innovation in general and tax incentives for innovation under crisis conditions in particular.

I observe innovation and resilience using financial statements and stock prices for a large sample of companies traded in the euro area (EA) member states—a group of 20 economies that have formed in a monetary union since 1999 but retain autonomy over business taxation, and therefore, implemented different fiscal policies in response to the COVID–19 pandemic. Specifically, my baseline sample includes all EA member states as of 1 January 2019 (thereby excluding Croatia, which adopted the euro on 1 January 2023) and around 1,200 companies operating across different industries and locations. To examine the role of fiscal policy in enhancing resilience, I restrict the sample to 17 member states that are also members of the Organization for Economic Cooperation and Development (OECD), as data on tax rates and incentives, especially those implemented during the COVID–19 pandemic, are provided by the OECD. Finally, to examine the role of institutions, I restrict the sample to 11 member states that have been classified by La Porta et al. (1998) as belonging to either of the four legal origins (English, French, German, and Scandinavian): in major part, those are the member states that formed the EA on 1 January 1999 and founded the OECD in 1960. Overall, I have panel data of around 190,000 company–week observations starting in 2019 and ending in 2021. [2]

By examining the relationship between corporate innovation and resilience, I contribute to several strands of economic literature. First and most importantly, I contribute to the growing literature on economic resilience, as referenced in the introductory paragraph above. Although I am not the first to examine whether more innovative companies are

[2]Upon recommendation of the World Health Organization, the pandemic ceased to be an emergency in the EA in May 2023. However, I exclude the years 2022 and 2023 due to the war in Ukraine, which constitutes another exogenous crisis affecting its member states starting in February 2022.

more resilient (see Ahn, Mortara, and Minshall (2018) and Bertschek, Polder, and Schulte (2019) for earlier evidence), this paper is the first—to the best of my knowledge—to utilize the setting of a monetary union in the absence of a fiscal union to examine whether the effect of innovation on resilience varies depending on different institutional environments and crisis response policies implemented by national governments. Analogously to La Porta et al. (1998, p. 1114), who asked whether being a shareholder in France gives investors the same privileges as being a shareholder in, for instance, the United States, I ask and provide an answer to the following question: Does being an innovator in France enable the same capacity for resilience as being an innovator in, for instance, Germany? In other words, *Does innovation contribute equally to corporate resilience in countries that are institutionally different and implement different policies during crises?* The answer is "no", as I find that institutions and policies do matter for resilience, and they do so in countries that are comparable along many dimensions relevant to economic outcomes (i.e., founding members of the EA and the OECD), as well as in the process of economic convergence (member states that joined the EA during the early– and mid–2000s). [3]

Secondly, I contribute to the literature on tax policy and business investment, which, dating to Hall and Jorgenson (1967) and as reviewed by Hassett and Hubbard (2002), suggests that tax incentives are cost–effective in stimulating private investment. Most prior research in this area, including the recent contributions by Zwick and Mahon (2017), Guceri and Liu (2019), and Dechezleprêtre et al. (2023), has focused on tax incentives provided during growth periods, while the scant empirical evidence on tax incentives during crises suggests that those are not effective due to high capital adjustment costs under uncertainty, which reduce investment (Guceri and Albinowski 2021). [4] Studying the extension of the

[3]The answer would most probably have been "yes" if one were to overlook the role of political economy in affecting resilience. This has been the case in recent research examining other factors: for instance, Copestake, Estefania–Flores, and Furceri (2024) study digitization and resilience in a heterogeneous group of 75 economies without considering either the institutional environment of these countries before the pandemic or public policies implemented in response to it. They reestimate their baseline regression equation excluding one country or region at a time and conclude that the "results are not dependent on any specific country or group of countries" (p. 8).

[4]Based on their simulation exercise, Bloom, Bond, and Van Reenen (2007, p. 411) note that "increases

R&D tax credit in Germany in July 2020 and its role in fostering the resilience of innovative companies during the COVID–19 pandemic, I argue that fiscal policy plays a key role in macroeconomic stabilization during crises, enabling faster recovery than would otherwise take place. [5] Besides extending the literature on the effectiveness of R&D tax credits in OECD countries (Bloom, Griffith, and Van Reenen 2002; Hall and Van Reenen 2000; Thomson 2017), I thereby contribute to the literature on the growth impact of discretionary fiscal policy during a recessionary period in the EA (Coenen, Straub, and Trabandt 2012, 2013; Devereux et al. 2020). More indirectly, I contribute to the literature on monetary–fiscal policy interactions in monetary unions with heterogeneous fiscal space (Beetsma and Jensen 2005; Bellifemine, Couturier, and Jamilov 2025; Davig and Leeper 2011).

Finally, I contribute to the literature on investment under uncertainty, which, since Bernanke (1983), suggests that companies may reduce or postpone investment, including R&D expense, due to exogenous shocks. Major contributions to this stream of literature are Dixit and Pindyck (1994), Bloom, Bond, and Van Reenen (2007), and Bloom (2009), while recent empirical evidence has been provided by, among others, Bachmann, Elstner, and Sims (2013), Baker, Bloom, and Davis (2016), and Kumar, Gorodnichenko, and Coibion (2023). The panel structure of my data set enables observing both *within–* and *between–firm* variation in R&D intensity during the pandemic, and I find that although average intensity declined during the pandemic, some companies, e.g., those operating in the information technology industry, increased investment *in response to* the pandemic. This

in uncertainty around major shocks, like September 11, 2001 and the 1970's oil shocks, could seriously reduce the responsiveness of investment to monetary or fiscal policy." However, they do not examine this proposition empirically. Similarly, Bloom et al. (2018, p. 1062) conclude that "uncertainty shocks not only impact the economy directly, but also indirectly change the response of the economy to any potential reactive stabilization policy." However, they consider only a wage subsidy in a small subsection of the paper (Section 6) and do not carry out a full–fledged analysis of an investment tax credit.

[5] A similar argument was made by Professor Martin Eichenbaum at the ASSA Annual Meeting in San Francisco (3–5 January 2025). See the webcast of the session "Is There a Core of Usable Macroeconomics We Should All Believe In?" available at: https://www.aeaweb.org/conference/webcasts/2025. The paper is forthcoming in the *AEA Papers and Proceedings*. I thank Professor Eichenbaum for his mentorship during the Annual Meeting.

finding is consistent with the literature on aggregate demand versus supply shocks during the pandemic from an industry or business sector perspective (del Rio–Chanona et al. 2020; Dingel and Neiman 2020; Guerrieri et al. 2022), suggesting that there is heterogeneity in investment response to exogenous shocks, even those that are broad–based.

The rest of the paper is organized as follows: Section 2 below describes the empirical setting, data, and measures I use. Section 3 elaborates on the econometric specification of panel data regressions, Section 4 provides the results, Section 5 discusses these in relation to the literature reviewed above, and Section 6 concludes. Additional details are available in the appendices.

2 Empirical Setting, Data, and Measures

2.1 Empirical Setting

The empirical setting in which I examine corporate resilience in the EA is the COVID–19 pandemic. In its Fall 2020 statement, dated 29 September 2020, the Euro Area Business Cycle Dating Committee of the Center for Economic Policy Research (CEPR) declared that the expansion that had started in Q2–2013 reached its peak in Q4–2019, and the EA entered a recession in Q1–2020 (Euro Area Business Cycle Network 2020). In its Fall 2021 statement, dated 9 November 2021, the Committee declared that the EA recession that had started after Q4–2019 reached its trough in Q2–2020; therefore, the pandemic–induced recession lasted for only two quarters, the shortest on record (Euro Area Business Cycle Network 2021). Despite its brevity, the recession was severe, as the seasonally adjusted gross domestic product (GDP) in the EA contracted at a rate of 11.8% in Q2–2020, the largest decline since the series was first observed in 1995 (Eurostat 2020).

2.2 Data

To address my first research question, i.e., whether innovation fosters resilience, I construct a panel data set linking financial statements, stock prices, and other characteristics (e.g., industry) of companies traded in the EA member states before, during, and after the

COVID–19 was declared a pandemic on 11 March 2020 (World Health Organization 2020). To examine the role of institutions and governments in fostering resilience and thereby address the second research question, I study public policy responses in individual member states from January 2020 to December 2021. [6] In particular, I study fiscal policies related to the corporate income tax (CIT), as those affect all incorporated businesses in an economy, and incentives for innovation, such as R&D tax credits, which affect innovative enterprises. I gather and match data from several sources, as elaborated below.

2.2.1 Corporate Identifiers

First, I obtain identifiers of publicly traded companies in the EA from the Bureau van Dijk (BvD) Orbis database. Specifically, I start the data collection with International Securities Identification Numbers (ISINs), i.e., standardized 12–digit alpha–numeric codes, the first two digits of which correspond to the two–letter ISO country code in which a company is incorporated (e.g., DE for Germany and FR for France). I retain only companies incorporated in 19 member states constituting the EA as of 1 January 2019 (European Union 2025). [7] From the population of 3,286 companies, [8] I exclude financial companies, i.e., those operating under NACE Rev.2 sections K (finance and insurance) and L (real estate) (Eurostat 2008), as the financial ratios of companies in these industries are not directly comparable to the financial ratios of companies in other industries (Fama and French 1992). [9] Thus, I obtain a sample of 2,495 companies.

[6] Besides the confounding effect of the war in Ukraine, as noted in the introduction, the end of the observation window in 2021 is appropriate as the OECD data on tax policy measures during the pandemic were last updated in April 2021. Similarly, the IMF data on COVID–19 policy responses were last updated in July 2021. See Section 2.2.4 for further details.

[7] The countries are, in alphabetical order, the following: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, and Spain.

[8] The version of the database I use is 357, last updated 15 January 2025.

[9] These sections correspond to Divisions 64–66 and 68, respectively. NACE is an abbreviation in French, standing for *Nomenclature statistique des activités économiques dans la Communauté européenne*, and it is translated as "Statistical classification of economic activities in the European Community." Rev.2 indicates that this is the second edition of the classification, superseding the original classification established in 1999.

2.2.2 Financial Statements

Secondly, I gather financial statement data of all companies in the sample. In particular, I obtain data on net income in 2019, i.e., in the pre–crisis year. I exclude companies with missing net income ($n = 367$), as well as companies reporting negative ($n = 662$) and zero ($n = 18$) net income. This is meant to ensure that losses incurred during the crisis are due to its impact rather than other, company–specific factors (Altman 1968). Thus, my sample is reduced to 1,448 companies. In addition, I obtain data on R&D expenses in 2019 to classify companies as either R&D spenders or non–spenders pre–crisis, as this enables me to claim exogeneity of the independent variable of innovation with respect to the dependent variables of resilience (see Sections 2.3 and 2.4, as well as Section 3 below). Non–missing non–zero values for R&D are available for 411 companies, and therefore, these are classified as R&D spenders. [10] For both R&D spenders and non–spenders, I gather additional financial data from both balance sheets and profit–loss accounts, e.g., total assets, current assets, and current liabilities, as these enable me to calculate measures of liquidity and profitability, which serve as controls in econometric estimation (see Section 3.2 below).

2.2.3 Stock Prices

Finally, I gather stock price data of all companies incorporated in 19 EA member states from the Refinitiv Eikon database. Price data for all weeks between W1–2019 and W52–2021 are available for 2,642 companies. Given the median price of EUR 9 and to ensure that extreme observations do not bias my estimates, I exclude companies the stocks of which traded below the 1st percentile (EUR 0.022) and above the 99th percentile (EUR 3,920) of the distribution in any of the weeks ($n = 53$ and $n = 34$, respectively). The matching of the resulting panel with the cross–section of 1,448 companies obtained above using the ISINs and retention of only those companies that appear in both data sets results in a strongly

[10] The Orbis database has data on R&D expenses reported in both Global Standard and Global Detailed formats. My classification is based on the Global Detailed format. Additionally, I perform a textual analysis of 2019 annual reports, which results in an increased share of R&D spenders (see Section 2.4 below). I use the latter in robustness checks (available as a supplementary material).

balanced panel of 1,209 companies observed over 156 weeks, i.e., 188,604 company–week observations. [11] In this panel, 379 companies (31%) are R&D spenders, and it constitutes the basis for most statistical analyses reported below. Figures 1 through 4 provide the distribution of companies by industries and locations, for both the sample as a whole and separately for R&D spenders and non–spenders.

2.2.4 Government Policies

I obtain data on government policies from three sources: the Oxford COVID–19 Government Response Tracker (OxCGRT) (Blavatnik School of Government 2023; Hale et al. 2021), the International Monetary Fund's (IMF) COVID–19 Policy Tracker (International Monetary Fund 2021), and the OECD Tax Policy Reforms report (Organization for Economic Cooperation and Development 2021). Data on corporate income tax rates and incentives for innovation before and during the pandemic are from two additional sources: the OECD Corporate Tax Statistics Database (Organization for Economic Cooperation and Development 2025a) and the European Commission (EC)–OECD Science, Technology, and Innovation Policy (STIP) Compass (Organization for Economic Cooperation and Development 2025b). Each of these five data sources is outlined below.

Oxford University Government Response Tracker: The most recent version of the OxCGRT data set, available as a GitHub repository since June 2023, provides a systematic record of government responses to COVID–19 in 185 countries and territories (as well as sub–national jurisdictions in eight countries) for three years from 1 January 2020 to 31 December 2022. [12] Overall, it includes 25 indicators organized into five groups: closure and containment, economic, health, vaccine, and miscellaneous, which are combined into four indices: Government Response Index (GRI), Stringency Index (SI), Containment and Health Index (CHI), and Economic Support Index (ESI). All EA member states are in the data set; however, the ESI, as acknowledged by the project team, "does not include sup-

[11] The fact that 2020 was a leap year and included an additional day (29 February) does not affect my week count for that year: the statistical software I use (Stata) has a convention that all years have 52 weeks irrespective of the number of days. See Cox (2022) for further details.

[12] See https://github.com/OxCGRT/covid-policy-tracker (last accessed 27 January 2025).

port to firms or businesses and does not take into account the total fiscal value of economic support," although it has income support indicators for "payments to firms if explicitly linked to payroll/salaries" (Blavatnik School of Government 2023). Therefore, from this data set, I retain only SI and CHI values from 1 January 2020 to 31 December 2021, [13] and I obtain data on fiscal policy related to CIT from IMF and OECD sources, as elaborated below. The time series of both indices are daily, and I use a monthly series with values taken on the first day of each month.

IMF COVID–19 Policy Tracker: The IMF COVID–19 Policy Tracker (last updated 2 July 2021) provides summaries of measures governments undertook to contain the spread as well as the economic impact of the COVID–19 pandemic. Besides containment (lockdown and vaccination) measures, it covers fiscal, monetary, and macro–financial policies implemented in 197 economies, including individual member states of the EA and the EA as a whole. Due to common monetary policy in the latter, I focus on the fiscal policy sections of these summaries. In particular, I retain data on the size of the fiscal stimulus package as a share of each country's 2019 GDP (e.g., 12.6% for Austria).

OECD Tax Policy Reforms Report: The 2021 edition of the Tax Policy Reforms report published by the OECD is dedicated to the COVID–19 pandemic, providing an analysis of tax policy measures in around 70 jurisdictions. An Excel spreadsheet associated with the report, last updated 22 April 2021, contains details on tax policies (e.g., type of tax concerned and date of legislation) in each jurisdiction, and all EA member states—except for Cyprus and Malta—have corresponding entries, as these two economies are neither members nor partners of the OECD. [14] Therefore, in further analyses, I focus on 17 EA member states that are also members of the OECD.

OECD Corporate Tax Statistics Database: The OECD Corporate Tax Database, last updated 11 July 2024, provides data on corporate income taxes in OECD member states

[13] GRI and SI are highly correlated, as there is an 87.5% overlap in the underlying indicators. See Blavatnik School of Government (2023) for further details.

[14] The spreadsheet is available for download from https://www.oecd.org/tax/covid-19-tax-policy-and-other-measures.xlsm; the author retains a copy. The list of current OECD members and partners is available at https://www.oecd.org/en/about/members-partners.html.

and partner economies. In particular, it has statistics on statutory and effective corporate tax rates as well as R&D tax incentives. Data are available at an annual frequency, and I obtain time series for three years (2019–2021) for two indicators in each of the 17 EA member states that are also members of the OECD: effective tax rates and implied tax subsidy rates on R&D. For the former, I consider both effective average and effective marginal tax rates; for the latter, consistently with my sample selection (see Section 2.2.2 above), I consider only the rates for large profitable firms. [15] Since 2019, the OECD has published an annual Corporate Tax Statistics report based on the database, and I refer to 2019–2021 editions for qualitative information on tax rates and incentives (see Organization for Economic Cooperation and Development (2024) for the latest edition and references to earlier editions).

EC–OECD STIP Compass: I supplement the OECD corporate tax data with more detailed information on R&D tax credits in each country from the Innotax Portal of the STIP Compass. Expect four countries (Estonia, Finland, Latvia, and Luxembourg), all EA member states that are also members of the OECD had expenditure–based tax credits for R&D as of 1 January 2020 (see Table 1 below). [16] The oldest is the French R&D tax credit *(crédit d'impôt recherche, CIR)*, in force since 1983, and three countries (Greece, Slovakia, and Slovenia) allow for full (100%) deduction of R&D from taxable income.

2.2.5 Institutions

Based on extensive background research in the field of law, La Porta et al. (1998) classify 49 economies as belonging to four legal origins: English, French, German, and Scandinavian. The overlap between the economies they classify and my sample of EA–OECD member states that provided R&D tax incentives during the pandemic is 11. These economies are

[15] Data are available also for small and medium enterprises and loss–making firms.

[16] Chapter 5 of the OECD Corporate Tax Statistics report (Organization for Economic Cooperation and Development 2024) provides a discussion of expenditure–based and income–based tax incentives for R&D. Estonia and Luxembourg have never had tax incentives, and therefore, there are no profiles for either country in the Innotax Portal. Finland introduced an expenditure–based tax credit in 2021. The tax credit in Latvia, introduced in 2014, ceased to be in force in 2018. See https://stip.oecd.org/innotax/countries/Finland and https://stip.oecd.org/innotax/countries/Latvia for further details.

representative of all four legal origins, as listed below:

1. **English:** Ireland;
2. **French:** Belgium, France, Greece, Italy, Netherlands, Portugal, and Spain;
3. **German:** Austria and Germany;
4. **Scandinavian:** Finland.

English and Scandinavian legal origins are each represented by only one country in my sample (Ireland and Finland, respectively); therefore, I focus on the distinction between countries belonging to French and German origins. La Porta et al. (1998) find that on average, countries belonging to the German civil law origin provide greater protection to investors than those belonging to the French civil law origin. Similarly, I expect to find a stronger impact of innovation on corporate resilience in Austria and Germany as compared to the seven countries belonging to the French civil law origin (Belgium, France, Greece, Italy, Netherlands, Portugal, and Spain). More narrowly, I expect to find a stronger impact of innovation on corporate resilience in Germany than in France.

Among the post–socialist economies that La Porta et al. (1998) did not classify, but the classification of which is possible due to their subsequent research (La Porta, Lopez–de–Silanes, and Shleifer 2008), Lithuania belongs to the French origin, while Slovakia and Slovenia belong to the German origin. I report the baseline estimates without these countries and include them in additional analyses.

2.3 Resilience Measures

Originating in natural sciences, the concept of resilience crossed disciplinary boundaries over the past several centuries (Alexander 2013) and reached administrative science in the 1980s (Meyer 1982; Linnenluecke 2017). According to Holling (1996, p. 33), the conception of resilience that may serve as a basis for its definition in economic theory, termed *engineering resilience*, focuses on "stability near an equilibrium steady state, where resistance to disturbance and speed of return to the equilibrium are used to measure the

property." Holling (1996, p. 33) contrasts the engineering conception of resilience to *ecological resilience* (Holling 1973), arguing that the latter "emphasizes conditions far from any equilibrium steady state, where instabilities can flip a system into another regime of behavior—that is, to another stability domain."

In line with the engineering conception of resilience, I measure resilience by two variables that are new to the economic literature: *impact resistance* and *recovery speed*. Impact resistance (IR) is a binary variable, such that, when measured with stock price (P):

$$IR = \begin{cases} 1 & \text{if } P_t \geq P_{t-s} \\ 0 & \text{otherwise.} \end{cases} \tag{1}$$

When calculated with weekly data, s in Equation 1 above equals 52, i.e., the number of weeks in a typical calendar year. For monthly and quarterly observations, $s = 12$ and $s = 4$, respectively.

Recovery speed (RS) is a count variable corresponding to the number of weeks, months, or quarters it takes to recover stock price to its pre–crisis levels:

$$RS \in \mathbb{N}. \tag{2}$$

In the context of the pandemic–induced recession in the euro area, whereby the start of the recession using weekly data can be dated to W12–2020, and there are observations up to W52–2021, the following is true:

$$1 \leq RS \leq 92. \tag{3}$$

For monthly and quarterly data in the same context, the maximum values for RS are 20 and 6, respectively. RS is not defined for companies that did not incur a loss throughout the crisis (i.e., $IR = 1$ in all weeks, months, or quarters).

Additional details and descriptive statistics of the two resilience measures are provided in appendices. Here, it suffices to note that weekly data provide the utmost precision in

measuring resilience: as not all companies recover during the observed period, measurement at lower frequencies is associated with a truncation of the RS variable, which, unless accounted for, results in biased estimates.

2.4 Innovation Measures

I measure innovation by R&D expenses. As opposed to patents, which capture the output of innovative activities of firms, R&D expenses capture the input of such activities and have been widely used in the innovation and productivity literature (Griliches 1998; Smith 2006). More importantly, R&D expenses are a better measure of the theoretical construct I aim to operationalize, i.e., the *allocation of resources* to innovation (Arrow 1962).

As noted in Section 2.2.2 above, the BvD Orbis database provides data on corporate R&D expenses (RDE) in 2019. Therefore, my first measure of innovation, *R&D spender* (RDS), is defined as follows:

$$RDS = \begin{cases} 1 & \text{if } RDE_{2019} > 0 \\ 0 & \text{otherwise.} \end{cases} \tag{4}$$

Based on this rule, 379 companies in the final sample (31% of the total) can be classified as R&D spenders. However, it should be noted that BvD data on R&D expenses are incomplete, as R&D costs that are incurred but do not meet the recognition criteria of the International Accounting Standard (IAS) 38: Intangible Assets (International Financial Reporting Standards 2025) are reported in narrative sections of corporate reports rather than financial statements. Thus, I perform a textual analysis of annual reports filed in 2019 to ascertain whether a company allocates resources to innovation, which results in an increased share of R&D spenders in the sample. I report baseline results using the BvD data, while the results based on textual classification are provided as robustness checks.

For most companies that report R&D, I calculate a second measure of innovation, *R&D intensity*, equal to R&D expenses in any given period divided by sales (turnover) in the same period. More specifically, I calculate intensities in 2019, 2020, and 2021, which roughly

correspond to crisis anticipation, response, and recovery phases.

2.5 Fiscal Policy Measures

I adopt two measures of fiscal policy: *containment tax cut* (CTC) and *recovery tax cut* (RTC). Both are binary variables, calculated based on the effective average tax rate (EATR). More formally,

$$CTC = \begin{cases} 1 & \text{if } EATR_{2020} < EATR_{2019} \\ 0 & \text{otherwise.} \end{cases} \tag{5}$$

Similarly:

$$RTC = \begin{cases} 1 & \text{if } EATR_{2021} < EATR_{2020} \\ 0 & \text{otherwise.} \end{cases} \tag{6}$$

The OECD Corporate Tax Statistics Database suggests that EATR in 2020 was lower than a year before in only five EA member states: Austria, Belgium, Finland, France, and Germany (see Table 2, column 1, and Figure 5 below). Among these, the generosity of R&D incentives, as measured by the implied tax subsidy rate (ITSR) (see Table 2, column 3, and Figure 6), increased in only two countries: Finland and Germany. The Finnish case is special as the R&D tax credit was introduced in 2021, and therefore, the ITSR turned to zero in 2020 and 2021 from its negative (-0.01) value in 2019. The German R&D tax credit (*Forschungszulage*) was in place before the pandemic (legislated in December 2019), and the rate increased from -0.02 in 2019 to 0.19 in 2020 and 2021. Notably, following the adoption of a fiscal stimulus package on 3 June 2020, the maximum amount of expenses qualifying for the tax credit was increased from EUR 2 million to EUR 4 million, and this extension is effective for the period between 1 July 2020 and 30 June 2026 (Federal Government of Germany 2020).

EATR in 2021 was lower than EATR in 2020 in four countries: France, Germany, Greece, and Italy; among these countries, ITSR in 2021 was higher than in 2020 in only two

countries: Belgium and Italy. The generosity of R&D tax incentives during the observed period decreased in four countries: Belgium (2021), France (both 2020 and 2021), Greece (2021), and Ireland (2020). Further details on reforms implemented in these countries are available as supplementary material.

3 Econometric Estimation and Controls

3.1 Econometric Estimation

I adopt three econometric approaches to examine whether more innovative companies are more resilient and whether fiscal policy enhances corporate resilience. First, I estimate binary outcome (logit) regression models for panel data to test the relationship between being an R&D spender and my first measure of resilience, *impact resistance* (Cameron and Trivedi 2022, pp. 1139–1190). Second, I estimate count data (Poisson) regression models for panel data to examine the relationship between being an R&D spender and my second measure of resilience, *recovery speed* (Ibid.). In each case, I have one baseline specification and two augmented specifications including firm–level controls and country–level fiscal policy variables, respectively. Third, to examine the role of fiscal policy in fostering corporate resilience in the country that extended its existing R&D tax credit during the pandemic (Germany), I estimate a two–way fixed–effects difference–in–differences (TWFE DID) regression model. Each approach is elaborated below.

3.1.1 Binary Outcome Models

My measure of impact resistance is a binary variable, and it equals one if a firm does not incur a loss due to a crisis in a specific week. Therefore, I estimate the following random–effects logit model as a baseline:

$$\Pr(IR_{it} = 1 \mid RDS_i, \boldsymbol{\beta}, \alpha_i) = \Lambda(\alpha_i + RDS_i\boldsymbol{\beta}), \tag{7}$$

where IR_{it} is the crisis impact resistance of firm i at time t; RDS_i is its status in terms

of R&D expense (spender or non–spender); and α_i is a random effect.

The augmented specification with controls (see Section 3.2 below) has the following form:

$$\Pr(IR_{it} = 1 \mid RDS_i, Z_i, \boldsymbol{\gamma}, \boldsymbol{\beta}, \alpha_i) = \Lambda(\alpha_i + RDS_i\boldsymbol{\beta} + \boldsymbol{z}_i'\boldsymbol{\gamma}). \tag{8}$$

The specification including a fiscal policy variable has an additional interaction term:

$$\begin{aligned} &\Pr(IR_{it} = 1 \mid RDS_i, RDS_i \times CTC_c, Z_i, \boldsymbol{\delta}, \boldsymbol{\gamma}, \boldsymbol{\beta}, \alpha_i) \\ &\quad = \Lambda(\alpha_i + RDS_i\boldsymbol{\beta} + \boldsymbol{z}_i'\boldsymbol{\gamma} + RDS_i \times CTC_c\boldsymbol{\delta}), \end{aligned} \tag{9}$$

where CTC is an indicator equal to one for each country c that implemented a containment tax cut during the pandemic and zero otherwise.

I expect the β coefficient in both Equations 7 and 8 to be positive, i.e., R&D spenders are less likely to incur a loss due to the crisis, *ceteris paribus*. Additionally, I expect the δ coefficient in Equation 9 to be greater for R&D spenders, i.e., a containment tax cut matters more for the crisis impact resistance of R&D spenders than non–spenders.

3.1.2 Count Data Models

My measure of recovery speed is a count variable equal to the number of weeks it takes for a company that has incurred a loss due to a crisis to recover to pre–crisis levels. Therefore, I estimate a random–effects Poisson regression model for only those companies that incurred a loss due to the crisis and subsequently recovered:

$$E(RS_{it} \mid RDS_i, \boldsymbol{\beta}, \alpha_i) = \exp(\alpha_i + RDS_i\boldsymbol{\beta}), \tag{10}$$

where RS_i is the recovery speed of firm i at time t; RDS_i is its status in terms of R&D expense (spender or non–spender); and α_i is a random effect.

The augmented specification that accounts for firm–level controls has the following form:

$$E(RS_{it} \mid RDS_i, Z_i, \boldsymbol{\gamma}, \boldsymbol{\beta}, \alpha_i) = \exp(\alpha_i + RDS_i\boldsymbol{\beta} + \boldsymbol{z}_i'\boldsymbol{\gamma}). \tag{11}$$

The specification including a fiscal policy variable has an additional interaction term:

$$\begin{aligned} &E(RS_{it} \mid RDS_i, RDS_i \times RTC_c, Z_i, \boldsymbol{\delta}, \boldsymbol{\gamma}, \boldsymbol{\beta}, \alpha_i) \\ &= \exp(\alpha_i + RDS_i\boldsymbol{\beta} + \boldsymbol{z}_i'\boldsymbol{\gamma} + RDS_i \times RTC_c\boldsymbol{\delta}), \end{aligned} \tag{12}$$

where RTC is an indicator equal to one for each country c that implemented a recovery tax cut during the pandemic and zero otherwise.

I expect the β coefficient in both Equations 10 and 11 to be negative, i.e., R&D spenders affected by the crisis recover faster than non–spenders, *ceteris paribus*. Additionally, I expect the δ coefficient in Equation 12 to be greater for R&D spenders, i.e., a recovery tax cut matters more for the crisis recovery speed of R&D spenders than non–spenders.

3.1.3 TWFE DID Model

For publicly traded companies in Germany, I estimate the following model to quantify the differential impact of fiscal policy on stock prices of R&D spenders:

$$lnPrice_{it} = \phi_i + \gamma_t + \alpha D_{it} + \upsilon_{it}, \tag{13}$$

where i denotes companies, and t denotes time (156 weeks spanning from W1–2019 to W52–2021 inclusive). D is a binary variable equal to one for R&D spenders in the post–legislation period (starting in W27–2020) and zero otherwise, ϕ_i denotes firm fixed effects, γ_t stands for week fixed effects, and υ_{it} is an error term clustered at the company level. My interest lies in estimating the parameter α, i.e., the average treatment effect on the treated (ATET). This parameter is identified if the two assumptions of parallel trends and Granger causality hold. I test both assumptions and provide appropriate test statistics and diagnostic graphs. [17]

[17] All analyses were carried out with Stata 18 software (StataCorp 2023). Specifically, I have utilized

3.2 Controls

While estimating random–effects logit and Poisson regression models, as specified above, I control for several factors that simultaneously affect corporate innovation and resilience. First, I control for *liquidity*, as less financially constrained firms are more likely to allocate resources to innovation (Hall and Lerner 2010; O'Sullivan 2006) and withstand exogenous crises (Fahlenbrach, Rageth, and Stulz 2021; Williams et al. 2017). Similarly, I control for *profitability*, as better–performing firms are more likely to allocate resources to innovation (Hall and Lerner 2010) and rebound from crises (Smith et al. 2024). Liquidity is measured by the pre–crisis current ratio, i.e., current assets in 2019 divided by current liabilities in the same year; profitability is measured by the pre–crisis return on assets, i.e., net income in 2019 divided by total assets in the same year. [18]

Second, I control for *industry*, as there are differences in the allocation of resources to innovation across industries, with some being more R&D–intensive than others (Malerba 2006; Smith 2006), and the impact of the COVID–19 pandemic was uneven across industries: industries that enabled work from home to a greater extent were less affected by the pandemic than other industries (del Rio–Chanona et al. 2020; Dingel and Neiman 2020). Industry is identified by the NACE Rev.2 section in which a company operates, and my sample is representative of 17 sections.

Third, I control for *age*, as older companies are more likely to allocate resources to innovation (Akcigit, Hanley, and Stantcheva 2022; Lazonick 2006) and have experience of prior exogenous crises (Smith et al. 2024). Age is measured by years since incorporation.

Finally, I control for *location*, as there are geographic disparities in the allocation of resources to innovation across the EA (European Commission 2025) and also the impact of the pandemic was uneven (Muggenthaler, Schroth, and Sun 2021). Location is identified

the `xtdidregress` command to estimate the ATET, as well as the `estat ptrends` and `estat granger` commands to obtain test statistics on the validity of parallel trends and Granger causality assumptions. Figures were obtained using `estat trendplots` and `estat grangerplot` commands, respectively.

[18] I prefer liquidity as a measure of financial constraints instead of leverage due to the reason (as noted in Section 2.1 above) that the recession induced by the pandemic was very short, and it therefore did not materially affect the long–run financial condition of most companies.

by the country in which a company is incorporated.

4 Results

4.1 Main Results

4.1.1 Random–Effects Logit and Poisson Regression Results

Random–effects logit regression results, as reported in Table 3 below, suggest that R&D spenders were less likely to incur a loss due to the crisis induced by the pandemic, *ceteris paribus*. The coefficient estimate of the baseline equation ($\beta = 0.256, s.e. = 0.081$) increases in size and retains its significance at the 1%–level when industry fixed effects are included in the regression specification ($\beta = 0.282, s.e. = 0.086$); it weakens but remains significant when location fixed effects are included ($\beta = 0.216, s.e. = 0.092$), suggesting that cross–country heterogeneity is an important factor affecting the relationship between innovation and resilience. The coefficient when all controls are included is also positive and significant (see Table 3, column 6: $\beta = 0.237, s.e. = 0.106$). The inclusion of interaction terms with fiscal policy (see Table 4 below) yields expected results: the estimated coefficient for the interaction term *(RDS = 1)* $\times$ *(CTC = 1)* ($\delta = 0.322, s.e. = 0.100$) is more than three times larger than the coefficient for the interaction term *(RDS = 0)* $\times$ *(CTC = 1)* ($\delta = 0.103, s.e. = 0.088$); it increases in size and retains significance at the 1%–level when other controls are included (see Table 4, columns 2–5).

Poisson regression results, as reported in Table 5 below, suggest that R&D spenders that incurred a loss due to the crisis recovered faster than non–spenders, on average ($\beta = -0.158, s.e. = 0.035$). The coefficient weakens when other controls are included, but it retains its significance at the 5%–level (e.g., $\beta = -0.082, s.e. = 0.040$ in Table 5, column 6). Similar to the impact resistance regressions, the inclusion of interaction terms with fiscal policy in recovery regressions (see Table 6 below) yields expected results: the estimated coefficient for the interaction term *(RDS = 1)* $\times$ *(RTC = 1)* ($\delta = -0.226, s.e. = 0.047$) is around four times larger than the coefficient for the interaction term *(RDS = 0)* $\times$ *(RTC = 1)* ($\delta = -0.060, s.e. = 0.036$); it weakens in size but retains significance at the 5%–level

when other controls are included (see Table 6, columns 2–5).

4.1.2 TWFE DID Regression Results

The two–way fixed–effects regression results for Germany (see Table 7 below) suggest that fiscal policy has a causal effect on resilience: the interaction term *R&D spender* × *Post* is positive and significant ($\alpha = 0.100, s.e. = 0.045$), suggesting that the stock prices of R&D spenders increased by 10%, on average, in the post–legislation period, i.e., after 1 July 2020. The parallel trends and Granger causality assumptions hold, as can be observed also from Figures 7 and 8 below. The coefficient is slightly larger and still significant at the 5%–level for manufacturing companies ($\alpha = 0.155, s.e. = 0.057$), but it is marginally insignificant for companies in service industries ($\alpha = 0.123, s.e. = 0.076$).

4.2 Heterogeneity Analyses

4.2.1 Legal Origins

Tables 8 and 9 below provide heterogeneity analyses of random–effects logit and Poisson panel data regressions by legal origins. As noted in Section 2.2.5 above, the French civil law origin includes seven countries (Belgium, France, Greece, Italy, Netherlands, Portugal, and Spain), while the German civil law origin includes two countries (Austria and Germany). There are more companies located in the combined sample of seven countries ($n = 716$) than in the combined sample of two countries ($n = 278$); therefore and due to the balanced nature of the panel, the number of company–week observations in the former group is substantially larger ($N = 111{,}696$) than in the latter ($N = 43{,}368$), and any differences in coefficient estimates cannot be attributed to sample size.

The baseline estimate for resilience as crisis impact resistance in French civil law countries (see Table 8, Panel A, Model 1 below) is positive but insignificant ($\beta = 0.173, s.e. = 0.114$); it stays insignificant as additional controls are added to the regression specification (see Table 8, Panel A, Models 2–3). By contrast, the baseline estimate for resilience as impact resistance in German civil law countries (see Table 8, Panel B, Model 1 below) is positive and significant at the 10%–level ($\beta = 0.271, s.e. = 0.150$); it increases—in both size

and significance—as additional controls are added to the regression specification (see Table 8, Panel B, Models 2–3 below): for instance, $\beta = 0.440$ ($s.e. = 0.171$) in the specification controlling for liquidity, profitability, and industry fixed effects.

The baseline coefficient estimate for resilience as crisis recovery speed in French civil law countries (see Table 9, Panel A, Model 1 below) is negative but insignificant ($\beta = -0.071, s.e. = 0.046$); it stays insignificant as additional controls are added to the regression specification (see Table 9, Panel A, Models 2–3). By contrast, the baseline coefficient estimate for resilience as recovery speed in German civil law countries (see Table 9, Panel B, Model 1 below) is negative and significant at the 5%–level ($\beta = -0.166, s.e. = 0.070$); it increases—in both size and significance—as additional controls are added to the regression specification (see Table 9, Panel B, Models 2–3 below): for instance, $\beta = -0.236$ ($s.e. = 0.084$) in the specification controlling for liquidity, profitability, and industry fixed effects.

4.2.2 Fiscal Space and Stimulus

Government debt in 2019 was below 60% of GDP in nine countries of the euro area: Estonia, Germany, Ireland, Latvia, Lithuania, Luxembourg, Malta, Netherlands, and Slovakia. [19] These countries were compliant with the first criterion of sustainable fiscal policy, as set out in the Maastricht Treaty (European Parliament 2025), before the crisis induced by the pandemic, and therefore, their governments had more fiscal space for effective crisis response (Romer and Romer 2019). Heterogeneity analyses provided in Table 10 below suggest that the relationship between innovation and resilience as crisis impact resistance is much stronger in countries with lower pre–crisis debt–to–GDP ratios.

The average size of the fiscal stimulus package implemented in 19 EA member states in response to the pandemic, as measured by the change in budget balance from 2019 to 2020 (Muggenthaler, Schroth, and Sun 2021), was 7.6% of GDP (median: 6.8%). [20] Countries that implemented larger packages in 2020 include Austria, Belgium, France, Greece, Italy,

[19] See https://data.ecb.europa.eu/publications/macroeconomic-and-sectoral-statistics/3030644 for aggregate and country–level debt statistics.

[20] See https://data.ecb.europa.eu/publications/macroeconomic-and-sectoral-statistics/3030642 for aggregate and country–level budget balance statistics.

Malta, Slovenia, and Spain. Heterogeneity analyses (see Table 11 below) suggest that the impact of innovation on resilience as crisis impact resistance is stronger in countries that implemented *below* average stimulus packages; therefore, it is the targeted nature of fiscal policy enhancing innovation, as discussed in the preceding section, that mattered during the response phase of the pandemic, rather than its size.

The average size of the fiscal stimulus provided in 2021 was 5.2% of GDP (median: 5.6%); countries implementing larger packages included Austria, Belgium, France, Greece, Italy, Latvia, Malta, Slovakia, Slovenia, and Spain. Regression results for resilience as recovery speed (see Table 12 below) suggest that R&D spenders in countries implementing larger stimulus packages recovered faster than non–spenders, on average; however, this relationship does not hold once industry differences are accounted for. Similar to the impact resistance regressions, the relationship holds for countries implementing below average stimulus packages, and this is robust to the inclusion of industry fixed effects.

4.2.3 Non–Fiscal Policy Responses

As discussed in Section 2.2.4, non–fiscal policy responses to the pandemic included closure, containment, and vaccination policies. I proxy these with the OxCGRT *Stringency* and *Containment and Health* indices, respectively (Blavatnik School of Government 2023). The former includes eight indicators, while the latter includes 14 indicators, as laid out below:

- **Stringency Index (SI):** school closure; workplace closure; cancellation of public events; restrictions on gatherings; public transport closure; stay at home requirements; restrictions on internal movement; and restrictions on international travel.
- **Containment and Health Index (CHI):** all eight indicators above plus: public information campaigns; testing policy; contact tracing; facial covering; vaccination policy; and protection of the elderly.

Both indices are standardized, ranging from zero to 100. SI values in 2020 were above the median (50.00) in six countries: France, Germany, Ireland, Italy, Portugal, and Spain; SI values in 2021 were above the median in all but four countries of the EA (Estonia,

Finland, Lithuania, and Luxembourg). CHI values in 2020 were above the median in only two countries: France and Italy; similar to the SI, CHI values in 2021 were above the median in all but three countries of the EA (Estonia, Finland, and Latvia). Heterogeneity analyses for resilience as impact resistance (see Table 13 below) suggest that R&D spenders were less likely to incur a loss in countries that had more stringent crisis response policies.

5 Discussion

The analyses carried out and presented in this paper suggest that innovation enhances corporate resilience, and this relationship is moderated by fiscal policies aimed at crisis containment and recovery. Most notably, I find that the impact of innovation on resilience—defined as crisis impact resistance and recovery speed—is stronger in countries that provided fiscal incentives for innovation during the COVID–19 pandemic, such as Germany. My findings are aligned with the long–standing literature on the effectiveness of tax incentives for business investment and innovation (Hall and Jorgenson 1967; Hassett and Hubbard 2002; Zwick and Mahon 2017), but, more importantly, they bring a novel insight into the field of macroeconomics: the provision of tax incentives for innovation during a recession may contain its severity as well as enable faster recovery.

My paper complements several recent papers on economic resilience. Specifically, it relates to research examining firm–level characteristics that contribute to resilience (Aghion et al. 2021; Ding et al. 2021; Li et al. 2021), as well as research on resilience in supply chains (Grossman, Helpman, and Lhuillier 2023; Grossman, Helpman, and Sabal 2024). My findings are in contrast to a recent study on digitization and resilience (Copestake, Estefania–Flores, and Furceri 2024), which does not find differential effects across a large number of countries and regions: I find that the impact of innovation on resilience is heterogeneous across 17 member states of the EA that are also members of the OECD, and this is largely due to fiscal policies they implement. Furthermore, I find heterogeneous effects across countries belonging to French and German legal origins.

As the absence of a fiscal union has been and remains a bottleneck in the process of European integration (European Parliament 2025), my findings support the need for

greater coordination of fiscal policies in the EA. There has been coordination in the realm of multinational enterprise taxation (e.g., the OECD Base Erosion and Profit Shifting Project); however, policies on corporate income taxation in general and incentives for innovation, in particular, are set by national governments, and there is wide variation in both respects, as evidenced by effective average tax rates and implied tax subsidy rates. My findings suggest that due to the lack of coordination on fiscal policies implemented during a union–wide recession, individual member states of a monetary union may emerge on different growth paths post–recession; thus, and due to interactions between fiscal and monetary policy (Beetsma and Jensen 2005), fiscal integration is indispensable to a long–lasting economic union.

6 Conclusion

This paper provided evidence on how innovation affects corporate resilience in euro area member states—countries that are in a monetary union but do not form a fiscal union, thus retaining autonomy over business taxation and expenditure. Drawing on prior research in the field of economics, I argued and found support for the hypothesis that fiscal policies aimed at crisis containment and recovery moderate the relationship between corporate innovation and resilience: the observed impact of the allocation of resources to R&D on resilience—defined as crisis impact resistance and recovery speed—is greater in countries that lowered effective average corporate tax rates during the COVID–19 pandemic at the same time increasing the implied tax subsidy rates for R&D. I also found evidence on the role of institutions in the study of corporate innovation and resilience: the observed impact of innovation on resilience is greater in German civil law countries.

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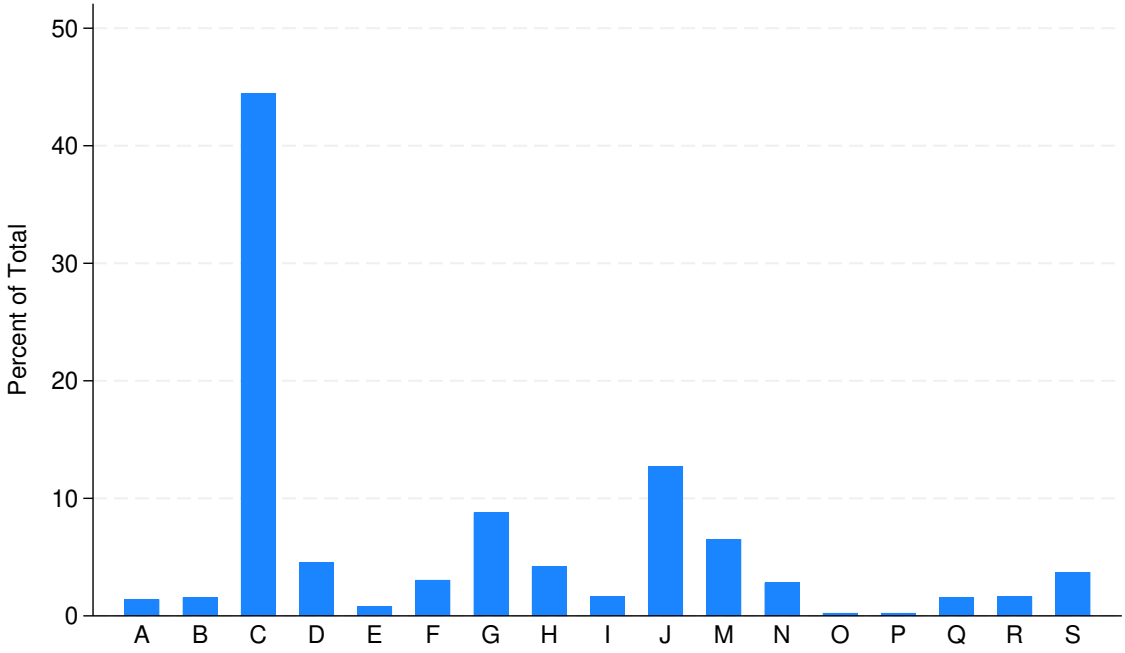
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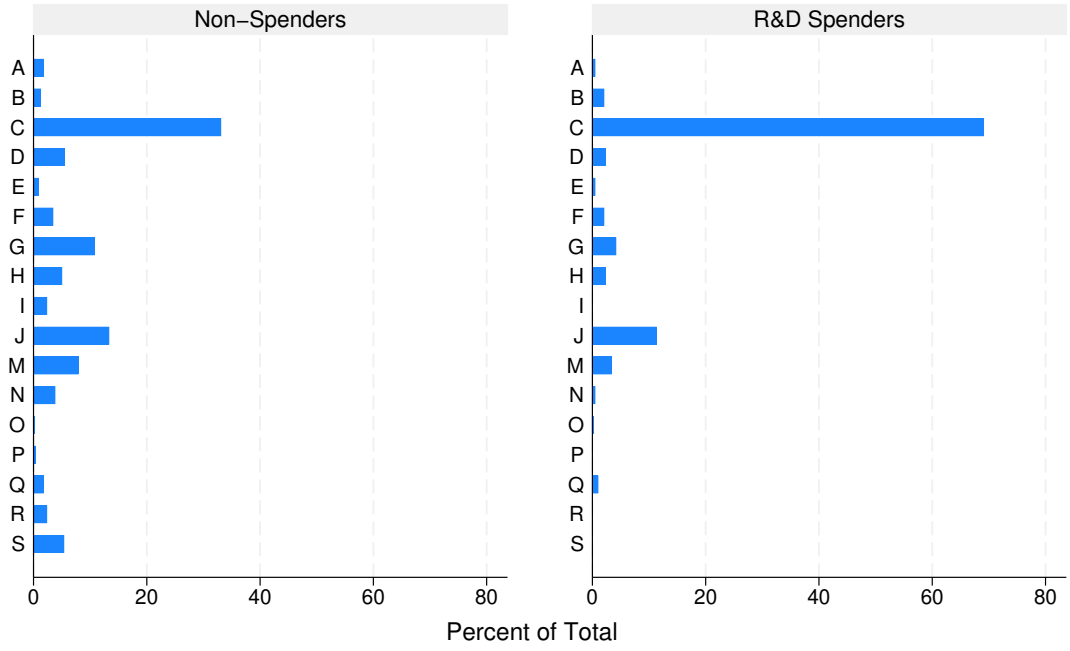
Figures

Figure 1: Distribution of the Sample by Industries



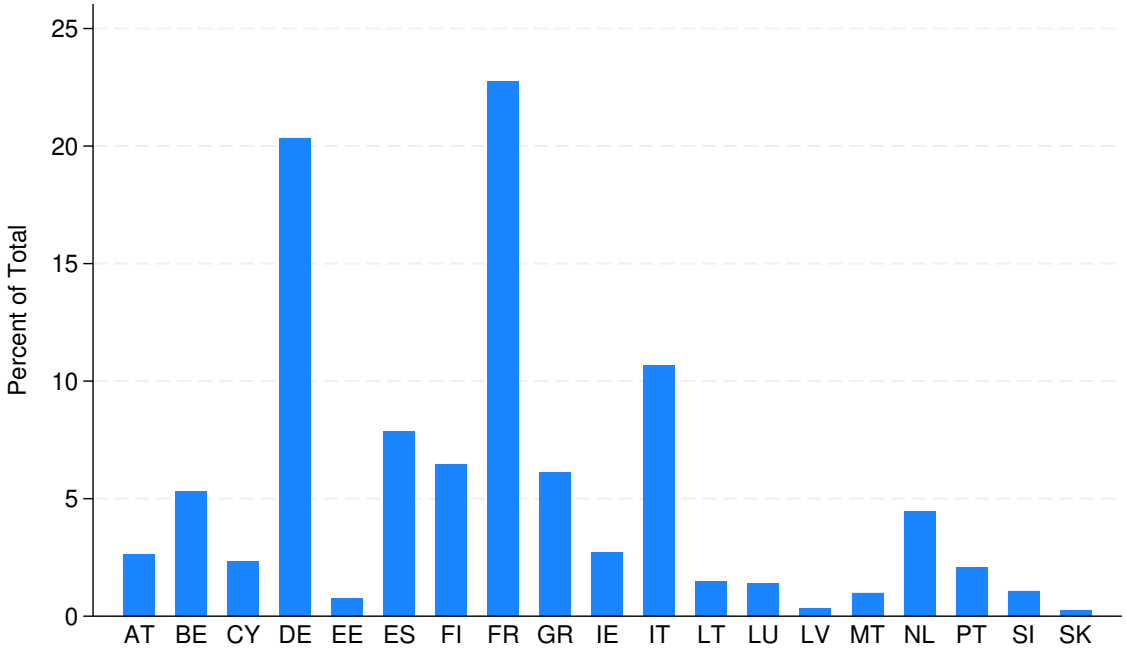
Notes: The sample includes 1,209 publicly traded companies in the EA member states as of 1 January 2019. NACE Rev.2 section codes are as follows: A (agriculture, forestry, and fishing), B (mining and quarrying), C (manufacturing), D (electricity, gas, steam, and air conditioning supply), E (water supply, sewerage, waste management, and remediation), F (construction), G (wholesale and retail trade; repair of motor vehicles and motorcycles), H (transportation and storage), I (accommodation and food services), J (information and communications), M (professional, scientific and technical services), N (administrative and support services), O (public administration and defense; compulsory social security), P (education), Q (human health and social work), R (arts, entertainment and recreation), and S (other services). Sections K (finance and insurance) and L (real estate) were excluded at the research design stage due to the incomparability of financial ratios of companies in those industries with companies in other industries (Fama and French 1992). See Eurostat (2008) for further details on the NACE Rev.2 classification.

Figure 2: Distribution of the R&D Spenders and Non–Spenders by Industries



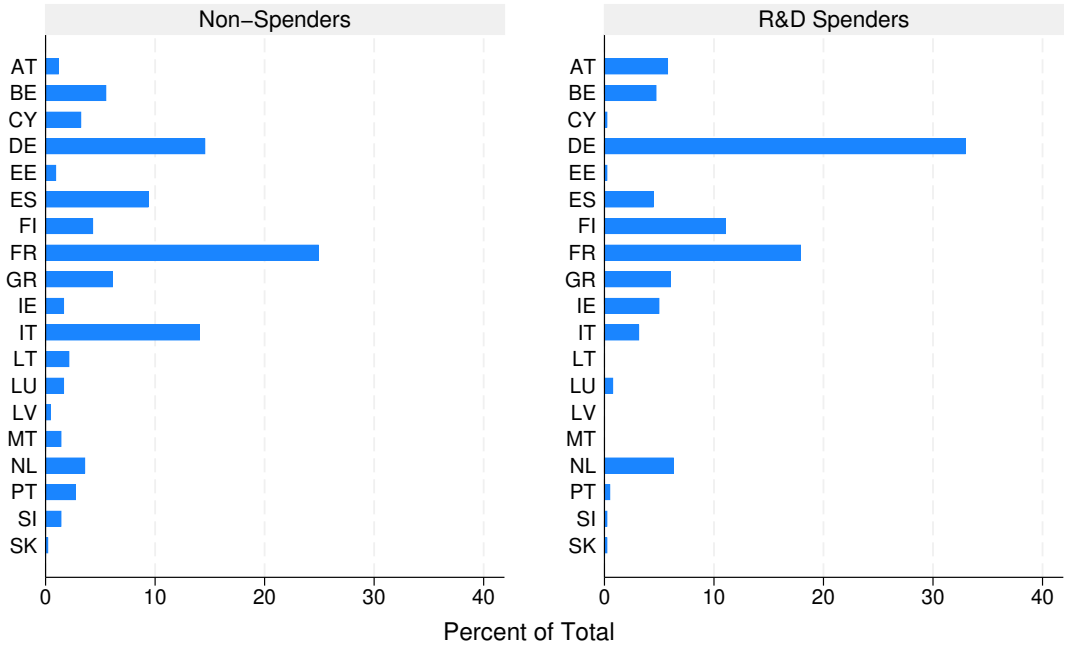
Notes: The sample includes 1,209 publicly traded companies in the EA member states as of 1 January 2019, of which 379 are R&D spenders according to the BvD Orbis data classification. NACE Rev.2 section codes as defined above.

Figure 3: Distribution of the Sample by Locations



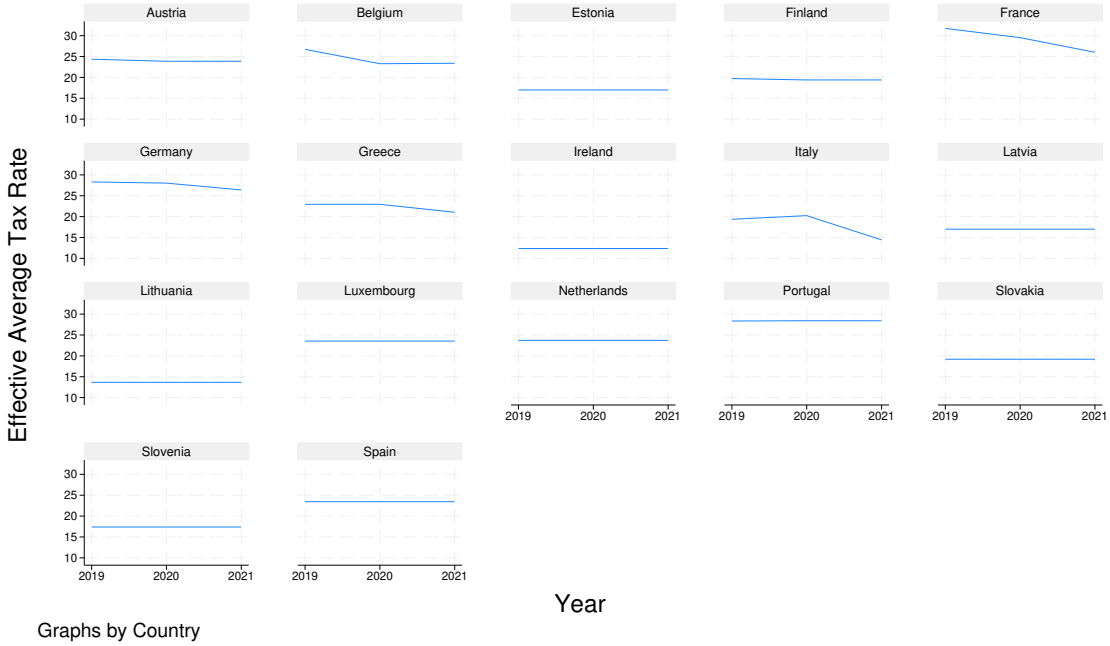
Notes: The sample includes 1,209 publicly traded companies in the EA member states as of 1 January 2019. Country codes are as follows: AT (Austria), BE (Belgium), CY (Cyprus), DE (Germany), EE (Estonia), ES (Spain), FI (Finland), FR (France), GR (Greece), IE (Ireland), IT (Italy), LT (Lithuania), LU (Luxembourg), LV (Latvia), MT (Malta), NL (Netherlands), PT (Portugal), SI (Slovenia), and SK (Slovakia).

Figure 4: Distribution of the R&D Spenders and Non–Spenders by Locations



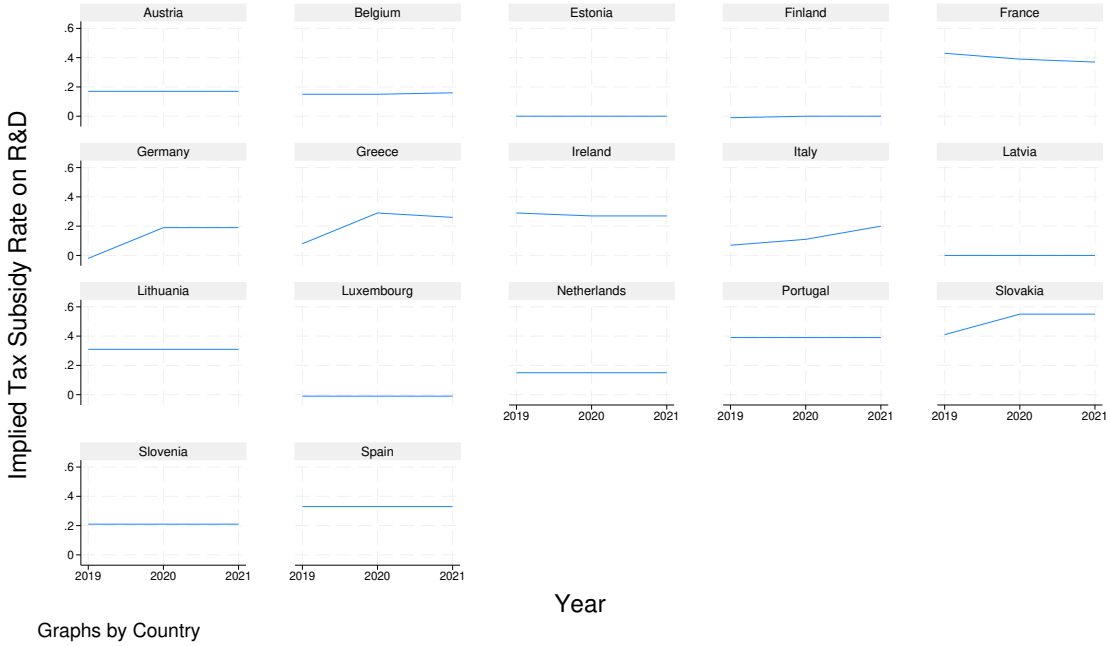
Notes: The sample includes 1,209 publicly traded companies in the EA member states as of 1 January 2019, of which 379 are R&D spenders according to the BvD Orbis data classification. Country codes as defined above.

Figure 5: Effective Average Tax Rates in EA–OECD Member States, 2019–2021



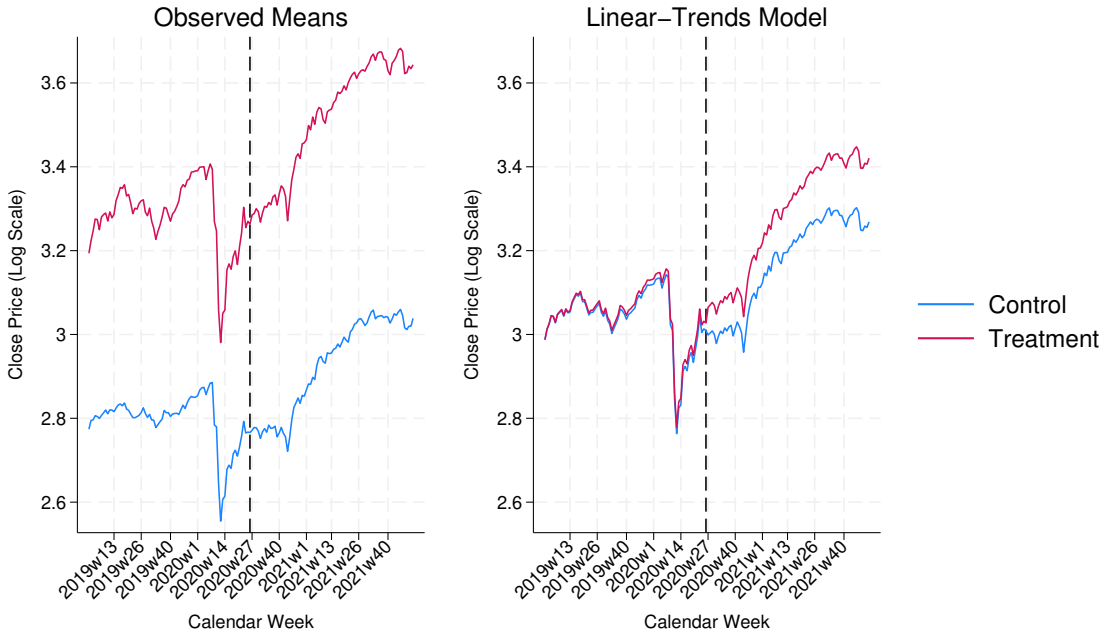
Source: Organization for Economic Cooperation and Development (2024)

Figure 6: Implied Tax Subsidy Rates on R&D in EA–OECD Member States, 2019–2021



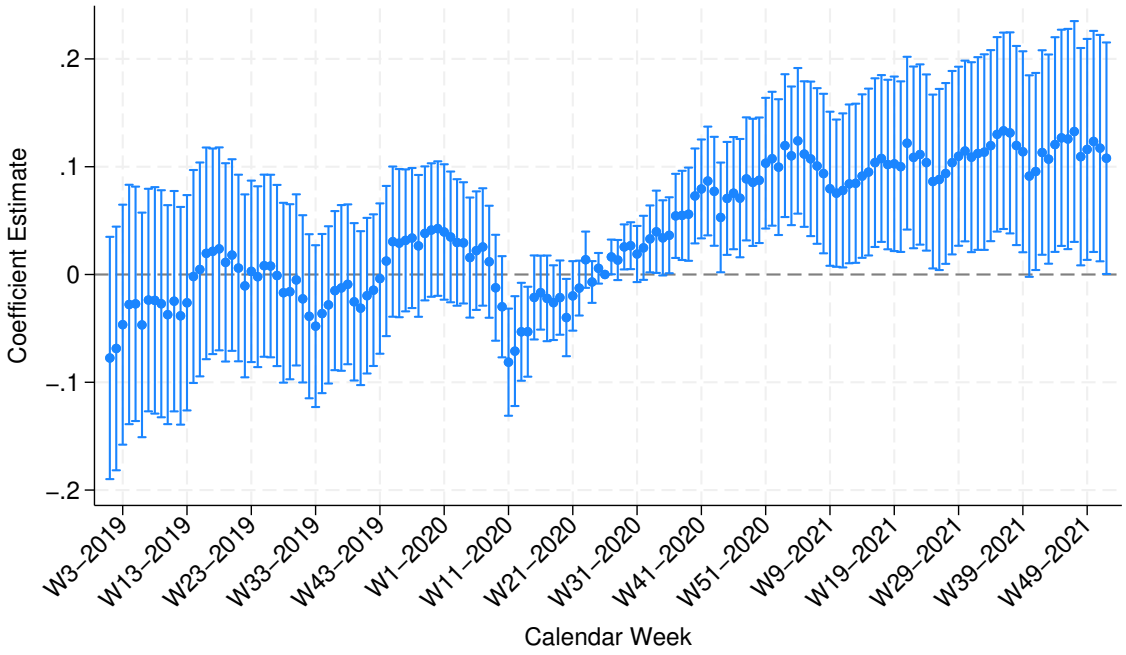
Source: Organization for Economic Cooperation and Development (2024)

Figure 7: Graphical Diagnostics for Parallel Trends



Notes: The sample includes 246 publicly traded companies incorporated in Germany; of these, 125 are R&D spenders according to the BvD Orbis data classification. Treatment is defined as being an R&D spender after the legislation on the extension of the R&D tax credit took effect, i.e., W27–2020 onwards.

Figure 8: Effects over Time, Leads, and Lags with 95% Confidence Intervals



Notes: The sample includes 246 publicly traded companies incorporated in Germany; of these, 125 are R&D spenders according to the BvD Orbis data classification. Treatment is defined as being an R&D spender after the legislation on the extension of the R&D tax credit took effect, i.e., W27–2020 onwards.

Tables

Table 1: Corporate R&D Tax Incentives in EA–OECD Member States

Country	Policy	Year	Base	Rate (%)
Austria	Research premium	2002	CIT	14
Belgium	R&D investment deduction	1992	CIT	13.5
France	R&D tax credit	1983	CIT	30
	(crédit d'impôt recherche, CIR)			
Germany	R&D tax credit	2020	CIT	25
	(Forschungszulage)			
Greece	R&D tax allowance	2004	CIT	100
Ireland	R&D tax credit	2004	CIT	25
Italy	R&D tax credit	2020	CIT	10
Netherlands	R&D tax credit	1994	SSC	32
Portugal	R&D tax credit	1997	CIT	32.5
Slovakia	R&D tax allowance	2015	CIT	100
Slovenia	R&D tax allowance	2005	CIT	100
Spain	R&D tax credit	2015	CIT	25

Source: Organization for Economic Cooperation and Development (2025b).

Notes: Year refers to the year in which the policy took effect, as opposed to the year when it was legislated. Base refers to the tax base for the policy (corporate income tax, CIT, or Social Security Contribution, SSC). In case of multiple rates (e.g., small vs. large firms and capital vs. labor costs), only the base rate applicable to large firms is reported. In case of multiple policies in force (e.g., Belgium and Slovakia), the oldest policy applicable to most firms is reported.

Table 2: Corporate Effective Tax Rates and R&D Incentives in EA–OECD Member States, 2019–2021

Country / Year	EATR			EMTR			ITSR (R&D)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
Austria	24.37	23.87	23.87	27.70	23.27	23.27	0.17	0.17	0.17
Belgium	26.73	23.29	23.39	15.03	18.14	19.05	0.15	0.15	0.16
Estonia	17.00	17.00	17.00	0.00	0.00	0.00	0.00	0.00	0.00
Finland	19.73	19.40	19.40	22.74	20.03	20.03	-0.01	0.00	0.00
France	31.75	29.53	26.02	25.24	22.64	11.50	0.43	0.39	0.37
Germany	28.32	28.03	26.41	27.67	24.92	9.18	-0.02	0.19	0.19
Greece	22.96	22.96	21.05	22.47	22.47	20.07	0.08	0.29	0.26
Ireland	12.36	12.36	12.36	13.21	13.21	13.21	0.29	0.27	0.27
Italy	19.37	20.24	14.44	-39.35	-31.39	-84.94	0.07	0.11	0.20
Latvia	17.00	17.00	17.00	0.00	0.00	0.00	0.00	0.00	0.00
Lithuania	13.67	13.67	13.67	7.25	7.25	7.25	0.31	0.31	0.31
Luxembourg	23.54	23.54	23.54	20.83	20.83	20.83	-0.01	-0.01	-0.01
Netherlands	23.71	23.71	23.71	21.89	21.89	21.89	0.15	0.15	0.15
Portugal	28.35	28.42	28.42	15.30	16.01	16.01	0.39	0.39	0.39
Slovakia	19.20	19.20	19.20	11.41	11.41	11.41	0.41	0.55	0.55
Slovenia	17.38	17.38	17.38	10.15	10.15	10.15	0.21	0.21	0.21
Spain	23.45	23.45	23.45	19.55	19.55	19.55	0.33	0.33	0.33

Notes: EATR stands for effective average tax rate; EMTR stands for effective marginal tax rate; ITSR stands for implied tax subsidy rate. See Organization for Economic Cooperation and Development (2024) for definitions.

Table 3: Random–Effects Panel Data Logit Regression Models for Resilience as Crisis Impact Resistance

	Baseline	Extensions				
	(1)	(2)	(3)	(4)	(5)	(6)
R&D spender	0.256	0.282	0.216	0.223	0.224	0.237
	(0.081)	(0.086)	(0.092)	(0.092)	(0.092)	(0.106)
Liquidity				0.061	0.039	-0.017
				(0.040)	(0.040)	(0.046)
Profitability					0.016	0.012
					(0.006)	(0.006)
Age						-0.020
						(0.003)
Constant	1.267	1.558	1.019	0.972	0.908	1.802
	(0.048)	(0.286)	(0.301)	(0.300)	(0.292)	(0.407)
Industry FE	No	Yes	Yes	Yes	Yes	Yes
Location FE	No	No	Yes	Yes	Yes	Yes
Observations	188,604	188,604	188,604	188,292	188,292	187,824
Log pseudo–L	-97,859.556	-97,833.508	-97,807.75	-97,587.996	-97,583.187	-97,347.111
Wald χ^2	9.95 (1)	183.19 (17)	246.57 (35)	228.66 (36)	155.72 (37)	140.80 (38)

Notes: Robust standard errors clustered at the company level (n = 1,209) in parentheses below coefficient estimates. Degrees of freedom next to Wald χ^2 statistics. See figures above for the distribution of companies across industries and locations.

Table 4: Random–Effects Panel Data Logit Regression Models for Resilience as Crisis Impact Resistance with Variation in Fiscal Policy

	Baseline	Extensions			
	(1)	(2)	(3)	(4)	(5)
(RDS = 0) × (CTC = 1)	0.103	0.083	0.082	0.099	0.207
	(0.088)	(0.089)	(0.089)	(0.088)	(0.099)
(RDS = 1) × (CTC = 0)	0.272	0.310	0.318	0.272	0.174
	(0.157)	(0.156)	(0.156)	(0.157)	(0.184)
(RDS = 1) × (CTC = 1)	0.322	0.330	0.332	0.363	0.535
	(0.100)	(0.104)	(0.104)	(0.105)	(0.122)
Liquidity			0.078	0.060	0.039
			(0.039)	(0.039)	(0.040)
Profitability				0.014	0.016
				(0.005)	(0.006)
Constant	1.214	1.549	1.503	1.422	0.908
	(0.067)	(0.286)	(0.286)	(0.285)	(0.292)
Industry FE	No	Yes	Yes	Yes	Yes
Observations	188,604	188,604	188,604	188,292	188,292
Log pseudo–L	-97,858.842	-97,833.065	-97,612.578	-97,609.077	-97,583.187
Wald χ^2	11.59 (3)	163.94 (19)	154.87 (20)	123.31 (21)	155.72 (37)

Notes: Robust standard errors clustered at the company level (n = 1,209) in parentheses below coefficient estimates. Degrees of freedom next to Wald χ^2 statistics. See figures above for the distribution of companies across industries.

Table 5: Random–Effects Panel Data Poisson Regression Models for Resilience as Crisis Recovery Speed

	Baseline	Extensions				
	(1)	(2)	(3)	(4)	(5)	(6)
R&D spender	-0.158	-0.128	-0.083	-0.086	-0.085	-0.082
	(0.035)	(0.038)	(0.039)	(0.040)	(0.040)	(0.040)
Liquidity				-0.028	-0.024	-0.017
				(0.020)	(0.020)	(0.019)
Profitability					-0.004	-0.013
					(0.002)	(0.002)
Age						0.001
						(0.000)
Constant	3.709	3.455	3.476	3.487	3.493	3.428
	(0.018)	(0.178)	(0.198)	(0.196)	(0.193)	(0.200)
Industry FE	No	Yes	Yes	Yes	Yes	Yes
Location FE	No	No	Yes	Yes	Yes	Yes
Observations	43,551	43,551	43,551	43,401	43,401	43,371
Log pseudo–L	-127,314.56	-127,296.65	-127,277.32	-126,805.02	-126,803.95	-126,715.91
Wald χ^2	57,955.26 (1)	91,083.64 (17)	90,000.94 (35)	92,620.14 (36)	349,479.12 (37)	292,791.10 (38)

Notes: Robust standard errors clustered at the company level (n = 1,120) in parentheses below coefficient estimates. Degrees of freedom next to Wald χ^2 statistics. See figures above for the distribution of companies across industries and locations.

Table 6: Random–Effects Panel Data Poisson Regression Models for Resilience as Recovery Speed with Variation in Fiscal Policy

	Baseline	Extensions			
	(1)	(2)	(3)	(4)	(5)
(RDS = 0) × (RTC = 1)	-0.060	-0.037	-0.032	-0.036	-0.044
	(0.036)	(0.038)	(0.038)	(0.037)	(0.037)
(RDS = 1) × (RTC = 0)	-0.149	-0.107	-0.106	-0.100	-0.087
	(0.056)	(0.060)	(0.060)	(0.060)	(0.061)
(RDS = 1) × (RTC = 1)	-0.226	-0.182	-0.181	-0.188	-0.207
	(0.047)	(0.050)	(0.050)	(0.050)	(0.050)
Liquidity			-0.043	-0.039	-0.034
			(0.020)	(0.019)	(0.019)
Profitability				-0.003	-0.003
				(0.002)	(0.002)
Constant	3.746	3.461	3.476	3.491	3.441
	(0.028)	(0.174)	(0.171)	(0.169)	(0.074)
Industry FE	No	Yes	Yes	Yes	Yes
Observations	43,551	43,551	43,401	43,401	188,292
Log pseudo–L	-127,313.16	-127,295.76	-126,822.54	-126,821.77	-97,583.187
Wald χ^2	58,330.80 (3)	90,056.32 (19)	93,761.96 (20)	117,692.09 (21)	155.72 (37)

Notes: Robust standard errors clustered at the company level (n = 1,120) in parentheses below coefficient estimates. Degrees of freedom next to Wald χ^2 statistics. See figures above for the distribution of companies across industries.

Table 7: TWFE DID Regression Results for Germany

	All Companies	Manufacturing	Non–Manufacturing
	($n = 246$)	($n = 126$)	($n = 120$)
R&D spender × *Post*	0.100	0.155	0.123
	(0.045)	(0.057)	(0.076)
	[0.012; 0.187]	[0.041; 0.269]	[-0.028; 0.273]
Company FE	Yes	Yes	Yes
Week FE	Yes	Yes	Yes
n (control)	121	38	83
n (treatment)	125	88	37
N (company–week obs.)	38,376	19,656	18,720
Parallel trends test	$F_{(1,245)} = 0.09$	$F_{(1,125)} = 1.74$	$F_{(1,119)} = 1.07$
Granger causality test	$F_{(77,245)} = 2.31$	$F_{(77,125)} = 9.03$	$F_{(77,119)} = 5.63$

Notes: The classification of a company as an R&D spender is based on the BvD Orbis database; "post" indicates weeks after the legislation on the extension of the R&D tax credit took effect, i.e., W27–2020 onwards. Manufacturing companies are those operating under Section C of the NACE Rev.2 classification. Robust standard errors clustered at the company level in parentheses below coefficient estimates; 95% confidence intervals in brackets. The null hypothesis for the parallel trends test is that linear trends in the pre–treatment time period are parallel; the null hypothesis for the Granger causality test is that there is no effect in anticipation of treatment.

Table 8: Heterogeneity Analysis by Legal Origins for Resilience as Impact Resistance

	Panel A. French Civil Law			**Panel B. German Civil Law**		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
R&D spender	0.173	0.156	0.162	0.271	0.407	0.440
	(0.114)	(0.115)	(0.115)	(0.150)	(0.168)	(0.171)
Liquidity			0.100			0.069
			(0.058)			(0.057)
Profitability			0.014			0.005
			(0.007)			(0.013)
Constant	1.190	1.134	1.077	1.272	1.365	1.276
	(0.055)	(0.436)	(0.428)	(0.113)	(0.168)	(0.183)
Industry FE	No	Yes	Yes	No	Yes	Yes
Observations	111,696	111,696	111,540	43,368	43,368	43,212
Log pseudo-L	-60,109.662	-60,093.746	-59,981.845	-21,881.729	-21,863.947	-21,752.666
Wald χ^2	2.29 (1)	134.51 (17)	93.12 (19)	3.26 (1)	– (13)	9.92e+07 (16)

Notes: French civil law includes seven countries: Belgium, France, Greece, Italy, Netherlands, Portugal, and Spain; German civil law includes two countries: Austria and Germany. Robust standard errors clustered at the company level ($n = 716$ for French civil law and $n = 278$ for German civil law) in parentheses below coefficient estimates. Degrees of freedom next to Wald χ^2 statistics. See figures above for the distribution of companies across industries.

Table 9: Heterogeneity Analysis by Legal Origins for Resilience as Recovery Speed

	Panel A. French Civil Law			**Panel B. German Civil Law**		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
R&D spender	-0.071	-0.042	-0.041	-0.166	-0.209	-0.236
	(0.046)	(0.048)	(0.049)	(0.070)	(0.080)	(0.084)
Liquidity			-0.048			-0.054
			(0.029)			(0.035)
Profitability			-0.003			0.000
			(0.002)			(0.005)
Constant	3.728	3.642	3.655	3.670	2.982	3.040
	(0.021)	(0.318)	(0.316)	(0.050)	(0.080)	(0.093)
Industry FE	No	Yes	Yes	No	Yes	Yes
Observations	27,342	27,342	27,258	9,339	9,339	9,273
Log pseudo-L	-80,209.132	-80,196.203	-79,926.671	-27,097.781	-27,089.62	-26,885.196
Wald χ^2	41,345.22 (1)	84,668.49 (17)	215,171.66 (19)	10,554.63 (1)	6,804.71 (14)	1,454.61 (16)

Notes: French civil law includes seven countries: Belgium, France, Greece, Italy, Netherlands, Portugal, and Spain; German civil law includes two countries: Austria and Germany. Robust standard errors clustered at the company level ($n = 669$ for French civil law and $n = 259$ for German civil law) in parentheses below coefficient estimates. Degrees of freedom next to Wald χ^2 statistics. See figures above for the distribution of companies across industries.

Table 10: Heterogeneity Analysis by Fiscal Space for Resilience as Impact Resistance

	Panel A. Narrow Fiscal Space			**Panel B. Wide Fiscal Space**		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
R&D spender	0.172	0.165	0.183	0.327	0.482	0.488
	(0.101)	(0.104)	(0.105)	(0.141)	(0.152)	(0.153)
Liquidity			0.055			0.090
			(0.047)			(0.070)
Profitability			0.012			0.012
			(0.006)			(0.009)
Constant	1.241	1.598	1.487	1.335	1.508	1.381
	(0.055)	(0.166)	(0.154)	(0.098)	(0.452)	(0.455)
Industry FE	No	Yes	Yes	No	Yes	Yes
Observations	126,828	126,828	126,672	61,776	61,776	61,620
Log pseudo-L	-67,133.495	-67,116.447	-67,005.927	-30,722.088	-30,705.386	-30,592.627
Wald χ^2	2.92 (1)	148.02 (17)	93.12 (19)	5.37 (1)	38.68 (15)	42.42 (17)

Notes: Fiscal space is measured by the pre–crisis (2019) debt–to–GDP ratio. Countries with narrow fiscal space include the following: Austria, Belgium, Cyprus, Finland, France, Greece, Italy, Portugal, Slovenia, and Spain; countries with wide fiscal space include Estonia, Germany, Ireland, Latvia, Lithuania, Luxembourg, Malta, Netherlands, and Slovakia. Robust standard errors clustered at the company level ($n = 813$ for narrow fiscal space and $n = 396$ for wide fiscal space) in parentheses below coefficient estimates. Degrees of freedom next to Wald χ^2 statistics. See figures above for the distribution of companies across industries.

Table 11: Heterogeneity Analysis by Fiscal Stimulus for Resilience as Impact Resistance

	Panel A. Limited Fiscal Stimulus			**Panel B. Broad Fiscal Stimulus**		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
R&D spender	0.354	0.477	0.482	0.064	0.043	0.061
	(0.125)	(0.136)	(0.136)	(0.106)	(0.108)	(0.109)
Liquidity			0.048			0.093
			(0.059)			(0.051)
Profitability			0.007			0.016
			(0.008)			(0.008)
Constant	1.365	1.530	1.440	1.209	1.582	1.528
	(0.085)	(0.383)	(0.392)	(0.058)	(0.224)	(0.197)
Industry FE	No	Yes	Yes	No	Yes	Yes
Observations	80,340	80,340	80,184	108,264	108,264	108,108
Log pseudo-L	-39,486.987	-39,470.032	-39,358.52	-58,362.327	-58,345.729	-58,232.943
Wald χ^2	7.99 (1)	42.04 (15)	42.92 (17)	0.36 (1)	141.53 (17)	133.26 (19)

Notes: Fiscal stimulus is measured by the change in budget balance from 2019 to 2020. Countries that implemented limited fiscal packages include the following: Cyprus, Estonia, Finland, Germany, Ireland, Latvia, Lithuania, Luxembourg, Netherlands, Portugal, and Slovakia; countries that implemented broad fiscal packages include Austria, Belgium, France, Greece, Italy, Malta, Slovenia, and Spain. Robust standard errors clustered at the company level ($n = 515$ for limited fiscal stimulus and $n = 694$ for broad fiscal stimulus) in parentheses below coefficient estimates. Degrees of freedom next to Wald χ^2 statistics. See figures above for the distribution of companies across industries.

Table 12: Heterogeneity Analysis by Fiscal Stimulus for Resilience as Recovery Speed

	Panel A. Limited Fiscal Stimulus			**Panel B. Broad Fiscal Stimulus**		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
R&D spender	-0.211	-0.207	-0.209	-0.076	-0.042	-0.044
	(0.055)	(0.063)	(0.064)	(0.045)	(0.047)	(0.048)
Liquidity			-0.017			-0.072
			(0.025)			(0.029)
Profitability			-0.001			-0.003
			(0.003)			(0.002)
Constant	3.675	3.609	3.620	3.728	3.086	3.113
	(0.033)	(0.212)	(0.211)	(0.022)	(0.281)	(0.259)
Industry FE	No	Yes	Yes	No	Yes	Yes
Observations	16,910	16,910	16,844	26,641	26,641	26,557
Log pseudo-L	-49,182.13	-49,174.123	-48,970.687	-78,124.206	-78,109.468	-77,837.96
Wald χ^2	18,665.36 (1)	22,319.02 (15)	22,366.13 (17)	40,943.48 (1)	93,131.57 (17)	605,151.92 (19)

Notes: Fiscal stimulus is measured by the change in budget balance from 2020 to 2021. Countries that implemented limited fiscal packages include the following: Cyprus, Estonia, Finland, Germany, Ireland, Lithuania, Luxembourg, Netherlands, and Portugal; countries that implemented broad fiscal packages include Austria, Belgium, France, Greece, Italy, Latvia, Malta, Slovakia, Slovenia, and Spain. Robust standard errors clustered at the company level ($n = 467$ for limited fiscal stimulus and $n = 653$ for broad fiscal stimulus) in parentheses below coefficient estimates. Degrees of freedom next to Wald χ^2 statistics. See figures above for the distribution of companies across industries.

Table 13: Heterogeneity Analysis by Non–Fiscal Policy Response for Resilience as Impact Resistance

	Panel A. Less Stringent			**Panel B. More Stringent**		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
R&D spender	0.121	0.119	0.133	0.314	0.340	0.343
	(0.148)	(0.157)	(0.157)	(0.097)	(0.104)	(0.104)
Liquidity			0.063			0.059
			(0.062)			(0.055)
Profitability			0.017			0.010
			(0.011)			(0.006)
Constant	1.458	1.636	1.460	1.178	1.377	1.320
	(0.098)	(0.357)	(0.369)	(0.054)	(0.395)	(0.389)
Industry FE	No	Yes	Yes	No	Yes	Yes
Observations	63,336	63,336	63,336	125,268	125,268	124,956
Log pseudo-L	-31,603.144	-31,589.726	-31,587.293	-66,248.036	-66,232.924	-66,012.165
Wald χ^2	0.66 (1)	74.81 (15)	77.90 (17)	10.47 (1)	100.57 (17)	76.08 (19)

Notes: Stringency is measured by the OxCGRT 2020 Stringency Index. Countries that implemented less stringent policies include the following: Austria, Belgium, Cyprus, Estonia, Finland, Greece, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Slovakia, and Slovenia; countries that implemented more stringent policies include France, Germany, Ireland, Italy, Portugal, and Spain. Robust standard errors clustered at the company level ($n = 406$ for less stringent response and $n = 803$ for more stringent response) in parentheses below coefficient estimates. Degrees of freedom next to Wald χ^2 statistics. See figures above for the distribution of companies across industries.

Appendices and Supplementary Material

(available upon request)