European Commission

Quarterly R&I literature review 2022/Q2

The financing of innovation

R&I PAPER SERIES
LITERATURE REVIEW

Research and Innovation

The financing of innovation

European Commission
Directorate-General for Research and Innovation
Directorate G — Common Policy Centre
Unit G.1 — Common R&I Strategy & Foresight Service

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Manuscript completed in [July] [2022]

EUROPEAN COMMISSION

The financing of innovation

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Literature review

2022 Directorate-General for Research and Innovation EN

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INTRODUCTION

This literature review is developed by the 'Economics of R&I' team of the Chief Economist unit of DG Research and Innovation. It provides a brief summary of a selection of recent publications on R&I economics and policy. Contributors for this edition: Valentina Di Girolamo, Alessio Mitra, Océane Peiffer-Smadja, Julien Ravet (team leader).

Financing innovation is a particularly challenging task. The specific nature of the innovation output (i.e., non-excludability and partly non-rivalry) makes innovation activities more risky in the eyes of private investors. Production processes of companies operating in knowledge-intensive sectors are characterized by high uncertainty, and these companies typically take a longer to deploy their results on the market. These specificities often translate into significant financial constraints preventing innovative firms from securing external financial resources and forcing them to rely on internal resources, limiting their innovation potential.

Being able to **attract riskier and more patient investments** is of pivotal importance.

Although the COVID-19 crisis did not produce significant disruptive effects on the EU venture capital market, a number of factors keep holding the EU back in realizing its innovation potential.

Understanding the relationship between firms' innovation activities and different types of financing sources is also key to **improve access to the financial resources** needed to successfully transition toward a green and digital economy.

This literature review looks into different aspects of innovation financing, relying on both **qualitative** and **quantitative analyses**. The selected papers cover a broad range of topics, looking into the different determinants of financial constraints to innovative firms, as well as into the relationship between innovation activities and different financing instruments, with a focus on green financing. The review also introduces the results on access to finance of the 2022 edition of the Science, Research and Innovation Performance of the EU report.

EU ACCESS TO FINANCE FOR A SUSTAINABLE FUTURE

European Commission, Directorate-General for Research and Innovation, (2022). Science, research and innovation performance of the EU, 2022: Building a sustainable future in uncertain times, Publications Office.

Messages	**1. The EU financing system continues to be strongly bank-dependent and equity investments still play a relatively minor role. 2. The EU suffers from a financing scale-up gap, and the EU VC market still lags behind its main international competitors 3. The EU VC market is characterised by a significant gender gap.**

The 2022 edition of the Science, Research and Innovation Performance (SRIP) of the EU report provides insights into how R&I policies can help build an **inclusive, sustainable, competitive and resilient Europe** by leveraging the essential role of R&I as a source of prosperity and catalyst for social, economic and environmental sustainability.

Chapter 7.2 of SRIP 2022 "Access to finance, the importance of equity and venture capital" identifies access to finance as a crucial framework condition which enables a fertile innovation environment.

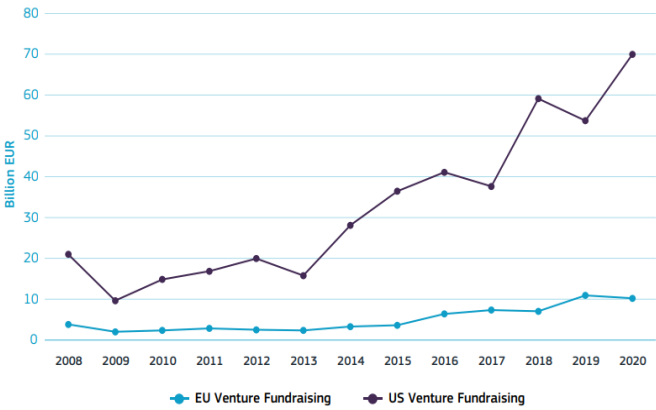
The chapter highlights that **intangible assets** are mostly financed by **non-bank financing**, given the difficulties in using them as collateral for bank lending. Also, switching to a green and digital economy will require a significant amount of targeted financing on cutting edge technologies.

At the EU level, **bank loans remain the predominant financing instrument**, while equity capital still plays a minor role compared to other international economies. Overall, **struggles to attract more risk-taking and more patient investments**, especially at the scale-up stage, are persisting.

Furthermore, the **gender investment gap** remains a concern. Women-led companies remain significantly underrepresented on the VC market.

The chapter concludes that (1) further progress in the **EU Capital Markets Union** would particularly benefit innovative firms operating in intangible-intensive sectors, (2) integrating **sustainability criteria into business financing** is essential to the decarbonisation of the economy, (3) providing financial **support to women in innovation** and entrepreneurship is essential to create fair, inclusive and prosperous European R&I ecosystems.

Figure 7.1-15: Venture funds raised in EU vs the United States, 2007-2020



DETERMINANTS OF FINANCIAL CONSTRAINTS

Santos, A., & Cincera, M. (2022). Determinants of financing constraints. Small Business Economics, 58(3), 1427-1439.

Messages	**1. Innovative SMEs show a higher probability of being financially constrained than their non-innovative counterparts. 2. Insufficient collaterals, significantly high interest rates and excessive administrative burdens represent the most important factors in determining firms' limited access to finance. 3. Guarantees for loans, easier access to public support measures and measures facilitating equity investment are identified as the best instruments to increase firms' access to financing resources, while tax incentives play only a minor role.**

The paper aims at investigating what factors play an important role in limiting firms' access to finance, and to what extent being an innovative firm can induce financial constraints. The analysis is carried out using data on over 44 000 firms located in the European Union retrieved from the SAFE survey, over the period 2014-2018.

In the paper, innovative firms are defined as those which have introduced in the last 12 months a new product, process, method, management organization, or selling strategy. Firms financially constrained firms are those reporting "access to finance" as most pressing problem in the survey questionnaire. The empirical analysis is carried out using a recursive bivariate probit model (RBPM).

Results from the analysis demonstrate that innovative SMEs are between 21% and 32% more likely to experience obstacles in accessing finance than non-innovative firms. Additionally, the paper identifies insufficient collaterals, significantly high interest rates and excessive administrative burdens as the main factors hindering firms' access to financing resources. From a policy perspective, the analysis provides some insights on the importance of different factors in easing access to finance. The findings suggest that guarantees for loans, easing the access to public support measures and policies aiming at facilitating equity investment constitute the most relevant factors to increase the availability of financing resources for SMEs in the future, while tax incentives play only a minor role.

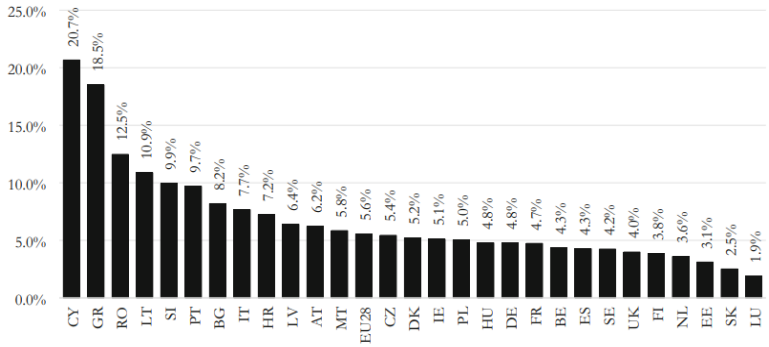


Fig. 2 Average probability of innovative firm to be financially constrained, by country. Authors' own elaboration based on SAFE database. Results refer to descriptive statistics (weighted mean) by country of the estimated probability of being financially constraints and to be an innovative firm. Figure S2 in supplement material shows the geographical distribution of the sample.

ACCESS TO FINANCE AND INSTITUTIONS

Rodríguez-Pose, A., Ganau, R., Maslauskaite, K., & Brezzi, M. (2021). Credit constraints, labor productivity, and the role of regional institutions: Evidence from manufacturing firms in Europe. Journal of Regional Science, 61(2), 299-328.

Messages	**1. Credit constraints represent an important obstacle to firms' labour productivity development, with more severe negative effects for micro and small companies. 2. Higher institutional quality has the potential to mitigate the negative effects of credit constraints, although does not suffice to fully compensate for the negative impact of credit rationing.**

The paper analyses the relationship between credit constraints and firms' labour productivity, accounting for differences in firm size, and to what extent regional institutional quality is able to affect such relationship. In doing so, the authors employ a firm-level dataset comprising of over 22 000 European firms active in the manufacturing sector, over the period 2009-2016. Firm-level data is retrieved from the Amadeus database, while regional institutional quality is measured through the European Quality of Government Index (EQGI).

The empirical strategy consists in the estimation of a system of two equations defined by: 1. a first step dynamic investment equation, used to investigate the extent to which firms' investments are sensitive to changes in firms' cash flows, thereby obtaining a proxy for firms' credit constraints. 2. A second step dynamic labour productivity equation used to analyse the extent to which credit constraints affect firms' labour productivity, and what role is played by institutional quality.

The results from the econometric estimation suggest that credit constraints are an important obstacle to firms' labour productivity, with the negative effect being higher for micro and small firms than for larger companies. Additionally, the authors find that higher regional institutional quality helps mitigating the negative effect of credit rationing, although it is not sufficient to fully compensate for the fact that credit constraints remain an important barrier for firms' dynamism. From a policy perspective, the findings of the paper confirm that schemes aiming at increasing financial support to micro and small enterprises are crucial to improve firms' productivity, but they need to be complemented with actions aimed at improving institutional quality.

SUBSIDIES AND BANK FINANCING

Chiappini, R., Montmartin, B., Pommet, S., Demaria, S. (2022), 'Can direct innovation subsidies relax SMEs' financial constraints?', Research Policy, 51(5), 104493

Messages	**1. French SMEs receiving innovation subsidies improve their access to bank financing. 2. This is driven by a certification effect. 3. Subsidized firms do not improve their equity ratio, due to a substitution effect between debt and equity financing within firms' capital structure.**

The impact of direct financial support on the ability of firms to access funding can be theoretically driven by two different mechanisms. First, it might allow a recipient firm to finance investments through internal financial resources that would have been used for other purposes. This is the treatment effect, or resource effect. Second, it conveys market-relevant information about the quality of the recipient firm, reducing the informational asymmetries the external investors face. This is the certification effect.

This paper examines whether innovation subsidies allow recipient firms to relax their financial constraints through a certification effect. It uses data on innovation subsidies provided by France's public investment bank and received by French SMEs over the 2000-2014 period. The analysis combines a matching method with a difference-in-difference regression to evaluate the impact of public subsidies on two financial constraint measures: the firms' financial (debt) leverage and their equity ratio.

The results suggest that recipient firms benefited from a significant improvement in bank debt financing after receiving a public subsidy. Results are mainly driven by a certification effect and not by a resource effect. The effect is heterogeneous and mainly concentrated on micro and small firms that have been operating for about six years. The authors do not find any significant improvement in access to equity financing. This is partly explained by a substitution effect between bank debt and equity financing.

The paper stresses the important role of public agencies in helping SMEs relax their financial constraints and finance their innovative activities by providing them not only with financial resources but also with certification.

Table 2. Innovation subsidies and access to external financing.

	Tot debt/tot assets	*Financial leverage*	*Equity ratio*	*Bank debt/tot debt*
SUB_{it}	0.0120***	0.0128***	-0.000993	0.0133***
	(0.00325)	(0.00292)	(0.00270)	(0.00326)
Intercept	0.526***	0.167***	0.139***	0.290***
	(0.00905)	(0.00719)	(0.00908)	(0.00873)
Observations	28,278	28,278	28,278	28,278
Number of firms	4,632	4,632	4,632	4,632
Firm FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES

Note: Standard errors (in parentheses) are clustered at the firm level to take into account potential autocorrelation.

*, ** and ***: Significance at the 10%, 5% and 1% level, respectively.

SUBSIDIES AND START-UP VENTURE CAPITAL

Berger, M., Hottenrott, H., (2021), 'Start-up subsidies and the sources of venture capital', Journal of Business Venturing Insights, 16, e00272

Messages	**1. Public subsidies increase the likelihood of start-ups raising venture capital. 2. Accounting for selection, the link persists mainly for government VC and business angel financing.**

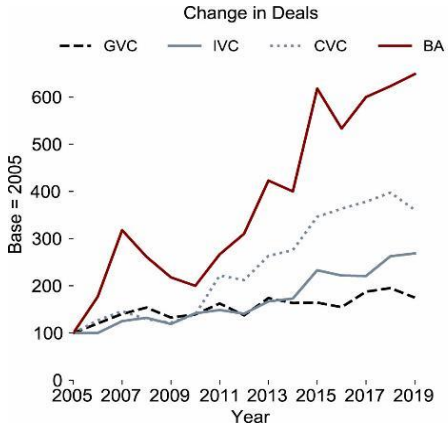
Do public subsidies influence the decision making of Venture Capital (VC) investors? Publicly financed start-ups appeal to VC investors for at least two reasons. First, public subsidies provide quality certification. Second, they finance risky early stage activities. However, do various sources of VC value public start-up subsidies differently?

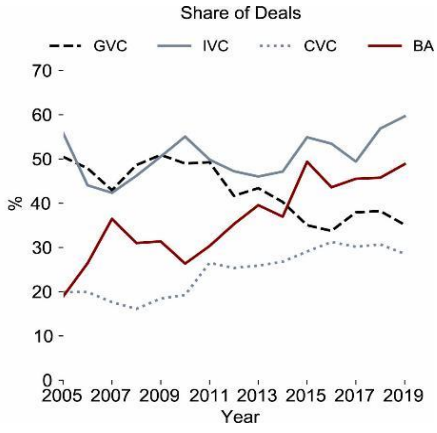
This paper analyses the link between start-up subsidies and VC, focusing on the heterogeneity of VC investors. It assesses the extent to which public support affects the likelihood to attract different sources of VC financing while differentiating between Government Venture Capital (GVC), Independent Venture Capital (IVC), Corporate Venture Capital (CVC), and Business Angels (BA).

The authors use data from 9743 start-ups founded between 2005 and 2018 in Germany. They apply an econometric matching approach that combines propensity score matching (PSM) with coarsened exact matching (CEM) to achieve comparability between subsidized and non-subsidized ventures based on founder and firm characteristics that likely drive both public funding and VC.

While there is a positive correlation between subsidies and all sources of VC financing, the matching results show that the follow-on financing effect is mainly linked to Government VC and Business Angel financing. This result suggests that public start-up subsidies do not per se facilitate follow-on financing, and that particularly IVC providers do not appear to rely on the information value carried by public subsidies.

These results have implications for both entrepreneurial firms and public policy. By participating in public funding programmes, founders may initiate further funding, but not with the same likelihood for all sources. The type of VC may determine the extent to which firms have access to managerial, financial capital in the long-run.





RENEWABLE ENERGY AND ACCESS TO FINANCE

Noailly, J., & Smeets, R. (2021). Financing Energy Innovation: Internal Finance and the Direction of Technical Change. Environmental and Resource Economics, 1-25.

Messages	**1. Firms specialising in renewable energy are more sensitive to internal finance availability than firms innovating in fossil-fuel technologies. 2. Energy transition policies should aim not only at mobilising more resources in support of clean technology production and development, but also discouraging the financing of fossil-fuel innovation.**

The paper investigates the relationship between firms' innovation activities in renewable energy technologies and firms' internal finance (in terms of cash flows and cash holdings), as compared to fossil-fuel technologies. In doing so, the analysis relies on a sample of 1 300 European firms over the period 1995-2009. Firms' financial data are retrieved from the Orbis database, while firms' innovation activities are measured in terms of patents counts, retrieved from PATSTAT database.

Using a non-linear count model, the authors test whether an expansion of internal finance is positively associated with innovation in renewable energy technologies, thus signalling the presence of binding financial constraints. In order to overcome econometric problems related to different sources of endogeneity in the data, the paper relies on lagged financial variables as instruments.

The results of the paper suggest that firms innovating in green energy technologies show higher innovation cash-flow sensitivities, i.e. they are more sensitive to shocks in the supply of internal finance, than firms patenting in non-green technologies. The differential between renewable energy firms and fossil-fuel ones remains significant also when the sample is restricted to only large and more mature firms. This suggests that the higher exposure to binding financial constraints experienced by firms specialising in renewable energy technologies is not explained by the lower maturity of the industry, but rather by the different risk profiles associated to the two types of technologies. From a policy perspective, the empirical findings of the paper show how distinct risk profiles between green and non-green technologies are likely to affect the financing of clean innovation and thus drive the direction of the technological change. As such, the analysis suggests that energy transition policies should not only focus on shrinking the low-carbon energy investment gap, but also on discouraging and limiting the financing of non-green innovation.

FINANCE AS DRIVER OF THE GREEN TRANSITION

Nykvist B., Maltais A. (2020). Too risky – The role of finance as a driver of sustainability transitions. Environment Innovation and Societal Transitions, Vol 42

Messages	**1. Customer demand is the most commonly reported incentive for financial sector actors to engage in sustainable finance. 2. Green investments are considered too risky for the financial system. 3. The financial regime cannot be expected to be a major driver of sustainability transitions without significant policy interventions or active governance from the public sector to alleviate the inherently higher risk.**

The paper explores role of the finance sector in sustainability transitions. The authors use Sweden as a case study and do 21 in-depth interviews with financial actors in Sweden: banks, mutual funds, hedge funds, asset managers, public and private pension funds, and private equity, stock exchange, a consultant specialised in environmental, social, and governance (ESG) data, issuers and investors in green bonds, and policymakers between September 2017 and April 2018.

The sector recognises the societal challenges that sustainability transitions entail, but actors see only few sector-specific incentives or regulations that would increase the pace of change. Among the interviewees, there was very limited willingness regarding acceptance of lower returns. This goes for products such as green bonds or ethical funds alike, and the core motivation thus remains the maximisation of risk-adjusted returns.

The authors find that the most commonly cited incentive to engage in sustainable finance is customer demand. But it does not necessarily have a strong impact. The primary mechanism is that large institutional players have started applying pressure on asset managers or banks to provide better reporting on ESG.

In the transition to more sustainable energy use and production, and the new fossil-fuel-free infrastructure required, there is an enormous need of capital to create more projects, but the investments are reportedly too risky for the financial system. Only a limited set of actors, found in the banking, private equity and insurance sectors, commands a clear long-term perspective that can alleviate some of this pressure. There is an important role for tools and methods in sustainable finance with regard to risk reduction, especially the widespread use of ESG analysis.

The main conclusion of the paper is that the financial regime cannot be expected to be a major driver of sustainability transitions without significant policy interventions or active governance from the public to create new partnerships and risk-sharing mechanisms that alleviate the inherently higher risk associated with more rapid deployment of sustainable finance.

GREEN FINANCE AND CLEAN ENERGY

Madaleno, M., Dogan, E. J., Taskin, D., T. (2022), A step forward on sustainability: The nexus of environmental responsibility, green technology, clean energy and green finance, Energy Economics, Vol 109 105945.

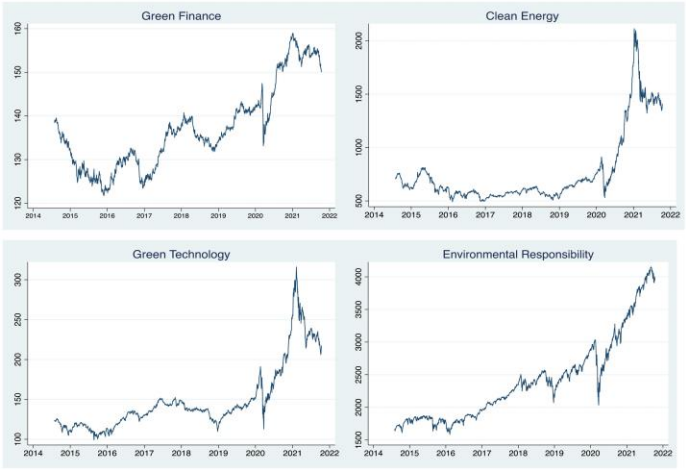
Messages	**1. Environmental responsibility and green technology indexes on the stock market are two of the main drivers of the clean energy financial index. 2. The green bond index has a lower but significant impact on clean energy investments. 3. The Covid pandemic has negatively impacted investments in clean energy. 4. Only with increased returns on investments in green finance and lower risks would investors be tempted to invest more in clean energy. 5. Green consciousness of consumers and investors is critical to promote clean energy.**

This paper aims to investigate the causal relationships between clean energy, green finance, environmental responsibility and green technology. The paper uses the Granger causality technique. Such method relaxes the hypothesis that the causality between the variables under consideration is constant over time and helps to identify the times of emergence and collapse of any causality event. The authors use the S&P Global Clean Energy Index as a proxy for clean energy investments, S&P Green Bond Index as a proxy for green finance, S&P Environmental and Social Responsibility Index as a proxy for environmental responsibility investments, and S&P Renewable Energy & Clean Technology Index as a proxy for green technology investments. The indexes are collected daily between July 31, 2014, and October 12, 2021.

The authors demonstrate a strong and significant causality running from green technology to clean energy and from environmental responsibility to clean energy for the entire studied period. They also show a significant (yet smaller) causality from the green finance to clean energy from 2016 until 2020, except in specific periods, and at the start of the pandemic. There are no significant causality impacts running from green finance to green technology noted.

During the pandemic and except for a spike observed at its start, the causality of both S&P Renewable Energy & Clean Technology and S&P Environmental and Social Responsibility indexes on clean energy decreased, raising concern about the disinvestment caused by the pandemic in the green transition.

The authors conclude that the causality from environmental responsibility to clean energy advocates for measures to promote green consciousness on consumers and investors. Only with increased returns in green finance and lower risks investors would be tempted to invest more in clean energy.



FINANCIAL INNOVATION AND GREEN INNOVATION

Yuan, G., Ye, Q., & Sun, Y. (2021). Financial innovation, information screening and industries' green innovation—Industry-level evidence from the OECD. Technological Forecasting and Social Change, 171, 120998.

Messages	**1. Financial innovation can provide financial intermediaries with better technology to screen information, screening out "dyed green" and "fake green" projects and provide more credit to high-quality green innovation projects. 2. Financial innovation promotes green innovation particularly in countries with stricter environmental regulations, lower degree of banking competition and in industries with higher energy-intensity.**

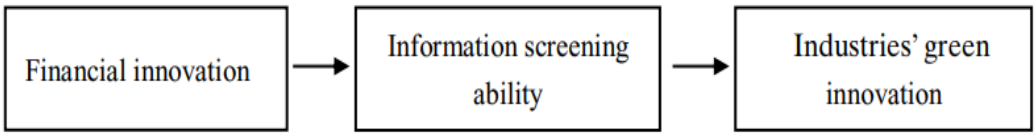
The paper provides evidence on the role that financial innovation can have in promoting green innovation. The authors employ industrial patent data for 23 OECD countries (Harvard Business School Patent Inventor Database) from 1994 to 2009, as well as country-industry level data on GDP, R&D expenditure, value added, export, financial structure etc. (OECD and UN databases). Financial innovation is defined as the ratio between financial intermediaries' R&D expenditure and their total value added.

A three-dimensional panel model with country, year and industry fixed effects is employed to estimate the impact of financial innovation on green technology patenting.

The authors find that financial innovation promotes overall innovation activity as well as green innovation in industries that are more high-tech intensive. At the same time, the increase in green innovation output is not driven by a rise in its share, but by an increase in the total innovation effort.

The paper also uncovers the heterogeneity of the impact of financial innovation on green innovation. It finds a positive relationship between financial innovation and the proportion of green innovation in countries with higher stringency in environmental regulation, while a negative relationship is reported in countries with less stringent environmental regulation. Such inverted relationship highlights how financial innovation without environmentally friendly framework conditions is not sufficient to incentivise green innovation. Financial innovation promotes the proportion of green innovation in countries with low degree of market competition in the financial sector, while it has no significant effect in countries with high degree of market competition. Financial innovation elevates the proportion of green innovation in industries with high energy-intensity, while it has no significant effect in industries with low energy-intensity.

Given these results, and the well-known challenge posed by climate chance, the authors call to governments to take measures such as subsidies or tax cuts to promote green innovation projects. Firms should incorporate actions to mitigate environmental and climate change into the management assessment process.

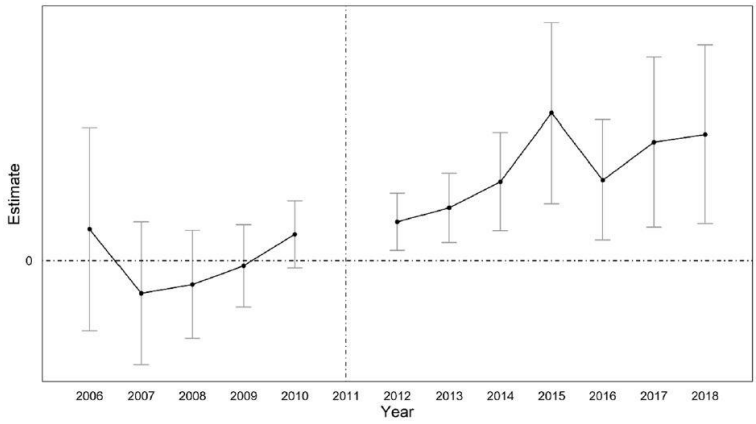


GREEN CREDIT AND GREEN INNOVATION

Liu, S., Xu, R., & Chen, X. (2021). Does green credit affect the green innovation performance of high-polluting and energy-intensive enterprises? Evidence from a quasi-natural experiment. Environmental Science and Pollution Research, 28(46), 65265-65277.

Messages	**1. In China, green credit guidelines policy has significantly improved the green innovation performance of high-polluting and high-energy consuming enterprises. 2. Green credit guidelines policy is more effective on state-owned high-polluting and energy intensive enterprises than on non-state-owned enterprises. 3. Green credit guidelines policy is more effective on weak market power enterprises than on strong market power enterprises.**

The paper provides evidence on the causal impact of 2012 "Green Credit Guidelines" policy enforced by the China Banking Regulatory Commission (CBRC) on firms' green innovation performance. Green patent data of Chinese listed enterprises from the patent database of the State Intellectual Property Office of China (SIPO), and additional data from the China Stock Market & Accounting Research Database (CSMAR) are employed in the analysis. Enterprises' green innovation is measured with green patent grants, as defined by the IPC Green Inventory of the World Intellectual Property Organization.



In February 2012, the CBRC issued the "Green Credit Guidelines" as new Chinese green credit policy system. Among others, Chinese banks were made to set stricter conditions for access to finance based on firms' environmental performance (to the point of refusing finance to enterprises with low environmental scores), while employing punitively high interest rates for the high-polluting and energy-intensive enterprises.

Propensity score matching (PSM) and the Difference-in-Difference (DID) methods are combined to obtain causal estimates of the 2012 Chinese green credit policy on firms green innovation.

The authors find that green credit policy promoted the green technology innovation (measured as patent grants) of high-polluting and energy-intensive enterprises both in the short and middle-long term. At the same time, it is observed that the policy led to a shortage of funds for R&D on green innovation in high-polluting and energy-intensive enterprises (because of their aggravated financial constraints). State owned-enterprises were more sensitive to the policy.

COVID PANDEMIC AND BIOTECH FINANCE

Senior, M. (2022). Innovators take cover as market bubble bursts. Nature Biotechnology, 1.

Messages	**1. The Covid pandemic has boosted private financing as well as company creation in the biotech sector. 2. This boost in finance has led to the formation of dozens of new early-stage companies lacking operational maturity. 3. As a consequence, biotech sector after the pandemic looks much riskier than many other sectors and stock index has dropped since 2021, which may lead to lasting damage for the sector.**

This paper gives an overview of the evolution of the biotech market over the 2017-2021 period. It uses interviews amongst financial investors and financial data. Demonstrating that, despite being the pandemic saviour sector, biotech has been hit relative to the rest of the market.

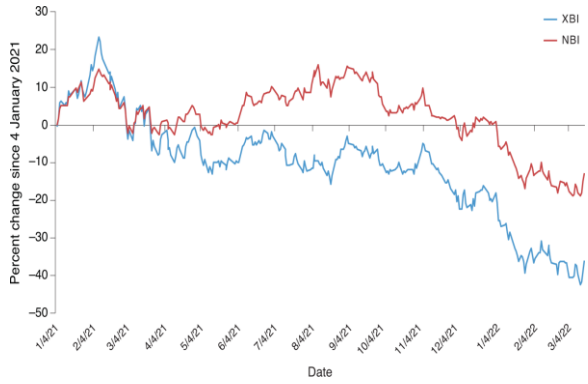
The author shows that biotech attracted more and deeper-pocketed investors before COVID-19 hit, and that the pandemic has boosted this trend. During the pandemic, in a historical reversal of roles, investors competed for deals, rather than biotech CEOs competing for capital. The average IPO reached $160 million in 2021, which is lower than in 2020, but is nevertheless the double of the 2017 value. Europe's biotechs made unprecedented profits during 2021. But, since the start of January 2021, the biotech stock index has dropped significantly.

The author demonstrates that some of the fall reflects unrealistic initial valuations. Abundant capital removed almost all barriers to company formation and many lacked operational maturity. The result of the boost during the pandemic is that biotech, with dozens of new, early-stage companies, looks now much riskier than many other sectors.

Excess capital and undiscerning public markets created a flood of listings from low-quality companies whose subsequent struggles could affect the broader sector reputation. Frantic competition in private rounds meant firms were being financed not according to how much they needed to reach certain milestones, but by investors' drive to invest as fast as possible.

The author also demonstrates that, although venture capital remains abundant (if now a little harder to access), talent, rather than money, has become the main bottleneck to company creation. That's a big shift for Europe, where biotech growth was long hampered by insufficient venture funding. Besides, the public sector has become more cautious in investing in this sector.

The author concludes that the large inflow of venture capital in the biotech sector during the Covid pandemic has increased investment risks, possibly leading to some damage when projects fail.



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