PRISM

Policy Research on International Services and Manufacturing

Understanding Firm Heterogeneity, Impacts, and Constraints on Research and Development (R&D) in South Africa.

Lawrence Edwards

School of Economics, University of Cape Town

Policy Research in International Services and Manufacturing (PRISM)

lawrence.edwards@uct.ac.za

David Fadiran

School of Economics, University of Cape Town

Policy Research in International Services and Manufacturing (PRISM)

david.fadiran@uct.ac.za

Godfrey Kamutando

Post-doctoral Research Fellow, School of Economics, University of Cape Town

Policy Research in International Services and Manufacturing (PRISM)

Godfrey.kamutando@uct.ac.za

Working Paper Series

Number 2025-3

Abstract

Business expenditure on research and development (R&D) in South Africa has declined significantly over the past decade, raising concerns about the country's future innovation capacity and productivity growth. This report unpacks firm and market related attributes that may be associated with this decline in R&D investment by firms in South Africa. The analysis shows that the decline in aggregate R&D expenditure is largely driven by a reduction in the number of firms undertaking R&D, particularly the exit of large manufacturing firms. Firms that engage in R&D differ systematically from other firms, in that, they are larger, more productive, more capital intensive, and more integrated into global markets through exporting and technology imports. The report also finds that declining public support, a weak investment climate, and skills constraints have contributed to falling business R&D. This suggests a need to improve the investment environment, policy incentives for R&D, and provide better support for innovation among exporting and smaller firms.

Keywords: research & development, in-licencing, firm heterogeneity, innovation

JEL Codes: O32, O31, L24, L25

Acknowledgments

This is based on a paper to be published in the Oxford Handbook of the Zambian Economy, which I co-authored with Dr. Vera Songwe. A link to the paper will be provided once the handbook is published. Any errors remain the authors own. The statements made and views expressed are solely the responsibility of the authors.

Recommended citation:

Edwards. L., Fadiran. D., Kamutando. G. 2025. 'Understanding Firm Heterogeneity, Impacts, and Constraints on Research and Development (R&D) in South Africa. *PRISM Working Paper 2025-3.* Cape Town: Policy Research on International Services and Manufacturing, University of Cape Town.

Policy Research in International Services and Manufacturing (PRISM) is a research and policy unit located within the School of Economics. PRISM provides a lens to focus research and policy work broadly on issues of globalization, trade and industrialization. It is home to a number of related research activities, projects and programmes concerned with issues of globalization, global value chains, industrialization paths, international trade, foreign investment, the defence industry, policy governance, infrastructure development, the role of knowledge intensive services, innovation, and international competitiveness. Another feature of PRISM's work has been its applied focus, responding to economic policy questions issues in South Africa, the rest of Africa and beyond

Working Papers can be downloaded in Adobe Acrobat format from
https://commerce.uct.ac.za/prism

School of Economics Building, Middle Campus,
University of Cape Town Private Bag,
Rondebosch 7701, Cape Town,
South Africa

Tel: +27 (0)21 6504470

Website: https://commerce.uct.ac.za/prism

UNDERSTANDING FIRM HETEROGENEITY, IMPACTS, AND CONSTRAINTS ON RESEARCH AND DEVELOPMENT (R&D) IN SOUTH AFRICA

Making sure it's possible

science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

NACI
NATIONAL ADVISORY COUNCIL ON INNOVATION

2030 NDP

ACKNOWLEDGEMENTS

The NACI Council would like to acknowledge the authors of this report:
Prof Lawrence Edwards
Dr David Fadiran
Dr Godfrey Kamutando

Policy Research in International Services and Manufacturing (PRISM)
University of Cape Town
South Africa

Prof David Kaplan provided project oversight and liaison

NACI Secretariat
Ms Hlengiwe Mbatha
Mr Lindile Adons
Mr Benny Nhlapo

The continuous contribution by the expert team members and NACI secretariat team is much appreciated.

Dr Mlungisi Cele
NACI CEO


Making sure it's possible

Table of Contents

Executive Summary 7

1 Introduction 12

2 Setting the context: South African R&D performance 12

3 A comparative perspective of South African R&D performance 17

4 Heterogenous firm characteristics and R&D expenditure 25

4.1 Data cleaning and data challenges 25

4.2 Summary statistics of consistent panel 27

4.3 Characteristics of aggregate R&D expenditure by firms in South Africa 29

4.4 Heterogeneity between R&D and non-R&D firms 42

4.5 Determinants of R&D activity and R&D intensity by firms 45

5 Impact of R&D on firm outcomes 49

5.1 R&D and firm productivity 49

5.2 R&D and firm export performance 56

5.3 R&D and firm employment 62

6 Policies to increase business expenditure on R&D 66

6.1 Comparative analysis of policies to increase R&D 66

6.2 R&D tax subsidy in South Africa 68

7 Summary of findings 74

8 Policy recommendations 75

8.1 Improvements in the national investment climate are critical for a recovery in expenditure on Research and Development. 75

8.2 Re-assess target of 1.5% GERD as share of GDP 75

8.3 Expand the range of incentives and support for businesses investing in R&D 76

8.3.1 Explore feasibility of providing tax exemptions and tax holidays for R&D expenditure 76

8.3.2 Raising the after-tax return on sales, lease or transfer of IP on the part of SA firms via a tax exemption would incentivise R&D 78

8.3.3 Incentivise the use of external knowhow 78

8.3.4 Accelerate reforms of the R&D tax incentive 78

8.3.5 Make use of more targeted interventions, including through grants and cash transfers, with a strong focus on firm exporting 79

8.3.6 Leverage venture capital for R&D purposes 79

8.3.7 Relax immigration and work-permit restrictions on skilled foreign workers required for R&D activities 79

References 80

Data Annex 83

Annex A: Additional figures 85

Annex B: Additional regression tables 87

Annex C: R&D and other sources of know-how as drivers of GDP growth 89

Annex D: R&D status and firm characteristics: Simple regression analysis 91

Annex E: Characteristics of small R&D firms 92

Annex F – Policies and empirical evidence 94

List of tables

Table 1: Comparison of investment, IP payment and R&D for sample of middle-income countries 18
Table 2: Average labour cost of business R&D, 2013-2020 23
Table 3: Summary statistics of sample of firms 28
Table 4: Summary of findings related to characteristics and drivers of R&D in firms 29
Table 5: Characteristics of firms by R&D status and royalty/licence fee status, average 2014-2019 41
Table 6: Mean characteristics of firms by R&D status, average 2018-2019 43
Table 7: Mean trade characteristics by R&D status, 2018-2019 44
Table 8: Estimates of characteristics determining the probability of being an R&D firm and the intensity of R&D within firms, 2017-2019 46
Table 9: Determinants of R&D intensity, 2017-2019 47
Table 10: R&D and firm productivity, 2010-2020 52
Table 11: R&D and export interaction, 2010-2020 59
Table 12: R&D status and firm export performance, 2010-2020 61
Table 13: R&D status and firm employment, 2010-2020 65
Table 14 Examples of R&D policies implemented by Türkiye, Thailand and Malaysia 76
Table 15: TFP difference between R&D firms and non-R&D firms across manufacturing industries 87
Table 16: Testing complementarity/substitutability effects of R&D and in-licencing on manufacturing firm TFP, 2018-2019 88
Table 17: Simple growth model estimates 90
Table 18: Difference between R&D firms and non-R&D firms, 2018-2019 91
Table 19: Summary of empirical evidence on effectiveness of R&D policies internationally and in South 94
Table 20: R&D policies applied by Türkiye, Malaysia, Thailand and South Africa 97

List of figures

Figure 1: Annual growth in real GDP per capita and TFP in South Africa and upper-middle-income countries 13
Figure 2: R&D expenditure in South Africa by sector 14
Figure 3: Real business R&D expenditure in South Africa 15
Figure 4: Gross fixed capital formation as share GDP (%) 15
Figure 5: R&D expenditure as share gross fixed capital formation in South Africa 16
Figure 6: Change in GERD (% of GDP) and business R&D expenditure as share GERD and their association with GDP per capita growth in South Africa 17
Figure 7: GERD as percentage of GDP against income per capita 18
Figure 8: GERD as percentage of GDP in South Africa compared to upper-middle-income countries 19
Figure 9: Payments for foreign intellectual property as percentage of GDP in South Africa compared to upper-middle-income countries 20
Figure 10: Number of researchers in R&D per million people in South Africa and upper-middle-income countries 20
Figure 11: Foreign receipts (% of GDP) for sale of IP in South Africa and upper-middle-income countries 21
Figure 12: Business expenditure on R&D as percent of GDP for selected comparator countries 22
Figure 13: Business expenditure on R&D as percent of GERD for selected comparator countries 22
Figure 14: Comparative analysis of initial share business expenditure on R&D as percent of GERD against the change in share from 2012 to 2020 23
Figure 15: Predicted 10-year rise in future real GDP per capita associated with expenditure on R&D in South Africa, 2006 and 2010. 24
Figure 16: Number of R&D firms categorised by value of real sales, unadjusted database 26
Figure 17: Aggregate expenditure on R&D by firms categorised by value of real sales, unadjusted database, R million 27
Figure 18: Real R&D expenditure, 2010 to 2020 30
Figure 19: Number of R&D firms, 2010 to 2020 31
Figure 20: Share total firms engaging in R&D, 2010 to 2020 31
Figure 21: R&D intensity, 2010 to 2020 32
Figure 22: Share R&D firms and R&D expenditure by firm size category, 2010 to 2019 32

Figure 23: Contribution to change in aggregate R&D expenditure and total number of R&D firms by firm size category, 2012 to 2019 33
Figure 24: R&D expenditure by major sector, 2010 to 2019 34
Figure 25: Share aggregate R&D expenditure manufacturing industry, average 2010, 2014 and 2019 34
Figure 26: Firm R&D intensity by manufacturing industry, average 2010, 2014 and 2019 35
Figure 27: Distribution of R&D firms according to number of years engaged in R&D activities from 2010 to 2019. 35
Figure 28: Entry and exit dynamics of R&D firms, 2010 to 2019 36
Figure 29: R&D firm dynamics and their contribution to growth in aggregate expenditure on R&D, 2012-2019 37
Figure 30: Firm expenditure on R&D directly and via foreign related firms compared to receipts from R&D by foreign related firms, 2010 to 2020 38
Figure 31: Average number of firms and share total firms paying royalty/license fees and engaging in R&D activities, average 2014-2019 39
Figure 32: Aggregate firm expenditure on R&D and Royalties/license fees 39
Figure 33: Comparison of shares aggregate expenditure on royalties/licence fees and R&D by major sector, average 2014-2019 40
Figure 34: Kernal density estimates of the distribution of firm value added per worker and firm employment over period 2018-2019 43
Figure 35: Percentage difference between R&D firms and non-R&D firms according to firm characteristic, 2018-2019 45
Figure 36: Trends in firm productivity, as measured by value added per worker, 2010-2020 50
Figure 37: Kernal density estimates of the distribution of TFP by firm R&D status, 2017/18 50
Figure 38: Percentage difference in TFP between R&D firms and non-R&D firms 53
Figure 39: Productivity premium for R&D firms compared to non-R&D firms by industry 53
Figure 40: TFP premium according to manufacturing firm characteristics 54
Figure 41: TFP premiums - complementarity between R&D and in-licensing of know-how in manufacturing firms 55
Figure 42: Share of firms by R&D and in-licensing status, 2018/19 55
Figure 43: South African aggregate export value, R billion in 2010 prices 57
Figure 44: Contribution of R&D firms to aggregate exports and high-tech exports 57
Figure 45: Distribution of firm export value and export transactions (in natural logarithm) by R&D status, 2018/19 58
Figure 46: Distribution of firm export value (in natural logarithm) by R&D and in-licensing status, 2018/19 58
Figure 47: Share distribution of firms according to R&D and export status, 2010-2020 59
Figure 48: Predicted export value by R&D intensity, 2010-2020 61
Figure 49: Average employment and wage by R&D status, 2018/19 63
Figure 50: Average employment by R&D intensity and in-licensing status, 2018/19 64
Figure 51: R&D policies applied by different countries 67
Figure 52: Government support for business R&D through direct funding and tax incentives in 2019, % of GDP 69
Figure 53: Government support for business R&D through direct funding and tax incentives in South Africa from 2003 to 2020 70
Figure 54: Implied tax subsidy rate on business R&D expenditure, 2019. 70
Figure 55: Comparison of implied funding from the indirect tax incentive as a share of BERD using the OECD data and the SARS-NT data 71
Figure 56: Indirect government support through the R&D tax incentive (% of GDP) against the implied tax subsidy rate 71
Figure 57: Number, share and approval rate of R&D tax incentive applicants 72
Figure 58: Average share composition of R&D firms and aggregate R&D expenditure by tax incentive application status, 2016-2019 73
Figure 59: Probability of engaging in R&D according to tax incentive application status 73
Figure 60: Real R&D expenditure according to different variables in the SARS-NT database 84
Figure 61: Manufacturing as share GDP (%) – South Africa compared to selected regions 85
Figure 62: Real GDP per capita in South Africa and upper-middle-income countries, 2015 constant US$ 85
Figure 63: Fixed investment (% of GDP) in 2005 and 2020 86
Figure 64: Gross expenditure on R&D as share fixed investment in 2005 and 2020 86
Figure 65: Firm R&D intensity by industry, 2009 86

Acronyms

BERD	Business Expenditure on R & D
CeSTII	Centre for Science Technology and Innovation Indicators
CIT	Corporate Income Tax
DSI	Department of Science and Innovation
DTIC	Department of Trade, Industry and Competition
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
HS	Harmonised System
HSRC	Human Science Research Council
IP	Intellectual Property
NACI	National Council on Innovation
OECD	Organization for Economic Coopration and Development
PPD	Product Process Development
R&D	Research and Development
SARS-NT	South African Revenue Service-National TreasuryTHRIP
SPII	Support Programme for Industrial Innovation
TFP	Total Factor Productivity
THRIP	Technology and Human Resources for Industry

Executive Summary

The 2019 White Paper on Science, Technology and Innovation (DST, 2019) aims to raise gross expenditure on research and development (GERD) as a percentage of GDP to 1.5%. However, the share of GERD in GDP has fallen over the past few years reaching a level of 0.6% of GDP in 2020. The driving force behind this decline has been the business sector. Real business expenditure on R&D in 2020/21 was less than half its 2008/09 value and its share of GERD had fallen to 30% (from 57%).

To provide more insight on the factors that account for the low and declining trend in Business Expenditure on R&D (BERD), the National Advisory Council on Innovation (NACI) commissioned this study of R&D at the level of the firm. The study draws on administrative tax data from the SARS-NT database and country-level data from the World Development Indicator database, CESTII-HSRC and Organization for Economic Cooperation and Development (OECD) Research and Development Statistics Data.

i. Trends in business expenditure on R&D in South Africa from a comparative perspective

The business sector is by far the most significant contributor to the decline in the level and share of GERD in GDP over the past decade. Had the business sector share of GERD not fallen from its 2008/09 levels, real GERD in 2020/21 would have been R18.5 billion rand higher (93% higher), raising the share of GERD in GDP to 1.58%.

A comparative analysis of South African R&D performance relative to its peers reveals several insights:

- ***South Africa currently spends as much on GERD as would be expected, given its average income per capita***. SA also did not underperform in 2020 compared to other upper-middle-income economies respect to several other metrics of knowledge acquisition, including foreign intellectual property payments, net foreign assets and GERD as a share of gross fixed investment in South Africa. However, where South Africa differs from comparator countries is its decline in GERD as a percentage of GDP and other indicators of innovation over the past decade.
- ***South Africa has performed poorly in terms of BERD relative to its peers.*** Of 40 countries for which data are available, South Africa had the second lowest share of business R&D in GERD in 2020. South Africa also experienced the most significant percentage point reduction (14 percentage points) in business R&D as a share of GERD over the period 2012 to 2020.
- ***South Africa has fewer researchers engaged in R&D activities.*** In 2020, only 473 researchers per million population were engaged in all R&D activities in South Africa. This contrasts with 1 657 researchers per million population for the median upper-middle-income country. Over 2013-2020, SA businesses employed 210 R&D personnel per million population, whereas other upper-middle-income countries employed 1 488 R&D personnel per million population.
- ***Labour costs associated with business R&D are disproportionately high in South Africa and discourage R&D engagement by firms.*** The average cost of each person employed in BERD in South Africa from 2012 to 2020 was US$ 100 thousand (in 2015 Purchasing Power Parity (PPP)) - more than double the average for upper-middle-income (US$ 47 thousand) and even exceeded the average for high-income countries (US$ 85.8 thousand) in the sample. The high labour costs are also reflected in relatively high shares of BERD allocated to cover labour costs (57.5% for South Africa, 47.4% on average for upper-middle-income countries). High researcher costs make it difficult for firms, particularly small firms, to engage in R&D activity, place local firms that wish to export R&D services at a competitive disadvantage relative to their peers in comparator countries, and reduce the responsiveness of firms to R&D incentives,

ii. Heterogenous firm characteristics and R&D expenditure

This report uses the administrative tax data from the SARS-NT database to analyse the characteristics and trends in R&D expenditure by South African firms between 2010 and 2019. Given data limitations, the firm analysis is restricted to firms with real sales value of R20 million or above (in April 2013 prices). This excludes many small firms that engage in R&D, but as shown in the analysis, large firms account for most of the aggregate expenditure on R&D.

The firm data provide several insights into the characteristics of R&D firms in the business sector.

1. ***Aggregate expenditure on R&D by firms in the SARS-NT data has declined since 2010***. Three factors explain this decline: (a) A decline in the number of R&D firms, (b) A decline in the share of all firms engaging in R&D, and (c) A decline in the intensity of R&D within the firm.

2. ***R&D expenditure is concentrated in a few large firms, with large firms being the main drivers of the downward trend in total R&D firm numbers and total R&D expenditure from 2012 to 2019***. Large firms with actual sales of R500 million or more account for only 14%-16% of all R&D firms, but make up 74% to 79% of aggregate R&D expenditure in the database.
3. ***Manufacturing firms are the largest source of aggregate R&D expenditure and have been the main, but not the only, contributor to its decline.***
4. ***The persistence of regular R&D expenditure is weak, with very few firms engaging in R&D activities on a continuous basis.*** Nearly half of the R&D firms only reported R&D expenditure in one financial year from 2010 to 2019. Only 1.8% of the R&D firms engaged in R&D activities in all years, with larger firms more likely to be found in this category.
5. ***The decline in the number of firms engaging in R&D is driven by higher rates of firm exit from R&D than firm entry rates into R&D***. The exit from R&D activities by firms is a significant contributor to the decline in growth of business expenditure on R&D.
6. ***Significantly more firms make use of royalty and licence agreements to access know-how than through in-house or related company R&D.*** Total in-licensing expenditure from all sources rose 72% from 2014 to 2019. In contrast, total R&D expenditure fell by 25%. By 2019, total in-licensing expenditure was 3.4 times the total expenditure on R&D activities. In-house R&D is, therefore, not the primary source of innovative knowledge among businesses.
7. ***There is a considerable degree of heterogeneity in terms of characteristics across all firms, including R&D firms***.
    a. R&D firms pay higher wages and are larger in terms of employment, value added, productivity, capital stock, and sales. They are also more likely to have foreign ownership and be part of a multinational enterprise (local or foreign-owned).
    b. R&D firms are far more integrated into global markets. They are more likely to be exporters and/or importers, particularly of high-technology products, and have higher export values and export varieties.
    c. c. High-productivity firms that export high-technology products while operating in less concentrated markets are more likely to engage in R&D activities and spend more on R&D than other firms.

iii. R&D and firm outcomes

This section uses the SARS-NT database to analyse the *association* between firm R&D and firm productivity, export performance, and employment.

R&D and firm productivity

R&D firms are significantly more productive than others, even after controlling for firm characteristics such as trade status, size, capital intensity, etc. Manufacturing firms that engage in R&D are estimated to be 18% more productive than firms that do not engage in R&D. The results also suggest that engagement in R&D is the primary driver of the total factor productivity premium, rather than the intensity of R&D expenditure. Encouraging more firms to invest in R&D appears to be the relatively more critical channel through which to drive increases in firm productivity, compared to raising the intensity of R&D within firms.

The productivity premium for R&D firms varies across industries, but in most industries, R&D firms are found to be more productive than non-R&D firms. Agriculture, mining, and wholesale & retail services have high labour productivity premiums of between 42% and 72%. Within manufacturing, statistically significant Total Factor Productivity (TFP) premiums are estimated for Food & beverages (18%) Chemicals (21%), Metal products and equipment (21%) and Furniture (29%). The results indicate that the productivity premium of R&D firms is not isolated to a few firms and a few sectors.

External acquisition of technology through in-licensing of know-how is equally if not more, important a source of firm productivity. Manufacturing firms that access knowhow through royalty/licence fee agreements are 22% more productive than other firms. Further, the number of firms that in-license know-how to acquire innovative knowledge exceeds the number of R&D firms. Overall, while R&D is an essential source of firm productivity, the data indicate that it is not the dominant nor most substantial source compared to alternative sources of innovative knowledge.

R&D expenditure and external knowledge acquisition through in-licensing are complements, with the productivity-enhancing effects of R&D stronger in firms that also have in-license know-how. Firms that in-license know-how or engage in R&D are 14 to 20% more productive than firms that engage in neither activity). However, firms that have both in-license knowledge AND engage in R&D are 60% more productive. There is a high complementarity between R&D and in-licensing in raising firm productivity.

R&D and firm export and employment performance

South Africa's aggregate exports have underperformed over the past decade. By 2019, real export values were no higher than those in 2014. This growth has been lower than comparator emerging economies, and the export bundle has remained concentrated amongst few firms, with little diversification from resource-based and primary products.

Firms that invest in R&D activities are more likely to export and have higher export values than other exporters. R&D firms are around 1.5 percentage points more likely to export than other firms, and when exporting, have export values that are 62% higher than other exporters. However, the intensity of R&D, measured by R&D expenditure as share sales, is not a significant driver of differences in export value across R&D firms.

There is a virtuous cycle between firms' entry into exporting and engagements in R&D, but this applies to very few firms. The empirical evidence reveals that once firms have commenced exporting, they are more likely to engage in R&D in the following period. However, firms that engage in both R&D and exporting only make up 1.6% of all firm observations in the data sample.

Firms that simultaneously invest in R&D and in-license know-how have higher export values than exporters that only invest in R&D or in-licence know-how. Exporters that do not invest in R&D or in-license know-how have the lowest average export values. In-licensing appears to complement R&D with respect to the number of export transactions (product-destination combinations), suggesting that R&D and in-licensing complement product innovation, enabling exporters to expand products and destinations they export to.

The contribution of R&D firms to aggregate exports and high-tech exports has declined considerably. The share of high-technology exports has declined significantly from 4.4% in 2010 to 1.9% in 2019, with R&D firms are a key contributor towards this decline.

R&D firms employ more workers and pay higher wages than non-R&D firms. On average R&D firms employed 95 workers compared to 43 for non-R&D firms in 2018-2019. The average wage R&D firms pay these workers was R161 thousand compared to R130 thousand for non-R&D firms.

Medium-intensive R&D firms and R&D firms with in-licence know-how employ more workers than other firms. Firms with medium R&D intensity are the largest, employing an average of 101 workers, compared to 73 workers in high R&D-intensity firms. Firms that engage in both R&D and in-licensing employ an average of 178 workers. However, these firms only constitute a small share of all firms in the sample.

Technology embodied in imports appears to have a stronger effect on employment than R&D and in-licensing. Firms that commence importing experience increases in employment by around 5.9%. If these importers also commence importing high-technology goods, they experience an *additional* increase in employment of between 3.7% and 5.4%.

Overall, innovative know-how boosts firm employment, whether acquired through R&D, in-licencing or use of high-technology imports in production.

iv. Comparative analysis of policies to increase business expenditure on R&D

To provide a comparative analysis of R&D policies, this study draws upon the Ernst & Young (2023) *Worldwide R&D Incentives Reference Guide, which provides detailed information on R&D policies for 46 countries,* including South Africa. Data from the OECD R&D Tax Incentive Indicators is also used to present a comparative perspective of SA R&D tax incentive. Finally, the SARS-NT data is used to analyse the R&D outcomes of South African firms according to whether their application for and success in being granted R&D tax relief.

South Africa offers a narrower range of R&D incentives than comparator countries. While a wide range of policy options exist to encourage business R&D, South Africa only offers the three most commonly used incentives: (a) tax deductions, (b) cash grants, and (c) accelerated depreciation.

Public support for business R&D as % of GDP in South Africa covering indirect funding through tax incentives and direct financing through grants and calls for projects is low compared to OECD countries, but not necessarily compared to other

emerging economies. Public support for business R&D in South Africa in 2019 was 0.018% of GDP compared to 0.14% of GDP for 47 countries, mainly from the OECD. However, government funding for R&D in South Africa is higher than in some emerging economies (Mexico, Argentina, Colombia) but is also substantially below the emerging economies of Brazil (0.14%) and Türkiye (0.19%).

Financial support for business R&D has fallen in South Africa since the early 2000s, with the decline in direct government-funded BERD the key contributing factor. Whereas direct financial support by the government for business R&D in South Africa equalled 0.1% of GDP in 2008, by 2019, it had fallen to 0.012% of GDP. The decline in direct government funding can explain a third of the decline in BERD as a share of GDP from 2008 to 2019.

The implied subsidy of the R&D tax incentive in South Africa (0.16) is generous compared to more than half of the countries in the OECD R&D Tax Incentive Indicators database. However, SA underperforms in terms of firm utilisation of the R&D tax incentives relative to its implied subsidy rate. The outcome is that the use of tax incentives has been insufficient to offset the decline in public support for business R&D through direct government funding.

The firm data shows a steady rise in the number of firms applying for the R&D incentive from the Department of Science and Innovation, but declining approval rates have diminished the growth in the number of firms benefiting from the incentive. Larger firms are also found to make greater use of the tax incentive, with the average employment size of approved firms engaging in R&D equal to 94.4, compared to below 11.7 for other R&D firms.

Cursory analysis of the firm data suggests that the tax incentive raises the probability of firms engaging in R&D activities. Firms that are successful with their application for tax relief are 2.7 percentage points more likely to engage in R&D activities in that year.

v. Policy recommendations

1. Improvements in the national investment climate are critical for a recovery in expenditure on Research and Development

The weak investment climate, together with low economic growth, is a major contributor towards the low and declining levels of business R&D in South Africa. Without improvements in the business climate, including the alleviation of key supply constraints related to electricity provision and transport, amongst others, it is unlikely that business R&D expenditure will increase substantially.

2. Re-assess the target of 1.5% GERD as a share of GDP

The research calls into question the ambitious goal to raise GERD as a share of GDP to 1.5%. South Africa already allocates a relatively high share of private investment towards R&D compared to other countries. High GERD as a share of GDP is also not always necessary, nor sufficient, to sustain growth, as is the case in Chile and Colombia, for example. The 1.5% benchmark can also be misleading if the available stock of complementary factors such as human and physical capital are not accounted for. Raising R&D should, therefore, be considered as part of a broader package of policies that cover complementary factors and supporting institutions that aim to boost business innovation.

3. Explore the feasibility of providing tax exemptions and tax holidays for R&D expenditure

South Africa provides relatively few instruments compared to its peers. Tax holidays extended to new firms may be particularly advantageous as a mechanism to increase the number of firms engaging in R&D.

4. Raising the after-tax return on sales, leases or transfer of IP on the part of SA firms via a tax exemption would incentivise R&D

Several countries offer incentives to firms to encourage the production, use and sale of IP. Türkiye, for example, offers corporate tax and VAT exemptions on the transfer, sale and leasing of patented inventions. Foreign receipts received for the sale of IP rose as a share of GDP in South Africa, suggesting a comparative advantage in the generation of knowledge in some areas of research. Strengthening these areas through raising the after-tax return on sales, lease or transfer of IP can assist in further growth in these receipts.

5. Incentivise the use of external knowhow

Reducing dependence on external knowhow, including through imported IP, should not be considered a motivation for raising in-house R&D by South African firms. Rather, policies that incentivise the use of external knowhow can boost firm productivity and raise R&D expenditures. The scope of the current R&D tax incentive in South Africa could be broadened to include expenditures on in-licensing that can be shown to complement R&D activities.

6. Accelerate reforms of the R&D tax incentive

The average turnaround time for providing decisions on R&D tax incentive applications has been reduced but still remains above the 90-day target (DSI, 2024). More can be done to simplify the application process and reduce incomplete submissions through better dissemination of information to firms on the application process and eligibility conditions.

The recent extension of the R&D tax incentive for another ten years until 31 December 2033 will provide greater certainty to firms interested in R&D. The National Treasury (2021, 2023) has also proposed several changes to the definition of R&D that should broaden the scope for firms to apply for the tax incentive. These are positive developments, but where possible, the changes should be accelerated. This includes finalising the proposed changes to the tax incentive.

7. Make use of more targeted interventions, including through grants and cash transfers, with a strong focus on firm exporting

The empirical analysis in this report finds a synergistic relationship between exporting and R&D, although few firms currently benefit from this. Targeted R&D incentives that focus on getting firms into the export market, can help kick-start a virtuous cycle between exporting, productivity gains and R&D.

Small firms are less likely to make use of the tax incentives, as they face more severe financial constraints than large firms. Grants and cash transfers can be a more effective approach to raising the R&D of these firms. While the SPII Product Process Development (PPD) scheme offers non-taxable and non-repayable grants to small, very small and micro enterprises, this programme can be expanded and advertised more widely than it is currently. Clearly articulated programmes, with strong co-ordination between the different departments (e.g. DTIC and DSI), that facilitate innovation across the full product development cycle from R&D to full-scale production will also reduce the costs and information gaps that are particularly problematic for small firms (Walwyn and Naidoo, 2019).

8. Leverage venture capital for R&D purposes

Venture capital funding is an important source of funding for research and development-intensive startup companies. One challenge is that the mandates of many large foreign venture capital funds prohibit them from investing directly in South Africa. To get around this, domestic startups are required to set up and transfer IP to an overseas holding company. This process is impeded by domestic regulations governing the transfer and protection of IP, as well as rules regarding payment of capital gains taxes upon transfer of the IP. Resolving these constraints can assist private funding of R&D, thus alleviating the funding burden of the state.

9. Relax immigration and work-permit restrictions on skilled foreign workers required for R&D activities

Compared to its peers, South Africa has significantly fewer personnel engaged in R&D. The labour costs of R&D are also substantially higher, reflecting a scarcity of available skills. The absence of human capital constrains R&D and innovation more generally by raising labour costs of R&D, reducing the capacity of firms to absorb innovative knowledge, and impeding foreign investment in R&D activities. Raising the availability of skilled labour supply is, therefore, a key policy consideration. A long-run policy object is an increase in the supply of skilled graduates and technicians from domestic higher education institutes. In the short term, the most effective policy would be to ease/encourage the immigration of researchers and technicians.

1. Introduction

The National Advisory Council on Innovation (NACI) wished to conduct an analysis of firm-level research and development (R&D) within the business sector of South Africa. This is a timely endeavour. Research and development (R&D) is a key driver of innovation and knowledge accumulation, which in turn boosts labour productivity, new product development and economic growth. Yet, in recent years economic growth has slowed in South Africa, with manufacturing declining as a share of Gross Domestic Product (GDP) at a rate faster than the average for other emerging economies (see Figure 61 in Annex A). Investment in R&D activities has also slowed and stagnated, with South Africa falling behind in its gross domestic expenditure on R&D (GERD) as a share of GDP when compared to some of its emerging economies counterparts.

Most concerning is the declining share of business sector R&D in GERD, which has fallen from 59 per cent in 2008/09 to 30 per cent in 2020/21 (NACI, 2023). Over the past few years, the level of real business sector R&D has been on a declining trend, with the level of business R&D in 2020/21 falling to 55% of the value in 2017. The declining investment in R&D in South Africa is contrary to what is occurring in several comparator countries and is occurring despite the availability of tax incentives provided to reduce the cost of R&D for private sector companies (National Treasury/DSI, 2021). The implication is that South Africa is failing to realise its goal of boosting R&D as articulated in the South Africa 2019 White Paper on Science, Technology and Innovation (DST, 2019). As argued by the World Bank (2017), South Africa's R&D performance points to a growing innovation gap in South Africa relative to many peers.

The decline in business enterprise expenditure R&D has severe negative implications for future innovation and growth of the South African economy. Raising long-term economic growth centres strongly on improvements in productivity and competitiveness of businesses in South Africa, with firm R&D playing a key role in this process. A study focusing on a deeper understanding of the sources and implications of the decline in expenditure on R&D by enterprises in South Africa is thus imperative. While research on firm-level R&D in South Africa is growing (James, 2017; Kreuser and Newman, 2018; Steenkamp et al., 2018; Tregenna et al., 2020; Kahn et al. 2022) limits remain on our understanding of firm characteristics that determine:

1. Whether R&D takes place, and the intensity and type of R&D expenditure by the firm;
2. The impacts of R&D on firm outcomes (such as productivity, product range, growth employment, etc.);
3. What factors might make existing firms expand R&D expenditure and encourage new firms to engage in such activities in the future; and
4. What targeted policies can be implemented to expand and increase R&D expenditure by firms?

In this paper, we bring forth new evidence on the determinants, the outcomes and the constraints to firm-level R&D expenditure in South Africa using a range of firm-level data. To set the context, the report commences in Section 2 with an overview of South African R&D performance. This is followed in Section 3 by an international comparative analysis of SA R&D performance as compared to other upper-middle-income countries. This is followed by a detailed analysis of business R&D using the firm level data that covers heterogeneity of R&D firms (Section 4) and estimates of the firm outcomes associated with firm R&D (Section 5). The report then shifts to policy. Section 6 provides an overview of policies used globally to incentivise R&D, and an analysis of the effectiveness of the SA R&D tax incentive in increasing business expenditure on R&D. Section 7, then summarises the main findings of the report, and Section 8 presents policy recommendations to increase business expenditure on R&D in South Africa.

2. Setting the context: South African R&D performance

Key findings

1. Over the past decade, South Africa has experienced a decline in income and productivity growth.
2. R&D expenditure in South Africa has failed to keep pace with GDP over the long-term, and has fallen precipitously since 2017.
3. The business sector is by far the largest contributor to SA's decline in the level and share of GERD in GDP.
4. Business R&D expenditures have declined faster than private sector gross domestic fixed investment.
5. The declining contribution of business R&D expenditure has coincided with a slowdown in South African labour productivity growth, as measured by growth in GDP per capita.

This section sets the context for the firm-level analysis of R&D expenditure by the business sector. It commences with a brief overview of South Africa's growth performance, which is followed by a more detailed overview of the level and composition of R&D expenditure in South Africa.

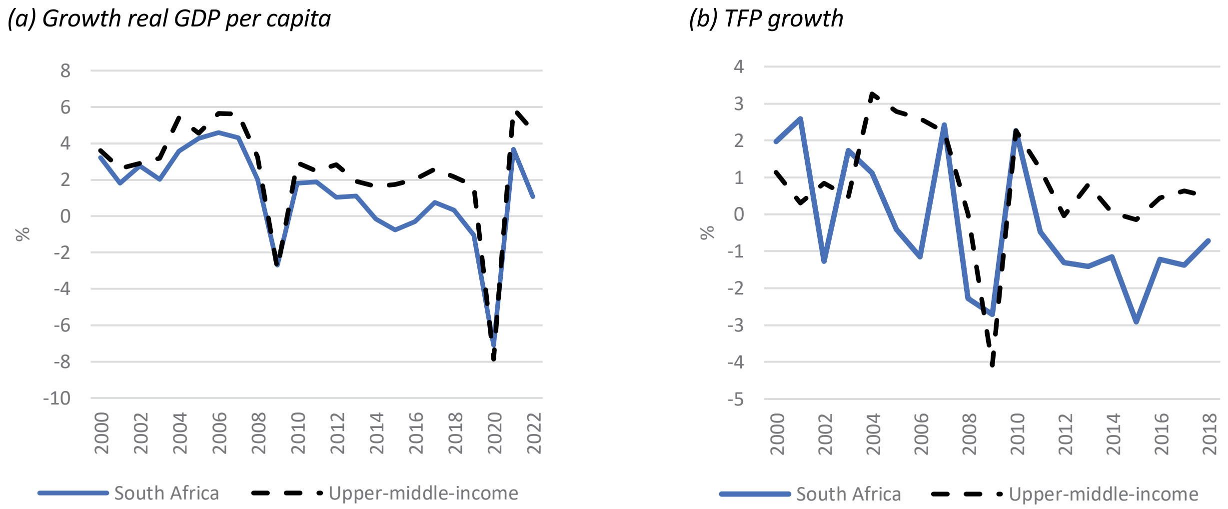
Over the past decade, South Africa has experienced a decline in income and productivity growth.

South Africa faces a severe growth constraint. Growth in real GDP per capita in South Africa has been falling since the early 2000s, with growth in GDP failing to exceed population growth from 2013. The implication has been a real GDP per capita stagnation over the past decade. This performance contrasts starkly with that of the average upper-middle-income country. Over the period 2000 to 2022, real GDP per capita in upper-middle-income countries grew by 2.55% per annum, whereas in South Africa, growth was tepid at 1.22% per annum (part (a) of Figure 1). The cumulative impact of lower growth in South Africa has been severe. Whereas individuals were 73% richer in terms of income in upper-middle-income countries in 2022 compared to 2000, South Africans' real incomes were only 22% higher.

Declining productivity growth is a key driver of lower growth in South Africa

Income growth can be generated through several channels, including raising employment, increases in investment that raises the amount of capital per worker, and rising productive efficiency (i.e., the amount of output that can be produced given a certain level of inputs, including labour and capital). One measure of productivity is total factor productivity (TFP), which measures the additional income that is generated given specific levels of employment and capital. Part (b) of Figure 1 plots TFP growth in South Africa against the average for upper-middle-income countries from 2000 to 2018 using data obtained from Dieppe et al. (2020). The trend in TFP growth for South Africa is downwards, with persistent negative TFP growth from 2012. South African productivity has thus been falling, serving as a drain on income growth. South Africa's TFP growth also contrasts starkly with upper-middle-income countries, particularly from 2010. Although productivity growth in upper-middle-income countries was also lower after 2010 than in the early 2000s, average TFP growth in the comparator countries exceeded TFP growth in South Africa every year from 2011 to 2018. The result is a widening productivity gap between South Africa and countries at similar initial income levels per capita.

Figure 1: Annual growth in real GDP per capita and TFP in South Africa and upper-middle-income countries

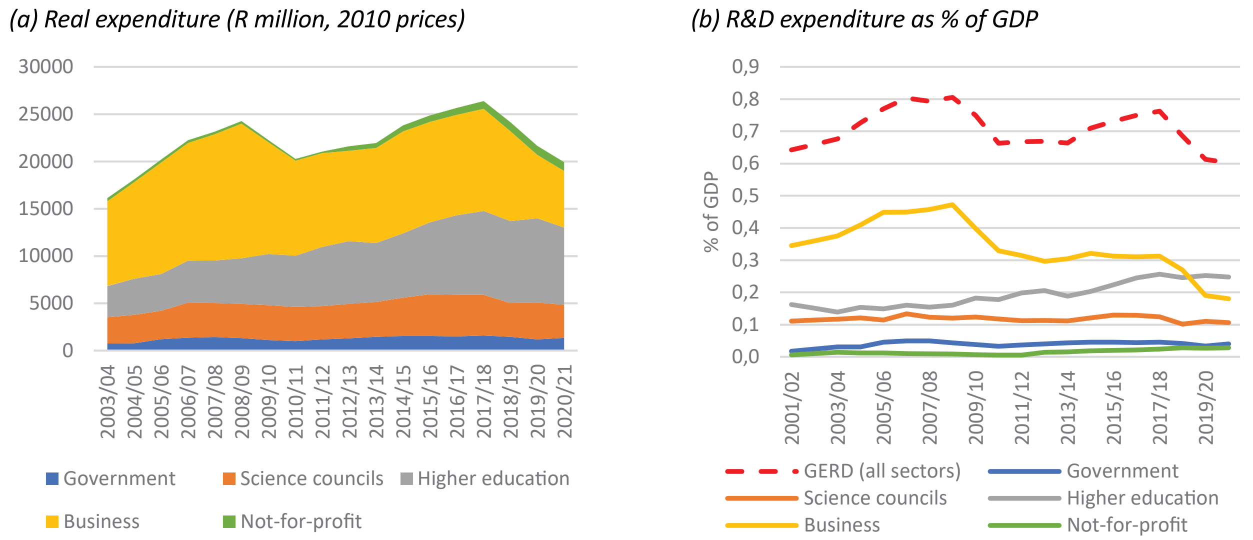


Source: Own calculations using World Development Indicator database and Dieppe et al. (2020). The upper-middle-income category comprises 68-73 countries yearly for GDP per capita growth and 48 to 52 countries for TFP growth. Upper-middle income category includes all countries that were declared upper-middle income in either 2005 or 2020.

Research and development (R&D) is generally agreed upon in the literature as an important driver of economic growth (Romer, 2012). This goes as far back as the works of Joseph Schumpeter, who identified the role of R&D in determining market structures and the nature of economic growth inherently. It also formed a significant aspect of endogenous economic growth theory as a key driver of productivity growth (Jones, 1995; Romer, 1990; Acemoglu. 2005). However, the public good nature of R&D, especially in the absence of perfect markets and intellectual property rights, means that markets may fail to provide sufficient quantities of it (Hall and van Reenen, 2000). For this reason, many countries find ways to fill the R&D gap, be it through incentives or actual government-sponsored R&D activities (Hall and van Reenen, 2000).

South Africa's performance concerning R&D expenditure and other indicators of innovation is well documented in the Science, Technology and Innovation (STI) Indicator reports produced by the National Advisory Council on Innovation (NACI), as well as the Statistical Reports of the National Survey of Research and Experimental Development produced by the Centre for Science, Technology and Innovation Indicators (CeSTII) on behalf of the Department of Science and Innovation (DSI).[1] Rather than duplicating these reports, this section highlights some of the main trends in R&D expenditures, focusing on the contributions by the business sector. We also compare trends with those in other upper-middle-income economies.

Figure 2: R&D expenditure in South Africa by sector



Source: Statistical Reports of the National Survey of Research and Experimental Development. Nominal values are deflated to 2010 values using the South African GDP deflator obtained from the South African Reserve Bank. Values for 2002/03 are estimated as the average of the two surrounding years.

R&D expenditure in South Africa have failed to keep pace with GDP over the long term and have fallen precipitously since 2017.

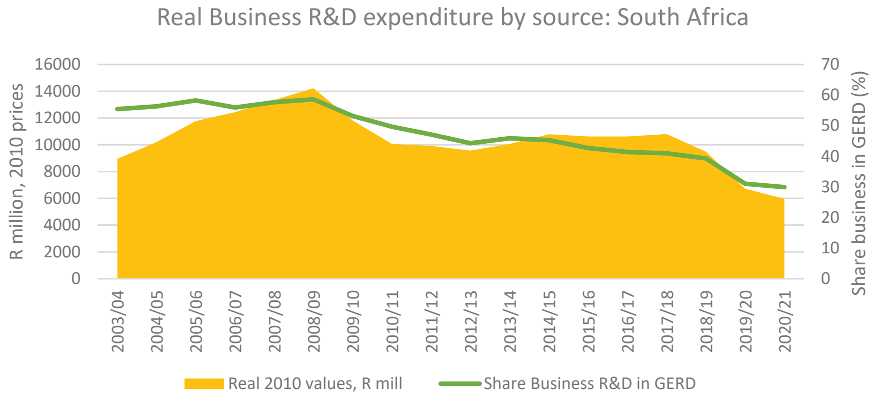
Figure 2 presents trends in real gross expenditure on R&D (GERD) in South Africa by source and as a share of GDP from 2003/04 to 2020/21. Real expenditure on R&D rose in the early 2000s both in levels and as a share of GDP, reaching 0.81% in 2008/2009. R&D expenditure fell sharply during the financial crisis, even more so than GDP. While real R&D expenditure recovered following 2010, the trend was not sustained, and from 2017/2018, real R&D expenditure fell sharply, falling by a quarter over the period 2017/18 to 2020/21. While GDP growth also slowed over this period, real expenditure on R&D fell even faster, with GERD as a share of GDP falling from 0.76% to 0.60% over the three years.

The business sector is by far the largest contributor to SA's decline in the level and share of GERD in GDP.

Figure 3 presents the real value (in 2010 prices) of R&D expenditure by the business sector from 2003/04 to 2020/21, as well as its share of GERD. From 2003/04 to 2008/09, business sector R&D grew rapidly rising from R8.9 billion to R14.2 billion, as did R&D by the other sources. Over this period, the business sector accounted for a relatively stable 57% of GERD. However, from 2009/10 to 2020/21, the business sector's contribution to GERD fell continuously as the level of business R&D expenditure fell. By 2020/21, real business expenditure on R&D had fallen by more than half to 42% of its 2008/09 values, and its share of GERD had fallen to 30% (from 57%).

1 For the list of available reports, see https://www.naci.org.za/index.php/studies/ and https://www.dst.gov.za/index.php/resource-center/rad-reports/r-d-survey-reports

Figure 3: Real business R&D expenditure in South Africa



Source: Statistical Reports of the National Survey of Research and Experimental Development. Nominal values are deflated to 2010 values using the South African GDP deflator obtained from the South African Reserve Bank.

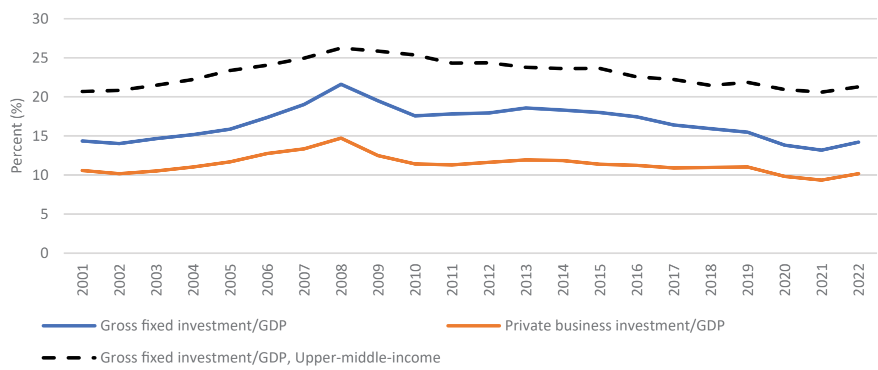
The business sector played a particularly large role in driving down GERD from 2017/18. Although R&D expenditure by other sectors (government, science councils, higher education) also fell from 2017/18, the contribution of these sectors to the decline in GERD was only a quarter, with the remaining 75% of the decline accounted for by businesses. Had the business sector share of GERD not fallen from its 2008/09 levels, real GERD in 2020/21 would have been R18.5 billion Rand higher (93% higher) raising the share of GERD in GDP to 1.58% - a value in line with the expectations set out in the 2019 White Paper.[2] The decline in business R&D is particularly concerning as it has high spillover effects and strengthens the capabilities of the business sector to absorb technology coming from abroad or from government and universities (Guellec and Potterie, 2001, cited in OECD, 2022).

R&D expenditure by the business sector has declined faster than gross domestic fixed investment by the private sector.

The fall in business sector R&D expenditure reflects a more general decline in the investment climate of the economy. The weakening economic growth over the past decade is in part attributed to declining investment by both the government and the private sector. To illustrate this, Figure 4 presents gross fixed capital formation and private business capital formation as a share of GDP over the period 2001 and 2022. Also presented is the average share of gross fixed investment in GDP for upper-middle-income countries.

As was the case with R&D expenditure, aggregate investment in South Africa rose strongly as a share of GDP from 2001 to 2008, but then fell subsequently. South Africa was not alone in experiencing declining investment rates with many other upper-middle-income countries facing similar trends. However, from 2015, weakening investment by the central government and public corporations depressed gross fixed investment relative to private sector investment (which also fell), as well as relative to the average for upper-middle-income countries.

Figure 4: Gross fixed capital formation as share GDP (%)

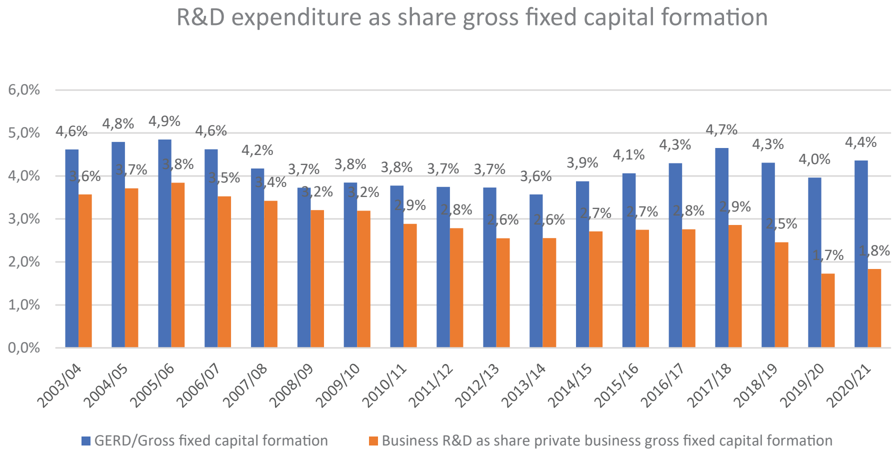


Source: Own calculations using South African Reserve Bank data for South Africa, and World Development Indicator data for upper-middle-income countries (42-45 countries per year).

2 The decomposition assumes that the business sector retains a 57% share of GERD.

The trends in business sector R&D, therefore, align with those of aggregate private sector investment. These trends point to a set of common underlying challenges to investment in South Africa, including slowing economic growth and declining investor confidence (EU, 2019). However, analysing the data more closely reveals that business sector expenditure on R&D fell faster than private sector investment. Figure 5, for example, plots the ratio of business sector R&D to private sector gross fixed capital formation (investment). *Whereas business sector R&D expenditure was equivalent to 3.8% of aggregated private sector fixed investment in 2005/06, by 2020/21 the share had more than halved to 1.8%.* In contrast, the ratio of GERD to total gross fixed investment fell only marginally over the period. However, this trend in recent years has mainly been driven by falling investments by the central government and public corporations rather than rising GERD.

Figure 5: R&D expenditure as share gross fixed capital formation in South Africa



Source: Own calculations using gross fixed capital formation data obtained from South African Reserve Bank (KBP6109J and KBP6009J) and R&D data obtained from the Statistical Reports of the National Survey of Research and Experimental Development. Note that the R&D data is based on the financial year of the firm, the investment data are based on the calendar year.

The declining contribution of business R&D expenditure has coincided with a slowdown in South African labour productivity growth, as measured by GDP per capita growth.

International empirical evidence broadly finds substantial positive impacts of R&D on productivity and economic growth, although the effects vary considerably across firms, industries and countries (Hall, 2010; OECD, 2015).[3] Output effects, for example, are found to be stronger for high-tech sectors and countries that rank highly in terms of quality of tertiary education and ease of doing business (Coe and Helpman, 2009). There is limited research on the impact of R&D on productivity within South Africa, but the available evidence on firms also points to positive productivity impacts. For example, Kreuser and Newman (2018) use the SARS/NT data and find a positive association between R&D expenditure and total factor productivity in South African manufacturing firms. Kahn et al. (2022) use direct measures of product and process innovation obtained from a business innovation survey and estimate significant positive effects of innovation on manufacturing firms' sales per worker (their proxy for productivity).

In Figure 6, a consistent (albeit variable) relationship between changes in GERD as a share of GDP and growth in labour productivity, as measured by GDP per capita, is shown for South Africa from 2002 to 2020. In the early 2000s, GDP per capita growth averaged around 3.5% per annum. This was also a period of rising GERD as a share of GDP (0.037 percentage points per annum from 2003-05). However, by 2018-2019 GDP per capita growth had swung negative (-0.36% per annum), as had changes in GERD as a share GDP (-0.074 percentage points per annum). The relationship between business R&D and GDP per capita growth is even stronger, as shown in part (b) of Figure 6. GDP per capita growth rose together with a rise in the share of business R&D in GERD in the early 2000s, but then simultaneously fell from 2008 for the rest of the 2008 to 2020 period.[4]

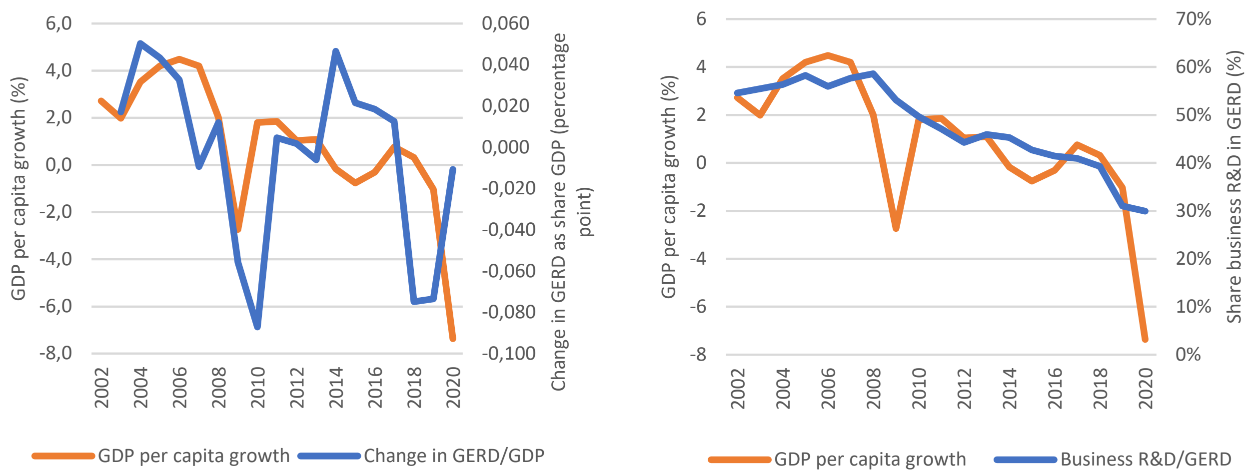
3 Simple cross-country growth regressions conducted for this project using data from the World Development Indicators also provides support for future growth in real GDP per capita arising from rising GERD, and increases in the share of business sector R&D in GERD (see Box 1). For example, our estimates indicate that a 1 percentage point increase in GERD as a share of GDP is associated with a 0.99 percentage point increase in the growth of GDP per capita in the following year (4.9 percentage points over the following 5 years). A 10 percentage point increase in the share of business R&D in GERD is associated with a 0.6 percentage point increase in growth in the following year (2.5 percentage points over the following 5 years).

4 Correlation coefficient between the two variables is 0.76.

Figure 6: Change in GERD (% of GDP) and business R&D expenditure as share GERD and their association with GDP per capita growth in South Africa

(a) GERD as share GDP and GDP per capita growth

(b) Business R&D expenditure as share GERD and GDP per capita growth



Source: Own calculations using GDP data obtained from the World Development Indicators database and R&D data obtained from the Statistical Reports of the National Survey of Research and Experimental Development.

3. A comparative perspective of South African R&D performance

Key findings

1. South Africa currently spends as much on R&D as would be expected given its average income per capita.
2. However, in 2020, South Africa is worse off relative to its peers than in the early 2000s, with respect to a range of indicators of growth, investment, and innovation.
3. An exception to these trends is foreign receipts received for the sale of Intellectual Property that rose as a share of GDP in South Africa.
4. South Africa has also performed poorly in terms of business expenditure on R&D. South Africa experienced the largest reduction in business R&D as a share of GERD relative to the comparator countries.
5. Labour costs associated with business R&D are disproportionately high in South Africa.
6. South Africa's reduction in R&D and business R&D has diminished the country's capacity for future growth.

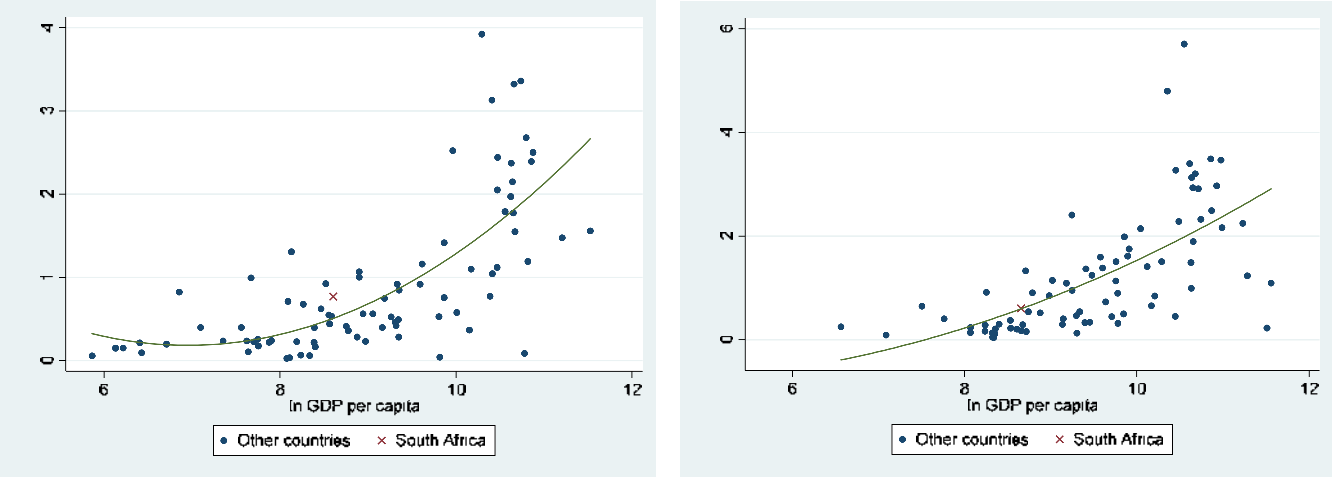
This section presents a brief comparative analysis of South African R&D performance. The objective is to locate South Africa within the spectrum of R&D performance by other upper-middle-income economies. Benchmarking against countries at similar levels of income per capita is important as the level and share of R&D in GDP is strongly linked to the level of development. While R&D is a source of economic growth, it is also a consequence of development as more developed economies have higher absorptive capacity and stocks of knowledge that raise the returns to R&D, as well as an industry composition more oriented towards R&D-intensive high-technology sectors. In several studies, R&D in SA is compared to higher income country groupings such as the OECD, particularly in the case of business sector R&D where access to data for emerging economies is limited (see OECD, 2022, for example). Such comparisons can lead to exaggerated estimates of South Africa's relatively low levels of R&D. An alternative approach is to compare R&D expenditure in SA with other upper-middle-income countries.

***South Africa currently spends as much on R&D as would be expected given its average income per capita*.**

Figure 7 draws on World Development Indicator data to present a scatter plot of GERD as a share of GDP against GDP per capita (in natural logarithms) for 2005 and 2020. Also presented is an estimated quadratic trend. The data shows a strong positive association between GDP per capita and GERD as a share of GDP. Although there are many exceptions, in general, the richer a country, the higher is GERD as a percent of GDP. Looking at part (b) for 2020, GERD (as % of GDP) in South Africa is situated exactly on the predicted line. In other words, in 2020, South Africa invested in as much R&D as would be expected given its GDP per capita. This is not an artefact of the year – a similar result is found when looking at 2019.

Figure 7: GERD as percentage of GDP against income per capita

(a) 2005 *(b) 2020*



Source: WDI for 2020. Includes quadratic trend. GDP per capita is measured in constant 2015 US$. South Africa is denoted by the ×.

The figure also highlights the depth of the challenge set out in the 2019 White Paper on Science, Technology and Innovation (DST, 2019) to raise GERD as a percent of GDP to 1.5%. In 2020, South Africa's GDP per capita (constant 2015 US$) was US$ 5749, and its GERD as a share of GDP equalled 0.6%. The average GDP per capita of countries with a GERD of between 1.4 and 1.6 of GDP over the period 2018 to 2020 was over 4 times higher at US$ 23.8 thousand. An achievement of the 1.5% goal would, therefore, be contingent on a dramatic increase in GDP per capita levels.

Table 1: Comparison of investment, IP payment and R&D for sample of middle-income countries

		Upper-middle income (Median)			South Africa		
		2005	2020	Change	2005	2020	Change
GDP per capita	2015 US$	6473	9363	44.6%	5458	5749	**5.3%**
R&D	% of GDP	0.42	0.54	28.1%	0.77	0.60	**-21.6%**
Payments for foreign IP	% of GDP	0.18	0.33	89.8%	0.37	0.35	**-4.5%**
Researchers in R&D	per million	840	1657	97.3%	355	473	**33.3%**
Gross fixed capital formation	% of GDP	23.62	21.56	-8.7%	15.88	13.81	**-13.0%**
R&D as share gross fixed capital formation	%	1.90	3.79	99.2%	4.85	4.37	**-9.9%**
FDI inflows	% of GDP	4.76	2.06	-56.8%	2.26	0.93	**-58.7%**
Net foreign assets	% of GDP	13.81	25.72	86.2%	10.63	21.42	101.5%

Source: World Bank World Development Indicators.

Notes: IP denote Intellectual Property. GDP denote Gross Domestic Product (measured in constant 2015 US$). FDI denote Net Foreign Direct Investment. Sample covers 35 upper-middle income countries available in both 2005 and 2020. Upper-middle income category includes all countries that were declared upper-middle income in either 2005 or 2020. Some countries migrated across income status categories over the period (E.g. Chile migrated from upper-middle income status to high-income status over the period.)

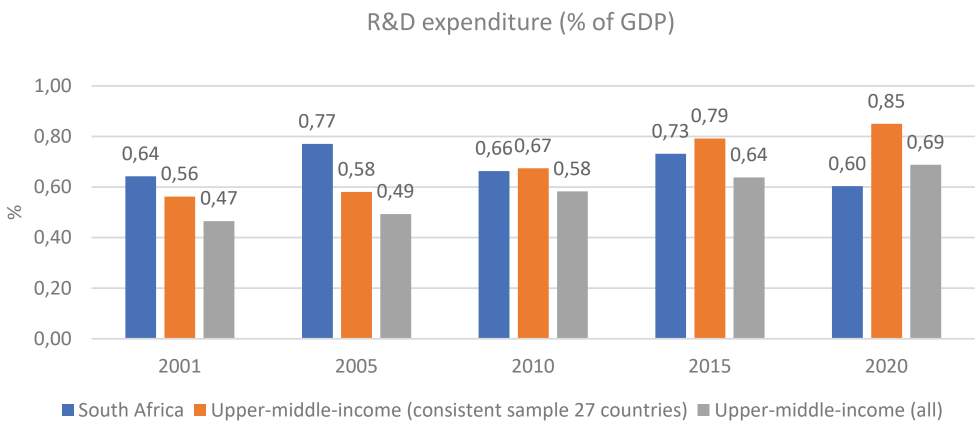
SA also does not seem to underperform in 2020 compared to other upper-middle-income economies with respect to several other metrics of knowledge acquisition. This can be seen in Table 1, which compares fixed investment, foreign intellectual property payments, R&D, net foreign assets and GERD as a share of gross fixed investment in South Africa in 2005 and 2020 against the median value for a set of 35 upper-middle-income countries. For example, payments for foreign intellectual property in South Africa in 2020 (0.35% of GDP) are very close to the median upper-middle-income country (0.33% of GDP). Net foreign assets (as % of GDP) in South Africa (21.4%) in 2020 is also relatively similar to the median upper-middle-income country (25.7%).

South Africa underperforms relative to the median upper-middle-income country in the number of researchers in R&D (473 per million vs. 1657 per million) and foreign direct inflows (0.93% of GDP vs. 2.06% of GDP). Further, South Africa severely under-performs with respect to gross fixed capital formation that averaged 13.8 % of GDP in 2020 compared to 21.6% for the median-upper-middle income country in the sample. When assessing GERD relative to gross fixed capital formation, South Africa actually performs relatively well (4.4% vs. 3.8% in 2020) (See also Figure 62 in Annex A). This suggests that the challenging investment climate in South Africa is the predominant source of South Africa's growth problem, rather than insufficient R&D.

More importantly, South Africa in 2020 is worse off relative to its peers when compared to the early 2000s, with respect to all indicators of growth, investment and innovation presented in Table 1.

Whereas, GERD as % of GDP in South Africa exceeded predicted values (see part (a) for 2005 in Figure 7), by 2020, South Africa had converged to the norm. What drove this convergence, was a stagnation of GERD (as % of GDP) relative to the country's peers. This is shown in Figure 8 that plots out GERD (% of GDP) for South Africa against the mean values for upper-middle-income countries for selected years from 2001 to 2020. Upper-middle-income countries are grouped into a sample of 27 countries for which data are available for each of the years, and a group containing all upper-middle-income countries for which data are available (36-41 countries per year).

Figure 8: GERD as percentage of GDP in South Africa compared to upper-middle-income countries

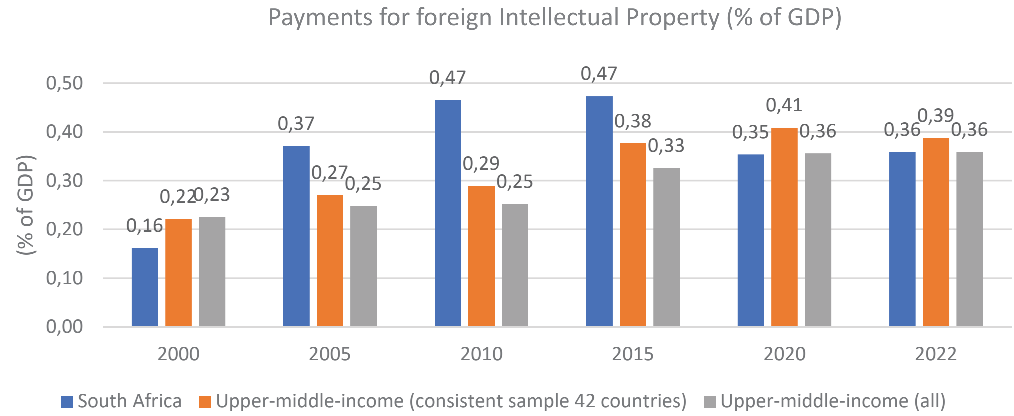


Source: World Bank World Development Indicators. Sample comprises between 36 and 41 upper-middle-income countries in each year. Upper-middle income category includes all countries that were declared upper-middle income in either 2005 or 2020. Some countries migrated across income status categories over the period (E.g. Chile migrated from upper-middle income status to high-income status over the period.)

Irrespective of the grouping, upper-middle-income economies experienced secular increases in GERD as a share of GDP from 2001 to 2020. Whereas GERD as a share of GDP in South Africa in 2001 was higher than the average upper-middle-income country (0.64% vs 0.47-0.56%), by 2020, South Africa had fallen to slightly below the average for the full sample of comparator countries (0.64% vs. 0.69%).

A similar trend holds with respect to access to foreign knowledge through payments for foreign intellectual property (IP) (Figure 9). From 2000 to 2010, payments for foreign IP rose as a share of GDP in South Africa at a rate faster than for the average upper-middle-income countries. The outcome was that the level of foreign IP payments (as % GDP) in South Africa exceeded that of its comparator countries in 2010 by a substantial amount (0.47% of GDP vs. 0.25-0.29% of GDP). However, from 2010 to 2015, payments for foreign IP stagnated in South Africa but continued to rise on average in other upper-middle-income countries. Since then, payments for foreign IP as a percent of GDP have fallen in South Africa (to 0.36% in 2022), and the country has fallen back to the level of its peers with respect to this indicator (0.36% to 0.39% in 2022).

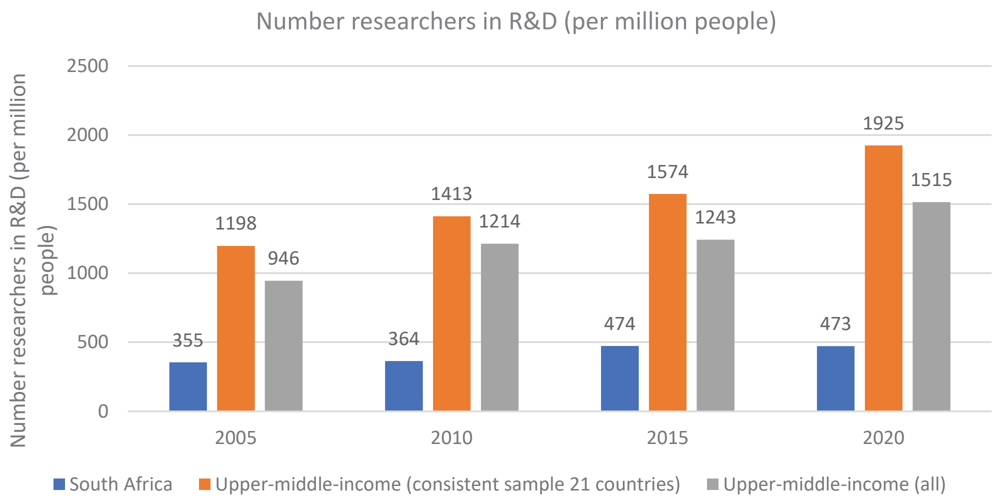
Figure 9: Payments for foreign intellectual property as percentage of GDP in South Africa compared to upper-middle-income countries



Source: WDI. Consistent sample of comprises 42 countries that were designated as upper-middle-income countries in 2005 or 2020, and for which data were available for all periods presented. The sample, including all upper-middle-income countries for which data are available, ranges from 50-62 countries per year. The simple average value for upper-middle-income countries is presented.

The same story holds when analysing South Africa's relative performance over time in expenditure on R&D as a share investment (fell in South Africa, rose for the average upper-middle-income country), foreign direct investment (fell for both SA and its peers, but faster in SA (see Figure 4)), researchers in R&D per million people (relative slow growth in SA as shown in) and gross fixed capital formation (faster declines in South Africa) (see Table 1). As the World Bank argues (2017), these indicators reflect a growing innovation gap in South Africa relative to its upper-middle-income peers.

Figure 10: Number of researchers in R&D per million people in South Africa and upper-middle-income countries



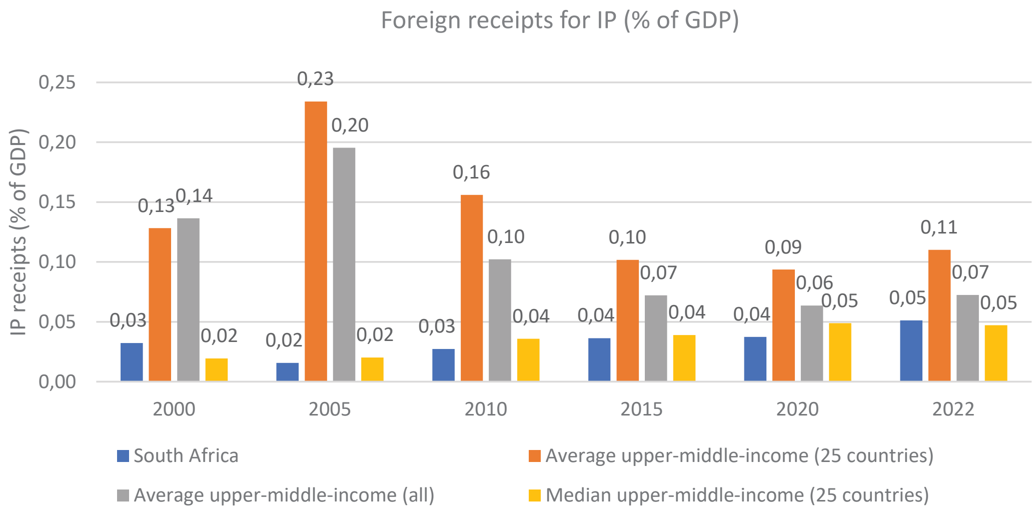
Source: WDI. Consistent sample of comprises 21 upper-middle-income countries. The sample including all upper-middle-income countries for which data are available ranges from 28 (2005) to 36 (2020) countries per year. The simple average value for upper-middle-income countries is presented.

An exception to these trends is foreign receipts received for the sale of IP that rose as a share of GDP in South Africa.

Foreign receipts for the sale of IP in South Africa are only a fraction (4% to 14% from 2005 – 2022) of foreign payments for IP. Nevertheless, the trends in South Africa regarding these indicators differ from 2015, with foreign receipts rising as a share of GDP, whereas payments fell. Similarly, foreign receipts (% of GDP) rose in South Africa relative to the average for upper-middle-income countries. For example, foreign receipts, as a per cent of GDP in South Africa rose from 0.02% in 2005 to 0.05 in 2022 but halved from 0.23% to 0.11% for the average upper-middle-income country over this period. However, this high average is driven by outlier countries. Foreign IP receipts as percent of GDP for the median country are substantially lower and follow a trend and level very similar to South Africa's.

Overall, South Africa is not distinctive in terms of its GERD as measured relative to GDP, but is distinctive in terms of its long-term poor performance and stagnation relative to its upper-middle-income peers. Further, SA differs from the average upper-middle-income country in its relatively poor performance with respect to other indicators of innovation, such as knowledge acquisition through the purchase of foreign IP, research in R&D and foreign direct investment. In what follows, we focus on a comparisons of business R&D as a share of GDP and contributor towards GERD.

Figure 11: Foreign receipts (% of GDP) for sale of IP in South Africa and upper-middle-income countries



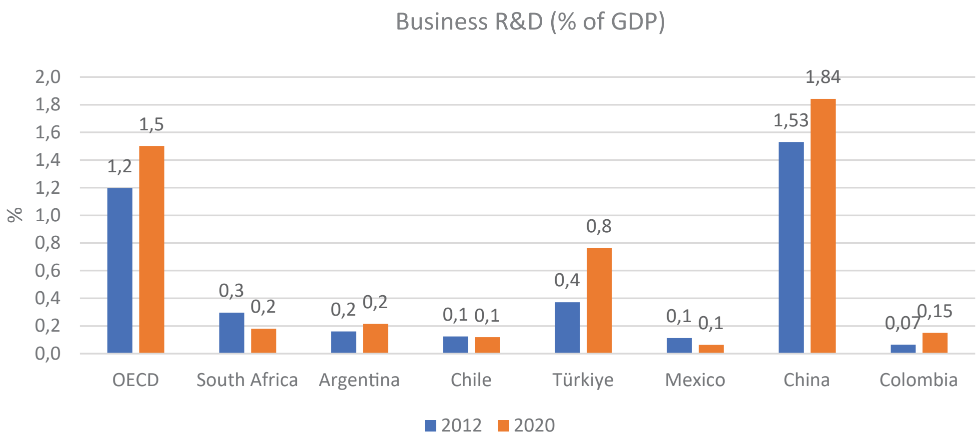
Source: WDI. Consistent sample of comprises 25 upper-middle-income countries. The sample including all upper-middle-income countries for which data are available ranges from 34 (2005) to 53 (2020) countries per year. The simple average value for upper-middle-income countries is presented.

South Africa has also performed poorly in terms of business expenditure on R&D relative to its peers.

Cross-country data on business expenditure on R&D, particularly for emerging economies, is unfortunately not widely available. One source of R&D expenditure data for business enterprises is the OECD's Research and Development Statistics database. While the R&D data is primarily available for OECD countries, it also includes data for a selection of non-OECD emerging economies, including South Africa, Argentina and the Russian Federation. Further, comparisons with South Africa are enabled by inclusion in the OECD of the upper-middle-income economies of Chile, Türkiye, Colombia and Mexico. For comparative purposes, we separate out the sample of upper-middle-income economies for which data are available in most periods (Argentina, Chile, Türkiye, South Africa, Colombia, China and Mexico).

Figure 12 presents trends in business R&D as a percentage of GDP for South Africa, the selected comparator countries, and the OECD average. With the exception of China, business expenditure on R&D is significantly lower in the upper-middle-income countries compared to the OECD average, reflecting relatively high levels of business R&D in high-income countries. South Africa in 2020 falls in the middle of the group of upper-middle-income countries with levels of business R&D (% of GDP) similar to that of Argentina and Colombia, but substantially lower levels than China (1.84%) and Türkiye (0.8%). Where South Africa differs is that business R&D fell as a share of GDP from 2012 to 2020, whereas, with the exception of Mexico, business R&D remained stable or rose in the other emerging economies.

Figure 12: Business expenditure on R&D as percent of GDP for selected comparator countries



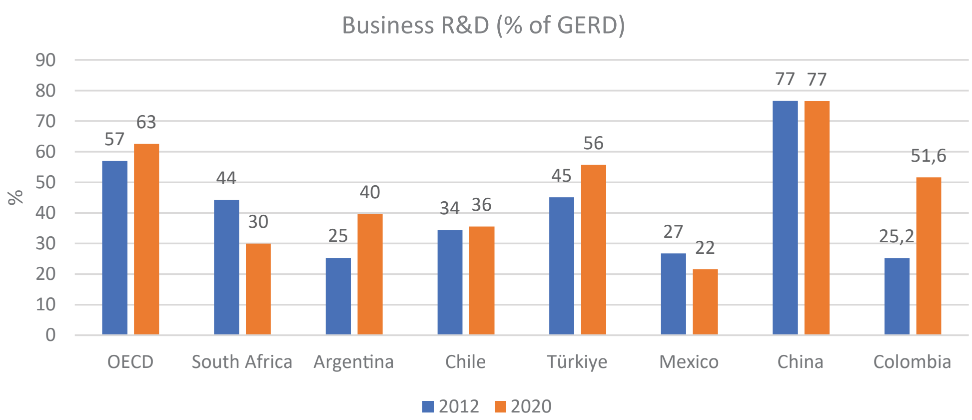
Source: Own calculations using the Research and Development Statistics database of the OECD obtained from OECD.Stat. The average value for OECD covers 32 countries. Data for Colombia and China covers 2013 and 2020.

South Africa also experienced the largest reduction in business R&D as a share of GERD relative to the comparator countries

Figure 13 compares business expenditure on R&D as a share of GERD in South Africa with the comparator countries. Whereas the share of business R&D in GERD was higher or similar in SA compared to all upper-middle-income economies with the exception of China in 2012, by 2020 all but Mexico had higher shares. South Africa's performance with respect to business R&D was also poor compared to all the other countries in the database. Of the 40 countries for which data are available, South Africa had the second lowest share of business R&D in GERD in 2020, with only Mexico having a lower share (22% for Mexico vs. 30% for South Africa).

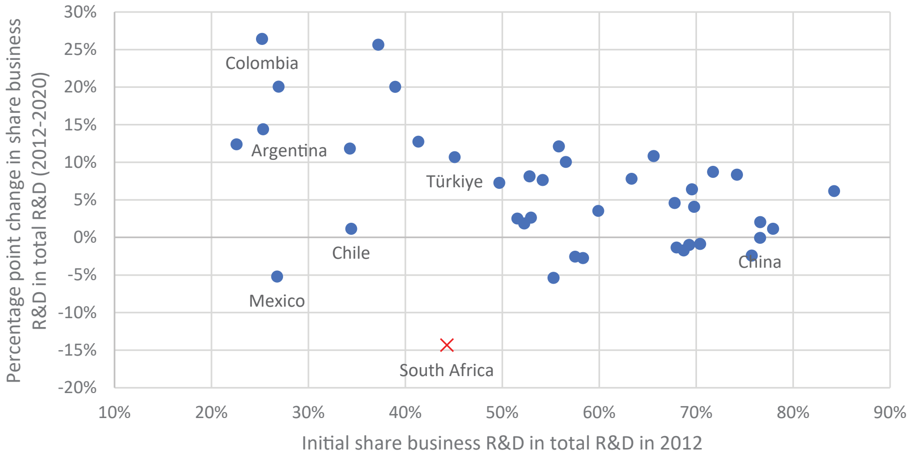
South Africa also experienced the largest percentage point reduction (14 percentage points) in business R&D as a share of GERD relative to all the countries over the period 2012 to 2020. South Africa's relative performance with respect to the initial (2012) level of business enterprise R&D in GERD and the change in this share from 2012 to 2020 is also shown in the scatter plot Figure 14. As shown in the figure, the share of business R&D in GERD (horizontal axis) in South Africa in 2012 was relatively high compared to most of the sample of upper-income countries and some of the other OECD countries. However, when evaluated regarding the change in the share business R&D in GERD from 2012 to 2020 (vertical axis), South Africa was least well performing with a large decline in share, as opposed to rising shares for most countries in the sample.

Figure 13: Business expenditure on R&D as percent of GERD for selected comparator countries



Source: Own calculations using the Research and Development Statistics database of the OECD obtained from OECD.Stat. The average value for OECD covers 32 countries.

Figure 14: Comparative analysis of initial share business expenditure on R&D as percent of GERD against the change in share from 2012 to 2020



Source: Own calculations using the Research and Development Statistics database of the OECD obtained from OECD.Stat.

Labour costs associated with business R&D are disproportionately high in South Africa

The OECD.Stat and HSRC-CeSTII provide data on the number of personnel involved in business R&D and the associated total labour costs. Personnel include researchers, technicians, and other supporting staff. This data enables a comparison of the average cost per worker engaged in R&D and the share of labour costs in total business expenditure on R&D. Table 2 presents average values of these labour cost indicators for South Africa and selected countries as well as for countries grouped according to income status from 2013 to 2020.

As shown earlier, South Africa is characterised by lower-than-average numbers of personnel engaged in R&D (210 vs 1488 for other upper-middle-income countries). However, BERD's share of labour cost is high at 57.5% compared to 47.4% for other upper-middle-income countries. Further, the average annual labour cost per R&D personnel in South Africa was US$ 100 thousand (2015 PPP), which far exceeds the average values for upper-middle-income (US$ 47 thousand) and high-income countries (US$ 85.8 thousand). For example, the cost of personnel engaged in business R&D in South Africa is three times the cost in Mexico and China. These differences are not attributed to differences in the share of researchers in business R&D personnel, the qualification of researchers (e.g. PhD) or the type of research engaged in (e.g. basic research, applied research, etc.). The labour cost associated with business R&D in SA remains high even after accounting for these factors.[5]

Table 2: Average labour cost of business R&D, 2013-2020

	Business R&D personnel (per million population)	Share labour cost in BERD (%)	Cost per R&D personnel (US$ 1000, 2015 PPP)
High income	4708	56.8	85.8
South Africa	210	57.5	100.0
Other upper-middle-income	1488	47.4	47.0
Specific countries			
Argentina	307	58.3	54.2
China	2413	31.9	31.4
Mexico	178	37.7	33.0
Turkey	1161	47.7	67.8

Source: Own calculations using the Research and Development Statistics database of the OECD obtained from OECD.Stat. Sample of other upper-middle-income includes: Argentina, Chile, China, Czechia, Estonia, Hungary, Lithuania, Latvia, Mexico, Poland, Romania, Russia, Slovakia, and Turkey. These are countries that were upper-middle-income in 2005 and/or 2020. The high-income category covers 25 to 27 countries (mostly OECD).

5 We run a simple regression of labour cost per personnel on share researchers, type of research engaged in, and qualification of personnel. The predicted wage gap for South Africa compared to other upper-middle-income countries actually rises to 133% (from 113%).

High researcher costs in South Africa can reflect a scarcity of skilled researchers able to conduct R&D. The scarcity of researchers, together with the high labour costs, make it difficult for firms, particularly small firms, to engage in R&D activity. The comparatively high labour costs also disadvantage local firms that wish to export R&D services. They face a cost disadvantage *vis-à-vis* other countries that reduces their competitiveness. Finally, constraints in the availability of skilled R&D personnel will reduce the responsiveness of firms to R&D incentives, such as the Section 11D tax incentive.

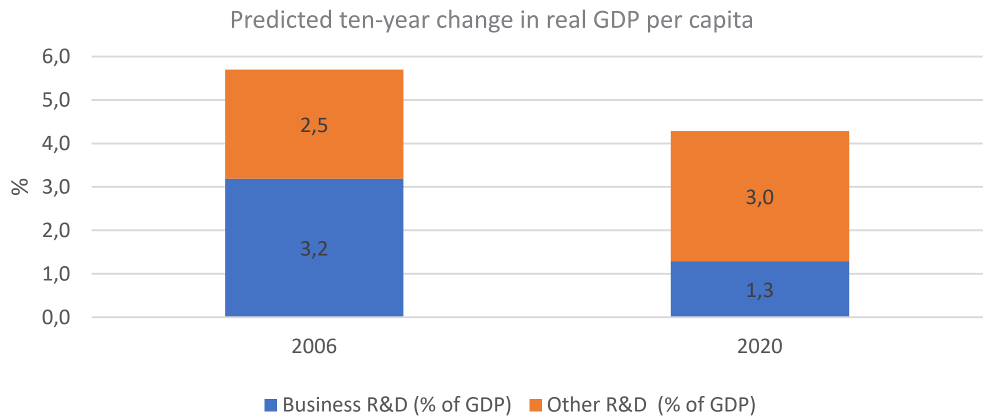
South Africa's reduction in R&D and business R&D has diminished the country's capacity for future growth

To better understand the implications of reduced R&D on future growth, a simple growth model is estimated using an unbalanced panel of data for 104 countries over the period 2005 to 2021. The data are obtained from the World Development Indicator database. This model is used to estimate the two-year growth rate in GDP per capita growth in a country as a function of prior levels (lag two years) of R&D, foreign assets, payments for foreign IP and gross fixed capital formation (all as % of GDP). Annex C provides further details.

The regression results provide support for the positive role that GERD, foreign IP, foreign ownership and fixed capital investment play in driving future growth. Countries with higher GERD as percent of GDP experience higher growth in GDP per capita in the following two years than countries with low GERD shares. The importance of business R&D in driving future growth is also shown in the results, although the sample of countries and time period covered (2013-2021) is much smaller, resulting in less precise estimates. Nevertheless, the results indicate that rising shares of business R&D in GERD are associated with higher growth rates.

The implication of these results is that South Africa's growth potential has diminished in response to the decline in GERD (% of GDP), the share of business R&D in GERD, as well as the declining share of foreign IP and gross fixed investment in GDP from the early 2000s to 2020 (see Table 1). According to the coefficient estimates (column (2) of Table), the contribution of GERD to future increases in GDP per capita over a 10-year period declined from 5.7 percent in 2006 to 4.3% in 2020 Table 17 in Annex C (Figure 15).

Figure 15: Predicted 10-year rise in future real GDP per capita associated with expenditure on R&D in South Africa, 2006 and 2010.



Notes: Own calculations based on R&D (% of GDP) coefficient estimates in column (2) in Table 17.

Assuming the same coefficients hold for business R&D and other R&D (which is a conservative estimate given relatively stronger impact of growth from business R&D shown in column (3) and (5)), the decline in business R&D (as % of GDP) reduced the ten-year growth potential from 3.2% to 1.3% over the period. Rising R&D in other sectors offset some fall in business R&D. Still, the growth potential associated with increases by other actors - tertiary education and science councils – is expected to be far lower.

In conclusion, South Africa experienced a decline in expenditure in R&D as a share of GDP from the early 2000s, which contrasts with the trend amongst its upper-middle-income country peers. The business sector has by far made the most significant contribution to South Africa's decline in R&D and R&D as a share of GDP. This steep decline in business R&D is particular to South Africa and is not broadly seen in other comparable countries. The labour costs associated with R&D activities are also very high compared to comparable countries. The effect has been a diminished capacity for economic growth in South Africa which partly helps explain South Africa's declining economic growth performance. These findings motivate a deeper understanding of the South African business sector and the factors that drive R&D expenditure by private firms and the outcomes thereof. The following section of the report, therefore, draws upon administrative tax data to provide firm-level insights into business expenditure on R&D.

4. Heterogenous firm characteristics and R&D expenditure

8. Aggregate expenditure on R&D by firms has declined since 2010, with three factors explaining this trend: (a) A decline in the number of R&D firms, (b) A decline in the share of all firms engaging in R&D, and (c) A decline in the intensity of R&D within the firm.
9. R&D expenditure is concentrated in a few large firms, with large firms being the main drivers of the downward trend in total R&D firm numbers and total R&D expenditure from 2012 to 2019.
10. Manufacturing firms make up the largest source of aggregate R&D expenditure and have been the main, but not the only, contributor to its decline.
11. Persistence of regular R&D expenditure is weak (as also found by Steenkamp, et al. 2018).
12. The decline in the number of firms engaging in R&D is driven by higher rates of firm exit from R&D than firm entry rates into R&D. The exit from R&D activities by firms is a major contributor to the decline in growth of business expenditure on R&D.
13. Expenditure on R&D activities mainly occurs directly within the firm and, to a lesser extent, through foreign-related companies.
14. Domestic firms are increasingly conducting R&D for foreign-related firms.
15. Firms increasingly spend more on royalties and license fees than on R&D.
16. There is a considerable degree of heterogeneity in terms of characteristics across all firms, including R&D firms.
    a. R&D firms pay higher wages and are larger in terms of employment, value added, productivity, capital stock, and sales. They are also more likely to have foreign ownership and be part of a multinational enterprise (local or foreign owned).
    b. R&D firms are also far more integrated into global markets. They are more likely to be exporters and/or importers, particularly of high-technology products, and have higher export values and export varieties.
17. High-productivity firms that export high-technology products while operating in less concentrated markets have a higher probability of engaging in R&D activities as well as a higher intensity of R&D expenditure compared to other R&D firms.

This section presents a firm-level analysis of business expenditure on R&D in South Africa using the South African Revenue Service and National Treasury Firm-Level database (SARS-NT database). It begins with a brief overview of the processes followed in cleaning and preparing the data for analysis. This is followed by a presentation of some defining characteristics of firms that engage in R&D activities.

4.1 Data cleaning and data challenges

This SARS-NT database combines three sources of administered data, namely: company income tax from registered firms who submit tax forms, employment data from employee income tax certificates submitted by employers, and customs records from traders. It provides detailed information on businesses, including industry, sales, costs, employment, exports and imports, foreign ownership, expenditure on R&D, expenditure on licenscing/royalties, etc, thereby enabling a detailed analysis of the characteristics of firms that engage in R&D activities. Further, the availability of firm identifiers allows researchers to track firms over time and consequently study how R&D expenditure is related to firm outcomes, such as productivity, employment, sales, trade performance, etc. Several studies have already used the SARS-NT data to analyse business R&D in South Africa (James, 2017; Kreuser and Newman, 2018; Steenkamp et al., 2018; Naidoo, 2020; Edwards et al., 2022).

Preparing the data for empirical analysis of business expenditures on R&D was a comprehensive process. The Data Annex provides further details on the processes followed. The final database covers the financial years 2010 to 2020, but because of incomplete submissions by several large firms in 2020, the analysis focuses mainly on the period 2010 to 2019.

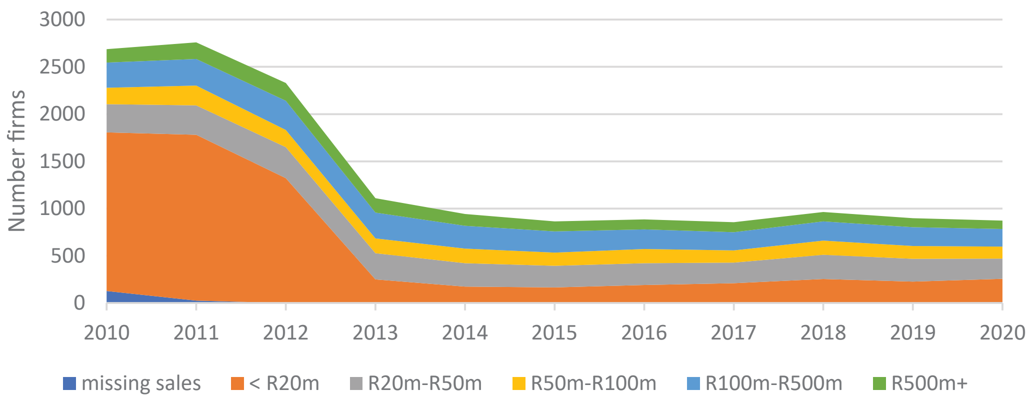
One specific challenge arose in dealing with firm submissions on R&D expenditure. Since 2012, 13 companies have been required to submit a new income tax form, the ITR14. All companies could submit information on R&D expenditure using the prior IT14 income tax form, but with the new ITR14 form, information on R&D expenditure was only collected for medium and large firms. These were firms with sales values of R14 million or more and/or R10 million of assets. From 30 March 2013, the minimum sales value for submitting the ITR14 form rose to R20 million.

The implication is that information on R&D expenditure by small firms has not been available from 2013 onwards. Without further cleaning, comparisons of R&D firm numbers and expenditure before and after 2013 are not possible given two selection effects: (a) the exclusion of R&D by small firms from 2013, and (b), from 2013, the submission of ITR14 form by small firms as they cross-over the minimum sales and/or asset values threshold to be classified as a medium/large firm.[6] Because the threshold for being classified as a medium/large firm is specified in nominal values (e.g., R20 million sales or R10 million of assets), small firms are pushed over the threshold by inflationary pressures even if their real sales values do not change.

To resolve these selection problems and enable us to compare a consistent panel of firms over the full 2010 to 2019 period, we deflate firms' sales and asset values to April 2013 prices using the aggregate producer price index available from Statistics South Africa. We chose April 2013 prices as the threshold for medium/large firms rose to R20 million at the end of March 2013. We then select all firms for which real sales values (in 2013 April prices) equal R20 million or above. In doing so, we avoid the selection effects of small firms crossing the nominal value threshold for medium/large firms after April 2013, as well as the bias from including small firms that submit information on R&D expenditure before 2013.

The impact on the number of R&D firms is reflected in Figure 16 that presents the total number of R&D firms in the unadjusted sample, with firms classified into several size categories based on real sales values measured in April 2013 prices. As can be seen in the figure, the total number of firms declaring R&D expenditures in the SARS-NT database plummeted in 2012 and 2013, but this decrease is almost entirely due to small firms (real sales values less than R20 million) who no longer supplied R&D information with the new ITR14 income tax form. For example, there are 1 637 R&D firms with missing sales and real sales values lower than R20 million each year between 2010 and 2012. After 2013, firms in this category made up only 211 firms on average each year.

Figure 16: Number of R&D firms categorised by value of real sales, unadjusted database

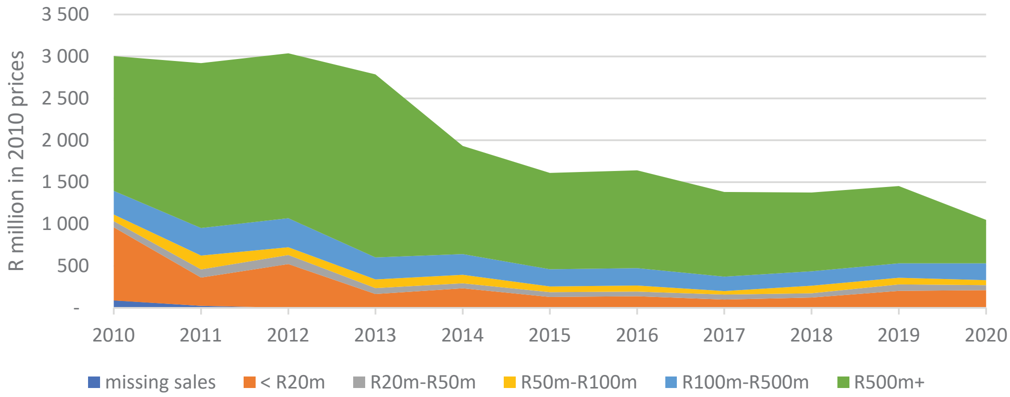


Notes: SARS/NT administrative tax data with no observations excluded. Sales categories are based on real sales valued at April 2013 prices. The sample excludes R&D purchases from related foreign and local firms.

To see the implication for aggregate R&D expenditure, Figure 17 presents the total value of R&D expenditure firms declare using the unadjusted SARS-NT database. The expenditure data are deflated to 2010 values using the GDP deflator for South Africa to enable comparisons with the aggregate analysis in the prior sections. While small firms (with sales less than R20 mill in April 2013 prices) made up a very high share of all firms from 2010 to 2012 (63%) (Figure 16), their share of aggregate R&D expenditure is much lower (20%).

6 Because the threshold to be classified as a medium/large firm is specified in nominal values (e.g., R20 million sales or R10 million of assets), inflation will push small firms over the threshold even if their real sales values do not change.

Figure 17: Aggregate expenditure on R&D by firms categorised by value of real sales, unadjusted database, R million



Notes: SARS/NT administrative tax data with no observations excluded. Sales categories are based on real sales valued at April 2013 prices. The sample excludes R&D purchases from related foreign and local firms.

The exclusion of firms with real sales of less than R20 million, therefore, reduces the sample, but the impact is greatest over the period 2010 to 2012. However, by excluding these firms, we can analyse changes in firm characteristics over the entire period using a consistently defined panel of firms. Nevertheless, one implication of this preliminary analysis is that our analysis does not cover many smaller firms that engage in R&D expenditure. A comprehensive picture of firms engaging in R&D will also, therefore, require a separate analysis of small firms.

A final consideration is the expenditure on R&D covered in the SARS-NT data. For R&D expenditure to be eligible for the Section 11D tax incentive, it needs to comply with tightly specified criteria, although the definition of R&D has recently been refined (National Treasury, 2022).[7] To be eligible for the tax incentive, the R&D also has to be approved by an adjudication committee comprising members from the Department of Science and Technology, the National Treasury and SARS. One implication is that the aggregate value of R&D expenditure in the SARS-NT data is significantly lower than the estimates provided, for example, in the HSRC-CeSTII South African National Survey of Research and Experimental Development (See the Data annexe for further comparisons). The level and trends in aggregate R&D expenditure in the SARS-NT database are therefore not readily comparable with other sources of R&D data.

4.2 Summary statistics of consistent panel

Table 3 presents summary statistics of the panel database used in much of the analysis. The sample covers all firms in the South African Revenue Services/National Treasury administrative tax data with real sales of R20 million or above, valued in April 2013 prices. The data covers the period 2010 to 2020, where the date refers to the financial year (e.g., 2015 refers to the 2014/15 financial year of the firm; see notes to Table 3 for further discussion on how the financial year for each firm is defined).

The total number of firms averaged close to 33 thousand each year from 2010 to 2020, ranging from 29,145 in 2010 to 35,216 in 2018. The total number of firms that declare R&D expenditure in their tax submissions, be it in-house or through foreign-related companies, averaged 784 per year, or 2.42% of all firms in the sample each year.

7 We cannot be certain what expenditure firms include in their tax submissions. Although the corporate income tax form (ITR14) specifies Section 11D when asking firms to declare research and development costs as an expense item, firms may declare R&D expenditure that does not comply with the eligibility criteria for the tax incentive. As shown later in the analysis, many firms declare R&D expenditure, but do not appear to have sought approval for the tax incentive.

Table 3: Summary statistics of sample of firms

	Number of firms						Share all firms in sample				
	All R&D expenditure firms	In-house R&D expenditure firms	R&D expenditure firms through foreign related company	R&D supplying firms to foreign related company	Firms with SD11 approval from DST	Total number firms in sample	All R&D expenditure firms	In-house R&D expenditure firms	R&D expenditure firms through foreign related company	R&D supplying firms to foreign related company	Share SD11 submitting firms with DST approval.
2010	878	878				29,145	3.01%	3.01%			
2011	978	978				30,510	3.21%	3.21%			
2012	1,008	1,006				30,959	3.26%	3.25%	0.01%	0.00%	
2013	863	861				31,941	2.70%	2.70%	0.02%	0.01%	
2014	775	768				32,622	2.38%	2.35%	0.03%	0.02%	
2015	709	700	14	17	42	33,968	2.09%	2.06%	0.04%	0.05%	30.43%
2016	704	693	21	17	174	34,217	2.06%	2.03%	0.06%	0.05%	23.08%
2017	660	646	22	18	170	34,722	1.90%	1.86%	0.06%	0.05%	15.53%
2018	723	709	21	22	193	35,216	2.05%	2.01%	0.06%	0.06%	11.75%
2019	689	671	24	26	187	34,644	1.99%	1.94%	0.07%	0.08%	8.80%
2020	637	618	22	27	179	31,604	2.02%	1.96%	0.07%	0.09%	7.40%
Average, 2010 to 2020	784	775	21	21	158	32686	2.42%	2.40%	0.05%	0.04%	16.16%

Notes: Sample covers SARS/National Treasury administrative tax data firms with sales of R20 million or above, valued in April 2013 prices. The year refers to the financial year of the firm. The financial year allocated to the firm is determined by the financial year end of the firm. The financial year of all firms whose financial year ends after August are defined as the year following the submission year (e.g. if a firm's financial year end is in November 2011, the financial year for that firm is 2012). If the financial year end is between January and August, the financial year is defined as the current year (e.g. for firms with a financial year end in June 2011, the financial year in the data is 2011). This is to ensure consistency with Pieterse, Kreuser & Gavin (2018) and to maximise alignment with the tax year (March to Feb in following year) for which employment data are provided by the firms. The numbers in the table do not therefore correspond with calendar years.

The ITR14 tax submission forms also request information on whether firms incur R&D expenditure or receive R&D income via foreign-related/connected companies. Very few firms declare expenditure or income through this channel, averaging only 21 firms each year. Finally, information from 2015 is available on whether a firm applied for and was granted approval by the Department of Science and Technology for the 150% tax deductions on R&D expenditure provided for under Section 11D (9) of the Income Tax Act. According to the data, the total number of applications increased from 138 in 2016 to 2420 in 2020. However, the share of these firms whose applications were approved fell from 30.4% to 7.4% over this period.

4.3 Characteristics of aggregate R&D expenditure by firms in South Africa

This section presents a background overview of the main trends and industry characteristics of R&D expenditure and firm engagement in R&D. The analysis is based on the consistent panel of firms with sales of R20 million and above, as valued in April 2013 prices. Table 4 provides a summary of some of the findings related to expected characteristics and drivers of R&D in firms.

Table 4: Summary of findings related to characteristics and drivers of R&D in firms

Expected characteristics and drivers of R&D in firms	Supported?
Size: Larger firms are more likely to invest in R&D than smaller firms because they have greater financial resources, research capabilities, and economies of scale, which enable them to allocate more funds to R&D activities.	Yes. Larger firms are are more likely to engage in R&D on a more sustained basis.
Industry characteristics: Industries with high technological intensity, such as pharmaceuticals, electronics, and biotechnology, exhibit higher R&D investments.	Yes. R&D intensity is higher in technologically sophisticated industries
Industry competition: Ambiguous relationships as in the face of competition, firms strive to innovate and differentiate themselves. Too much or too little competition, however, reduces expected returns in terms of profits from innovation (Aghion et al., 2015, for a summary see Halpern and Muraközy, 2015).	Yes. R&D probability and firm R&D intensity are lower in highly concentrated industries
Profitability and financial performance: Firms with higher profitability and financial performance are more likely to allocate resources to R&D. Positive financial outcomes provide the necessary resources to support R&D initiatives and absorb potential risks associated with innovation.	Yes, Firms with higher value-added/worker, a measure of financial performance, are more likely to engage in R&D
Intellectual property rights: Strong intellectual property rights protection, such as patents, copyrights, and trademarks, positively influence R&D investments. These protections incentivise firms to invest in R&D by providing exclusive rights and potential returns on their innovations.	Could not test this relationship
Collaboration and knowledge spillovers: Collaborative activities, such as joint ventures, research partnerships, and alliances, have been found to positively impact R&D investments. By sharing resources, knowledge, and risks, firms can enhance their R&D capabilities and benefit from knowledge spillovers.	Higher probability of R&D in multinational enterprises. In-licensing of external knowhow a significant determinant and complement to R&D activities
Government support and incentives: Government policies and incentives, such as R&D tax credits, grants, subsidies, and public research funding, have a significant impact on R&D investments. Firms are more likely to engage in R&D when they can access financial assistance and when governments prioritize research and innovation.	Some support, but effectiveness of tax incentive appears limited
Human capital and skilled workforce: The availability of a skilled workforce, including scientists, engineers, and researchers, is crucial for R&D investments. Firms with access to highly skilled labour are more likely to invest in R&D to capitalize on their expertise and drive innovation. Higher skills are expected to increase absorptive capacity of firms raising returns to R&D.	No skills data is available, but higher wage firms, which are more likely to be skill-intensive, engage more in R&D. More capital-intensive firms also more likely to be R&D firms

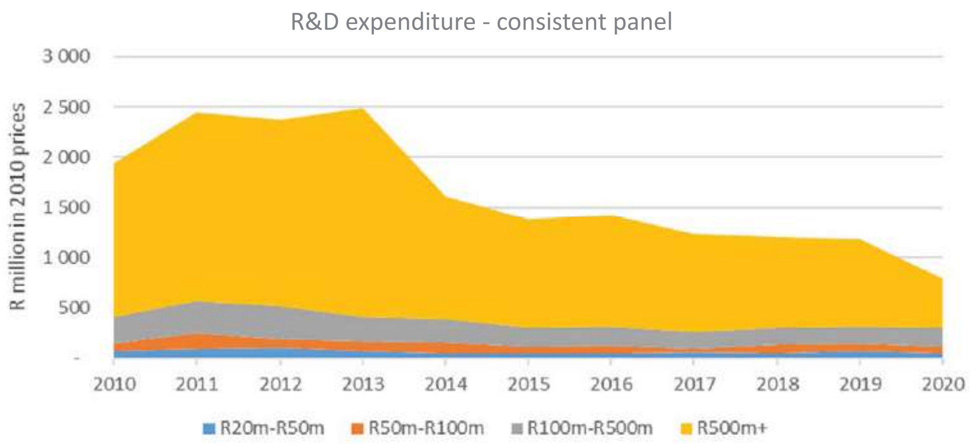
Expected characteristics and drivers of R&D in firms	Supported?
Market orientation and customer demand: Firms that are more market-oriented and responsive to customer demands tend to invest more in R&D. Understanding consumer needs, preferences, and market trends helps firms develop innovative products and services, leading to increased R&D investments.	Could not test this relationship
Globalisation and internationalisation: Firms that engage in international activities, such as foreign direct investment and exports, tend to have higher R&D investments. Internationalization provides firms with access to new markets, resources, and knowledge, which can fuel R&D efforts.	Yes. R&D activities more likely in firms that engage in exporting and importing, particularly of high-technology goods. Multinational enterprises have higher probability of engaging in R&D
Technological infrastructure: Availability of advanced technological infrastructure, such as research facilities, laboratories, and supportive ecosystems, positively influences R&D investments. Regions with robust technological infrastructure attract more R&D investments from firms.	Could not test this relationship

Source: Various sources

Aggregate expenditure on R&D by firms has declined from 2010

Figure 18 presents the trend in aggregate real expenditure (valued in R2010 GDP deflator prices) on R&D by the panel of firms from the 2010 to 2020. Aggregate expenditure by firms on R&D fell by 46 percent between 2010 and 2019. Whereas aggregate real expenditure, averaged between R2 billion and R2.5 billion per year from 2010 to 2012, it fell sharply in 2014 to R1.6 billion, and then continued to decline falling to R1.18 billion in 2019. R&D expenditure also declined in 2020, but this may also be attributed to the late submissions of corporate income tax forms by very large firms in the data set. Data for the 2020 financial year is therefore not considered in much of the analysis.

Figure 18: Real R&D expenditure, 2010 to 2020



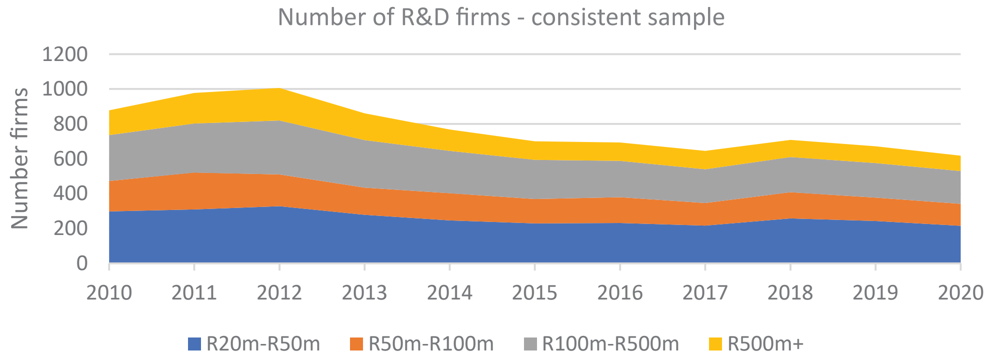
Notes: Firm panel based on R20 million in turnover in April 2013 prices cut-off. Excludes R&D purchases from related foreign firms. The year denotes the financial year of the firm.

Three factors have contributed towards the decline in the level of R&D expenditure and its share in total sales: (a) A decline in the number of R&D firms, (b) A decline in the share of all firms engaging in R&D, and (c) A decline in the intensity of R&D within the firm.

Firstly, the number of firms engaging in R&D activities has fallen

Figure 19 presents the number of firms engaging in R&D activities from 2010 to 2020. The sample is split according to a firm size category, as determined by real sales value. After rising marginally from 2010 to 2012, the number of R&D firms in the sample fell by 39% from just over 1000 in 2012 to 671 in 2019. Decreases in R&D firm numbers from 2012 to 2019 occurred in all size categories, but the percentage decline was greatest for large firms (a 49% decline).

Figure 19: Number of R&D firms, 2010 to 2020

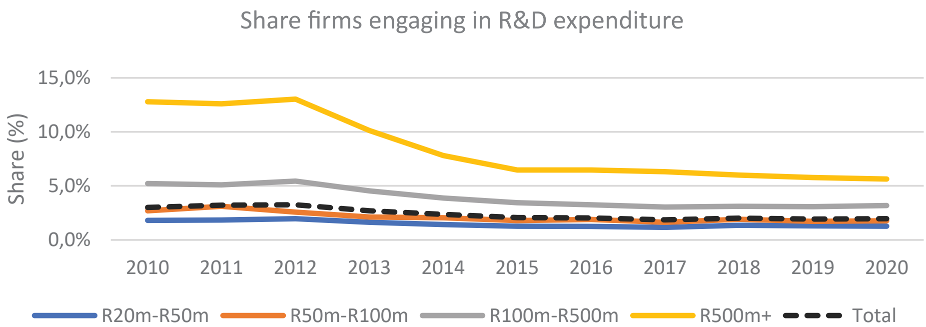


Notes: Firm panel based on R20 million in turnover in April 2013 prices cut-off. Excludes R&D purchases from related foreign firms.

Secondly, the shares of firms engaging in R&D has fallen

Figure 20 presents the annual share of all firms in the panel that engaged in R&D over the period 2010 to 2020. The share of firms engaging in R&D fell from 3% in 2010 to 1.9% in 2019. Declining shares were experienced across all firm size categories. Large firms with sales above R500 million are shown to be more likely to engage in R&D expenditure, with smaller firms (R20 million to R50 million) the least likely. The share of large firms engaging in R&D expenditure in the sample of firms in the analysis (Figure 20), fell from 13% in 2010 to 2012, to just below 6% in 2019/2020. The share small firms engaging in R&D expenditure fell from 1.8% to 1.3% over the same period.

Figure 20: Share total firms engaging in R&D, 2010 to 2020

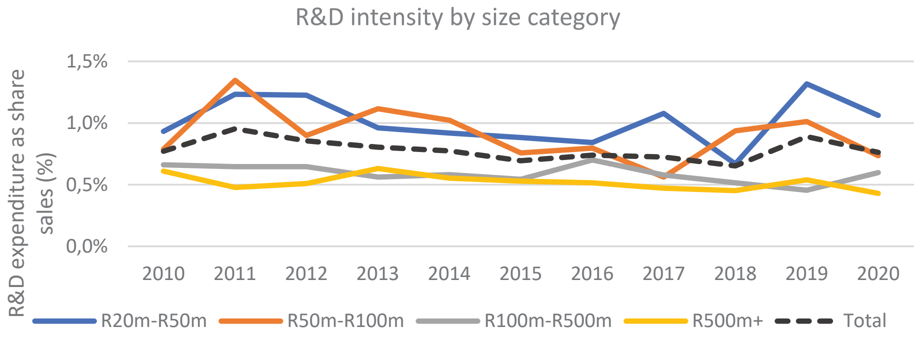


Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D purchases from related foreign firms.

Thirdly, the intensity of R&D expenditure by firms has fallen

Figure 21 presents a measure of the average R&D intensity by firm size category, where intensity is calculated as the share R&D expenditure in total firm sales. Only firms that engage in R&D are included in the sample. In 2011, the average expense by R&D firms on R&D activities was equivalent to 0.95% of the firm's total sales value. This share fell subsequently, reaching 0.65% in 2018. In 2019, the share rose sharply, but this fell back to 0.77% in 2020, although given the COVID-19 pandemic, little inference can be drawn from the 2020 observation.

Figure 21: R&D intensity, 2010 to 2020



Notes: Firm panel based on R20 million in turnover in April 2013 prices cut-off. Excludes R&D purchases from related foreign firms. R&D intensity is measured as R&D expenditure as share sales. The top 1% of R&D intensity values (157 observations) are dropped to deal with outliers distorting the averages. Only firms that incur R&D expenditure are included in the sample.

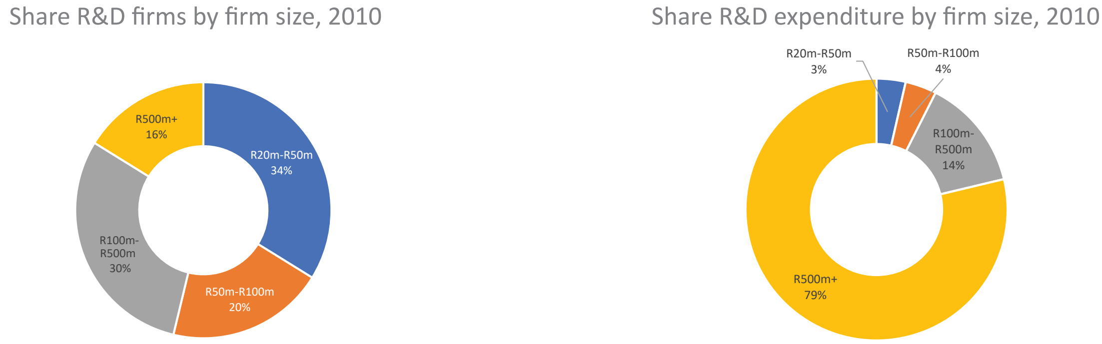
Firms across all the size categories experience the general decline in R&D intensity from 2010 to 2018. R&D intensity is higher amongst smaller firms, averaging 1% for firms with sales in the range of R20 million to R100 million over the entire period. For firms with R100 million or above sales, the average R&D intensity was substantially lower, although more stable, at 0.6%. On average, R&D intensity declined for firms in all these size categories from 2011 to 2018. The category of small firms mainly drives the v-shaped increase and decrease in average R&D intensity in 2019. The effect of this change on aggregate R&D expenditure is minimal given the small contribution of these firms to aggregate R&D expenditure.

R&D expenditure is concentrated in a few large firms.

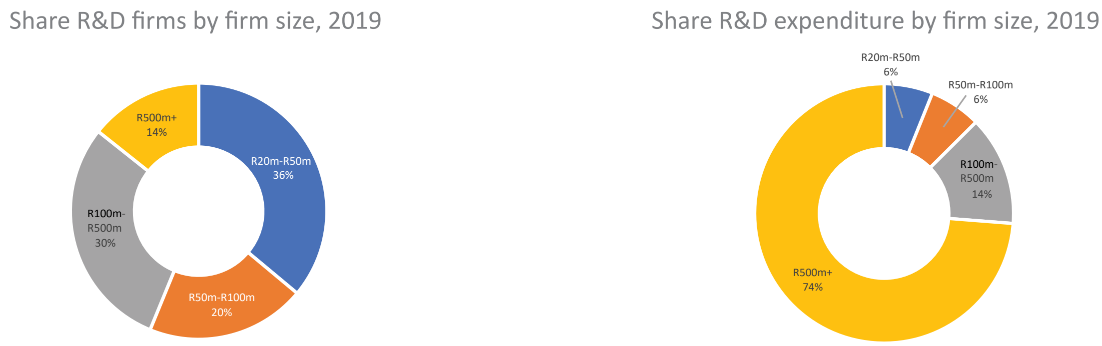
Figure 22 presents pie charts illustrating the distribution of R&D firms across firm size categories and their share of total R&D expenditure in 2010 and 2019. Large firms with real sales of R500 million or more account for only 14%-16% of all R&D firms, but make up 74% to 79% of aggregate R&D expenditure. When looking within this large R500 million plus firm category, firms with sales of R1 billion or higher account for just over 90% of the share R&D expenditure by this group of large firms (they make up 66% of firms in the large firm category).

Figure 22: Share R&D firms and R&D expenditure by firm size category, 2010 to 2019

(a) 2010



(f) 2019



Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D purchases from related foreign firms.

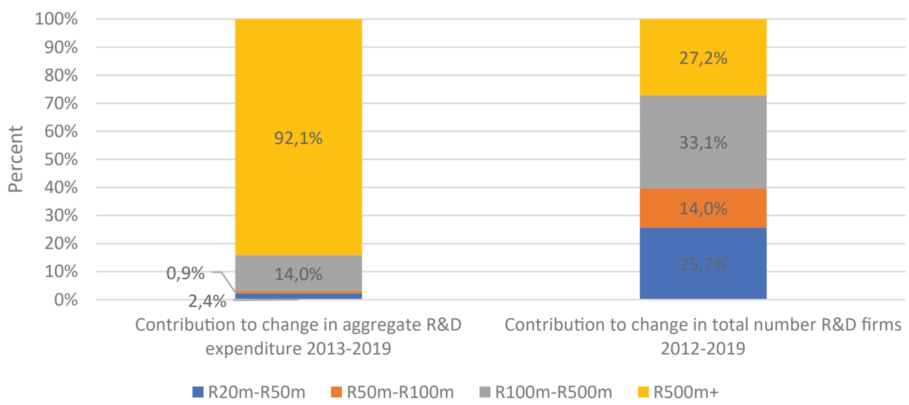
The sales category R20 million to R50 million accounts for the highest share of R&D firms (34%-36%) but the lowest share of aggregate R&D expenditure (3%-6%). The size distributions have mostly stayed the same over the 2010-2019 period, although there has been a slight decline in the relative share of the R500 million-plus firms, both in terms of firm numbers and R&D expenditure. Further, the share of the smallest firms in aggregate R&D expenditure doubled from 3% to 6%.

Large firms were the main drivers of the downward trend in total R&D firm numbers and total R&D expenditure from 2012 to 2019.

As shown earlier, the sharp decline in aggregate R&D expenditure by the panel of firms in the sample commenced in 2013, while the decline in the total number of R&D firms commenced in the year prior, 2012. To assess the relative contribution of firms by size category to these declines, Figure 23 decomposes the change in aggregate R&D expenditure and number of R&D firms from 2012 to 2019 into the shares attributable to each size category. Aggregate expenditure on R&D halved between 2012 and 2019, with the bulk (83%) of this decline attributable to falling R&D expenditure by large firms with annual sales of R500 million or more. Large firms only accounted for 78% of total R&D expenditure in 2012, implying a disproportionate contribution to the decline in aggregate R&D expenditure over the period.

Similarly, the number of R&D firms declined by a third between 2012-2019, with large firms accounting for 27% of this decline, despite initially making up only 19% of R&D firms. While small and medium firms engaged in R&D activities also fell, their contribution to the aggregate decline (26%) was lower than their initial share of firms in 2012 (33%). In conclusion, large firms with annual sales of R500 mill and above, disproportionately drove the decline in the number of R&D firms and the aggregate expenditure by firms on R&D activities over the past decade.

Figure 23: Contribution to change in aggregate R&D expenditure and total number of R&D firms by firm size category, 2012 to 2019

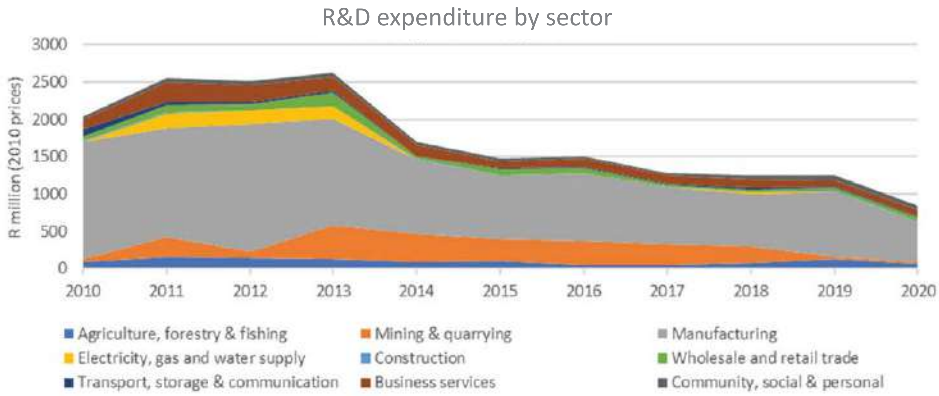


Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D purchases from related foreign firms.

Manufacturing firms make up the largest source of aggregate R&D expenditure and have been the main, but not the only, contributor to its decline

Figure 24 presents R&D expenditure by major economic sector, as defined according to the 1-digit Standard Industrial Classification. Manufacturing firms are the primary source of business R&D expenditure, making up 62% of aggregate R&D expenditure, on average, each year from 2010 to 2019. Manufacturing is followed by mining & quarrying (14%), business services (8%) and agriculture, forestry & fishing (6%). Construction firms make up the lowest share, with less than half a per cent over the period.

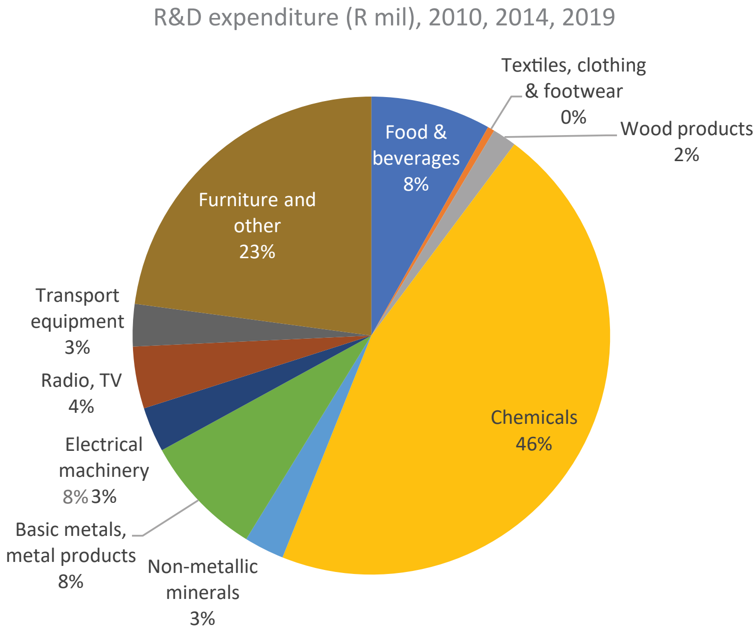
Figure 24: R&D expenditure by major sector, 2010 to 2019



Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D purchases from related foreign firms. Sectors are classified at the 1-digit level of the Standard Industry Classification (SIC).

The industry composition of aggregate R&D expenditure changes considerably over years, with R&D by mining firms rising strongly from 2% in 2010 to 22% in 2014, before falling back down to 3% in 2019. Nevertheless, over the entire 2010-2019 period, manufacturing firms disproportionately contributed towards the decline in aggregate R&D expenditure, accounting for 90% of the total decline from 2010 to 2019. Over this period, the manufacturing firm's share of total R&D expenditure fell from 77% to 68%.

Figure 25: Share aggregate R&D expenditure manufacturing industry, average 2010, 2014 and 2019

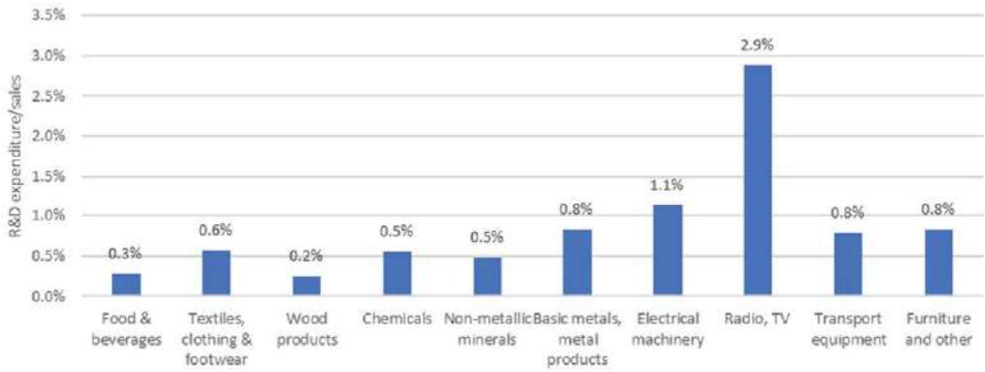


Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D purchases from related foreign firms. Industries are classified at the 2-digit level of the Standard Industry Classification (SIC).

Within manufacturing, Chemicals firms account for the highest share of R&D expenditure (43%), followed by other firms (23%) and Basic metals/metal products firms (10%) (Figure 25). The industries contributing the lowest share to aggregate R&D expenditure are Textiles, clothing & footwear (<1%), and Wood products (2%).

Firms in the Radio, TV & communications and Electrical machinery industries also make up low shares of aggregate R&D expenditure (3%-4% each) but rank highly when measured in terms of firm R&D intensity, as shown in Figure 26 R&D firms in the Radio, TV, and communication industry spend the equivalent of 2.9% of their sales on R&D activities. The average R&D intensity for electrical machinery firms is 1.1%. R&D intensity in R&D firms in the Chemical industry is substantially lower (0.5%) despite the industry accounting for the highest share of R&D expenditure. Low R&D intensity levels are also found in Food and beverages (0.3%) and Wood products (0.2%).

Figure 26: Firm R&D intensity by manufacturing industry, average 2010, 2014 and 2019 no 2019



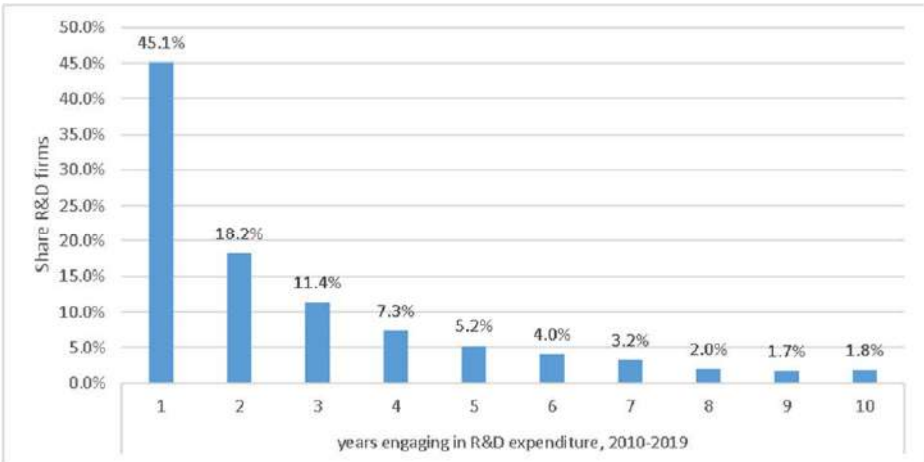
Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D purchases from related foreign firms. Industries are classified at the 2-digit level of the Standard Industry Classification (SIC).

Relatively high R&D intensity levels are also found in several of the services industries. For example, the average R&D intensity within R&D firms in 2019 exceeded 2% for Auxiliary business services (3.1%), Education services (2.6%) and Computer services (2.1%) (see Figure 65 in Annex A).

Persistence of regular R&D expenditure is weak (as also found by Steenkamp, et al. 2018)

Significantly few firms engage in R&D activities on a persistent basis. Figure 27 presents the distribution of R&D firms according to the years they were engaged in R&D activities from 2010 to 2019. Nearly half of the firms (45%) only reported R&D expenditure in one financial year. Only 1.8% of the R&D firms engaged in R&D activities in all years. The larger firms are far more likely to persist in R&D expenditure than smaller firms, but even these large firms only engage in R&D activities on an irregular basis. For example, from 2010 to 2019, large firms with sales above R500 million (in 2013 prices) that engaged in R&D activities only did so for 3.4 years, whereas R&D firms with annual sales between R20 million to R50 million engaged in R&D activities for 2.4 years on average.[8]

Figure 27: Distribution of R&D firms according to number of years engaged in R&D activities from 2010 to 2019



Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D purchases from related foreign firms. Sample covers 2954 firms that reported R&D expenditure at least once from 2010 to 2019.

The decline in the number of firms engaging in R&D is driven by higher rates of firm exit from R&D than firm entry rates into R&D

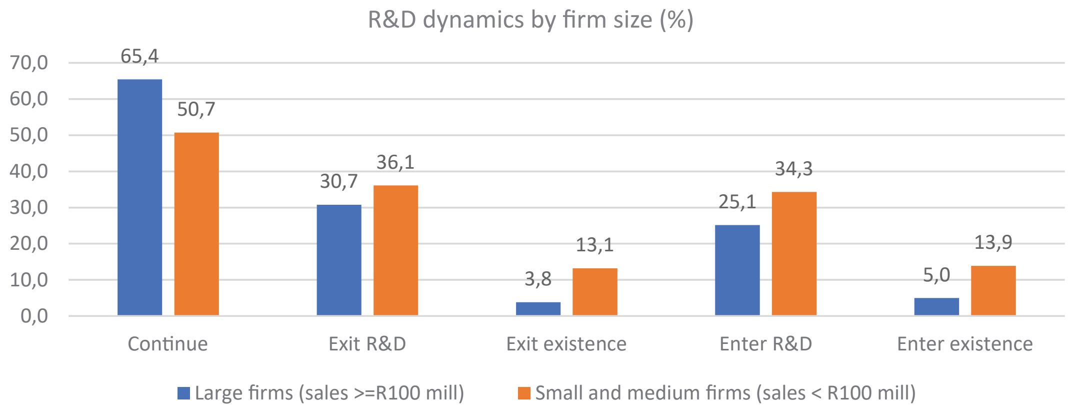
Additional insight into the R&D firm dynamics is provided in *Figure 28*. This figure presents the average share of firms that continue, exit or commence R&D activities each year from 2010 to 2019. "*Continue*" denotes R&D firms that continue R&D

8 These values reflect the mean number of years firms engage in R&D activity, after taking into account the probability of a firm exiting the sample. It is necessary to take this into account as smaller firms are more likely to exit from the corporate income tax database. The values are derived from a regression of the number of years engaged in R&D activity on size categories, while including a variable for the count of years the firm is observed in the sample. The sample covers 2954 firms that reported R&D expenditure at least once from 2010 to 2019.

activities into the current period, measured as the share of the number of R&D firms in the prior year. The exiting of firms from R&D activities can either reflect the discontinuation of R&D activities by firms that continue to operate or the exit of firms from the sample. Firms may exit from the sample because they have closed and discontinued production or did not submit their income tax documents. It is impossible to systematically identify which of these two exit options apply. Consequently, we split exiting R&D firms into those that exit from the database (denoted "*Exit existence*") and those that continue production but discontinue R&D activities ("*Exit R&D*"). The exit rates are calculated as the number of firms that exit in the current year as a share of the total number of R&D firms in the prior year.[9]

Also presented are entry rates for continuing firms that commence R&D expenditure in the current year (denoted "*Enter R&D*") and firms engaging in R&D that enter the sales data in the current financial year. The entry rates are calculated as the number of R&D entrants as a share of all R&D firms in the year of entry. To assess how firm size affects R&D firm dynamics, the sample of firms is split into small and medium-sized firms with real sales from R20 million to R100 million and larger firms with real sales of R100 million and above.

Figure 28: Entry and exit dynamics of R&D firms, 2010 to 2019



Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D purchases from related foreign firms. Sample covers firms that reported R&D expenditure at least once from 2010 to 2019. Firms are allocated to a size category according to their mode of real sales over the period.

R&D firm entry and exit rates are high, particularly for small and medium firms. On average, 49% of small and medium firms discontinue R&D activities, with 13 percentage points of this driven by firms exiting the sample and 36 percentage points attributed to continuing firms that no longer incur expenditure on R&D activities. The exit rate for larger firms is lower at 34.6%, with 30.7 percentage points driven by operating firms discontinuing R&D expenditure.

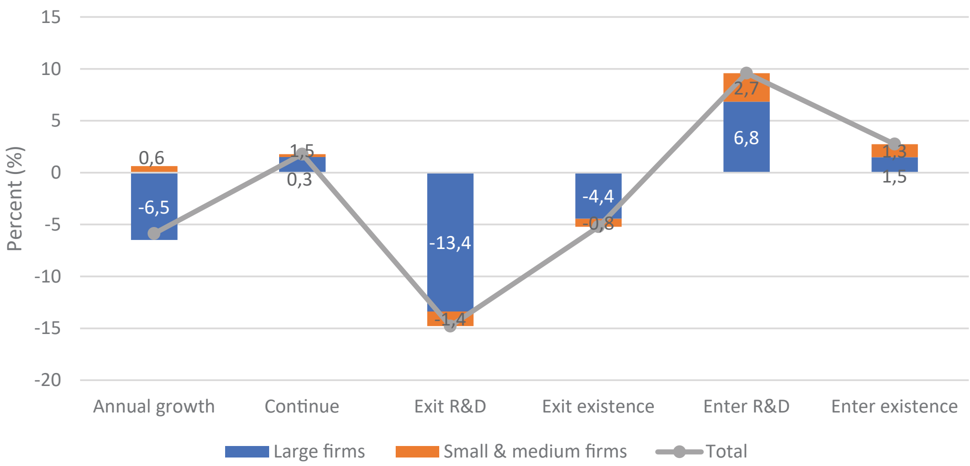
The firm entry rates into R&D are also high (48.2% for small and medium firms, 30.1% for larger firms) but lower than the exit rates, leading to a decline in the total number of R&D firms over the period. This is particularly the case for larger firms, which explains their disproportionate contribution to the decline in the total number of R&D firms.

The exit from R&D activities by firms is a major contributor to the decline in growth of business expenditure on R&D

Using simple decomposition approaches, we isolate the contribution of firm entry, exit and continuing dynamics to growth in aggregate expenditure on R&D. Figure 29 summarises the finding of the decomposition analysis and presents the contribution of R&D expenditure by continuing firms (intensive margin contribution) and exiting/entering firms (extensive margin contribution) to growth an aggregate business expenditure on R&D over the period 2012 to 2019.

9 Regressions of the probability of exiting from R&D show that larger, more productive firms that export and are part of a multinational company are less likely to exit from R&D activities than other firms.

Figure 29: R&D firm dynamics and their contribution to growth in aggregate expenditure on R&D, 2012-2019



Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D purchases from related foreign firms. Firms are allocated to a size category according to their mode of real sales over the 2010-2019 period.

Business expenditure on R&D fell by an average of 6% per year from 2012 to 2019, with all of this decline attributed to the larger firms.[10] Surprisingly, the positive impact of continuing R&D firms on growth in aggregate expenditure on R&D is very low (1.5% for larger firms, 0.3% for small and medium firms). Continuing R&D firms, on average, are not increasing their R&D expenditure. The most significant driver of the change in aggregate spending in R&D is the exit of firms from R&D activities, particularly for large firms. In total, larger firms exiting from R&D expenditure through both exit channels reduced aggregate expenditure on R&D by 17.8% per year.

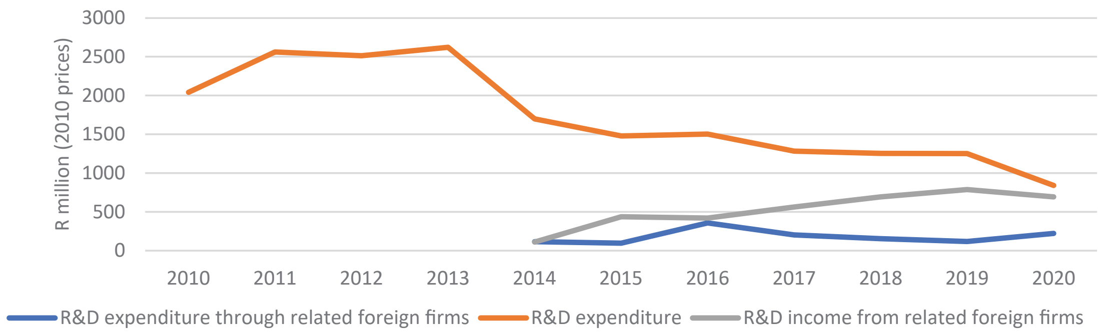
New firms engaging in R&D activities could only offset part of the loss in aggregate R&D expenditure associated with R&D firm exit. However, in contrast to larger firms, entry into R&D by small and medium firms more than offset the losses associated with exit from R&D by this category of firms. The contribution of these small- and medium-sized firms to changes in aggregate expenditure on R&D. however, is low, given their relatively minor share of the total expenditure by businesses on R&D.

Expenditure on R&D activities mainly occurs directly within the firm and, to a lesser extent, through foreign-related companies

South African branches of overseas companies can conduct R&D activities within the branch ('in-house') or through their foreign-related partner. In effect, these South African branches are conducting R&D through their foreign connected partner. This expenditure is declared in the corporate income tax submissions under the Transfer Pricing component of the submission. Figure 30 presents R&D expenditure through related foreign firms with R&D expenditure within the firm. R&D expenditure on related foreign firms shows no distinctive trends, averaging R172 million from 2014 to 2020. The low value reflects the low number of firms (less than 25) that declare expenditure through foreign-related companies. Nevertheless, R&D expenditure through foreign associated companies has been more resilient to the general decline in business investment, including in R&D.

10 Note that small and medium firms experienced a slight increase in R&D expenditure, which contrasts with the earlier findings where R&D expenditure fell for all size groups. This arises because in Figure 29, firms are allocated to a size category according to their mode of real sales over the 2010-2019 period.

Figure 30: Firm expenditure on R&D directly and via foreign related firms compared to receipts from R&D by foreign related firms, 2010 to 2020



Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. The line for R&D expenditure excludes expenditure through related foreign firms. Only 19 to 32 firms declare R&D income from related foreign companies between 2014 and 2020.

Domestic firms are increasingly conducting R&D for foreign related firms

Several firms are part of multinational groups and receive income for R&D conducted for the connected companies. Under Section 31 of the Income Tax Act of 58 of 1962 (ITA), any cross-border transactions with related parties are to be declared in the income tax submissions and priced according to an 'arms-length' principle (a price that would be negotiated in the open market between a willing buyer and willing seller). This rule applies to South African branches of overseas companies that have cross-border related party transactions.

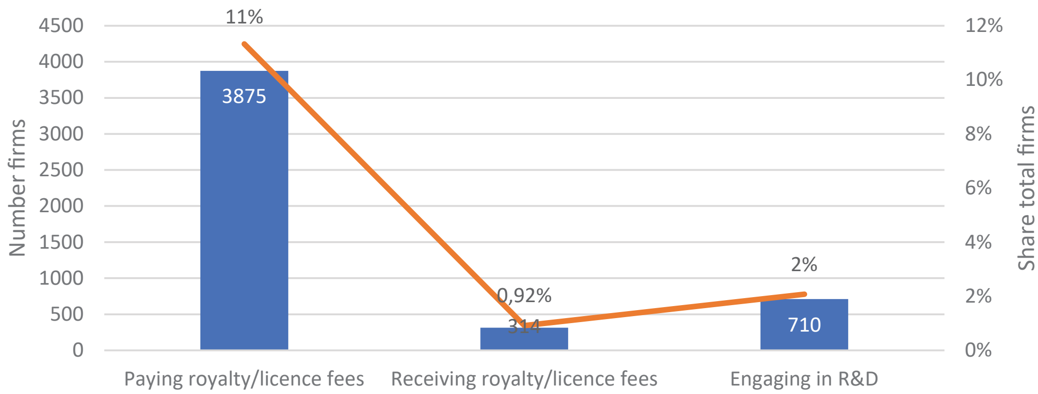
According to the income tax data, receipts from R&D conducted for foreign-related companies have risen steadily from around R438 million in 2015 to R694 million in 2020. This trend contrasts with the trend in aggregate R&D expenditure. However, these numbers are driven by very few, albeit rising numbers of firms (from 17 in 2015 to 26 in 2019), indicating that this type of R&D is not widespread. The low numbers also imply that it is impossible to draw meaningful conclusions regarding these firms' firm and industry characteristics.

Significantly more firms make use of royalty and licence agreements to access know-how than through in-house or related company R&D

Firms can produce innovative knowledge and intellectual property in-house through R&D and acquire this through the payment of royalties or licence fees to patent owners for the right to use that asset. Firms may also access foreign technology and know-how through foreign ownership and technology embodied in imported intermediate and capital goods. The availability of multiple sources of technology and know-how raises several interesting questions. For example, are R&D expenditures, royalty payments, and imported technology embodied in goods complements or substitutes? Does access to outside patents reduce or increase the incentive or need for R&D within a company? Firms, for example, may need to complement imported or external technologies with local research efforts to tailor products and processes to local needs (Hines, 1995).[11]

11 "*R&D can serve functions not directly tied to the creation of new products, such as concept exploration, hypothesis testing, and market credibility, which are all activities that can complement the investment made on a technology licensed from other firms or institutions*" (Ceccagnoli et al., 2014: 126).

Figure 31: Average number of firms and share total firms paying royalty/licence fees and engaging in R&D activities, average 2014-2019



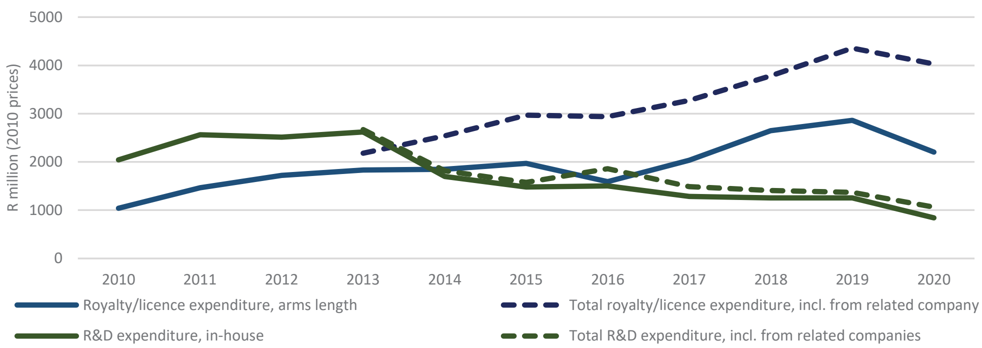
Note: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Includes R&D and royalty/licence fees from related foreign firms.

For insight into the relative prevalence of in-house R&D compared to the acquisition of external know-how through royalty/licence agreements, Figure 31 plots the average number of firms sourcing knowhow through these two channels between 2014 and 2019. Far more firms acquire innovative knowledge through in-licensing than through in-house R&D. On average, 3 875 firms made use of royalty/licensing agreements each year from 2014 to 2019, compared to 710 firms that engaged in R&D activities.

Firms increasingly spend more on royalties and licence fees than on R&D

Figure 32 compares aggregate expenditure on R&D with total firm expenditure on royalty and licence fees. The figure shows diverging trends in aggregate firm R&D expenditure and royalty/licence fees (in-licensing expenditure) payments. The CIT data provides information on different sources of in-licensing expenditure: (i) gross expenditure on royalties and licensing fees from non-related companies ('arms-length), and (ii) expenditure from related companies (almost entirely foreign). Whereas total in-licensing expenditure from all sources rose 72% from 2014 to 2019, total R&D expenditure fell by 25%. By 2019, total in-licencing expenditure was 3.4 times the total expenditure on R&D activities.

Figure 32: Aggregate firm expenditure on R&D and Royalties/License fees

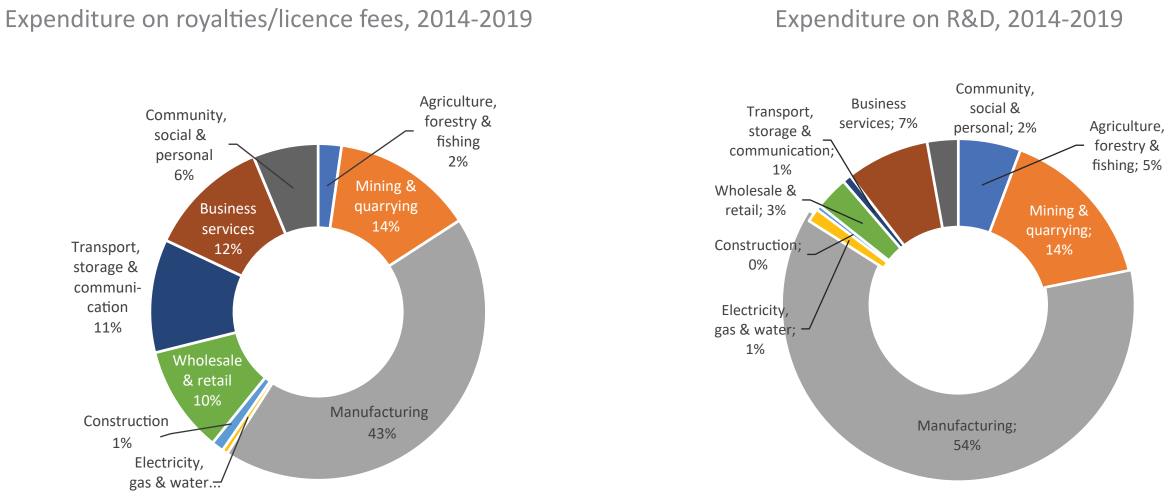


Note: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Includes R&D and royalty/license fees from related foreign firms. Nominal values are deflated to 2010 values using the GDP deflator.

The composition of in-licensing expenditure has also changed, with expenditure on foreign-related companies rising from 27% in 2014 to 44% in 2019. This contrasts with expenditure on R&D conducted by foreign-related companies, which remained low (11% on average) throughout the period.

Aggregate expenditure on royalties/licence fees is also more broadly spread across major sectors than R&D expenditure. However, manufacturing firms still dominate making up 43% of total expenditure (vs. 54% for R&D expenditure) on average each year from 2014 to 2019 (Figure 33 and Table 5). The share of aggregate expenditure on royalties/license fees is also relatively high in Transport, storage & communication (14%), Wholesale and retail (10%) and Community, social & personal services (6%), but is lower in Agriculture (2% vs. 5%).

Figure 33: Comparison of shares aggregate expenditure on royalties/licence fees and R&D by major sector, average 2014-2019



Note: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Includes R&D and royalty/licence fees from related foreign firms. Nominal values are deflated to 2010 values using the GDP deflator. The pie graphs are constructed using the average of the annual share of each sector over the period 2014 to 2019.

Finally, firms that have in-license know-how spend more on royalty/licence fees as a share of their sales (Royalty/licence intensity) than the expenditure by R&D firms on R&D activities (R&D intensity). For example, in-licencing firms spent the equivalent of 1.6% of their sales value on royalty/licence fees between 2014 and 2019, whereas R&D firms only spent the equivalent of 0.8% of their sales on R&D. The share royalty/licensing expenditure in sales is highest for Business services (3.2% of sales from 2014 to 2019), followed by Community, social & personal services (2.5%) and mining & quarrying (1.7%). The greatest share of firms making use of royalty payments/licence fees to access intellectual property is in mining & quarrying (26.6%), followed by wholesale and retail trade (14.8%) and Agriculture, forestry & fishing (14.5%). Although manufacturing firms account for the highest share of royalty/licence fees (43%), this is concentrated within 10.4% of manufacturing firms.

Table 5: Characteristics of firms by R&D status and Royalty/licence fee status, average 2014-2019

	R&D expenditure and shares				Royalty and licence fee expenditure and shares			
	Total value (R million) (2010 prices)	Share total value (%)	R&D firms as share all firms (%)	R&D intensity (%)	Total value (R million) (2010 prices)	Share total value (%)	Royalty/licence fee firms as share all firms (%)	Royalty/licence expenditure as share sales (%)
Agriculture, forestry & fishing	90.8	5.0%	2.8%	0.8%	701.9	2.1%	14.5%	0.6%
Mining & quarrying	255.3	14.0%	3.9%	0.9%	4441.4	13.4%	26.6%	1.7%
Manufacturing	985.7	54.1%	3.9%	0.7%	14122.7	42.7%	10.4%	1.5%
Electricity, gas and water supply	19.9	1.1%	2.5%	0.6%	187.5	0.6%	7.2%	1.1%
Construction	6.9	0.4%	0.7%	0.6%	387.1	1.2%	4.2%	0.8%
Wholesale and retail trade	48.5	2.7%	0.7%	0.4%	3355.9	10.1%	14.8%	1.4%
Transport, storage & communication	12.5	0.7%	1.0%	0.6%	3995.1	12.1%	7.2%	1.6%
Business services	121.2	6.7%	1.9%	1.6%	3774.3	11.4%	8.2%	3.2%
Community, social & personal	45.0	2.5%	2.2%	0.9%	2145.9	6.5%	9.9%	2.5%
Total	1821.0	100.0%	2.1%	0.8%	33111.8	100.0%	11.3%	1.6%

Note: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Includes R&D and royalty/license fees from related foreign firms. Nominal values are deflated to 2010 values using the GDP deflator. R&D intensity is calculated as the R&D expenditure as share firm sales value. Royalty/licence fee expenditure as share sales (final column) only covers firms that in-licence knowhow.

Box 2: Characteristics of small R&D firms

This section presents an overview of how findings of the small firms differ/complement the findings in of large firms in the tax data. This small firm analysis draws on the firm-level innovation survey dataset for South African small and micro enterprises firms collected in 2019 in Johannesburg (for details, see Kamutando & Tregenna, 2023). The survey data were collected for the manufacturing firms with 50 or fewer workers. A total of 711 eligible firms were enumerated. The dataset includes information on firm characteristics (such as firm age, industry, ownership, sales, capital, employment), and innovation and R&D. In the survey *innovation* refers to a new or improved product or process that differs significantly from the previous products or processes done in this establishment. In contrast, *R&D* refers to creative work undertaken on a systematic basis to increase the stock of knowledge and using it for innovation. The definitions of R&D therefore differs, and is broader, than that in the tax data.

To understand firm heterogeneity in innovation and R&D decisions, firms are grouped into four categories: innovative and R&D, innovative and non-R&D, non-innovative and R&D, and non-innovative and non-R&D. See Annex E for detailed small firm results.

How do the findings of the small firms differ/complement the findings in the tax data?

The findings from the small firm survey and tax data offer complementary and different insights.

- Larger firms tend to be more involved in both innovation and R&D compared to smaller counterparts. Results from the small firm survey and the tax data both show that it is large firms that are more engaged in R&D than smaller firms.
- The small firm survey shows that Food, Beverages and Tobacco have the highest proportion of firms engaging in R&D and innovation,. In contrast, the tax data shows that, within manufacturing, Chemicals firms account for the highest share of R&D expenditure. This difference might be a result of differences in the definitions of R&D between small firm surveys and the tax data.

Other insights exclusive to small firm survey

- Formal firms are more likely to engage in R&D and innovation than informal firms.
- Financial constraints are a big challenge for small firms. Financially constrained firms are less likely to be involved in R&D and innovation activities.
- The majority of firms source innovation externally. This may reflect a lack of firm resources or capabilities to conduct innovation in-house and/or a greater willingness to collaborate with external entities.
- Most small firms are engaged in product innovation (developing new products or improving existing ones) compared to process innovation.
- Firms that introduce new products or processes while engaging in R&D tend to report positive changes in sales and profits.

4.4 Heterogeneity between R&D and non-R&D firms

The prior section presented an aggregate picture of firm R&D expenditure. Firms differ enormously in terms of their characteristics, including productivity, size, employment and international trade status. This section digs deeper to analyse how R&D firms differ from non-R&D firms in terms of their firm characteristics.

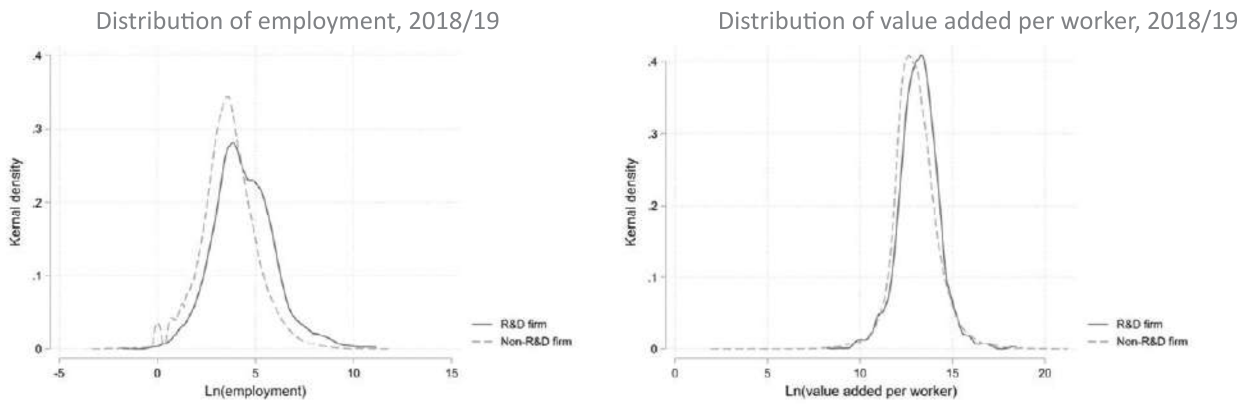
There is a considerable degree of heterogeneity in terms of characteristics across all firms, including R&D firms.

Available firm literature points to substantial heterogeneity across firms, even within narrowly defined industries. This also applies to South African firms. To illustrate this, Figure 34 presents kernal density estimates of the distribution of value added per worker and employment across firms in 2018 and 2019. Firms are separated according to whether they engaged in R&D (R&D firm) or not (non-R&D firm). The sample of firms only covers those with real sales values of R20 million or more (in February 2018 prices). Smaller firms are, therefore, excluded from the analysis.

Looking first at employment, the range of firm sizes according to employment numbers is wide, with the bulk of firms falling within the range of 13 to 1800 workers (or, in natural logarithms, from 2.5 to 7.5). The distribution of R&D firms is slightly to the right of non-R&D firms, indicating higher average employment levels for firms. For example, the average size of an R&D firm in the sample of the 2018-2019 period was 522 compared to 147 for non-R&D firms. Similarly, productivity levels, measured as real value added per worker, vary widely, with the distribution of R&D firms slightly to the right of non-R&D firms revealing higher productivity levels of R&D firms on average.

However, even within R&D firms, we find wide variation in employment levels and productivity (and many other indicators such as trade values, wages, sales, etc). These within-category differences in firm characteristics swamp the differences in the average value of firm characteristics between categories. The implication in this context is that the average R&D firm is not necessarily representative of the other R&D firms. Similarly, the responsiveness to policies to increase R&D is likely to vary considerably across firms.

Figure 34: Kernal density estimates of the distribution of firm value added per worker and firm employment over period 2018-2019.



Note: Firm panel based on R20 million in turnover in February 2018 prices sales cut-off. Excludes R&D purchases from related foreign firms.

Despite the high variation, the mean values of firm characteristics can still provide useful insights into key differences between R&D and non-R&D firms.

R&D firms pay higher wages and are larger in terms of employment, value added, productivity, capital stock, and sales. They are also more likely to have foreign ownership and be part of a multinational enterprise (local or foreign owned).

Table 6 compares the simple average values of firm characteristics between R&D and non-R&D firms from 2018 to 2019. On average, R&D and non-R&D firms differ enormously in most production and employment levels. Value added of the average R&D firm over this period (R40 million in 2013 prices) was nearly three times the value added of the average non-R&D firm (R14 million). The value gap added per worker (R412 thousand for R&D firms, R350.7 thousand for non-R&D firms) is much lower than the gap in value-added, reflecting the significantly higher employment levels in R&D firms. The higher value-added per worker in R&D firms, in part, arises from higher levels of capital per worker (R65.2 thousand vs. R37.6 thousand). Wages in R&D firms are also higher on average (R160.6 thousand vs. R129.5 thousand), which can arise from the higher productivity of their workers together with differences in the skill composition of the workforce. Unfortunately, the data do not provide information on the education status of workers, so a comparison according to skills or education levels is not possible. Finally, R&D firms are more likely to be foreign-owned (10.4% vs. 5.3%) and part of a local or foreign-owned multinational enterprise (18.1% vs. 7.9%).

Table 6: Mean characteristics of firms by R&D status, average 2018-2019

		R&D firms	Non-R&D firms
Value added	R mill	40.1	14.0
Capital stock	R mill	6.6	1.6
Capital/Labour	R'000	65.2	37.6
Value added/Labour	R'000	412.0	350.7
Sales	R mill	114.5	60.0
Employment		95.4	42.5
Wage	R'000	160.6	129.5
Foreign ownership strict	share (%)	10.4%	5.3%
Multinational enterprise	share (%)	18.1%	7.9%

Note: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D and royalty/licence fees from related foreign firms. The averages are based on the mean log value of each variable, with exception of foreign ownership and multinational enterprise.

R&D firms are also far more integrated into global markets. They are more likely to be exporters and/or importers, particularly of high-technology products, and have higher export values and export varieties.

Table 7 presents mean trade characteristics by firm R&D status using data for 2018-2019. Just over two-thirds of R&D firms exported over the 2018-2019 period, compared to less than a third (28.1%) of non-R&D firms. Their average export value per annum (R192.7 million) is more than twice that of non-R&D firms (R91.4 million). On average, R&D exporters export 82.6 varieties, which is defined as a product-destination combination, compared to 56.7 varieties for non-R&D firms that export. However, R&D firms tend to export a narrower range of products to each destination (6.5 vs. 10.2), albeit to a broader range of destinations per product (1.9 vs. 1.6).

R&D firms are also more likely to export high-technology products (37% vs. 12.4%). As Lall (2000), who developed the technology classification system used, compared to other products, technology-intensive products offer better prospects for future growth as global demand for these products has risen strongly; they have greater potential for further learning because they offer scope to apply scientific knowledge, and they have larger spillover effects in terms of creating new skills and generic knowledge. R&D firms that export are also more likely to be integrated into global value chains, as reflected by a higher share of R&D firms that import (70.7%) than non-R&D firms (30.7%). Close to half of the R&D firms import high-technology goods to be used in production, including the production of the high-technology goods exported. Edwards et al. (2022), for example, show a close association between firm imports of high-technology goods and export propensity, export value, and range of products and destinations.

Table 7: Mean trade characteristics by R&D status, 2018-2019

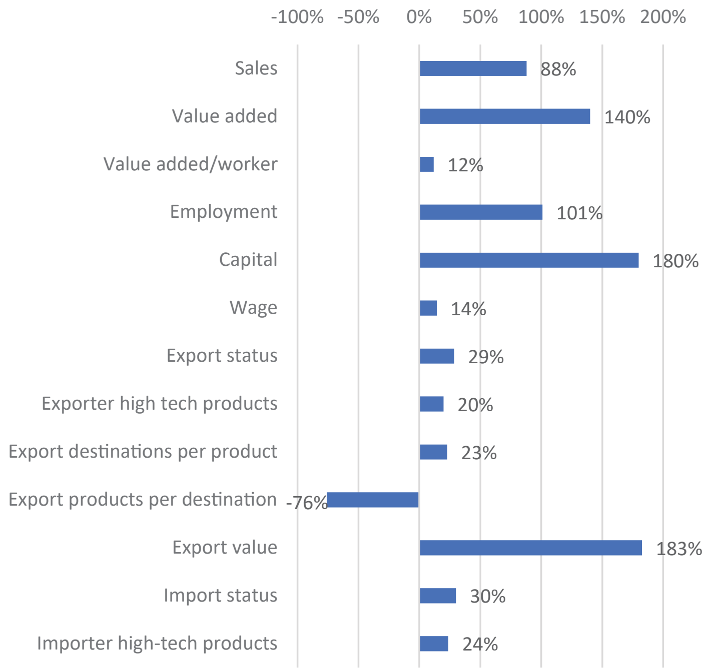
	R&D firms	Non-R&D firm
Share exporters	67.2%	28.2%
Share exporters high-tech	37.0%	12.4%
Export products per destination	6.5	10.2
Export destinations per product	1.9	1.6
Export varieties	82.6	56.7
Export value (R mill)	192.7	91.4
Import value (R mill)	121.4	79.0
Import products per origin	4.4	5.1
Import origins per product	1.4	1.4
Import variety	69.6	55.7
Share importers	70.7%	30.7%
Share importers high-tech	47.4%	17.0%

Note: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D and royalty/licence fees from related foreign firms. High-technology products are classified according to the technology classification of trade developed by Lall (2000). The averages are based on the mean log value of each variable, with the exception of the share variables.

While informative of how firm trade, production and employment characteristics vary by firm R&D status, the comparisons presented do not control for other firm characteristics such as industry, time and location. We, therefore, test for significance in the difference in attributes across importer status by following the approach of Bernard and Jensen (1995). In this approach, we regress each firm characteristic on R&D status together with industry (SIC 3-digit level), financial year and province fixed effects (See Box 3 for an explanation of fixed effects in regression analysis). The results, including further discussion of the specification, are presented in the Annex D.

The estimated percentage difference between R&D firms and non-R&D firms for each firm characteristic is presented in Figure 35. The results corroborate those presented in Table 6 and Table 7. In all but one case (for export products per destination), R&D firms have statistically significantly higher values in terms of characteristics than non-R&D firms. Overall, these results show that firms that engage in R&D are characterised by higher production, employment, wages, productivity, and export performance as measured by export participation, high-technology exports, number of products, and export value compared to other firms.

Figure 35: Percentage difference between R&D firms and non-R&D firms according to firm characteristic, 2018-2019



Note: Based on ordinary least squares regressions of firm characteristics on R&D status plus fixed effects for 3-digit industry, financial year and province over 2018-2019. The sample of firms is based on R20 million in turnover in April 2013 prices sales cut-off. Excludes R&D and royalty/licence fees from related foreign firms. The percentage difference is calculated as the exponent of the estimated coefficient on R&D status minus 1. See Annex D Table 18 for the regression results.

Box 3: The role of fixed effects

The inclusion of **fixed-effects variables helps control for potential unobserved characteristics that also influence the relationship between the variables of primary interest. These fixed effects** help diminish biases in the estimated coefficients that could otherwise arise.

- **Time fixed effects:** Controls for aggregate year shocks affecting all firms regardless of geographic location or industry.
- **Province fixed effects:** Controls for the difference between firms associated with their geographic location. These fixed effects help control for influences such as the density of firms that could affect both firm performance and R&D activities.
- **Industry fixed effects:** Controls for the difference between firms associated with their industry. Firms in some industries, such as the electrical machinery industry, are likelier to engage in R&D activities. Industry-fixed effects are included to ensure that this industry-specific feature does not drive the results.
- **Firm fixed effects:** Controls for the difference between firms that do not change over time and are unrelated to the firm's geographic location or industry. This fixed effect has significant implications for how the results are interpreted. The inclusion of firm fixed effects implies that the analysis results are determined by changes in firm R&D status and outcomes (exports, productivity, etc.) that occur *within* firms over time. Differences in firm characteristics (that do not change over time) do not influence the outcome. These firm-fixed effects help to control for some of the endogeneity concerns that could bias the estimates.

  For example, firms with better management may be more productive and consequently more able to cover the costs of R&D goods. If we don't control for management ability, then an estimated positive association between R&D technology and firm productivity could merely reflect the management-productivity association. Because we don't have information on management abilities and other firm characteristics that don't change over time, we use the firm fixed effect to control such associations and ensure they do not bias our estimated coefficients.

4.5 Determinants of R&D activity and R&D intensity by firms

While Figure 35 reveals distinct differences in the characteristics of R&D firms compared to non-R&D firms; these differences do not control for confounding influences from other variables. For example, the positive association between size and R&D status, may indirectly reflect the greater likelihood that productive firms, which also tend to be large, engage in R&D. The figure, therefore, does not reveal the relative importance of each of the firm characteristics in explaining whether a firm engages in R&D activities Further, aggregate R&D expenditure is a function of the number of firms engaging in R&D activities and the value of R&D expenditure by these firms. Firm characteristics driving the intensity of R&D expenditure (measured as R&D expenditure as share sales) within an R&D firm may differ from those characteristics explaining how much the R&D firm spends on R&D.

Table 8, therefore, presents several estimates to provide insight into extensive margin drivers of R&D engagement by firms (column (1)), as well as the firm characteristics that influence how much these firms spend on R&D, i.e., the intensive margin drivers (columns (2) and (3)). The regressions are estimated over the period 2017 to 2019.

Determinant of R&D activity

In column (1) of Table 8, we estimate a linear probability model to assess how different firm characteristics jointly contribute to the probability of a firm engaging in R&D.[12] The dependent variable in this regression equals one if the firm engages in R&D, and the coefficients on the explanatory variables reveal how they influence the probability that the firm engages in R&D.

Table 8: Estimates of characteristics determining the probability of being an R&D firm and the intensity of R&D within firms, 2017-2019

	(1)	(2)	(3)
	R&D participation	R&D intensity	
	R&D status	Excluding zero R&D firms	Including zero R&D firms
	OLS	OLS	PPML
Value added/worker	0.007**	0.001+	0.338**
	(0.001)	(0.001)	(0.067)
Employment	0.008**	-0.001	0.205**
	(0.001)	(0.000)	(0.062)
Exporter	0.012**	0.000	0.504*
	(0.002)	(0.001)	(0.219)
Importer	0.012**	-0.001	0.318
	(0.002)	(0.001)	(0.222)
Exporter high tech products	0.009**	0.005**	0.816**
	(0.003)	(0.002)	(0.261)
Importer high-tech products	0.006+	0.001	0.29
	(0.003)	(0.001)	(0.242)
Foreign ownership	-0.021*	-0.003	-0.555
	(0.009)	(0.005)	(0.516)
Multinational enterprise	0.016*	0.003	0.459
	(0.008)	(0.004)	(0.479)
Royalty paying firm	0.012**	-0.004**	-0.274
	(0.003)	(0.001)	(0.235)
Industry concentration	0.002+	-0.001*	-0.239**
	(0.001)	(0.001)	(0.1)
Constant	-0.112**	-0.003	-14.289**
	(0.013)	(0.008)	(1.047)
Observations	88,935	1,829	88,931
R-squared	0.034	0.064	

Note: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D and royalty/licence fees from related foreign firms. R&D intensity is measured as the R&D expenditure as a share of sales. The estimates include fixed effects for three-digit industries, financial year and province. Value added/worker, employment and industry concentration are in natural logarithms, while the remaining variables are categorical variables. Foreign ownership is defined according to the strict definition of Kilumelume et al. (2021), i.e. firms declaring themselves to "being ultimately foreign-controlled". Industry concentration of sales is measured using the natural log of the Herfindahl–Hirschman index at the 3-digit level of the Standard Industrial Classification (SIC). Robust standard

12 We also estimate the determinants of R&D participation using a logit model. The results largely hold, although the significance levels are lower for some coefficients.

*errors clustered at the firm level are presented in parentheses. ** p<0.01, * p<0.05, + p<0.1.*

Measures of productivity (value added/worker), size (employment), and trade status are all found to be significant positive predictors of a firm's R&D status. A 10 percent increase in employment size raises the probability of a firm conducting R&D activity by 0.08 percentage points, equivalent to five percent of the average share of firms engaged in R&D from 2014-2019. Exporters are 1.2 percentage points more likely to be an R&D firm, but this rises to 2.4 percentage points if the firm also imports.

The regression includes additional variables to account for imports and exports of high-technology goods. Both raise the probability that a firm engages in R&D, although the coefficient for importers of high-technology goods is only weakly significant. Controls for other sources of knowledge transfer, namely foreign ownership, part of a multinational enterprise and whether the firm accesses technology through royalty/licence fees, are also included. The results indicate that in-licensing of know-how through royalty/licence agreements is a significant predictor of whether the firm also engages in R&D. Firms with in-licensing expenditure are 1.2 percentage points more likely to engage in R&D than other firms. The results also suggest that foreign firms are less likely to be R&D firms. At the same time, members of a multinational group are more likely to engage in R&D. These results, however, lose significance if we estimate the relationship using a logit model.

Finally, we include a measure of the concentration (Herfindahl–Hirschman index) of firm sales at the 3-digit level of the SIC to test whether lower competition in an industry reduces R&D activities by firms. There is weak evidence that higher concentration levels within an industry reduce engagement by firms in R&D activities. This is consistent with the finding by Aghion et al. (2005) that low low-levels of product market competition (as measured by mark-ups) have a large negative impact on productivity growth in South African manufacturing industry.[13]

Determinants of R&D intensity

High productivity firms that export high-technology products while operating in less concentrated markets have a higher probability of engaging in R&D activities and a higher intensity of R&D expenditure compared to other R&D firms.

In column (2), we extend the regression results to include estimates explaining R&D intensity, as measured by R&D expenditure as a share of sales within the firm. Using OLS, the estimates in column (2) only include firms with positive R&D expenditure, resulting in low observations.[14] A few of the estimated coefficients are statistically significant, as is the case with similar regressions for South Africa by Naidoo (2020). Exports of high-tech products contribute towards higher R&D intensity, as does higher value added per worker (although imprecisely estimated). R&D firms in industries with high levels of sales concentration also experience significantly lower levels of R&D expenditure, reinforcing the findings on competition and R&D participation found earlier. The coefficient signs on these firm characteristics are the same as those in column (1), indicating that higher productivity, high-technology exporting firms that operate in less concentrated markets have a higher probability of engaging in R&D activities and a higher intensity of R&D expenditure compared to other R&D firms.

Table 9: Determinants of R&D intensity, 2017-2019

	(1)	(3)
	Excluding zero R&D firms OLS	Including zero R&D firms PPML
Value added/worker	0.001+	0.338**
	(0.001)	(0.067)
Employment	-0.001	0.205**
	(0.000)	(0.062)
Exporter	0.000	0.504*
	(0.001)	(0.219)
Importer	-0.001	0.318

13 The weak significance may reflect a non-linear inverted U-shaped relationship between competition and R&D, as argued by Aghion et al. (2005). The HHI index is also not necessarily a direct measure of competitiveness. Finally, Budlender (2019) finds unclear relationships between firm-level markups, industry-level concentration and firm-level market share using the SARS-NT data.

14 One limitation of these estimates is that R&D expenditure is truncated with a lower bound of zero for firms that don't engage in R&D expenditure. Naidoo (2020) therefore follows the Heckman two-step approach towards estimating the determinants of R&D within a firm. In the first step she estimates a selection model, while in the second she estimates the intensity of R&D expenditure, while including the inverse Mills ratio (the selection control) as an explanatory variable. Finally, she estimates a tobit model with the selection variable.

	(1)	(3)
	(0.001)	(0.222)
	Excluding zero R&D firms	Including zero R&D firms
	OLS	PPML
Exporter high-tech products	0.005**	0.816**
	(0.002)	(0.261)
Importer high-tech products	0.001	0.290
	(0.001)	(0.242)
Foreign ownership	-0.003	-0.555
	(0.005)	(0.516)
Multinational enterprise	0.003	0.459
	(0.004)	(0.479)
Royalty paying firm	-0.004**	-0.274
	(0.001)	(0.235)
Industry concentration	-0.001*	-0.239**
	(0.001)	(0.100)
Constant	-0.003	-14.289**
	(0.008)	(1.047)
Observations	1,829	88,931
R-squared	0.064	

*Note: Firm panel based on a cut-off of R20 million in turnover in April 2013 prices. Excludes R&D and royalty/licence fees from related foreign firms. The estimates include fixed effects for two-digit industries, financial year and province. Robust standard errors clustered at the firm level are presented in parentheses. Foreign ownership is defined according to the strict definition of Kilumelume et al. (2021), i.e. firms declaring themselves to "being ultimately foreign-controlled". R&D intensity is calculated as R&D expenditure over sales. Industry concentration of sales is measured using the natural log of the Herfindahl–Hirschman index at the 3-digit level of the Standard Industrial Classification (SIC). Robust standard errors clustered at the firm level are presented in parentheses. ** p<0.01, * p<0.05, + p<0.1.*

In column (3), we re-estimate R&D intensity but include the zero values to also account for the extensive margin contribution to R&D intensity. We estimate the relationship using the Poisson pseudo-maximum likelihood estimation approach of Silva and Tenreyro (2006). The results reinforce the prior results. In particular, the rise in significance of the coefficients compared to those in column 2 reveals the importance of the extensive margin in driving R&D intensity. The relevance in terms of policy is that raising the number of firms engaging in R&D expenditure is a key driver of R&D intensity across firms, on average.

One contrary result is the association between accessing external knowledge through royalty or licence fee payments and the probability of engaging in R&D (positive, column 1) and the R&D intensity within these firms (negative, column 2). These contrary signs imply that in column 3, the coefficient on royalty paying status is not significantly different from zero. As shown in the descriptive statistics earlier, royalties or acquisitions of know-how from outside of the firm have risen in importance for firms, while R&D participation and expenditure have fallen. R&D and in-licensing may therefore be "alternatives" or substitutes, with the decline in firm-level R&D, in part, "compensated" for by firms acquiring technology from other firms. Later in the report, we study the interactions between R&D and in-licensing of technology and how they jointly affect firm outcomes, including productivity, employment and exports.

5. Impact of R&D on firm outcomes

This section uses the SARS-NT database to analyse some of the firm outcomes associated with R&D by the firm. We focus on three main outcomes: (a) firm productivity, (b) export performance, and (c) employment. One of the main challenges in identifying the *causal* outcome of R&D is that the decision by the firm to invest in R&D is not independent of the firm outcomes analysed. For example, firms invest in R&D to develop and introduce new products and processes. The capacity to innovate and derive a return from investment in R&D, however, is influenced by the firm's capacity to produce and absorb new innovative knowledge, which is, in turn, dependent on existing firm productivity levels and prior investments in R&D. [15]

Isolating the causal association from R&D to productivity, exports, and employment is complex and requires the application of sophisticated estimation techniques that go beyond what is possible for this project (see, for example, Doraszelski and Jaumandreu (2013)). Our approach, therefore, is to estimate the association between firm engagement in R&D activities and firm outcomes while controlling for other firm characteristics, such as firm size, trade status, capital intensity, etc, that may also influence the firm outcome.

5.1 R&D and firm productivity

Key findings

1. Productivity, as measured by real value added per worker, is higher for R&D firms, but has stagnated from 2010.
2. Average TFPs vary widely across manufacturing industries, but R&D firms are more productive than other firms, even after controlling for trade status, size, capital intensity, etc.
3. The productivity premium for R&D firms varies across industries, but in most industries R&D firms are found to be more productive than non-R&D firms.
4. External acquisition of technology through in-licencing of know-how or technology embodied in high-technology imports are equally, if not more, essential sources of firm productivity.
5. R&D expenditure and external knowledge acquisition through in-licensing complement each other, with the productivity-enhancing effects of R&D being stronger in firms that also have in-licence know-how.

This section evaluates the association between firm engagement in R&D and firm productivity.

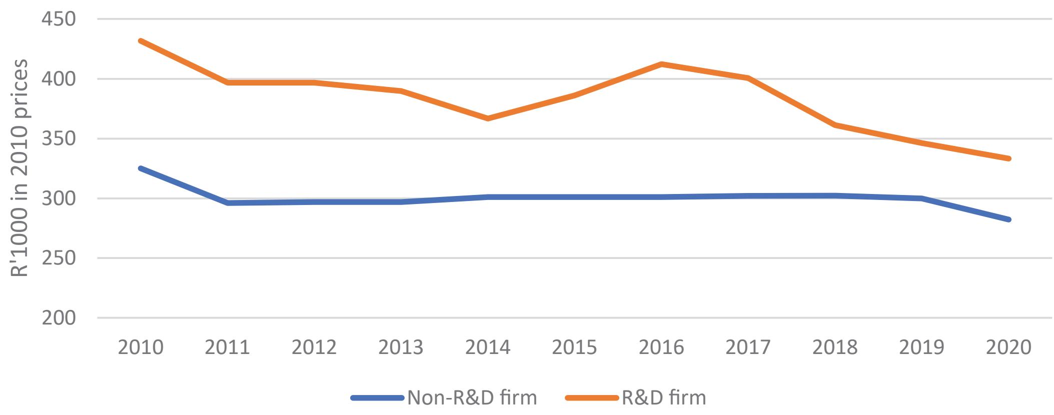
Productivity-specific descriptive statistics

Productivity, as measured by real value added per worker, is higher for R&D firms but has stagnated from 2010.

Figure 36 presents the real value added per worker (R thousand, 2010 prices) for R&D and non-R&D firms using firms from all sectors in the panel database. Given the low number of R&D firms, non-R&D firms' value added per worker of non-R&D firms closely maps to the trend for all firms. Value added per worker of the average firm fell in 2011 but then remained stable for the following 8 years to 2019. Value added per worker fell in 2020, which is attributable to the exclusion of large productive firms that had not yet submitted their tax returns for the 2020 financial year. Mean value added per worker is higher for R&D firms but more volatile and with a stronger downward trend. However, the downward is affected by changes in the composition of R&D firms over time, particularly the exit of large firms that are relatively productive from R&D activities.

15 The productivity relationship can be defined as $\omega_{it} = g(\omega_{it-1}, R\&D_{it-1}) + \epsilon_{it}$ where ω_{it} denotes firm i productivity at time t.

Figure 36: Trends in firm productivity, as measured by value added per worker, 2010-2020



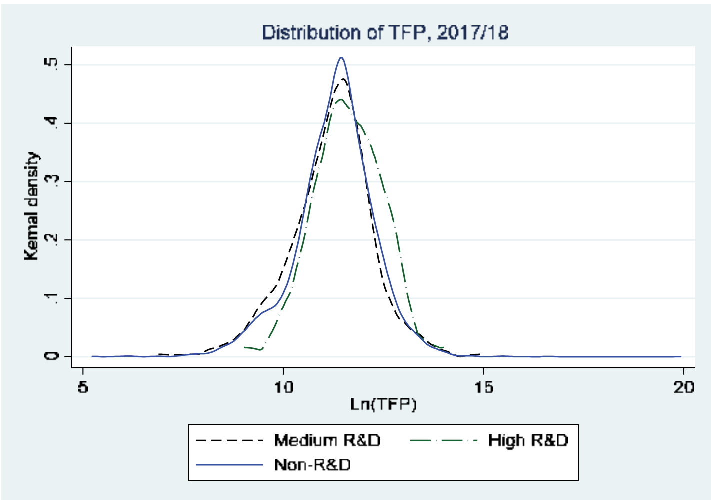
Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D expenditure by foreign related firms. Calculated using the mean of the log value added per worker across firms. Nominal values are deflated using the annual GDP deflator.

There is wide variation in average TFP across manufacturing industries, but R&D firms are more productive than others

Figure 37 presents kernel density estimates of the distribution of TFP by firm R&D status using data for 2017 and 2018. The firms are split into three categories: Non-R&D firms with no R&D expenditure, Medium R&D firms with below mean R&D intensity (R&D expenditure/sales value), and High R&D firms with above mean R&D intensity. The TFP data are estimated by Kreuser and Brink (2021) and only cover manufacturing firms.

The kernel estimates illustrate the wide variation in TFP across manufacturing firms. There are large overlaps in the distribution across firms by R&D status. However, the density estimate for high R&D firms is slightly to the right of those for the other firms. This signals a positive association between TFP and R&D status, particularly for firms that have higher levels of R&D expenditure as a share of their sales value.

Figure 37: Kernal density estimates of the distribution of TFP by firm R&D status, 2017/18



Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D expenditure by foreign related firms. TFP data are estimated by Kreuser and Brink (2021) and only cover manufacturing firms.

Productivity model specifications

Analysis of the impact of R&D on firm productivity is widespread (Hall and Mairesse, 1995; Hall et al., 2009). The primary model used is the knowledge capital model of Griliches (1979), in which R&D investment increases the firm's knowledge capital, thereby boosting production. The production relationship is specified as $Y_{it} = AL_{it}^{\alpha}C_{it}^{\gamma}RD_{it}^{\delta}K_{it}^{\rho}\epsilon^{\mu_{it}}$ (1) where RD_{it} is own knowledge (R&D) capital and K_{it} is external knowledge capital. A firm's investment in R&D creates a stock of knowledge within the firm that enters the production function. Doraszelski and Jaumandreu (2013) extend this approach to allow for the endogeneity between R&D and firm productivity.

Few studies have analysed R&D and productivity using firm data in South Africa. Steenkamp et al. (2018) apply the knowledge capital model to SA manufacturing firms using the SARS-NT data. They estimate an elasticity of R&D expenditure of around 0.02 (using sales and material inputs) to 0.12 (using VA) when using their within-industry estimator. Their results imply an estimated return to R&D in South Africa that is high compared to OECD countries.

Alternative studies focus more on innovation, of which R&D is one source, and its impact on productivity. The approach adopted by Crépon, Duguet, and Mairessec (1998) (CDM) is commonplace in this literature and estimates the productivity relationship through the effect of R&D on innovation and then innovation on productivity. Baum et al. (2017) update this approach, allowing productivity to feed back into innovation. Kahn et al. (2022) apply the CDM approach to estimate the effect of technological innovation success and intensity on firm productivity using a sample of manufacturing firms from the Business Innovation Survey (BIS) 2014–2016 data. They find that introducing product or process innovations has significant positive effects on productivity in South African manufacturing firms.[16]

In this section, we provide additional estimates of the relationship between R&D and firm productivity. We do so in two ways. Firstly, we follow Steenkamp et al. (2018) and estimate the knowledge capital model of Griliches (1979) using R&D status as a proxy for the stock of R&D knowledge capital. These regressions are applied to all sectors. Secondly, we adopt a two-stage approach where we regress estimates of firm TFP on R&D status and other firm controls (see Box 4). We draw on TFP estimates for manufacturing by Kreuser and Brink (2021) over the 2010-2018 period. Kreuser and Brink (2021) deal with endogeneity of productivity and input choices using the semi-parametric approach of Ackerberg et al. (2015). In all regressions, R&D status and other explanatory variables lagged for one period to help minimise biases from reverse causation. In addition, 3-digit-industry by financial year fixed effects are included to control for industry specific trends in the data. Some estimates firm fixed effects, which then implies that the relationships are identified by within-firm changes in productivity and the explanatory variables.

Box 4: TFP specification

The following regression equation is estimated to capture the direct relationship between engagement in R&D and firm total factor productivity (TFP):

$$TFP_{it} = \alpha + \beta_1 RD_{it-1} + \beta_2 DM_{it-1} + \beta_3 DX_{it-1} + \beta_4 DRoyalty_{it-1} + \sum_m \beta_m C_{it-1}^{m} + \lambda_{st} + \varepsilon_{it} \qquad (2)$$

where TFP_{it} is an indicator of total factor productivity of firm *i* at period *t*. RD denotes whether a firm engages in R&D (equals 1, zero otherwise), DX denotes export status, DM denotes import status, DRoyalty denotes whether a firm in-licences knowhow through royalty/licence fees, and denotes all other firm characteristics included in the regressions. Finally, are industry (SIC three-digit) by financial year fixed effects.

A positive coefficient () on the R&D variable provides support for a positive association between engaging in R&D and firm productivity. When regressions include firm fixed effects (), the coefficient on R&D status measures how productivity within the firm changes following entry into R&D activity.

Productivity model results

Several different estimates are presented to tease out the association between R&D and firm productivity. This includes how R&D intensity affects firm productivity, as well as the association between firm productivity and other sources of know-how, including technology embodied in high-technology imports and in-licensed know-how through royalty/licence fee payments. The focus is mainly on manufacturing firms given the available estimates of TFP, but results from estimates based on the knowledge capital model of Griliches (1979) using the full sample of data yield comparable findings.

16 This study provides new insights on innovation and productivity in South Africa. It also has the advantage of directly measuring innovation, rather than using inputs into innovation such as R&D. The trade-off, however, is that their study relies on a survey of firm, and the results are not necessarily representative of the population. For example, firms that don't innovate may be less likely to respond to the survey leading to selection bias. The survey response rate appears to be very low (15%), reflecting the challenges of conducting firm surveys in South Africa. Finally, their measure of productivity is sales per worker, which is an imperfect measure of productivity. Our study complements their analysis using the full population of firms and more precise estimates of firm productivity.

R&D firms are significantly more productive than other firms, even after controlling for firm characteristics such as trade status, size, capital intensity, etc.

Table 10 presents estimates of the association between manufacturing firm TFP and R&D status of a firm, while controlling for the influence of other firm characteristics. For visual interpretation of the R&D-TFP results, Figure 38 presents the estimated gap between R&D firms and non-R&D firms based on the regression estimates.

Table 10: R&D and firm productivity, 2010-2020

	(1)	(2)
VARIABLES	Basic	R&D intensity
R&D firm $_{t-1}$	0.167**	
	(0.028)	
Medium-intensity R&D firm $_{t-1}$		0.158**
		(0.030)
High-intensity R&D firm $_{t-1}$		0.216**
		(0.062)
Royalty/licence fee firm $_{t-1}$	0.201**	0.201**
	(0.023)	(0.023)
Exporter $_{t-1}$	0.123**	0.123**
	(0.017)	(0.017)
Importer $_{t-1}$	0.055**	0.055**
	(0.018)	(0.018)
Importer high-tech products $_{t-1}$	0.243**	0.243**
	(0.016)	(0.016)
Foreign ownership $_{t-1}$	-0.191*	-0.192*
	(0.079)	(0.079)
Multinational enterprise $_{t-1}$	0.642**	0.643**
	(0.074)	(0.074)
Employment $_{t-1}$	-0.302**	-0.302**
	(0.007)	(0.007)
Capital/Labour $_{t-1}$	0.022**	0.022**
	(0.005)	(0.005)
Constant	12.032**	12.031**
	(0.069)	(0.069)
Observations	41,579	41,579
Adj. R-squared	0.466	0.466

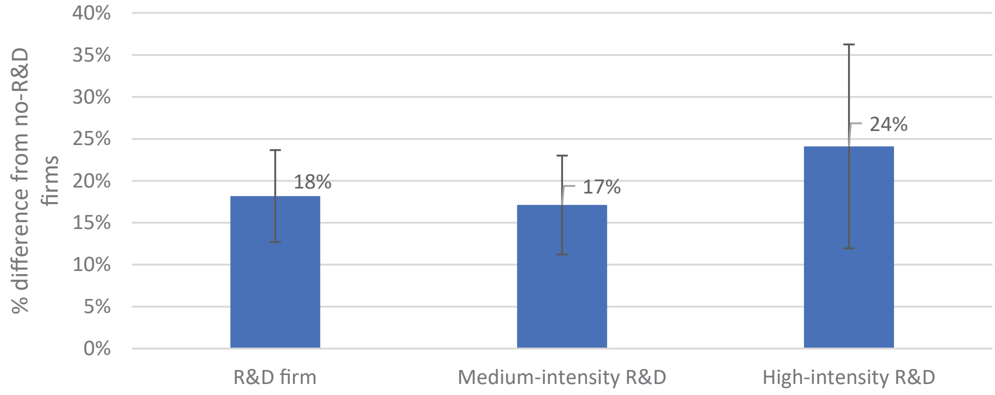
*Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes foreign-related expenditure on R&D and royalty/license fees. All estimates include SIC three-digit industry by financial year fixed effects. Employment and the capital/labour ratio are in natural logarithms, while the remaining variables are categorical variables. Foreign ownership is defined according to the strict definition of Kilumelume et al. (2021), i.e. firms declaring themselves to "being ultimately foreign-controlled". Medium-intensity R&D firms are firms where R&D intensity is below the mean R&D intensity of R&D firms. High-R&D firms have above mean R&D intensity levels. The omitted group are non-R&D firms. The dummy variable "Importer of high-tech products" denotes firms that import high-technology products as defined by Lall (2000). Robust standard errors clustered at the firm level are presented in parentheses. ** p<0.01, * p<0.05, + p<0.1.*

The estimates show that firms that engage in R&D are 18% (calculated as exponent of 0.167 minus 1) more productive than firms that do not engage in R&D (from column (1)).[17] This TFP premium exists even after controlling for firm size (proxied by employment), capital intensity, trade status, foreign ownership, and membership in a multinational enterprise.

Column 2 extends the estimates by splitting R&D firms into those with below and above-median levels of expenditure as a share of their sales (R&D intensity). As shown in Figure 38, both high- and medium-R&D-intensive firms are more productive than non-R&D firms (24% and 17%, respectively), but the difference in TFP premium between the two categories of R&D firms is not statistically significant. A low number of R&D firms may affect the preciseness of the estimates, but the results suggest that engagement in R&D is the primary driver of the TFP premium rather than the intensity of R&D expenditure. *Encouraging more firms to invest in R&D appears to be the relatively more important channel through which to drive increases in firm productivity, compared to raising the intensity of R&D within firms.*

17 The percentage effect is calculated as the exponent of the coefficient minus 1. E.g. exp(0.167)-1 gives the productivity effect of firms engaged in R&D.

Figure 38: Percentage difference in TFP between R&D firms and non-R&D firms



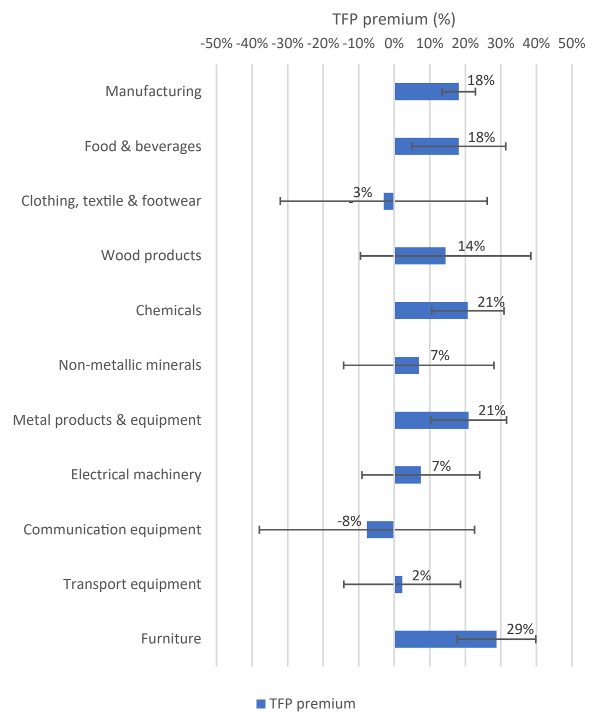
Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes foreign related expenditure on R&D and royalty/licence fees. The values reflect the percentage difference in TFP between R&D firms and no-R&D firms. The values for R&D firms are calculated using column (1) of Table 10 while the R&D intensity estimates are based on column (2). Medium-intensity R&D firms are firms where R&D intensity is below the mean R&D intensity of R&D firms. High-R&D firms have above mean R&D intensity levels. The vertical error bars reflect the 95% confidence interval.

The productivity premium for R&D firms varies across industries, but in most industries, R&D firms are found to be more productive than non-R&D firms.

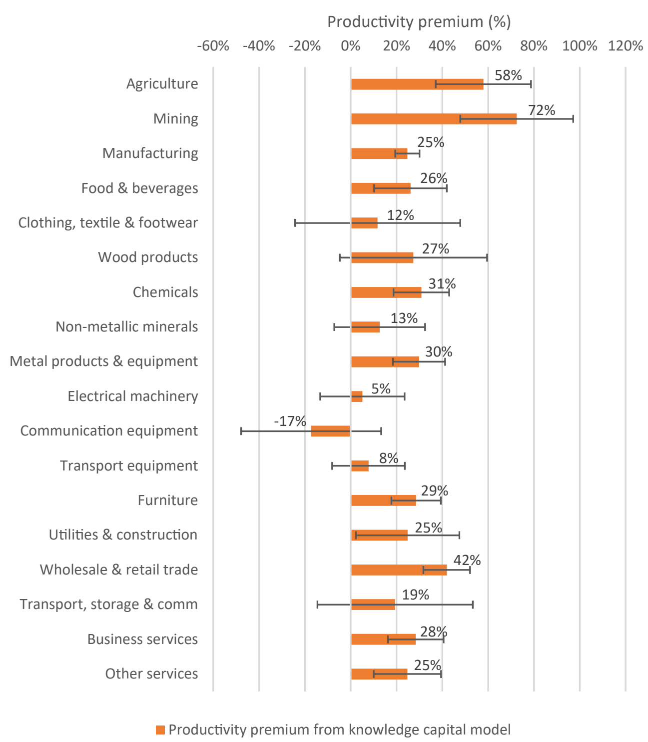
Figure 39 presents the estimates of the productivity premium of R&D firms relative to non-R&D firms by industry. The productivity premium is measured in two ways: (a) using the direct estimates of TFP for manufacturing firms by Kreuser and Brink (2021), and (b) from estimates of the knowledge capital model presented in equation 1.[18] The TFP estimates are only available for manufacturing, but the value-added estimates are available for all industries. The results for manufacturing are provided at the SIC 2-digit level, while results for the other sectors are at the SIC 1-digit level (see Annex B Table 15 for the TFP regressions).

Figure 39: Productivity premium for R&D firms compared to non-R&D firms by industry

(a) TFP estimates for manufacturing industries



(b) Knowledge capital model estimates



Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. The premiums are based on estimates of TFP or the knowledge capital model using value-added per worker as the dependent variable, while controlling for capital, labour and all other explanatory variables and fixed effects used in the regressions of Table 10. The values reflect the percentage difference in productivity of R&D firms relative to non-R&D firms. The premium is calculated as the exponent of the estimated coefficient on the R&D dummy minus 1. The vertical error bars reflect the 90% confidence interval based on robust standard errors clustered at the firm level

18 We replace the stock of knowledge capital with a dummy variable for lagged R&D expenditure by the firm.

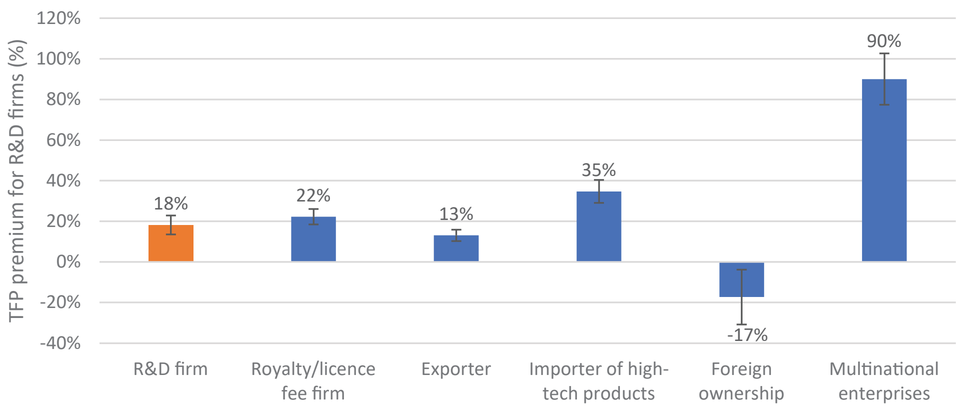
The figure reveals that R&D firms are characterised by higher levels of productivity, irrespective of the measure used, in most industries. In the case of the TFP results (part a of Figure 39), some of the premiums are imprecisely estimated, given the low numbers of R&D firm observations. The productivity premiums using the knowledge capital model tend to be slightly higher than those using the TFP estimates of Kreuser and Brink (2021). Agriculture, mining and wholesale & retail services have very high productivity premiums of between 42% and 72%. Within manufacturing, statistically significant TFP premiums are estimated for Food & beverages (18%) Chemicals (21%), Metal products and equipment (21%) and Furniture (29%). The estimated TFP premiums for the other manufacturing industries are not statistically significant. Nevertheless, the results indicate that the productivity premium of R&D firms is not isolated to a few firms and a few sectors.

External acquisition of technology through in-licensing of know-how or technology embodied in high-technology imports are equally, if not more, important sources of firm productivity.

The results presented in Table 10 provide additional insights into sources of TFP advantages for particular firms. Innovative knowledge can be generated in-house through investment in R&D, but can also be acquired externally through royalty/licence agreements, participation in exporting (through learning by exporting), technology embodied in high-technology imports and disembodied knowledge through foreign ownership or membership in multinational companies.

Figure 40 presents the TFP premium associated with each of these possible channels of knowledge transfer. With the exception of foreign ownership, all channels are associated with higher levels of TFP in manufacturing firms. The TFP premium for importers of high-technology products is 35%, which is substantially higher than the premium for R&D firms, as is also found by Edwards et al. (2022). Manufacturing firms that access know-how through royalty/licence fee agreements are also found to have higher TFP than other firms, with a premium of 22%. Ownership patterns yield mixed results. Companies that are part of a multinational enterprise are 90% more productive (in terms of TFP) than other firms, but foreign ownership is associated with a negative TFP premium of 17%.

Figure 40: TFP premium according to manufacturing firm characteristics



Notes: Estimates based on column (1) results in Table 10

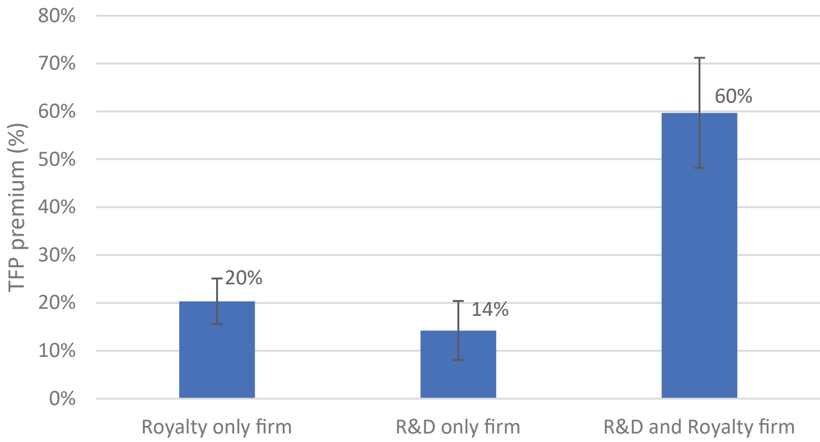
The results indicate that manufacturing firms make use of alternative options to research and development (R&D) to enhance firm innovation. The number of firms making use of these alternative channels to acquire innovative knowledge also exceeds the number of R&D firms. Overall, therefore, while R&D is an important source of firm productivity, the data indicate that it is not the dominant nor strongest source compared to alternative sources of innovative knowledge. Focusing on R&D alone will, therefore, give a partial picture of the productivity implications of innovative activities (Masso and Tiwari, 2022).

R&D expenditure and external knowledge acquisition through in-licencing are complements, with the productivity-enhancing effects of R&D stronger in firms that also in-licenae know-how.

The results in Figure 40 suggest that firms face alternative options to drive innovation. However, this does not imply that internal knowledge through in-house R&D and external knowledge acquisition through in-licensing are substitutes. For example, external knowledge can provide firms with the opportunity to learn, which in turn raises the absorptive capacity and profit incentive of firms to engage in R&D (Vega-Jurado et al., 2009). The empirical evidence on the substitutability/complementarity of R&D and external knowledge acquisition is mixed, and is influenced by the industry, the type of innovation and the absorptive capacity of firms (Vega-Jurado et al., 2009; Ceccagnoli et al. 2014; Masso and Tiwari, 2022; Fang and Lin, 2010; Pallayil et al. 2023).

The background descriptive analysis earlier has already shown that R&D firms are also likely to use royalty/licence agreements. To assess the potential productivity association, we re-estimate the productivity estimates but include an interaction between the firm's R&D status and whether it spends on royalty/licence fees. A positive (negative) coefficient on the interaction would signal that in-house R&D and external knowledge acquisition through royalty/licence fee agreements are complements (substitutes). Figure 41 summarises the regression results (the detailed results are presented in Table 16 in Annexure B) and presents the TFP premium for combinations of firms that engage in R&D and/or in-licensing compared to firms that do neither. The figure corroborates the earlier finding that firms that engage in R&D or acquire know-how through in-licensing are more productive than firms that do neither. Firms that either in-licence know-how or engage in R&D are 14 to 20% more productive than firms that engage in neither activity (the base firms). However, firms that generate internal knowledge through in-house R&D and acquire external knowledge through in-licence are 60% more productive than the base firms. These firms also have significantly higher TFP levels than those that source knowledge through either option. The results suggest a high level of complementarity between R&D and in-licensing in raising firm productivity.[19]

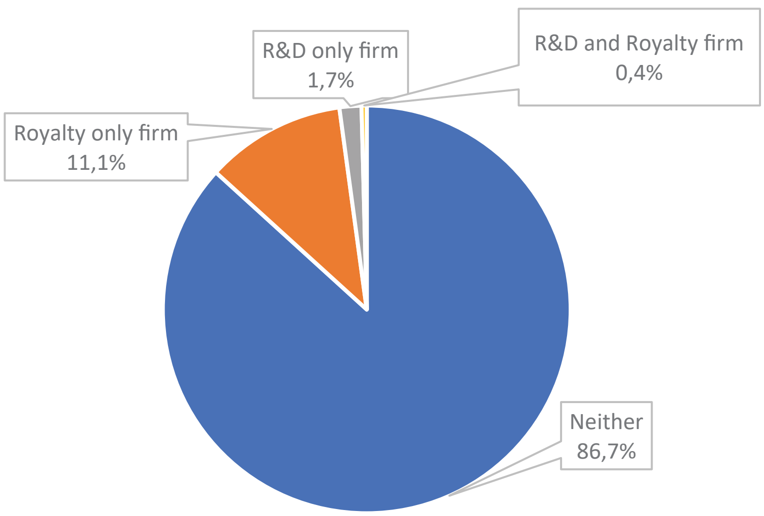
Figure 41: TFP premiums - complementarity between R&D and in-licensing of know-how in manufacturing firms



Note: Margin estimates based on the regression results in column (3) of Table 16 in Annexure B. The sample covers manufacturing firms over the period 2010 to 2018. The firm TFP estimates are obtained from Kreuser and Brink (2021).

The share of firms that engage in both R&D and in-licencing, however, is extremely low. As shown in Figure 42, only 0.4% of firms engaged in R&D and in-licence know-how. Most R&D firms do not also in-licence know-how

Figure 42: Share of firms by R&D and in-licensing status, 2018/19



Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices.

19 Additional estimates suggest that in-licencing is only complementary for medium R&D intensity firms. High R&D intensity firms also benefit from in-licencing, but no more than non-R&D firms.

5.2 R&D and firm export performance

Key findings

1. South Africa's aggregate exports have underperformed over the past decade.
2. The contribution of R&D firms to aggregate exports and high-tech exports has declined considerably.
3. R&D firms, on average, have higher export values and export transactions (defined as a product-destination combination) each year than other exporters, but there is enormous variation across firms with respect to these export measures.
4. Firms that simultaneously invest in R&D and in-licence know-how have higher export values than exporters that only invest in R&D or in-licence know-how. Exporters that do not invest in R&D or in-licence know-how have the lowest average export values.
5. There is a virtuous cycle between entry into exporting and engagements by firms in R&D, but this applies to very few firms, leading to small aggregate export effects.
6. While R&D firms have higher export values and more export transactions (product-destination combinations) than other firms, the intensity of R&D is not a significant driver of differences in export value across R&D firms.
7. R&D firms are more likely to export high-technology products at higher values than other exporters.

The relationship between firm export performance and productivity is well-established, including in South Africa (Matthee et al., 2018). More productive firms are more likely to select exporting as they are able to cover the fixed costs of entering the export market. Exporters can also learn from exporting, thereby raising their productivity. R&D can influence both these dynamics. For example, Aw et al. (2011) developed a structural model of producers' decision to invest in R&D and exports, allowing both choices to endogenously affect future productivity. They highlight two key channels. First, the return to investment in R&D and entry into the export market increases with the producer's underlying productivity. This leads high-productivity producers to self-select into both exporting and investment in R&D. Second, both exporting and R&D investment directly affect future productivity, which acts to reinforce the selection effect. Positive shocks that reduce the cost of R&D or access to international markets can, thus, induce a virtuous interaction between R&D, exporting and firm productivity.

Naidoo (2020) finds marginal support for this virtuous cycle in South Africa using the SARS-NT data from 2010 to 2016. South African firms with prior R&D investments are estimated to be 8.5 per cent more likely to export in the future.[20] However, the evidence is weaker when assessing the direction of the relationship from exporting to investments in innovation. The likelihood of R&D investment is only marginally increased by the firm's prior export status. Naidoo (2020) concludes that firms do not perceive the returns to innovation to increase once they have entered export markets.

This section provides additional insight into the relationship between R&D and export performance in South African firms. It extends the analysis by Naidoo (2020) by including a broader sample of R&D firms.[21] The analysis commences with a brief descriptive analysis of firm R&D and export performance. This is then followed by a test of the virtuous interaction between R&D and exporting. Finally, the results from econometric estimates of the relationship between R&D and export outcomes, including export values, number of destinations, etc., are presented.

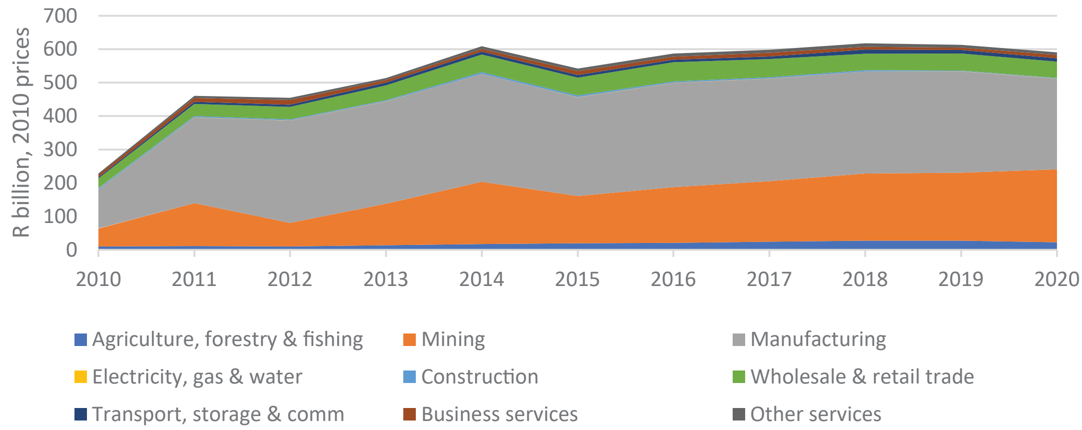
Export descriptive statistics

South Africa's aggregate exports have underperformed over the past decade.

Figure 43 presents the real value of South African exports (deflated using GDP deflator) from 2010 to 2020. The export values only reflect those of the consistent panel of firms, so do not perfectly map to the national statistics. Whereas real export values grew from 2010 to 2014, growth then stagnated, and by 2019, real export values were no higher than those in 2014. This growth has been lower than comparator emerging economies and the export bundle has remained concentrated amongst few firms, with little diversification from resource-based and primary products (Edwards, 2021; Purfield et al. 2014). This is also shown in Figure 43 by the declining value and contribution of manufacturing firms to aggregate export values over the period 2014 to 2019.

20 Kahn et al. (2022) also find export status to be good predictor of innovation status and intensity in South Africa using survey data.
21 Naidoo (2020) restricts the sample to a balanced panel of firms, and analysis the relationship over a shorter 2010 to 2016 period.

Figure 43: South African aggregate export value, R billion in 2010 prices



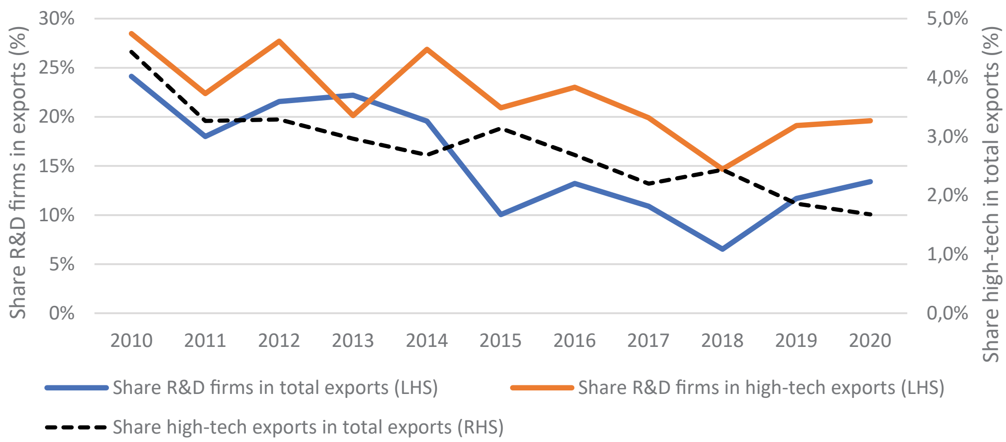
Notes: Own calculations using SARS-NT firm panel based on R20 million in April 2013 prices sales cut-off. Nominal export data are converted to 2010 values using the GDP deflator. The values in this figure will differ from the aggregate national values because (a) the years reflect financial, not calendar years, and (b) the sample only covers firms for which sales equal or exceed R20 million (valued in April 2013 prices).

The contribution of R&D firms to aggregate exports and high-tech exports has declined considerably.

One measure of innovative capacity in a country is its exports of high-technology products. South African high-technology exports are low and are falling. As shown in Figure 44, the shares of high-technology exports in the sample of firms more than halved from 4.4% in 2010 to 1.9% in 2019. R&D firms are a key contributor towards this decline. Exports of R&D firms are more strongly oriented towards exporting high-technology goods than other firms. Their share of high exports, for example, exceeds their share of overall exports, and they are 20% more likely to export high-technology products than other firms (Figure 36).

The implication is that the decline in R&D firms has been associated with a decline in both their contribution to aggregate exports (24% in 2010 to 12% in 2019) and their contribution to high-technology exports (28% in 2010 to 19% in 2019).

Figure 44: Contribution of R&D firms to aggregate exports and high-tech exports

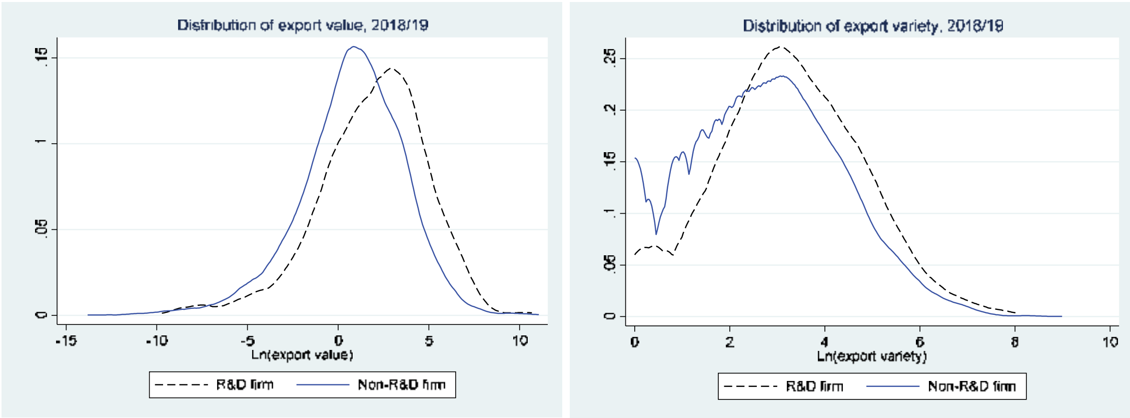


Notes: Own calculations using SARS-NT firm panel based on R20 million in April 2013 prices sales cut-off. See notes to Figure 43.

R&D firms, on average, have higher export values and export transactions (defined as a product-destination combination) each year than other exporters, but there is enormous variation across firms with respect to these export measures.

Figure 45 presents kernel density estimates of the export value and the number of export transactions (defined as an HS six-digit product-destination combination at the firm level) in 2018/19 for R&D firms and other exporters. The figures illustrate the enormous variation in the value of exports and the number of export transactions within each firm category. Consequently, there is a wide overlap in the kernel density functions across importer categories. However, the figures also show how export value and exporter transactions generally rise when firms engage in R&D activities.

Figure 45: Distribution of firm export value and export transactions (in natural logarithm) by R&D status, 2018/19

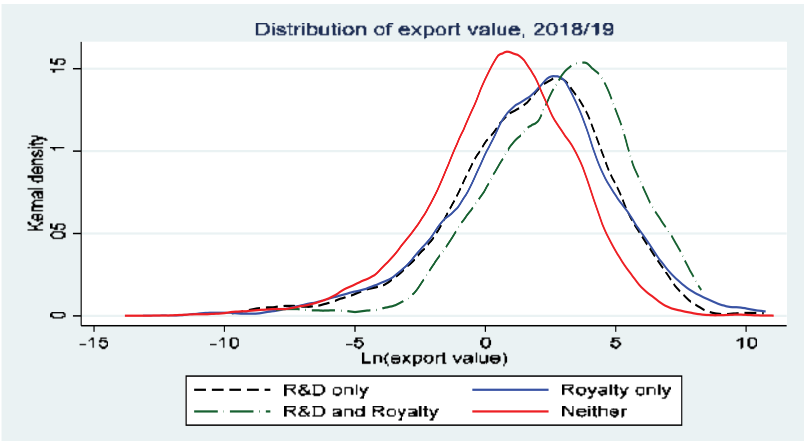


Notes: Own calculations using SARS-NT firm panel based on R20 million in April 2013 prices sales cut-off.

Firms that simultaneously invest in R&D and in-licence know-how have higher export values than exporters that only invest in R&D or in-licence know-how. Exporters that do not invest in R&D or in-licence know-how have the lowest average export values.

Figure 46 presents the distribution of firm export value by R&D and in-licensing status. The distributions of export value for exporters that only invest in-licence know-how or only invest in R&D overlap closely, suggesting little difference in export value, on average, between these groups of firms. In contrast, the distribution of export value of exporters that neither invest in R&D nor in-licence know-how is to the left of the other categories, signalling substantially lower export values. Exporters that both invest in R&D and in-licence technology have much higher export values than the other groups. As with the productivity results, this suggests a complementarity between R&D investment and in-licensing of know-how. The robustness of this association after controlling for other confounding factors will be tested in the regression analysis.

Figure 46: Distribution of firm export value (in natural logarithm) by R&D and in-licensing status, 2018/19



Notes: Own calculations using SARS-NT firm panel based on R20 million in April 2013 prices sales cut-off.

There is virtuous cycle between entry into exporting and engagements by firms in R&D, but this applies to very few firms

To analyse the interaction between exporting and R&D, we follow Naidoo (2020), who applies the approach of Aw et al. (2008) and regresses current export and R&D status on lags of these variables and measures of capital stock and firm profitability. The inclusion of one-year lags of R&D and export status is to account for persistence in these activities that can arise from the presence of sunk costs associated with exporting and investing in R&D. We estimate each relationship using a simple linear probability model, and therefore do not fully control for the simultaneity of the relationships, nor potential lagged dependent variable biases. The regressions are primarily illustrative of the interactions between engaging in R&D and exporting.[22]

22 Naidoo (2020) estimates these relationships using the system GMM estimator of Arellano & Bond.

Table 11 presents the regression results. R&D status is strongly correlated with prior R&D status, as well as with prior export status. Firms that export are 0.9 percentage points more likely to engage in R&D in the following period (column 1). Similarly, firms that engage in R&D are 2.5 percentage points more likely to engage in exporting in the following period. As found by Naidoo (2020) the channel from R&D to exporting is stronger than the channel from exporting to R&D. Nevertheless, the persistence in exporting and R&D is high (although higher for exporting), suggesting that the long-term outcomes of the interaction between R&D and exporting will be substantially higher than the short-term effects.

Table 11: R&D and export interaction, 2010-2020

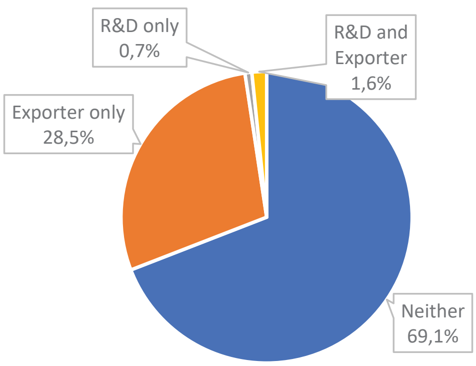
	(1)	(2)
	R&D firm	Export firm
R&D firm$_{t-1}$	0.601*	0.025*
	(0.007)	(0.002)
Export firm $_{t-1}$	0.009*	0.845*
	(0.000)	(0.002)
ln(capital) $_t$	0.001*	0.001*
	(0.000)	(0.000)
ln(profitability) $_t$	0.002*	0.006*
	(0.000)	(0.000)
Constant	-0.00*	0.033*
	(0.001)	(0.002)
Observations	249,962	249,962
Adj R-squared	0.403	0.798

*Notes: Own calculations using SARS-NT firm panel based on R20 million in April 2013 prices sales cut-off. The probability relationship is estimated using a linear probability model over the period 2010 to 2020 that includes fixed effects for SIC three-digit industries and financial years. Following Aw et al. (2008), relative profitability is calculated as the log of the firm's revenue share expressed as a deviation from the mean log market share in the industry. R&D firm and Export firm denote dummy variables for firms that invest in R&D and firms that export, respectively. Capital is measured as the fixed capital assets report by companies. Robust standard errors clustered at the firm level are presented in parentheses. ** p<0.01, * p<0.05, + p<0.1.*

Despite the presence of a virtuous cycle between exporting and R&D, the aggregate effect on each outcome in South Africa appears small.

The aggregate effect of the virtuous cycle between exporting and R&D is small because very few firms engage in R&D. Figure 47 presents a pie chart of the share of firms according to R&D and export status over the period 2010-2020. Although a high share of R&D firms also export, these firms only make up 1.6% of all firm observations, and 5.4% of all exporter observations.

Figure 47: Share distribution of firms according to R&D and export status, 2010-2020



Notes: Own calculations using SARS-NT firm panel based on R20 million in April 2013 prices sales cut-off. The figure is based on data for the full 2010 to 2020 period.

The results nevertheless highlight the presence of a potential *un-virtuous* cycle reducing R&D investment. The number of exporters in South Africa has declined since 2016. For example, using export transaction data for South Africa reveals that exporter numbers in 2021 were 15% lower than they were in 2016, and are no higher than they were in 2011. The decline in exporter numbers can be attributed to several factors, including declining efficiency in transport and port infrastructure and supply constraints arising from electricity shortages. According to the findings in Table 11this decline in the number of exporters will have contributed to the falling number of R&D firms. Given the relative importance of R&D firms in the export of high-technology products, the simultaneous decline in R&D firms and exporters will be particularly pronounced for the production and export of these products. Together, these trends signal a falling behind from the technology frontier.

1. Estimates of firm export outcomes

This section reports some of the results from econometric estimates of an export model. Box 5 provides further details on the export model's specification.

Box 5: Export model specification

To capture the relationship between firm R&D and exporting, we estimate the following regression equation:

$$X_{it} = \alpha + \beta_1 RD_{it-1} + \beta_2 DM_{it-1} + \beta_3 DMHT_{it-1} + \beta_4 DX_{it-1} + \beta_5 DRoyalty_{it-1} + \sum_m \beta_m C_{it}^m + \lambda_{st} + \varepsilon_{it} \quad (3)$$

where X_{it} is an indicator of export performance (propensity, value, variety) of firm *i* at period *t*. Variety is defined as a product-destination/origin combination, while propensity is a dummy variable that equals one if a firm has a positive export value in that year. The variable DM_{it} denotes firm importer, while $DMHT_{it}$ denotes and importer of high-technology imports. This is included given the close association between firm imports of high-technology products and export outcomes (Edwards et al., 2022). The total impact of imported technology on export outcomes is . Time-varying controls () (all in logs) such as the number of employees, the capital-labour ratio and wage (a proxy for skill composition) are included to control for time-varying firm shocks that might be correlated with importing. In some estimates, a variable for lagged export propensity () is also included. Finally, SIC three-digit industry by financial year fixed effects (λ_{st}) are included to account for industry specific trends such as global demand shocks and international prices. To help minimise biases from reverse causation, explanatory variables are lagged one period.[1]

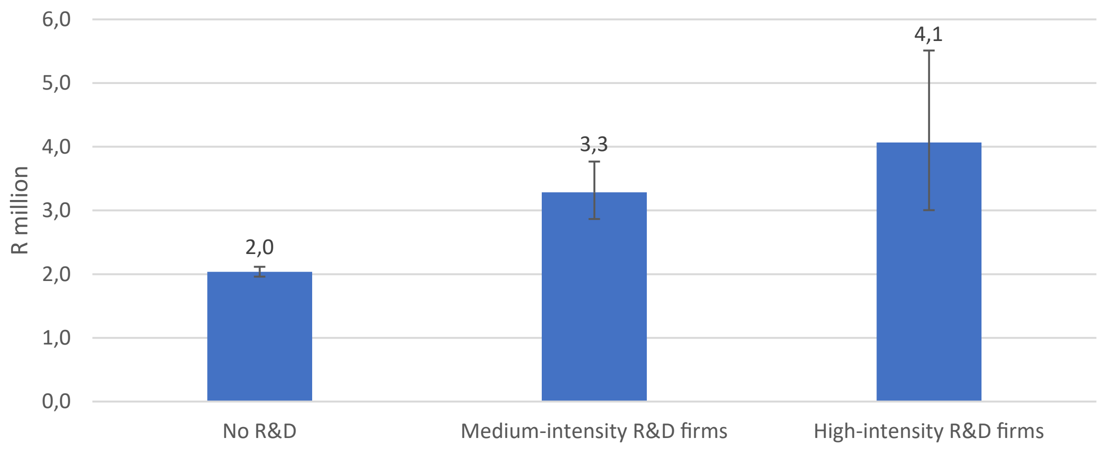
Table 12 presents the set of results of the association between firm R&D engagement and export outcomes, including the probability of exporting (column 1), export value (columns 2 & 3), number of export transactions (column 4) and the export probability and value of high-technology exports (column 5 & 6). Several key findings follow from the regression results.

While R&D firms have higher export values and more export transactions (product-destination combinations) than other firms, the intensity of R&D is not a significant driver of differences in export value across R&D firms

The regression results corroborate the earlier unconditional associations between R&D statistics and export performance (Table 7). The value of exports of R&D firms is 62 percent higher (exp(0.483)-1) than non-R&D firms that export (column 2).[23] When looking at how the intensity of R&D expenditure affects export value, we find that R&D firms with the above mean R&D intensity (measured as R&D expenditure as share sales value) export higher values than other R&D firms that export, but the difference is not significant. This is illustrated in the overlap in the 95% confidence intervals around the predicted value of exports for medium- and high-intensive R&D firms plotted in ***Figure 48*** (based on column 3) results of Table 12.

23 When firm fixed effects are included, the coefficients on the R&D status variable become insignificant. This may be because there are simply too few R&D firm observations to identify the within firm impacts of changes in R&D on export performance.

Figure 48: Predicted export value by R&D intensity, 2010-2020



Notes: Margins based on column (3) estimates in Table 12. The vertical error bars reflect the 95% confidence interval.

R&D firms are more likely to export high-technology products and at higher values than other exporters.
Column (5) and (6) of Table 12 estimate the relationship between R&D status and exports of high-technology products. R&D firms are around four percentage points more likely to export high-technology products than other firms, and when exporting, their export values are 43% (exp(0.355)-1) higher than those of other exporters.

In-licensing is an additional driver of export value and export transactions, but we only find significant complementary effects between R&D and in-licensing for export transactions.

According to the results in column (2), in-licensing raises the export values of firms by 22% (exp(0.197)-1). This increase in export value occurs irrespective of whether the firm engages in R&D or not (see insignificant coefficient on interaction term). However, in-licensing appears to complement R&D concerning the number of export transactions (column 4). For example, in-licensing is associated with an 8% higher export value for exporters not engaged in R&D. Still, a 28.5% higher export value when the firm also invests in R&D. To the extent that export transactions reflect product varieties, as is common in the field, these results suggest that R&D and in-licensing complement product innovation, enabling exporters to expand products and destinations they export to.

Table 12: R&D status and firm export performance, 2010-2020

	(1) Export probability	(2) ln(export value)	(3) ln(export value)	(4) ln(Export transactions)	(5) Probability exporter of high-tech	(6) Ln (High-tech export value)
R&D firm $_{t-1}$	0.015**	0.483**		0.107*	0.037**	0.355**
	(0.003)	(0.075)		(0.042)	(0.009)	(0.121)
Medium-intensity R&D firm $_{t-1}$			0.478**			
			(0.070)			
High-intensity R&D firm $_{t-1}$			0.692**			
			(0.155)			
Royalty/licence fee firm $_{t-1}$	-0.004**	0.197**	0.212**	0.078*	0.003	-0.276**
	(0.001)	(0.054)	(0.052)	(0.031)	(0.003)	(0.086)
(R&D firm)x(Royalty/ licence fee firm) $_{t-1}$	0.007	0.144		0.173*	0.029	-0.276
	(0.005)	(0.140)		(0.084)	(0.019)	(0.240)
Exporter $_{t-1}$	0.770**	2.790**	2.790**	1.710**	0.335**	1.038**
	(0.003)	(0.044)	(0.044)	(0.020)	(0.004)	(0.080)

	(1) Export probability	(2) ln(export value)	(3) ln(export value)	(4) ln(Export transactions)	(5) Probability exporter of high-tech	(6) Ln (High-tech export value)
Importer $_{t-1}$	0.136**	0.208**	0.208**	0.501**	0.128**	0.631**
	(0.002)	(0.043)	(0.043)	(0.023)	(0.003)	(0.068)
Importer high-tech products $_{t-1}$	0.001	0.241+	0.237+	-0.135	-0.002	-0.225
	(0.004)	(0.138)	(0.139)	(0.083)	(0.013)	(0.178)
Foreign owned $_{t-1}$	0.007+	0.395**	0.397**	0.370**	0.081**	0.718**
	(0.004)	(0.127)	(0.127)	(0.075)	(0.011)	(0.161)
Multinational enterprise $_{t-1}$	0.008**	0.547**	0.547**	0.326**	0.033**	0.584**
	(0.001)	(0.025)	(0.025)	(0.014)	(0.001)	(0.037)
Employment $_{t-1}$	0.006**	0.512**	0.512**	0.369**	0.028**	0.367**
	(0.000)	(0.019)	(0.019)	(0.011)	(0.001)	(0.025)
Capital/Labour $_{t-1}$	0.001**	0.135**	0.136**	-0.033**	-0.004**	-0.014
	(0.000)	(0.013)	(0.013)	(0.007)	(0.000)	(0.018)
Constant	-0.101**	-12.817**	-12.819**	-4.558**	-0.495**	-13.008**
	(0.007)	(0.353)	(0.353)	(0.195)	(0.020)	(0.513)
Observations	238,790	81,548	81,548	81,549	238,790	37,924
Adjusted R-square	0.801	0.246	0.246	0.260	0.389	0.140

*Notes: Firm panel based on R20 million in April 2013 prices sales cut-off. Excludes foreign related expenditure on R&D and royalty/licence fees. All estimates include SIC 3-digit industry by financial year fixed effects. Employment and the capital/labour ratio are in natural logarithms, while the remaining variables are categorical variables. Foreign ownership is defined according to the strict definition of Kilumelume et al. (2021), i.e., firms declaring themselves to "being ultimately foreign-controlled". Medium-intensity R&D firms are firms where R&D intensity is below the mean R&D intensity of R&D firms. High-R&D firms have above-mean R&D intensity levels. The omitted group are non-R&D firms. The dummy variable "Importer of high-tech products" denotes firms that import high-technology products as defined by Lall (2000). Robust standard errors clustered at the firm level are presented in parentheses. ** p<0.01, * p<0.05, + p<0.1.*

5.3 R&D and firm employment

Key findings

1. R&D firms employ more workers and pay higher wages than non-R&D firms
2. Medium-intensive R&D firms and R&D firms that have know-how employ more workers than other firms
3. Changes in R&D intensity do not have a significant difference in impact on employment within firms.
4. In-licensing of know-how also has a significant positive effect on firm employment
5. Technology embodied in imports appears to have a stronger effect on employment than R&D and in-licensing.

The final section presents an analysis of the association between firm R&D and employment. Investment in R&D can affect firm employment outcomes through several channels. Innovation through R&D can be directed towards improvements in productivity (process innovation) and/or the introduction of new products (product innovation). The empirical literature generally finds that product innovation is labour-friendly, whereas process technological change may be labour-saving. However, the net employment effect of labour-saving process innovation in the firm will depend on the direct impact of the innovation on firm sales. Rising sales from innovation offsets some of the potential losses associated with rising productivity within the firm. Naidoo (2000), for example, estimates net increases in employment in firms that engage in R&D in South African firms. The net positive employment effect also holds for exporters, where the direct employment effect of R&D more than offsets the labour-saving productivity enhancements from R&D that are necessary for firms to compete internationally. Edwards et al. (2022) find similar outcomes when analysing the impact of imported technology on firm employment. While imports of high-technology products boost productivity, the increases in firm output more than offset the productivity-induced decline in employment per unit output, leading to net increases in firm employment.

In this section we analyse the net employment effect of changes in R&D status on firm employment using descriptive analysis and estimation of simple employment regressions (See Box 6 for a discussion of the employment specification).

Box 6: Employment model specification

To analyse the employment association with firm R&D, we estimate a static labour demand equation drawing on the specification developed by Van Reenen (1997) and used by Naidoo (2020) for South Africa:

$$l_{ist} = \beta_0 + \beta_1 w_{it} + \beta_2 k_{it} + \beta_3 RD_{ist} + \quad {}_{m} \delta_m \theta_{it}^{m} + \lambda_{st} + \lambda_i + \varpi_{ist} \quad (4)$$

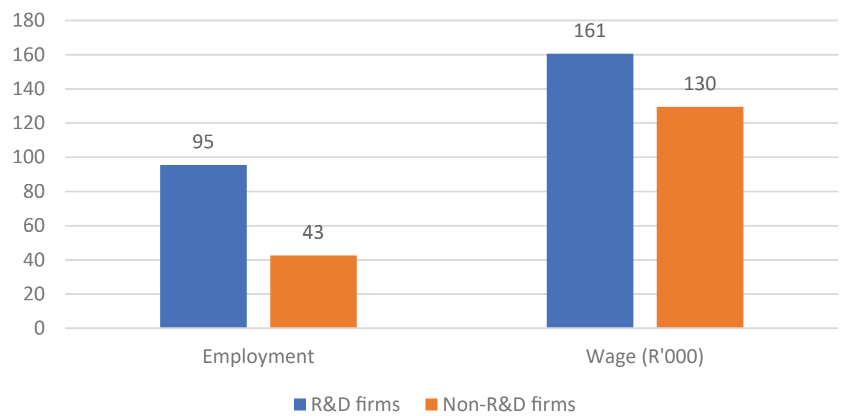
where l is firm employment, w is the wage, and k is the capital stockTheta denotes the set of other firm characteristics variables used in the export and productivity regressions. Whereas Naidoo (2020) includes ssector-level demand variables, we include a SIC three-digit industry by financial year fixed effect (lambda sub s t to control for all industry-level trends. We also do not include lagged employment. The equation is estimated using OLS, without controlling for potential endogeneity of wages. We, therefore, pay little attention to the size of the wage relationship.

Background employment descriptives

R&D firms employ more workers and pay higher wages than non-R&D firms.

Figure 49 presents the simple average employment and wage of R&D and non-R&D firms in 2018/19. On average R&D firms employ 95 workers compared to 43 for non-R&D firms. The average wage R&D firms pay these workers is R161 thousand compared to R130 thousand for non-R&D firms.

Figure 49: Average employment and wage by R&D status, 2018/19

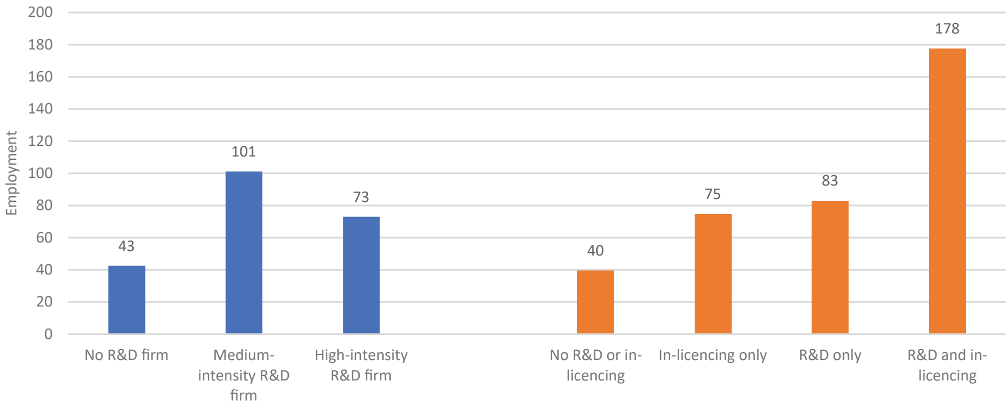


Note: Firm panel based on R20 million in April 2013 prices sales cut-off. Excludes R&D and royalty/licence fees from related foreign firms. The averages are based on the mean log value of employment and wages.

Medium-intensive R&D firms and R&D firms that have in-licence know-how employ more workers than other firms

Figure 50 looks at how employment levels differ according to the intensity of R&D expenditure within firms and the use of in-licensing agreements to access innovative knowledge. Looking first at R&D intensity, firms with medium R&D intensity are the largest employing on average 101 workers, compared to 73 workers in high R&D-intensity firms. When looking at employment in firms according to their R&D and in-licensing status, we find similar employment levels (75-83 workers per firm) across firms that engage in either in-licensing or R&D. In contrast, firms that engage in R&D and in-licensing employ 178 workers on average. Note, however, that these firms only constitute a small share of all firms in the sample.

Figure 50: Average employment by R&D intensity and in-licensing status, 2018/19



Note: Firm panel based on R20 million in April 2013 prices sales cut-off. Excludes R&D and royalty/licence fees from related foreign firms. The averages are based on the mean log value of employment and wages.

Employment model results

Table 13 presents several estimates of the employment relationship. The results provide several insights.

R&D firms employ significantly more workers than other firms.

As found by Naidoo (2020), R&D firms employ significantly more workers than other firms. This is shown in column 1: results that control for industry (SIC three-digit) by time trends. Employment is estimated to be 75% (exp(0.560)-1) higher in R&D firms compared to non-R&D firms while controlling for other firm characteristics. Higher employment levels are also found in firms that export, import, and in-licence know-how, are more capital-intensive, are part of multinational enterprises and pay lower wages. Employment is lower in more productive firms.

In column 2, we extend the regression and include firm fixed effects. These regressions capture how changes in R&D status affect employment levels within the firm. In effect, in these regressions, we track when firms commence (or end) R&D and assess how employment changes thereafter. Upon commencing with R&D, firm employment increases by 5%. The impact is lower than in column 1 results, where the R&D relationship is determined by changes in R&D status and employment within the firm, as well as the selection of larger firms into R&D activities (i.e., the cross-firm variation). In column 3 the sample is restricted to manufacturing firms, but the employment effect of R&D does not change. The employment outcomes of firms that commence with R&D are no different between manufacturing firms and other firms when treated as a group.

An implication of these findings is that the reduction in the number of firms engaging in R&D over the past decade will have contributed to slower growth in aggregate employment.

Changes in R&D intensity do not have a significant difference in impact on employment within firms.

In column 4, firms are classified according to whether their R&D intensity lies above or below the mean R&D intensity across all firms over the period. The coefficient on these variables measures the employment outcome when firms transition from no R&D to medium- or high-R&D intensity. The transition to medium-R&D-intensity is associated with a 5.2% increase in employment, whereas the transition to high-R&D intensity (from no R&D) is associated with a 4.6% increase in employment, but the difference is not statistically significant.

In-licensing know-how also has a significant positive effect on firm employment.

The regressions also provide insight into changes in employment within firms as they commence with in-licensing know-how through royalty/licence fee agreements. Employment across all firms rises by approximately 2.4% after the commencement of in-licensing (column 2), with slightly stronger increases (3.9%) for manufacturing firms. Firms that both engage in R&D and in-licensing, therefore have substantially larger employment outcomes than firms that engage in neither, or that engage in either of the two activities. However, the within-firm results in column 5 suggest that there are no additional complementary effects from the joint engagement in R&D and in-licensing. When we exclude the firm fixed effects, we find an additional employment boost when firms engage in both activities. However, this largely reflects the likelihood that larger firms with higher employment levels are more likely to select into both activities.

Technology embodied in imports appears to have a stronger effect on employment than R&D and in-licensing.

The regressions include dummy variables for whether the firm imports and whether the importing firm imports high-technology products. Consequently, the regressions provide insight into employment changes within firms when they commence importing and when they commence importing high-technology goods. Firms that commence importing experience increases in employment of around 5.9%, with slightly higher impacts if they are manufacturing firms (6.4%). If these importers also commence importing high-technology goods, they experience an additional increase in employment of between 3.7% and 5.4%. Edwards et al. (2022) find similar results in their study on imported technology and firm outcomes.

Table 13: R&D status and firm employment, 2010-2020

	(1)	(2)	(3)	(4)	(5)
				R&D intensity	R&D and royalty
VARIABLES	All firms	All firms	Manufacturing	All firms	All firms
R&D firm	0.560**	0.051**	0.052**		0.055**
	(0.031)	(0.010)	(0.012)		(0.011)
Medium-intensity R&D firm				0.052**	
				(0.011)	
High-intensity R&D firm				0.046*	
				(0.022)	
Royalty/licence fee firm	0.432**	0.024**	0.039**	0.024**	0.025**
	(0.016)	(0.006)	(0.011)	(0.006)	(0.006)
(R&D firm)x(Royalty/licence fee firm)					-0.020
					(0.021)
Exporter	0.167**	0.044**	0.041**	0.044**	0.044**
	(0.015)	(0.007)	(0.010)	(0.007)	(0.007)
Importer	0.060**	0.059**	0.064**	0.059**	0.059**
	(0.015)	(0.007)	(0.011)	(0.007)	(0.007)
Importer high-tech products	0.402**	0.037**	0.054**	0.037**	0.037**
	(0.016)	(0.005)	(0.008)	(0.005)	(0.005)
Foreign owned	-1.008**	-0.017	0.056	-0.017	-0.018
	(0.073)	(0.022)	(0.036)	(0.022)	(0.022)
Multinational enterprise	1.733**	-0.026	-0.095**	-0.026	-0.026
	(0.067)	(0.020)	(0.033)	(0.020)	(0.020)
value added/worker	-0.558**	-0.151**	-0.130**	-0.151**	-0.151**
	(0.007)	(0.006)	(0.009)	(0.006)	(0.006)
Capital/Labour	0.040**	0.003+	0.003	0.003+	0.003+
	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)
Wage	-0.176**	-0.038**	-0.036**	-0.038**	-0.038**
	(0.007)	(0.003)	(0.005)	(0.003)	(0.003)
Constant	12.420**	6.207**	5.948**	6.207**	6.207**
	(0.069)	(0.081)	(0.126)	(0.081)	(0.081)
Observations	218,430	212,121	64,428	212,121	212,121
Adjusted R-squared	0.421	0.910	0.915	0.910	0.910
Fixed effects					
Industry by year	Y	Y	Y	Y	Y
Firm		Y	Y	Y	Y

*Notes: Firm panel based on R20 million in April 2013 prices sales cut-off. Excludes foreign related expenditure on R&D and royalty/licence fees. All estimates include SIC three-digit industry by financial year fixed effects. Employment and the capital/labour ratio are in natural logarithms, while the remaining variables are categorical variables. Foreign ownership is defined according to the strict definition of Kilumelume et al. (2021), i.e., firms declaring themselves to "being ultimately foreign-controlled". Medium-intensity R&D firms are firms where R&D intensity is below the mean R&D intensity of R&D firms. High-intensity R&D firms have above mean R&D intensity levels. The omitted group are non-R&D firms. The dummy variable "Importer of high-tech products" denotes firms that import high-technology products as defined by Lall (2000). Robust standard errors clustered at the firm level are presented in parentheses. ** p<0.01, * p<0.05, + p<0.1.*

6. Policies to increase business expenditure on R&D

Key findings

1. A wide range of policy options exist to encourage business R&D. These policies include, for example, tax incentives, cash grants, tax holidays, VAT reimbursements, financial support, loans, etc.
2. SA follows other comparator countries in that it offers the three of the most commonly used R&D incentives by these countries, namely: (a) tax deductions, (b) cash grants, and (c) accelerated depreciation.
3. South Africa offers a narrower range of R&D incentives than comparator countries. Whereas comparator countries offer nearly six types of R&D incentives, South Africa only offers three.
4. Public support for business R&D as % of GDP in South Africa covering indirect funding through tax incentives and direct financing through grants and calls for projects is low compared to OECD countries, but not necessarily compared to other emerging economies.
5. Financial support for business R&D has fallen in South Africa since the early 2000s, with the decline in direct government-funded BERD the key contributing factor.
6. The decline in direct government funding can explain a third of the decline in BERD as a share of GDP from 2008 to 2019.
7. South Africa's implied subsidy of the R&D tax incentive is generous compared to more than half of the countries in the OECD R&D Tax Incentive Indicators database.
8. The use of tax incentives has been insufficient to offset a decline in public support for business R&D through direct government funding.
9. SA underperforms regarding firm utilisation of the R&D tax incentives relative to its implied subsidy rate.
10. The SARS-NT firm data shows a steady rise in the number of firms applying for the R&D incentive from the Department of Science and Innovation, but declining approval rates have diminished the growth in the number of firms benefiting from the incentive.
11. Larger firms are also found to make greater use of the tax incentive, with the average employment size of approved firms engaging in R&D equal to 94.4, compared to below 11.7 other R&D firms.
12. Cursory analysis of the SARS-NT firm data suggests that the tax incentive raises the probability of firms engaging in R&D activities by up to 2.5 percentage points.

This section provides an overview of policies used to increase business expenditure on R&D. The section first presents a comparative overview of a range of policies adopted by countries. An analysis of the effectiveness of the R&D tax subsidy in South Africa then follows this.

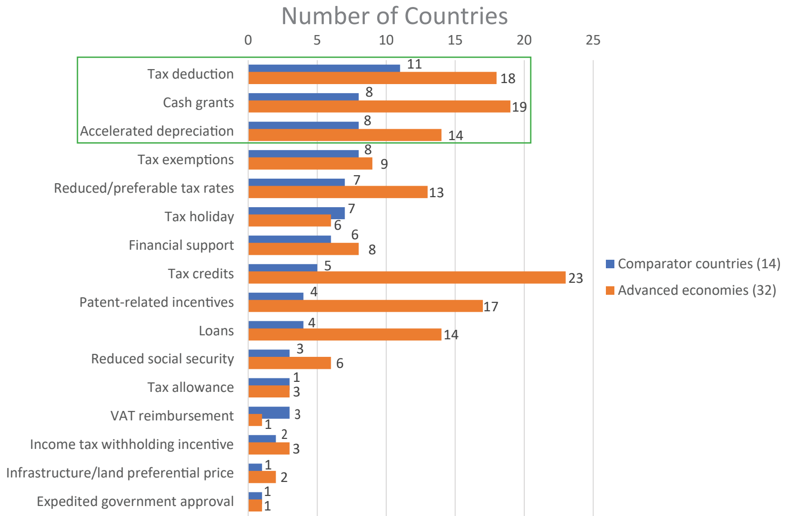
6.1 Comparative analysis of policies to increase R&D

Countries differ widely in terms of the type and range of policies adopted to encourage R&D. To benchmark the policies adopted by South Africa against those of other countries, we draw upon the Ernst & Young (2023) *Worldwide R&D Incentives Reference Guide*. This guide provides detailed information on R&D policies for 46 countries, including South Africa. Figure 51 draws on the data to present a list of types of R&D policies applied and the number of countries that use them. The countries are divided into a comparator group 14, and an advanced economy group (32 countries). The types of policies are sorted by the frequency of use by the comparator group.

A wider range of policy options exist to encourage business R&D.

Figure 51 lists 16 types of policies used to incentivise R&D expenditure. These policies include, for example, tax incentives, cash grants, tax holidays, VAT reimbursements, financial support, loans, etc. Half or more of the comparator countries make use of tax deductions (79%), cash grants (57%), accelerated depreciation (57%), tax exemptions (57%), reduced/preferential tax rates (50%) and tax holidays (50%). High shares of advanced economies also offer tax deductions, cash grants and accelerated depreciation. They are also more likely to use tax credits than tax deductions, and make greater use of patent-related incentives and loans compared to the comparator countries. Compared to the comparable countries, advanced economies use less tax holidays and tax exemptions (fewer than 30%). Expedited government approval, infrastructure/land preferential prices and income tax withholding incentives are not commonly used (fewer than 15% of countries in each group).

Figure 51: R&D policies applied by different countries



Source: Own calculations using Ernst & Young (2023) Worldwide R&D Incentives Reference Guide. The 14 comparator emerging economies cover Argentina, Brazil, Chile, China Mainland, Colombia, India, Indonesia, Malaysia, Philippines, South Africa, Thailand, Tunisia, Türkiye and Vietnam.

The incentives offered within these categories differ substantially across countries. For example, Brazil allows a 100% depreciation on eligible R&D assets during same year of acquisition. In contrast, South Africa allows for an accelerated depreciation over three years (50:30:20) for capital expenditure incurred on machinery or plant used for R&D. Lithuania also offers accelerated depreciation for certain fixed assets used in R&D activity. Still, the depreciation period differs by type of asset and can range from 2 to 8 years (Ernst & Young, 2023).

SA follows other comparator countries in that it offers three of the most commonly used R&D incentives by these countries, namely: (a) tax deductions, (b) cash grants, and (c) accelerated depreciation.

Tax deductions are the most commonly used incentive, with over 60% of countries offering this type of support. Tax deductions are particularly common amongst the comparator countries with 11 out of the 14 countries adopting the policy. More than half the comparator countries also apply cash grants (8) and accelerated depreciation policies (8). Cash grants for R&D by private enterprises in South Africa are primarily attributed to two incentive schemes:

a) the *Support Programme for Industrial Innovation* (SPII)[24] that offers non-taxable and non-repayable grants to cover qualifying costs incurred during technical development and
b) the *Technology and Human Resources for Industry* (THRIP) scheme, which offers a cost-sharing grant of up to R8 million per year for a period of three years for collaborative R&D projects in science, engineering, and/or technology conducted between industry and government (working with academia).

Both these schemes are administered by the Department of Trade, Industry and Competition (DTIC). Three additional instruments are offered to accelerate the commercialisation of research downstream: (i) the Technology Innovation Agency to support innovative start-ups, (ii) the National Intellectual Property and Management to support and protect IP emanating from publicly financed R&D, and (iii) the Intellectual Property Rights from Publicly Funded Research and Development Act for encouraging a more effective use of IP and the deployment of Technology Transfer Offices (OECD, 2016).

South Africa offers a narrower range of R&D incentives than comparator countries.

On average, countries in the sample offer approximately five types of R&D incentives, with comparator countries offering a slighter more incentives than advanced economies (5.8 vs. 4.9). Of the comparator countries in the sample, South Africa makes use of the fewest incentives (3). In contrast, India makes use of the most (10). South Africa ranks 34th (out of 46) in terms of the number of types of incentives offered. The top-ranking country is Hungary, which has 12 types of R&D incentives.

24 The SPII Product Process Development (PPD) scheme offers non-taxable and non-repayable grant to small, very small and micro enterprises and to individuals to cover qualifying costs incurred during technical development. The share of costs covered is based on percentage ownership by certain disadvantaged groups. The SPII Matching scheme offers non-taxable and non-repayable grant to all enterprises and individuals, with grants ranging between 50% and 75% of qualifying costs incurred during technical development stage (maximum ZAR5 million per project). The percentage is based on the percentage ownership by certain disadvantaged groups (Ernst & Young, 2023: 485)

6.2 R&D tax subsidy in South Africa

In 2006, South Africa adopted a new tax subsidy policy (s11D) to replace the older s11B allowance for R&D expenditure, providing a 100% deduction of operating expenditure and a four-year write-off for capital expenditure.[25] Although the conditions have changed over time (e.g., the introduction of the pre-approval process in 2012), the new s11D tax subsidy allows taxpaying firms that incur expenditures directly attributable to scientific or technological R&D to claim 150% of qualifying expenditures pre-approved by the Department of Science and Innovation (DSI). This is equivalent to a 14% saving on every Rand spent on R&D given the corporate tax rate of 28% (13.5% saving from April 2022 with reduction in corporate tax rate to 27%). New and unused R&D machinery or plants also qualify for a three-year write-off (50%, 30% and 20%) if they meet specific criteria (Ernst and Young, 2023). The high-level objectives of the policy are to (a) encourage businesses to conduct R&D in South Africa, (b) advance scientific knowledge and technological advancement to create new or significantly improved materials, devices, products or processes, and (c) increase positive spill-overs to the rest of society (NACI, 2020: 221).

Several studies have analysed the impact of the R&D tax incentive on firm R&D (DST, 2016, 2019; Tregenna et al. (2020); World Bank (2019); James (2017); Kreuser and Newman (2018) (see Box 7 for a summary of some studies). The DSI also provides background data and analysis of applications in their reports to Parliament (DSI, 2024). In this section, we use data obtained from OECD R&D Tax Incentive Indicators to present a comparative assessment of utilisation of the R&D tax incentive in South Africa. Further, we draw on the SARS-NT data to provide additional insights into the utilisation of the tax incentive, as reported by companies in their income tax submissions.

Box 7: Effectiveness of R&D Tax Incentives

Research on the effectiveness of tax incentive policies for R&D investment yields mixed results. Hemphill (2009) found that the US R&E tax credit had a negligible effect on increasing industry-applied research investment. However, Crespi et al., (2016) reported that a tax credit scheme in Argentina was effective in increasing firms' innovation efforts, with varying effects based on the type of innovation investment, industrial sector, and firm size. Guceri and Liu (2019) provided evidence of the positive impact of tax credits for R&D in the UK, with an estimated user-cost elasticity of around -1.6. Lokshin and Mohnen (2012) found level-based fiscal tax incentives effective but can bring about crowding out for medium to large firms. However, incremental tax credits may be less susceptible to deadweight loss than level-based ones, especially in small firms (Baghana and Mohnen, 2009).

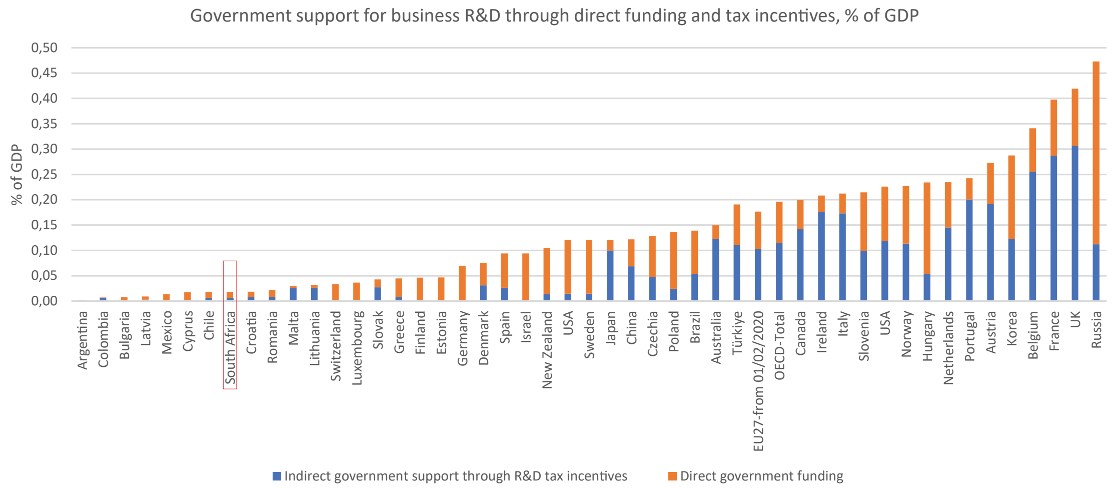
The effectiveness of tax incentive policies for R&D investment in South Africa is a topic of debate, but not much has explicitly focused on South Africa. Pouris (2003) recommended a tax incentive scheme for R&D, but did not provide a direct assessment of its effectiveness. Marire (2021) suggested that the reallocation of business R&D expenditure from experimental to applied research, influenced by tax incentives, harmed the productivity of the national system of innovation. The firm-level analysis includes Kreuser and Newman (2018), who used the NT-SARS panel dataset for the period 2010 – 2013 and found a positive and significant correlation between R&D expenditure and productivity, as well as a positive correlation between R&D tax allowances and total factor productivity. James (2017) estimated that companies benefiting from the incentive spend an additional R4 million on R&D compared to those who conducted R&D but did not benefit from the incentive (cited in National Treasury, 2021: 19). Tregenna et al. (2020) use the SARS-NT data for manufacturing firms and find positive and significant effects associated with the R&D tax incentive. Companies that received the R&D tax allowance increased in-house R&D investment in expenditure and intensity but reduced technology in-licensing. Finally, the World Bank (2019) conducted an impact evaluation study and found some evidence that the incentive increased R&D spending by companies (more than doubled expenditure) and increased the remuneration of R&D employees in beneficiary companies. However, their findings were based on a very limited set of data (18 treated companies, 14 control companies).

25 Section 11D Research and Development Incentive (R&D) was introduced into the Income Tax Act in 2006. Details on the tax incentive are provided by the South African Revenue Services (https://www.sars.gov.za/businesses-and-employers/my-business-and-tax/). For details on the evolution of the tax incentive scheme, see the draft discussion document reviewing the design, implementation and impact of South Africa's R&D tax incentive released by the National Treasury (2021). See also DSI (2024). For details on proposed amendments, see National Treasury (2021, 2022, 2023).

Comparative analysis of the tax incentive using the OECD R&D Tax Incentive Indicators

Public support for business R&D as % of GDP in South Africa covering indirect funding through tax incentives and direct financing through grants and calls for projects is low compared to OECD countries, but not necessarily compared to other emerging economies[26] Figure 52 plots direct and indirect (via tax incentives) funding support by government for business R&D. The estimate for South Africa for 2019 is 0.018% of GDP compared to 0.14% of GDP for the sample of 47 countries, mainly from the OECD. However, government funding for R&D in South Africa is higher than in some emerging economies (Mexico, Argentina, Colombia) but is also substantially below the emerging economies of Brazil (0.14%) and Türkiye (0.19%).

Figure 52: Government support for business R&D through direct funding and tax incentives in 2019, % of GDP



Source: Own calculations using data obtained from OECD R&D Tax Incentive Indicators. Estimates of the cost of Government Tax Relief for R&D (GTARD) specify the actual amount of tax support provided by governments through R&D tax relief provisions for business R&D expenditure. Estimates reflect the sum of foregone tax revenues. Government-funded business R&D is the component of R&D performed by business enterprises that they attribute to direct government funding. It includes grants and payments for R&D contracts for procurement, but not R&D tax incentives, repayable loans or equity investments. Values are for 2019, or nearest available year.

Financial support for business R&D has fallen in South Africa since the early 2000s, with the decline in direct government-funded BERD the key contributing factor

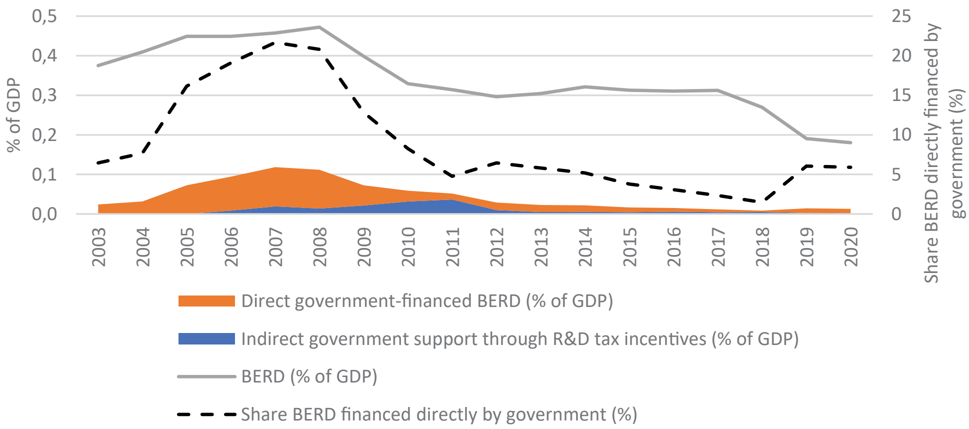
Figure 53 This chart presents the South African government's direct and indirect financial support for BERD as a share of GDP from 2008 to 2019.Whereas direct financial support for business R&D in South Africa equalled 0.1% of GDP in 2008, by 2019, it had fallen to 0.012% of GDP. Most of the decline in direct government-funded business R&D occurred from 2008 to 2010.

The decline in direct government funding can explain a third of the decline in BERD as a share of GDP from 2008 to 2019

As shown in Figure 53, BERD as a share of GDP fell from 0.47% to 0.19% (0.28 percentage points) over the period 2008 to 2019 (see Figure 53). The decline in direct government-funded BERD over this period (0.1 percentage point of GDP) is therefore equivalent to 34% of the decline in BERD. If we look over the period 2008 to 2011, when the decline in government funding was most severe, the contribution to the decline in BERD rises to 58%.

26 The value of direct government-financed business R&D in the OECD data corresponds with the values provided in the HSRC-CeSTII South African National Survey of Research and Experimental Development.

Figure 53: Government support for business R&D through direct funding and tax incentives in South Africa from 2003 to 2020

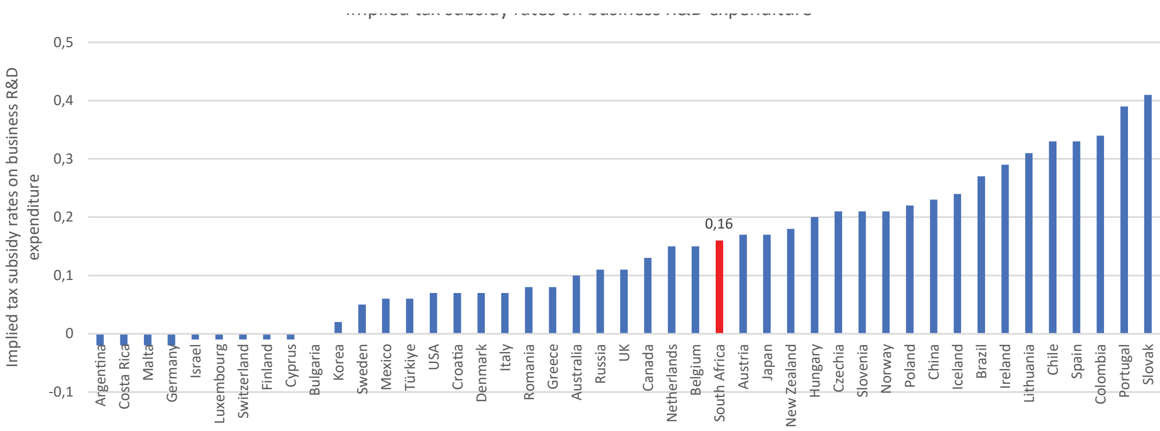


Source: Own calculations using data obtained from OECD R&D Tax Incentive Indicators, Statistical Reports of the National Survey of Research and Experimental Development. The data on indirect government support through tax incentives is obtained from DSI (2024)
Notes: BERD denotes business expenditure on R&D.

The implied subsidy of the R&D tax incentive in South Africa is generous compared to more than half of the countries in the OECD R&D Tax Incentive Indicators database.

Figure 54 compares the implied marginal R&D tax subsidy rate (measured as 1 minus the B-Index; see notes to the table) for business R&D in South Africa in 2019 with those of the other countries for which data are available. The implied marginal subsidy rate for South Africa is 0.16, which is higher than the median country's (0.12).

Figure 54: Implied tax subsidy rate on business R&D expenditure, 2019

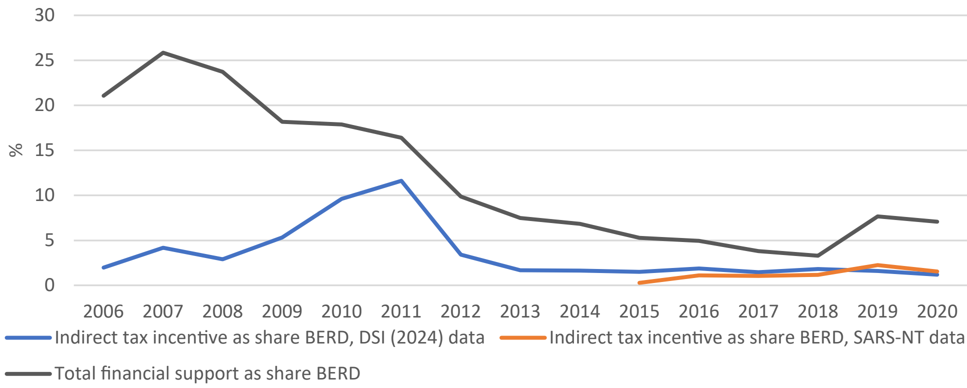


Source: Own calculations using data obtained from OECD R&D Tax Incentive Indicators. Implied marginal R&D tax subsidy rates, customarily derived as 1 minus the B-Index, specify the notional level of subsidy (before tax) on one additional unit of R&D outlay. The B-Index measures the reduction in before-tax income required for a representative firm to break even on USD1 of R&D outlay. The estimates are calculated for a representative large profitable firm (small business corporations (SBC) in terms of tax legislation have lower corporate tax rates, the benefit accruing to them through the incentive is, therefore, less (NT, 2021: 29)). Values are for 2019, or nearest available year.

The use of tax incentives has been insufficient to offset a decline in public support for business R&D through direct government funding

Indirect support through tax incentives (as % of GDP) is also presented Figure 53. Although indirect support through the tax incentive rose as a share of GDP from its initiation in 2006 to 2011, this increase was insufficient to compensate for the decline in direct government funding of BERD. From 2011, the taxes foregone through the R&D tax incentive fell dramatically and has been attributed to the administrative delays and backlogs associated with the pre-approval system introduced in 2013 (DST, 2019). By 2019, indirect funding for BERD as a percent of GDP had fallen to a third of its value in 2012 (from 0.01% to 0.003%). The net effect has been a decline in the share of business expenditure on R&D supported through government funding, as can be seen in Figure 55. Whereas direct and indirect government support accounted for just over a quarter of BERD in 2007, the share in 2019 was only 7.7% (note of a reduced aggregate value). The effective savings from the tax incentive constitute low and stagnant share (less than 3%) of total Business R&D.

Figure 55: Comparison of implied funding from the indirect tax incentive as a share of BERD using the OECD data and the SARS-NT data

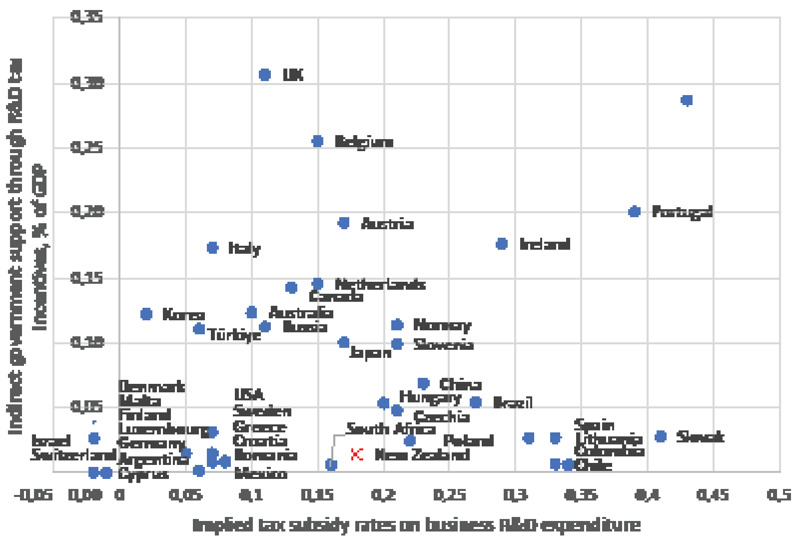


Notes: Own calculations. Data on indirect government support through tax incentives is obtained from DSI (2024). The indirect tax incentive as a share of BERD using the SARS-NT data is based on reported R&D expenditure by firms that received approval for the s11D tax credit from the DSI. The implied tax contribution is calculated as declared R&D x 0.5 x 0.28, where 0.28 denotes the corporate income tax, and 0.5 denotes the 50% additional deduction from taxable income allowed per year for qualifying direct R&D costs. Total financial support from the government is calculated using direct funding by the government obtained from OECDstat, and indirect funding from DSI (2024). (see sheet FigSOF in file DSI_HSRC_statisticalreports_4Dectemp_11Jan.xls)

SA underperforms regarding firm utilisation of the R&D tax incentives relative to its implied subsidy rate

R&D tax incentives are expected to stimulate BERD, with higher implicit subsidies leading to higher levels of BERD. To assess the effectiveness of the tax subsidies in driving BERD, Figure 56 plots the implied funding of R&D through the tax incentive against the implied subsidy rate using all available countries in the OECD R&D Tax Incentive Indicators database. There is a generally positive relationship between the two indicators, although there is substantial variation across countries. South Africa, however, lies far below the simple regression line, with indirect support through the tax incentive only equalling 0.006% of GDP, compared to between 0.05% (Hungary) and 0.26% (Belgium) for other countries with similar implied subsidy rates. In other words, businesses' use of the tax incentive to finance R&D in South Africa is far below what we would predict based on the implied subsidy provided.

Figure 56: Indirect government support through the R&D tax incentive (% of GDP) against the implied tax subsidy rate



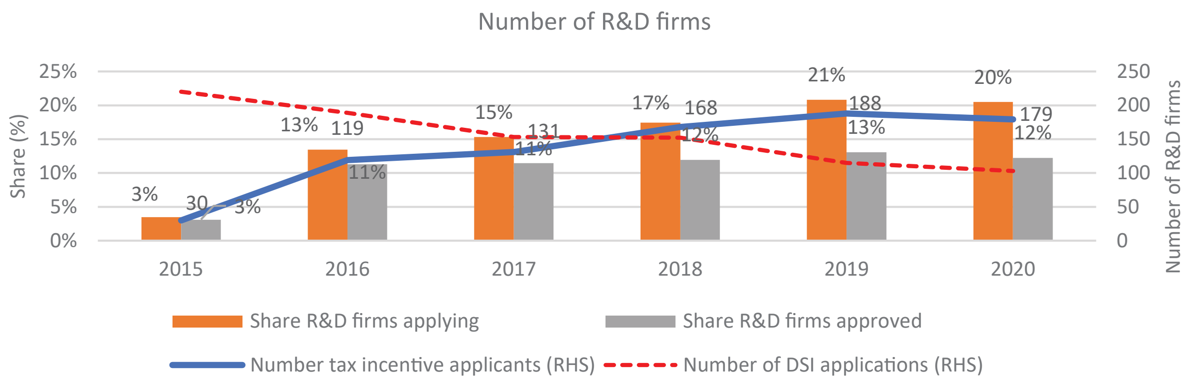
Source: Own calculations using data obtained from OECD R&D Tax Incentive Indicators. Implied marginal R&D tax subsidy rates, customarily derived as 1 minus the B-Index, specify the notional level of subsidy (before tax) on one additional unit of R&D outlay. The B-Index measures the reduction in before tax income required for representative firm to break even on USD1 of R&D outlay. Values are for 2019, or nearest available year.

Firm-level analysis of tax incentives using SARS-NT database

The SARS-NT database provides additional insights. The 'Tax Allowances/Limitations' section of the income tax form contains a question on whether the "...*company obtain approval from the Department of Science and Technology as contemplated in s11D?*". We use firm responses to this question to provide a rough analysis of the number of firms that apply and successfully obtain approval for their applications for R&D tax relief. A more comprehensive analysis of the actual submissions and acceptance rates is possible using the applications submitted to the Department of Science and Innovation (see National Treasury, 2021). However, the advantage of the SARS-NT data is that it provides additional information on the firms. Unfortunately, due to confidentiality constraints, merging the data sets has not been possible (National Treasury, 2021).

In the analysis, we assume that only firms that applied for the R&D tax relief fill in this question. We also generally restrict the analysis to those sets of firms that engage in R&D. Finally, we focus on the period 2016 to 2019, given the few observations before this period. The precise number of applicants in this analysis thus deviates from those based on the actual submissions to the DSI. ***The firm data shows a steady rise in the number of firms applying for the R&D incentive, but declining approval rates have diminished the growth in the number of firms benefiting from the incentive. Very few R&D firms ultimately use the tax incentive.*** Figure 57 presents information on the number of R&D firms that applied for the tax incentive in each financial year. According to the data, the number of applicants in the sample rose from 119 in 2016 to 188 in 2019. This increase reflects a rising share of firms that engage in R&D. For example, the share of R&D firms applying for the incentive rose from 13% in 2016 to 21% in 2019. However, the success rate of applications fell sharply over the period, from a 90% approval rate in 2016 to a 63% approval rate in 2019. The implication is that the number of successful applicants as a share of R&D only rose from 11% to 13% between 2016 and 2019. The number of successful applicants in the sample only rose from 100 to 118.

Figure 57: Number, share and approval rate of R&D tax incentive applicants



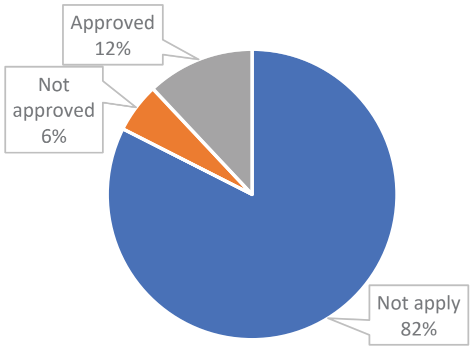
Source: SARS-NT data. Sample only includes all firms that declare R&D expenditure and DSI (2024) https://www.dst.gov.za/rdtax/. Note the Department of Science and Innovation (DSI) applications include multiple applications by firms. In 2017/18, 115 companies submitted 152 applications. In 2020/21 123 applications from 103 companies were received. The number of applications fell from 305 from 2012/13. The difference between the SARS/NT and DSI data is due to several factors: (a) not all the applications submitted to the DSI are approved, and (b) several of the applications cover multi-year projects that would be also be declared in the tax returns in the years following approval.

The contribution of approved R&D tax incentive firms to aggregate R&D far exceeds their share of all R&D firms, implying that larger R&D expenditure firms make greater use of the tax incentive

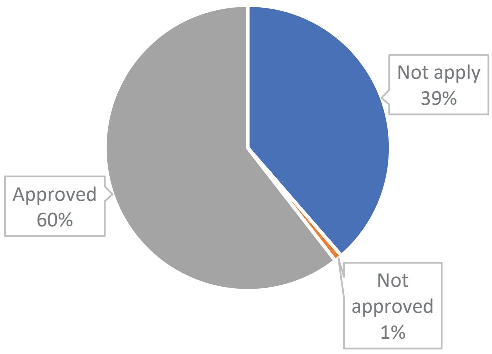
Figure 58 presents pie charts of the average share composition of R&D firms and aggregate R&D expenditure by R&S tax incentive application status using data for 2016 to 2019. On the other hand, R&D firms with tax incentive approval only made up 12% of R&D firms from 2016 to 2019, accounting for 60% of aggregate R&D expenditure. R&D expenditure by firms that do not receive approval only make up 1% of aggregate R&D expenditure. Firms with relatively large R&D expenditures are, therefore, more likely to make use of the incentive, as is also found in the impact evaluation by the World Bank (2019). The average employment size of approved firms engaging in R&D is 94.4, compared to 11.7 for not-approved R&D firms and two for R&D firms that did not apply for the tax incentive. In their analysis of the application data, the DSI (2024) also found that firms with a turnover of R100 million or more account for a disproportionate share of tax incentive participants (cumulative 33.6% for the period Oct 2012 to Feb 2021).

Figure 58: Average share composition of R&D firms and aggregate R&D expenditure by tax incentive application status, 2016-2019

(a) Share composition of R&D firms



(b) Share composition of aggregate R&D expenditure

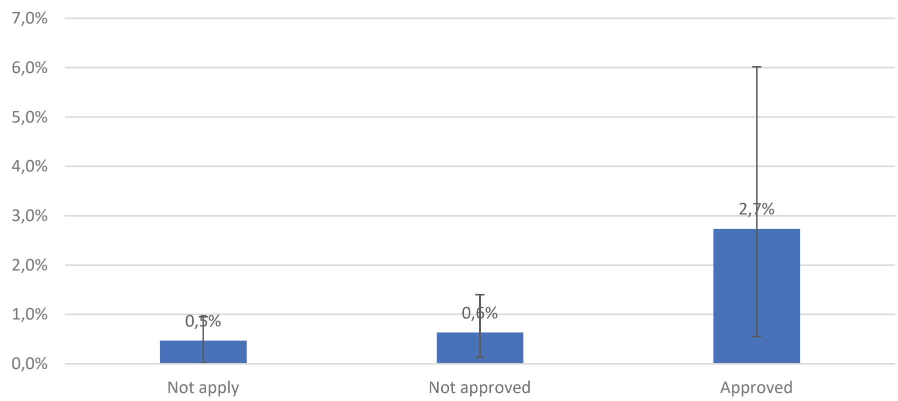


Source: SARS-NT data. Sample only includes all firms that declare R&D expenditure.

A cursory analysis of the firm data suggests that the tax incentive raises the probability of firms engaging in R&D activities. Identifying the causal effect of the tax incentive on R&D participation and R&D expenditure in South Africa is very difficult given the low number of R&D tax incentive recipients, and the limited detail on the nature of the R&D expenditure by the firm (see the World Bank (2019) for an impact evaluation study for South Africa).[27] To assess whether the application by firms for the R&D tax incentive is associated with R&D activity, we regress a dummy variable for current R&D activity on a categorical variable for whether the firm applied for the incentive and whether the firm was successful in its application in the prior financial year. Firm fixed effects are included so that we, in effect, follow how transitions by the firm across application status affect subsequent R&D. SIC 3-digit industry fixed effects are included to control for industry-specific trends. Also included are variables for size (employment), productivity (value added per worker) and multinational status.

Figure 59 presents the estimated probability that a firm engages in R&D by tax incentive application status. There is no significant increase in the probability of firm engagement in R&D if the firm does not apply for the tax incentive. For firms that apply and are not successful there is a small increase in the probability that the firm engages in R&D. However, firms whose application for the tax incentive are approved experience a significant increase in the probability of engaging in R&D. These results do not necessarily imply causality, but they suggest that firms investing in R&D are more likely to make use of the tax incentive.

Figure 59: Probability of engaging in R&D according to tax incentive application status



Source: SARS-NT data. Sample includes all firms over the period 2016 to 2019.

27 One option is to try to exploit the distinct changes in the R&D tax policy after 2006. The challenge in this regard is the low number of R&D firm observations and isolating an appropriate control group.

7. Summary of findings

The 2019 White Paper on Science, Technology and Innovation (DST, 2019) sets the goal of raising gross expenditure on research and development (GERD) as a percent of GDP to 1.5%. This is an ambitious target. Yet aggregate expenditure on R&D has disappointed, and the share of GERD in GDP has fallen over the past few years, reaching 0.6% of GDP in 2020. The driving force behind this decline has been the business sector. Business expenditure on R&D (BERD) has fallen in real terms and as a share of GDP since 2008. By 2020, real BERD was less than half (42%) of its value in 2008, and its share of GERD had fallen to 30% (from 58.6% in 2008). While real private fixed capital investment also fell over this period, the decline in BERD was even faster. The declining contribution of business R&D expenditure has coincided with a slowdown in South African labour productivity growth, as measured by growth in GDP per capita.

We show in this report that South Africa's performance concerning business R&D has also been poor from an international comparative perspective. The country experienced the largest reduction in business R&D as a share of GERD relative to a range of comparator middle-income countries for which data are available. Relatively low numbers of personnel engaged in R&D activities, combined with substantially higher labour costs of business R&D indicate a scarcity in the availability of researchers and technicians. The decline in business R&D has resulted in reduced capacity for innovation and future growth.

Understanding some of the drivers behind the decline in BERD requires a closer look at firm behaviour, including engagement by firms in R&D and the intensity of R&D by these firms. This paper uses the administrative tax data from the SARS-NT database to analyse the characteristics and trends in R&D expenditure by South African firms between the financial years 2010 and 2019. Given data limitations, the analysis is restricted to firms with a real sales value of R20 million or above (in April 2013 prices). This excludes many small firms that engage in R&D, but as we show in the report, the large firms account for a very high share of aggregate expenditure on R&D. Further, the declared expenditure on R&D under the S11D tax incentive is required to conform with tightly specified criteria. The R&D expenditure values, therefore, differ substantially (much lower) from other sources, such as the HSRC-CeSTII South African National Survey of Research and Experimental Development.

The firm analysis, corroborates the trend shown by BERD. Aggregate expenditure on R&D by the sample of SARS-NT firms has declined from 2010 to 2019 as fewer firms engage in R&D activities. The impact of the exit of large firms from R&D activities is particularly pronounced. Manufacturing firms, which make up the largest source of aggregate R&D expenditure, have been the main contributor to the decline in aggregate R&D, but engagement in and expenditure on R&D activities by firms in other sectors have also fallen. The decline in the number of firms engaging in R&D is driven by higher rates of firm exit from R&D than firm entry rates into R&D. This reflects a weak persistence of regular R&D expenditure by firms, as is also found by Steenkamp, et al. (2018).

Our analysis shows considerable heterogeneity across R&D firms in terms of their characteristics. R&D firms differ from other firms in several important respects. They are larger in terms of sales, have higher levels of fixed capital, and are more likely to have foreign ownership and be part of a multinational enterprise (local or foreign-owned). As expected, R&D firms are significantly more productive than other firms, even after even after controlling for firm characteristics such as trade status, size, capital intensity, etc. External acquisition of technology through in-licensing know-how and technology embodied in high-technology imports are also important sources of firm productivity. We find evidence of strong complementary relationships between R&D expenditure and external knowledge acquisition through in-licensing, with the productivity-enhancing effects of R&D stronger in firms that also in-license know-how.

R&D firms are also far more integrated into global markets – they are more likely to be exporters and/or importers and have higher values of exports and export varieties. R&D firms are also particularly important for the export of technologically sophisticated products. For example, they are more likely to export high-technology products at higher values than other exporters. Finally, we find support for a virtuous cycle between entry into exporting and engagements by firms in R&D, although this applies to very few firms. These findings indicate that the decline in the number of R&D firms may have contributed towards the stagnation of aggregate exports and high-tech exports over the past decade.

Finally, R&D firms are important sources of employment and wage income. They employ more workers and pay higher wages than non-R&D firms. Although R&D expenditure enhances firm productivity, which can reduce the required number of workers per unit of output, the growth in output of these firms dominates leading to higher overall levels of firm employment.

This report also presents a comparative overview of R&D incentives offered by South Africa. SA follows other comparator countries in that it offers three of the most commonly used R&D incentives by these countries, namely: (a) tax deductions, (b) cash grants, and (c) accelerated depreciation. However, South Africa offers a far narrower range of R&D incentives than many other countries. For example, the 14 comparator countries offer, on average, 5.8 types of R&D incentives, compared to the three offered by South Africa.

An assessment of public support for R&D in SA, reveals that financial support for business R&D has fallen in South Africa since the early 2000s, with the decline in direct government-funded BERD the key contributing factor. This decline in direct government funding can explain a third of the decline in decline in BERD as a share of GDP from 2008 to 2019. The s11D tax R&D tax incentive scheme initiated in 2006 is generous when compared to 46 countries for which data are available in the OECD R&D Tax Incentive Indicators database. However, the use of tax incentives by firms has been insufficient to offset the decline in public support for business R&D through direct government funding. Finally, SA appears to underperform in terms of firm utilisation of the R&D tax incentives relative to its implied subsidy rate.

8. Policy recommendations

Key recommendations

1. Improvements in the national investment climate are critical for a recovery in expenditure on Research and Development.
2. Expand the range of incentives and support for businesses investing in R&D.
3. Explore the feasibility of providing tax exemptions and tax holidays for R&D expenditure.
4. Raising the after-tax return on sales, leases, or transfers of IP by SA firms via a tax exemption would incentivise business R&D.
5. Accelerate reforms of the R&D tax incentive.
6. Make use of more targeted interventions, including through grants and cash transfers, with a strong focus on firm exporting.
7. Leverage venture capital for R&D purposes.
8. Relax immigration and work-permit restrictions on skilled foreign workers required for R&D activities.

The empirical analysis provides strong evidence that increasing firms' investment in R&D can contribute to growth in sales, productivity, exports, and employment. However, to turn the tide of declining business expenditures on R&D, careful consideration of additional policy options will be required.

To comprehensively assess existing policies and formulate targeted policies that can effectively address and mitigate limitations to R&D by firms, requires a stand-alone comprehensive analysis of available and possible policies, together with interviewing managers/owners of selected firms to identify specific challenges to R&D that firms face. There is also no shortage of policy recommendations to improve R&D and innovation in South Africa. The R&D tax incentive, for example, has been reviewed several times, each feeding into new policy recommendations (DSI, 2016, 2019; National Treasury, 20201; NACI, 2020).
Our empirical analysis provides some policy-relevant insights that can contribute towards improvements in firm R&D.

8.1 Improvements in the national investment climate are critical for a recovery in expenditure on Research and Development

The weak investment climate, together with low economic growth, is a major contributor to the low and declining levels of business R&D in South Africa. Without improvements in the business climate, including the alleviation of key supply constraints related to electricity provision and transport, amongst others, it is unlikely that business R&D expenditure will increase substantially.

8.2 Re-assess the target of 1.5% GERD as a share of GDP

The research calls into question the ambitious goal of the 2019 White Paper on Science, Technology and Innovation (DST, 2019) to raise GERD as a share of GDP to 1.5%. South Africa already allocates a relatively high share of private investment towards R&D compared to other countries. GERD as a share of GDP in South Africa is at levels consistent with the country's level of economic development, as measured by GDP per capita. High GERD as a share of GDP is also not always necessary, nor sufficient, to sustain growth. For example, Chile and Colombia have been able to sustain growth in real GDP per capita over long periods despite low levels of GERD as a share of GDP (below 0.35%). The target also elevates the importance of R&D above other productivity-enhancing measures, including external acquisition of innovative know-how. Finally, benchmarking firm innovation on R&D expenditure goals can be misleading if the available stock of complementary factors such as human and physical capital are not accounted for (Cirera and Maloni, 2017). Raising R&D should, therefore, be considered as part of a broader package of policies that cover complementary factors and supporting institutions that aim to boost business innovation.

8.3 Expand the range of incentives and support for businesses investing in R&D

The empirical analysis shows that public support for R&D in South Africa has declined, and the country lags behind other comparator countries in terms of the range of R&D policies offered to companies. To isolate additional policy instruments to consider, we follow a three-prong strategy:

(a) We identify the most commonly used R&D policies across countries, as obtained from the Ernst & Young (2023) *Worldwide R&D Incentives Reference Guide*.
(b) We isolate middle-income countries for which Ernst & Young (2023) R&D policy data are available that have experienced a combination of strong growth in real GDP per capita and GERD as percent of GDP.
(c) We draw on empirical evidence to assess the effectiveness of each of these R&D policies.

Following this process, we identify three comparator countries: Malaysia, Thailand, and Türkiye. These countries experienced a compound annual growth of real GDP per capita of between 2.8% and 3.3% between 2005 and 2019. GERD as a percent of GDP for these countries rose by 0.4 to 0.9 percentage points. Türkiye, for which data on BERD are available, experienced a 14% average annual compound growth in real BERD from 2012 to 2020.

From this sample, we identify three common policies not applied by South Africa that are both widely used across countries in the Ernst & Young (2023) Worldwide R&D Incentives Reference Guide, and for which there is supportive empirical evidence that they can be effective in boosting business R&D. (see Table 14 and Table 19 in Annex F for a table with examples of empirical research regarding each of these). These are: (i) Tax exemptions (ii) Tax holidays, and (iii) IP-related Incentives.

8.3.1 Explore the feasibility of providing tax exemptions and tax holidays for R&D expenditure

South Africa's fiscus constrains the National Treasury's ability to offer additional tax concessions to companies. Nevertheless, once the constrained fiscal environment alleviates, options to expand tax-related incentives to firms to engage in R&D should be considered. Table 14 summarises some examples of tax exemption and tax holiday policy applied by Malaysia, Thailand and Türkiye that SA authorities could consider.

Table 14 Examples of R&D policies implemented by Türkiye, Thailand and Malaysia

Policy	Example
Tax exemptions	**Türkiye** • A range of documents (e.g., contracts and payroll slips) issued in relation to R&D are exempt from stamp tax. • Goods imported from foreign countries in the scope of R&D projects are exempt from customs duties. • New machinery and equipment deliveries made for the exclusive use of R&D, innovation and design activities are exempted from VAT. Exemption from VAT on R&D expense items in Technology Development Zones

Policy	Example
	Malaysia: • Investment tax allowance: up to 100% tax allowance on qualifying capital expenditures incurred for specific period. • Incentives for researchers to commercialize research findings: 50% tax exemption for five years on the income received. • Incentives for companies undertaking the commercialisation of public sector R&D: eligible income tax exemption of 100% of statutory income for 10 years • Incentives for investments in companies undertaking commercialisation of R&D by public and private research institutes: Eligible for a tax deduction equivalent to the amount of investment made in the subsidiary company. **Thailand** • Exemption/reduction of import duty on materials and machinery imported for use in the R&D process.
Tax holiday	**Thailand** • Exemption of corporate income tax (unlimited amount) for up to eight years, extendable to 13 years subject to R&D expenditure reaching a certain threshold. • Double deduction on expenses related to transport, electricity and water supply, depending on location.
IP-related incentives	**Singapore:** • Approved company is eligible for a reduced corporate tax rate of either 5% or 10% on a percentage of qualifying IP income derived by it during the qualifying incentive period (10 years extendable to 20 years). Qualifying IP income refers to royalties or other income receivable by the approved company. **Türkiye** • The IP that emerges at the end of the R&D project can be registered or owned abroad. • Corporate tax and VAT exemptions applied to transfer, sale and leasing of patented inventions. The corporate tax exemption applies to 50% of the income derived from the transfer, sale or leasing of these intangible rights, and/or to 50% of the income attributed to the intangible rights derived from the sale of invented manufactured products. However, to benefit from the R&D incentives, R&D activities should be performed in Türkiye. **Malaysia** • Qualifying taxpayers are eligible for a 100% income tax exemption on qualifying IP income for a period of up to 10 years. • Generally, no specific intellectual property (IP) requirements are imposed on tax holiday incentive. • Royalties and licensing fees are exempted from income tax under the IP incentive.
Other	**Thailand** • Unlimited (but reasonable) number of visas and work permits for qualifying expatriates. • Eligibility to own land, with no foreign ownership restriction.
	Malaysia • Cash grants: Reimbursable dollar-for-dollar grant on qualifying R&D expenditure.

Source: Ernst & Young (2023) Worldwide R&D Incentives Reference Guide

To incentivise commercialisation of research findings, Malaysia offers tax exemptions on the income received. They also allow for tax deductions on investments made in subsidiary companies undertaking commercialisation of R&D by public and private research institutes. Many countries (including Türkiye and Thailand) exempt imported materials and equipment from import duties and, in some cases, VAT (e.g. R&D expenses in Turkish Technology Development Zones). Tax holidays rather than exemptions are used by Thailand, where companies are exempted from income tax for between eight and 13 years, subject to meeting a threshold of R&D expenditure. Further, they allow double deductions on expenses related to transport, electricity and water supply in some locations. Tax holidays extended to new firms may be particularly advantageous to increase the number of firms engaging in R&D.

8.3.2 Raising the after-tax return on sales, leases or transfer of IP on the part of SA firms via a tax exemption would incentivise R&D

Several countries offer IP-related incentives to firms to encourage IP production, use and sale. Türkiye, for example, offers corporate tax and VAT exemptions on the transfer, sale and leasing of patented inventions. The corporate tax exemption applies to 50% of the income derived from the transfer, sale or leasing of these intangible rights, and/or to 50% of the income attributed to the intangible rights derived from the sale of invented manufactured products. In Malaysia, qualifying taxpayers are eligible for a 100% income tax exemption on qualifying IP income for up to ten years. Singapore also provides reduced corporate tax rates on qualifying IP income.

As shown in this report, foreign receipts received for the sale of IP rose as a share of GDP in South Africa, suggesting a comparative advantage in the generation of knowledge in some research areas. Strengthening these areas through raising the after-tax return on sales, lease, or transfer of IP can assist in further growth in these receipts.

8.2.3 Incentivise the use of external know-how

Access to external know-how through in-licensing is strongly associated with firm productivity, exports and employment. Further, there are strong synergistic relationships between R&D and the in-licensing of external know-how in raising firm productivity. Access to external knowledge can provide a shortcut to adopting existing technologies, allowing a company to expedite the innovation process and bring products to market faster. Further, acquiring external knowledge through in-licensing can reduce the risks associated with R&D by leveraging proven technologies. In-licensing of external know-how is also beneficial where the cost of developing a technology internally is high or where a company lacks the internal capacity or expertise required for a particular innovation. The implication is that R&D and in-licensing are not rivalrous. Reducing dependence on external know-how, including through imported IP, should not be considered as a motivation for raising in-house R&D by South African firms. Instead, policies that incentivise the use of external know-how can boost firm productivity as well as raise R&D expenditure.

There are several options to consider on this front. Malaysia exempts royalties and licensing fees from income tax under their IP incentive programme. The scope of the current R&D tax incentive in South Africa could be broadened to include expenditure on in-licensing that can be shown to complement R&D activities, as is also recommended in the World Bank South Africa Economic Update on Innovation for Productivity by Dessus et al. (2017).

8.3.4 Accelerate reforms of the R&D tax incentive

The analysis in this paper suggests that the R&D tax incentive is not as effective as it could be in driving firm R&D. The number of applicants for the tax incentive has been on a long-term downward trend. Some of this can be explained by the bureaucratic processes and delays associated with the approval of R&D projects. While the turnaround time for providing application decisions has improved, the average turnaround time (114 days in 2020/21) remains above the 90-day target (DSI, 2024). Only 19 (17%) of the 113 applications with decisions in 2020/21 were provided within 90 days (DSI, 2024). As is recognised by the DSI (2024), more can be done to simplify the application process and reduce incomplete submissions through better dissemination of information to firms on the application process and eligibility conditions.

The recent extension of the R&D tax incentive for another ten years until 31 December 2033 will provide greater certainty to firms interested in engaging in R&D. The National Treasury (2021, 2023) has also proposed several changes to the definition of R&D that should broaden the scope for firms to apply for the tax incentive. In particular, the proposed revised definition of R&D shifts away from the intellectual property purpose tests (that the R&D must be patentable), in recognition of the inherent uncertainty of the outcome of R&D. Further, the exclusion of R&D related to internal business processes is to be deleted, meaning that projects can qualify regardless of whether the innovation is intended for sale or use by connected parties or even internally (KPMG, 2023). The improved clarity on what is applicable for the tax incentive may also assist in reducing incomplete applications for the tax incentive that increase the turn-around time (DSI, 2024). These are all positive developments, but where possible, the changes should be accelerated. This includes finalising the proposed changes to the tax incentive.

8.3.5 Make use of more targeted interventions, including through grants and cash transfers, with a strong focus on firm exporting

South Africa faces a significant export challenge, with stagnating export volumes, fewer firms, and declining exports of high-technology products. R&D can be central in driving firm entry into the export market. Raising productivity through process innovation is a key driver of firms' international competitiveness. Too few firms appear able to compete internationally, particularly in the export of sophisticated high-technology products. Further, product innovation can open up new markets for exporters. The domestic market is too small to drive widespread product innovation. Export markets provide the scale for rapid growth in sales of new competitively produced products. Further, the empirical analysis in this report shows a synergistic relationship between exporting and R&D. Targeted R&D incentives that focus on getting firms into the export market can help kick-start a virtuous cycle between exporting, productivity gains and R&D.

Small firms are an additional focus point for targeted grants and cash transfers. The analysis of survey data for small firms in Johannesburg shows that many small firms are involved in R&D activities. However, these firms are less likely to use the tax incentives, as they face more severe financial constraints than large firms. Grants and cash transfers can be a more effective approach to raising R&D of these firms. The SPII Product Process Development (PPD) scheme offers non-taxable and non-repayable grants to small, very small and micro enterprises. This programme can be expanded and advertised more widely than it is currently. Clearly, articulated programmes, with strong coordination between the different departments (e.g. DTIC and DSI), that facilitate innovation across the full product development cycle from R&D to full-scale production will also reduce the costs and information gaps that are particularly problematic for small firms. Respondents in the mixed methods study of Walwyn and Naidoo (2019), for example, highlighted a lack of coordination between departments and incentive opportunities as a barrier to innovation.

8.3.6 Leverage venture capital for R&D purposes

Venture capital funding can be an essential source of funding for research and development (R&D) intensive startup companies. Access to finance through banks is a challenge for these companies given the uncertainty of R&D outcomes. Empirical evidence suggests that venture capital can be an important source of industrial innovations, as is found by Kortum and Lerner (2000) in the US, and by Graff et al. (2021) in their analysis of agricultural technology startups.[28]

Raising foreign capital is essential for startup companies that require significant finance to ramp up production for global markets. One challenge is that the mandates of many large foreign funds prohibit them from investing directly in SA. To get around this, domestic startups are required to set up and transfer IP to an overseas holding company. This process is impeded by domestic regulations governing the transfer and protection of IP, as well as rules regarding payment of capital gains taxes upon IP transfer (Lewis, 2023). Resolving these constraints can assist private R&D funding, thus alleviating the funding burden of the state.

8.3.7 Relax immigration and work-permit restrictions on skilled foreign workers required for R&D activities

The absence of human capital constrains R&D and innovation more generally and raises the labour costs of R&D. This is a particular concern for South Africa as the data reveals significantly higher labour costs of business R&D compared to its peers. High labour costs inhibit engagement by firms, particularly small firms, in R&D. Scarcity of skilled labour also reduces the capacity of the firm to absorb innovative knowledge, whether through R&D or in-licensing. The outcome is a reduced return to firm investment in R&D, thereby reducing aggregate expenditure in R&D.

Scarcity of skills can also impede foreign investment in R&D activities. Much of innovation in India, China, and other countries takes place in foreign-funded R&D centres, with a key attraction being the cheap labour costs of researchers and technicians. SA has high-quality researchers and technicians and attracts some of this foreign investment, e.g., Amazon, but it could attract far more if the supply of skilled labour were increased.

Many policies could increase the supply of skilled labour. Raising the supply of skilled graduates and technicians from domestic higher education institutes is a critical long-run policy. In the short term, the most effective policy would be to ease/encourage immigration of researchers and technicians.

28 The impact of venture capital on innovation is shown to depend on whether it is involved at early or later stages of the enterprise innovation cycle (Xiwen and Yunjia 2022). Further, Lerner and Nanda (2020) present a more cautious tale of the limitations of venture capital on innovation.

References

Aghion, P., Bloom, N., Blundell, R., Griffith, R., and Howitt, P. (2005). Competition and innovation: An inverted-u relationship. *The Quarterly Journal of Economics*, 120(2), 701–728.

Aghion, P., Braun, M., and Fedderke, J. (2008). Competition and productivity growth in South Africa. *Economics of Transition*, 16(4): 741-768

Arrow, K. (1962). Economic welfare and the allocation of resources for invention. In: Nelson, R. (Ed.), The Rate and Direction of Inventive Activity. National Bureau of Economic Research Conference Report.

Aw, B. Y., Roberts, M. J., and Xu, D. Y. (2011). R&D Investment, Exporting, and Productivity Dynamics. *The American Economic Review*, 101(4), 1312–1344.

Aw, B. Y., Roberts, M. J., and Xu, D. Y. (2008). 'R&D Investments, Exporting, and the Evolution of Firm Productivity'. *The American Economic Review*, 98(2): 451–56.

Baum, C., Lööf, H., Nabavi, P., and Stephan, A. (2017). "A New Approach to Estimating the R&D–Innovation–Productivity Relationship. *Economics of Innovation and New Technology*, 26 (1-2): 121–133.

Bhattacharya, M, and Bloch, H. (2004). Determinants of innovation. *Small business economics*, *22*: 155-162.

Bloom, N., Jones, C.I., Van Reenen, J. and Webb, M. (2020). Are ideas getting harder to find?. *American Economic Review*, 110(4), pp.1104-1144.

Budlender, J. (2019). Markups and market structure in South Africa: What can be learnt from new administrative data?, WIDER Working Paper, No. 2019/58, ISBN 978-92-9256-692-0, The United Nations University World Institute for Development Economics Research (UNU-WIDER), Helsinki,

Ceccagnoli, M., Higgins, M.J. and Palermo, V. (2014). Behind the Scenes: Sources of Complementarity in R&D. *Journal of Economics & Management Strategy*, 23: 125-148.

Cirera, X., and Maloney, W. (2017). The Innovation Paradox : Developing-Country Capabilities and the Unrealized Promise of Technological Catch-up : The innovation paradox : developing-country capabilities and the unrealized promise of technological catch-up. Washington, D.C. : World Bank Group.

Coe, D.T., Helpman, E., and Hoffmaister, A. (2009)."International R&D Spillovers and Institutions", *European Economic Review*, 53(7): 723-741.

Cre´pon, B., Duguet, E., and Mairesse, J. (1998). Research, innovation, and productivity: An econometric analysis at the firm level. *Economics of Innovation and New Technology,* 7, 115–156.

Dessus, S., Goddard, J. and Hanusch, M. (2017). South Africa economic update : innovation for productivity and inclusiveness (English). South Africa economic update, no. 10 Washington, D.C. : World Bank Group.

Dieppe, A., Celik, S., and Kindberg-Hanlon, G. (2020). Global Productivity Trends. In A. Dieppe (editor) *Global Productivity: Trends, Drivers, and Policies*. Washington, DC: World Bank.

DSI (2024). Research and Development Tax Incentive Programme; Report to Parliament 2020/21. Pretoria: Department of Science and Innovation.

DST (2019). White Paper on Science, Technology and Innovation Science, Technology and Innovation. Department of Science and Technology

DST. (2016). Report of the Joint Government Industry Task Team on the Research and Development Tax Incentive. Pretoria: Department of Science and Technology.

DST. (2019). Research and Development Tax Incentive Programme; Report to Parliament 2017/18. Pretoria: Department of Science and Technology.

Edwards, L. (2021). South Africa's International Trade. In A. Oqubay, F. Tregenna, & I. Valodia (Eds.), *Oxford Handbook of the South African Economy*. Oxford University Press.

Edwards, L., Ismail, Z., and Venter, F. (2022). An econometric analysis of the impacts of access to foreign technology on South African firms. Report prepared for National Advisory Council on Innovation.

Ernst and Young (2023) Worldwide R&D Incentives Reference Guide.

European Union (2019). Discussion paper: Investment Climate in South Africa. Paper prepared for the Southern Africa Europe CEO Dialogue 2019 (Ambrosetti Forum) and the South Africa Investment Conference 2019. https://www.euchamber.co.za/wp-content/uploads/2020/10/Investment-Climate-in-South-Africa-2019.pdf

Fang, W. and Hsiu-Kan, L. (2010). Do R&D expenditure, royalty and technology licensing expenses increase operational performance of the biotech industry in Taiwan?. *Problems and Perspectives in Management*, 8(3).

Graff, G., Silva, F. , and Zilberman, D. (2021). Venture Capital and the Transformation of Private R&D for Agriculture. In Petra Moser (ed.) Economics of Research and Innovation in Agriculture, National Bureau of Economic Research, University of Chicago Press.

Griffiths, W. and Webster, E. (2010). What governs firm-level R&D: Internal or external factors?. *Technovation*, *30*(7-8), pp.471-481.

Griliches, Z. (1979). "Issues in assessing the contribution of research and development to productivity growth". *Bell Journal of Economics*, 10 (1), 92–116.

Guellec D., and van Pottelsberghe de la Potterie, B. (2001). R&D and productivity growth: panel data analysis of 16 OECD countries. OECD Economic Studies No. 33, 2001/II.

Hall, B., and Van Reenen, J. (2000). How effective are fiscal incentives for R&D? A review of the evidence. *Research policy*, *29*(4-5), pp.449-469.

Hall, B., and Mairesse, J. (1995). Exploring the Relationship Between R&D and Productivity in French Manufacturing Firms. *Journal of Econometrics*, 65: 263–93.

Hall, B., Mairesse, J. and Mohnen, P. (2009). Measuring the Returns to R&D. In: B. Hall and N. Rosenberg (eds.), *Handbook of the Economics of Innovation*. Amsterdam: Elsevier.

Halpern, L., and Muraközy, B. (2015). The relationship between competition and R&D: Theoretical approaches and quantitative results. In P. Valentiny., F. L. Kiss., K. Antal-Pomazi., & C. I. Nagy (dds.), *Competition and regulation*, 2015 (pp. 113–137). Budapest: Institute of Economics, Centre for Economic and Regional Studies, Hungarian Academy of Sciences.

Harris, R. and Trainor, M. Why Do Some Firms Undertake R&D Whereas Others Do Not? SERC DISCUSSION PAPER 20

Hines, J. (1995). Taxes, Technology Transfer, and R&D by Multinational Firms. In Martin Feldstein, James R. Hines Jr. and R. Glenn Hubbard (eds.) *Taxing Multinational Corporations*. University of Chicago Press.

James S. (2017). Effectiveness of the Research and Development Incentive in Encouraging Research in South Africa. Washington, DC: The World Bank Group

James S.S. (2017). Effectiveness of the Research and Development Incentive in encouraging Research in South Africa. The World Bank Working Paper commissioned by the Davis Tax Committee (South Africa), 2017.

Jones, C.I. and Williams, J.C. (2000). Too much of a good thing? The economics of investment in R&D. *Journal of economic growth*, *5*: 65-85

Jones, C. (1995). R & D-based models of economic growth. *Journal of political Economy*, 103(4), pp.759-784.

Kahn, A., Sithole, M., and Buchana, Y. (2022). An analysis of the impact of technological innovation on productivity in South African manufacturing firms using direct measures of innovation. *South African Journal of Economics*, *90*: 37-56.

Kamutando, G., and Tregenna, F. (2023). Complementarity between product and process innovation in small and micro-enterprises in Johannesburg, South Africa. *Economics of Innovation and New Technology*, pp.1-27

Kilumelume, M., Reynolds, H., and Ebrahim, A. (2021). Identifying foreign firms and South African multinational enterprises: CIT-IRP5 panel v4.0. Helsinki: UNU-WIDER: UNU-WIDER Technical Note.

Kortum, S., and Lerner, J. (2000). Assessing the Contribution of Venture Capital to Innovation. The RAND Journal of Economics, 31(4), 674–692.

KPMG (2023). Tax and Legal News Alert, March 2023. https://assets.kpmg.com/content/dam/kpmg/us/pdf/2023/03/tnf-sa-mar9-2023.pdf

Kreuser, C.F., and Newman, C. (2018). Total factor productivity in South African manufacturing firms. *South African Journal of Economics*, *86 (S1)*: 40-78.

Lall, S. (2000). The Technological Structure and Performance of Developing Country Manufactured Exports, 1985-98, *Oxford Development Studies*, 28(3): 337-369.

Lederman, D., and Maloney, W.F. (2003). R&D and development. Policy Research Working paper. World Bank. # 3021

Lerner, J., and Nanda, R. (2020). Venture Capital's Role in Financing Innovation: What We Know and How Much We Still Need to Learn. The Journal of Economic Perspectives, 34(3), 237–261.

Lewis, D. (2023). Start-ups require changes in mindset and regulations: Impediments holding back the more rapid growth of the start-up sector can be overcome relatively easily. Business Day, 21 November 2023.

Li, X., and Yunjia, Z. (2022) Research on the Impact of Venture Capital Strategy on Enterprise Innovation Performance: Based on Evidence of Investment Timing and Rounds. Frontiers in Environmental Science, 10.

Masso, J. and Tiwari, A. (2024). Productivity Implications of R&D, Innovation, and Capital Accumulation for Incumbents and Entrants: Perspectives from a Catching-up Economy. *Technological Forecasting and Social Change*, 199

Matthee, M., Rankin, N., Webb, T., and Bezuidenhout, C. (2018). Understanding Manufactured Exporters at the Firm-Level: New Insights from Using SARS Administrative Data. *South African Journal of Economics*, 86(S1), 96-119.

NACI (2023) South African Science, Technology and Innovation Indicators Report 2023. National Advisory Committee on Innovation, Department of Science and Innovation.

National Treasury. (2022). Draft explanatory memorandum on the proposed refinements to Section 11D of the income tax act.

https://www.sars.gov.za/wp-content/uploads/Legal/Drafts/Legal-LPrep-Draft-2022-61-20221007-Draft-EM-on-proposed-changes-to-the-RD-tax-incentive-7-October-2022.pdf

National Treasury. (2023). Draft Response Document on the 2023 Draft Revenue Laws Amendment Bill, 2023 Draft Revenue Administration and Pension Laws Amendment Bill, 2023 Draft Rates and Monetary Amounts and Amendment of Revenue Laws Bill, 2023 Draft Taxation Laws Amendment Bill and 2023 Draft Tax Administration Laws Amendment Bill. October 2023. https://www.treasury.gov.za/comm_media/press/2023/2023102701%20Draft%20Response%20Document%20on%202023%20Tax%20Bills%2025%20Oct%202023.pdf

National Treasury. (2021). Reviewing the design, implementation and impact of South Africa's Research and Development Tax Incentive. Discussion Document.

OECD (2015). The Impact of R&D Investment on Economic Performance: A Review of the Econometric Evidence. Paper produced for the Working Party of National Experts on Science and Technology Indicators. OECD, DSTI/EAS/STP/NESTI(2015)8. https://one.oecd.org/document/DSTI/EAS/STP/NESTI(2015)8/en/pdf

Pallayil, B., Ambrammal, S. K., and Ramachandran, R. (2023). In-house R&D, Importing Technology and R&D Tax Credit on the Productivity of Manufacturing Industry: Evidence from India. *Studies in Microeconomics*, 0(0).

Purfield, M. C., Farole, T., and Im, F. (2014). South Africa Economic Update: Focus on Export Competitiveness. Washington, DC.: South Africa economic update issue no. 5. .

Romer, P.M. (1990). Endogenous technological change. *Journal of political Economy*, *98*(5, Part 2): S71-S102.

Romer, D. (2012). Advanced Macroeconomics. 4th Edition, McGraw-Hill Irwin, New York.

Santos, S. and Tenreyro, S. (2006). The Log of Gravity. The Review of Economics and Statistics, 88 (4): 641–658.

Schumpeter, J.A., (2013). *Capitalism, socialism and democracy*. Routledge.

Shefer, D. and Frenkel, A., 2005. R&D, firm size and innovation: an empirical analysis. *Technovation*, *25*(1): 25-32.

Steenkamp, A., Schaffer, M.E., Flowerday, W., and Goddard, J.G., (2018). *Innovation activity in South Africa: Measuring the returns to R&D* (No. 2018/42). WIDER Working Paper.

Tregenna, F., Kraemer-Mbula, E., and Bengoa, M.. (2020). Effectiveness of the R&D Tax Incentive: Evidence from South African Manufacturing Firms. University of Johannesburg

Vega-Jurado, J., Gutiérrez-Gracia, A., and Fernández-de-Lucio, I. (2009). Does external knowledge sourcing matter for innovation? Evidence from the Spanish manufacturing industry. *Industrial and Corporate Change*, 18(4): 637–670.

Walwyn, D., and Naidoo S. (2019). Policy mixes and overcoming challenges to innovation in developing countries: Insights from a mixed methods study of South Africa's manufacturing sector. *African Journal of Science, Technology, Innovation and Development*, 11(6): 1-14.

World Bank. (2017). South Africa Economic Update #10: Innovation for productivity and inclusiveness. Washington, DC: World Bank.

World Bank. (2019). Impact Evaluation of the R&D Tax Incentive in South Africa.

Data Annex

A comprehensive process was followed in preparing the data for empirical analysis of business expenditure on R&D. The highly disaggregated customs transaction data are used to construct firm-specific indicators, such as product range traded and number of trading partners. These indicators are constructed such that they align with the firm's reported financial year to ensure consistency in the time period covered. These indicators are then merged into the corporate income tax submissions using the firm identifiers provided.[29]

The empirical analysis is structured around the firm's financial year. One issue is that the financial year end of firms can be any month of the year, although most firms align their financial year with the tax year (March to Feb the following year). An additional consideration is that all the firm employment data applies to the tax year and, therefore, does not align with the financial and trade data of firms whose financial year end is not in February. To maximise alignment between financial year and tax year, we follow Pieterse, Kreuser & Gavin (2018). In this approach, all firms whose financial year ends after August are defined as the year following the submission year (e.g., firms with a November 2011 financial year-end are allocated to the financial year 2012). If the financial year end is between January and August, the financial year is defined as the current year (e.g., firms with a financial year ending in June 2011 are allocated to the financial year 2011).

Further challenges relate to the preparation of the export and import transaction data. The Harmonised System product classification used to classify traded products is revised every five years. Consequently, the data include products defined according to the HS's 2007, 2012 and 2017 revisions. To ensure a consistent sample of products, each revision of the HS is mapped to a consistent six-digit HS classification, as used in the World Bank Exporter Dynamics database. This approach results in approximately 4 500 products.

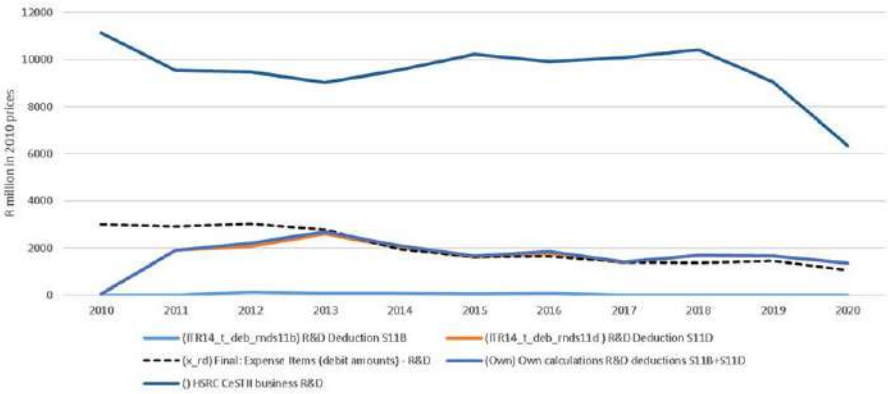
Several cleaning processes were implemented to prepare the Corporate Income Tax (CIT) data for analysis. In cleaning the CIT database, companies that declare themselves dormant, have zero or missing sales value, and zero or missing labour payment values are excluded from most of the analysis. Further, given the importance of capital stock in calculating productivity, firms with no information on fixed capital stock are also excluded.

The SARS-NT database contains several different variables for R&D expenditure. The total expenditure on R&D for each of these variables, as reported by all firms in the SARS-NT database, is presented in Figure 60. The values are in R million, deflated to 2010 prices using the GDP deflator for South Africa. Also presented is the total business expenditure on R&D reported in the HSRC-CeSTII (Centre for Science Technology and Innovation) South African National Survey of Research and Experimental Development. The trends in expenditure vary according to the indicator used.[30] According to the SARS-NT variable x_rd "*Final: Expense items (debit amounts) - R&D*", total annual expenditure on R&D by companies equalled between R1.4 billion to R3 billion Rand between 2010 and 2019. This amount falls substantially below the HSRC-CeSTII estimated value of R10 billion to 15.9 billion Rand spent by businesses on R&D. The trends also differ, with the HSRC-CeSTII estimates rising from 2013 to 2018, whereas R&D expenditure according to the SARS-NT database fell over this period. More detailed sectoral comparisons by Edwards et al. (2022) also shows very different sectoral compositions of R&D expenditure across the two sources. Manufacturing accounted for 65 percent of declared R&D expenditure in the SARS-NT database in 2017, compared to 28 percent in the HSRC/DSI (2019) survey. Financial Intermediation, Real Estate and Business Services is the major R&D sector in the HSRC (2019) survey (44 percent), but only makes up 14 percent of declared expenditure in the SARS-NT database.

29 To deal with revisions (2012 and 2017) of the product classification system, namely the Harmonised System (HS), we convert to a consistent six-digit HS classification used in the World Bank Exporter Dynamics database. This approach results in approximately 4 500 products.

30 Not shown in this figure is a variable t_deb_rnds11 labeled as "Final: R&D deduction S11B+S11D". The values in this variable, however, appear incorrect and are almost precisely double the sum of the values in the individual variables for R&D deductions through scheme S11B and S11D.

Figure 60: Real R&D expenditure according to different variables in the SARS-NT database



Source: SARS-NT database and raw data from the HSRC CeSTII (Center for Science Technology and Innovation) South African National Survey of Research and Experimental Development. Section 11D Research and Development Incentive (R&D) was introduced into the Income Tax Act, in 2006 to replace the previous research and development rule that existed in terms of section 11B.

These wide disparities indicate that the SARS-NT data and HSRC/DSI survey contain very different measures of R&D expenditure. The SARS-NT data appears to measure narrowly defined R&D expenditure that conforms with the Section 11D R&D tax incentive requirements. Section 11D allows (a) A deduction equal to 150% of the expenditure incurred directly for Research & Development and, (b) An accelerated depreciation deduction (that is, 50:30:20) for capital expenditure incurred on machinery or plant used for R&D (https://www.sars.gov.za/businesses-and-employers/my-business-and-tax/research-and-development-incentive/). The R&D has to be approved by an adjudication committee comprising of members from the Department of Science and Technology, National Treasury and SARS. The R&D that is potentially eligible for the tax incentive is tightly specified (https://www.dst.gov.za/rdtax/index.php/legislative-basis/section-11d-of-the-income-tax-act/3-section-11d/file), although the definition of R&D has recently been refined (National Treasury, 2022).

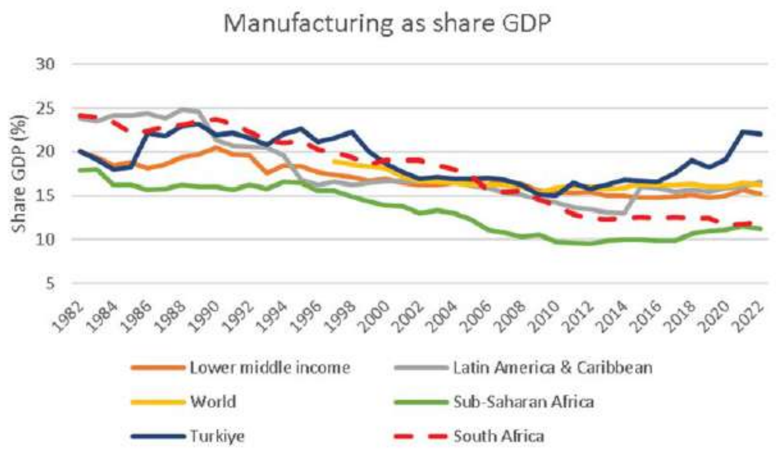
The HSRC/DSI survey captures a broader measure of firms' R&D expenditure, not all of which can be claimed for tax relief.[31]

The interpretation of the definition of R&D is also subject to the manager's response to the survey questionnaire. Further, the sample of firms may differ across the two data sources. Unfortunately, we cannot identify the overlap in firms declaring R&D expenditure across the two data sources, so it is not possible to check for consistency at the firm level.

31 According to the HSRC/DSI survey questionnaire, the definition of Research and Experimental Development (R&D) follows the approach of the Organisation for Economic Co-operation and Development (OECD), and is defined as: "*(a) Research is creative work and original investigation undertaken on a systematic basis to gain new knowledge, including knowledge of humanity, culture and society. (b) Development is the application of research findings or other scientific knowledge for the creation of new or significantly improved products, applications or processes. The basic criterion for distinguishing R&D from related activities is the presence in R&D of an appreciable element of novelty and the resolution of scientific and/or technological uncertainty, i.e. when the solution to a problem is not readily apparent to someone familiar with the basic stock of commonly used knowledge and techniques in the area concerned*."

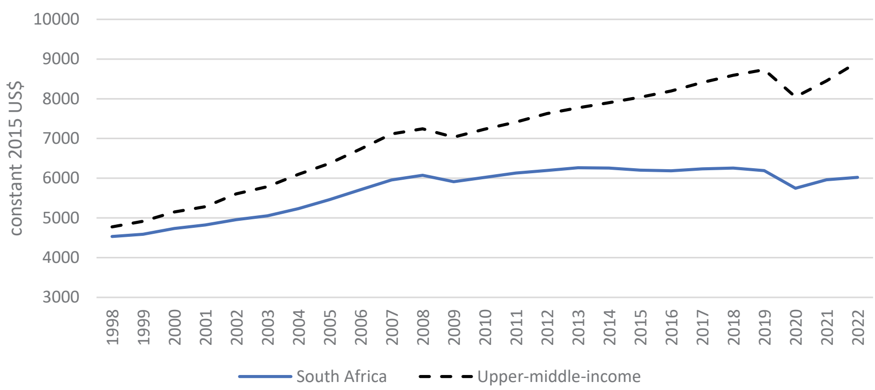
Annex A: Additional figures

Figure 61: Manufacturing as share GDP (%) – South Africa compared to selected regions



Source: World Development Indicators

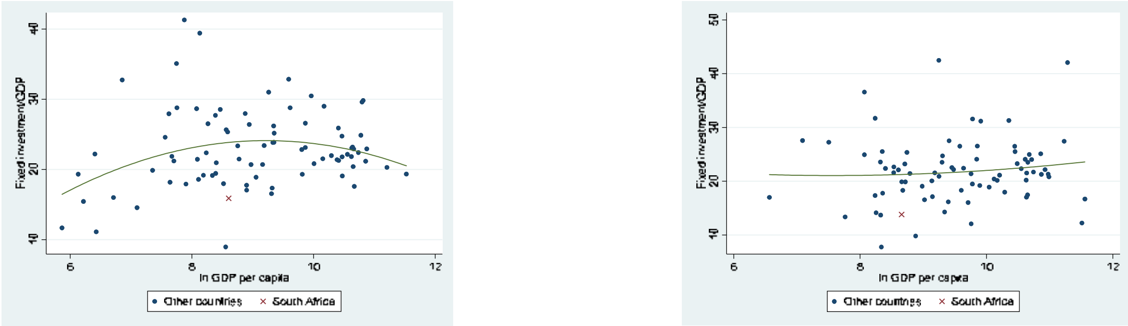
Figure 62: Real GDP per capita in South Africa and upper-middle-income countries, 2015 constant US$



Source: World Development Indicators. The sample of upper-middle-income countries comprises of between 68 to 72 countries per year.

Figure 63: Fixed investment (% of GDP) in 2005 and 2020

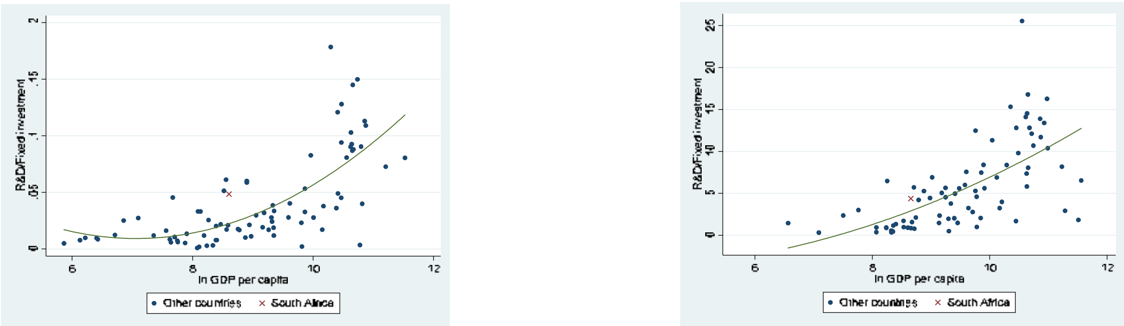
(a) 2005 *(b) 2020*



Source: Own calculations using World Bank World Development Indicators.

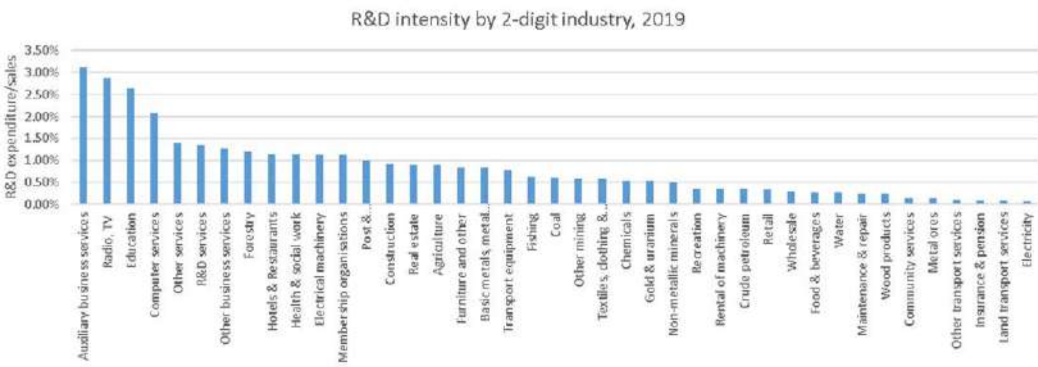
Figure 64: Gross expenditure on R&D as share fixed investment in 2005 and 2020

(a) 2005 *(b) 2020*



Source: Own calculations using World Bank World Development Indicators.

Figure 65: Firm R&D intensity by industry, 2009



Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D purchases from related foreign firms. Industries are classified at the 2-digit level of the Standard Industry Classification (SIC).

Annex B: Additional regression tables

Table 15: TFP difference between R&D firms and non-R&D firms across manufacturing industries

	Manufacturing	Food & beverages	Clothing, textile & footwear	Wood products	Chemicals	Non-metallic minerals	Metal products & equipment	Electrical machinery	Communication equipment	Transport equipment	Furniture
R&D firm	0.167**	0.167*	-0.032	0.135	0.188**	0.067	0.190**	0.072	-0.089	0.022	0.253**
	(0.028)	(0.077)	(0.163)	(0.136)	(0.060)	(0.121)	(0.063)	(0.096)	(0.169)	(0.095)	(0.065)
Royalty/licence fee firm	0.201**	0.330**	0.353**	0.437**	0.193**	0.234*	0.072	0.417**	-0.084	0.052	0.283**
	(0.023)	(0.066)	(0.093)	(0.092)	(0.053)	(0.115)	(0.048)	(0.127)	(0.129)	(0.063)	(0.065)
Exporter	0.123**	0.249**	0.067	-0.021	0.204**	0.240*	0.135**	0.029	-0.163	0.157**	0.069
	(0.017)	(0.063)	(0.072)	(0.059)	(0.045)	(0.119)	(0.031)	(0.095)	(0.133)	(0.045)	(0.044)
Importer	0.055**	0.035	0.053	0.081	0.067	0.253*	-0.023	-0.034	-0.096	0.056	0.015
	(0.018)	(0.062)	(0.100)	(0.058)	(0.046)	(0.117)	(0.032)	(0.131)	(0.199)	(0.058)	(0.044)
Importer high-tech products	0.243**	0.290**	0.189**	0.208**	0.233**	0.350**	0.251**	0.372**	0.405**	0.280**	0.214**
	(0.016)	(0.061)	(0.056)	(0.067)	(0.043)	(0.118)	(0.030)	(0.107)	(0.136)	(0.060)	(0.036)
Foreign-owned	-0.191*	0.177	-0.357+	-0.352	-0.235	-1.372**	-0.172	-0.243	0.200	-0.002	-0.354+
	(0.079)	(0.145)	(0.197)	(0.279)	(0.239)	(0.207)	(0.189)	(0.225)	(0.512)	(0.212)	(0.183)
Multinational enterprise	0.642**	0.418**	0.640**	0.637**	0.728**	1.964**	0.650**	0.553**	0.300	0.436*	0.699**
	(0.074)	(0.122)	(0.080)	(0.201)	(0.231)	(0.194)	(0.182)	(0.151)	(0.511)	(0.198)	(0.170)
Employment	-0.302**	-0.235**	-0.307**	-0.201**	-0.302**	-0.331**	-0.324**	-0.315**	-0.462**	-0.284**	-0.368**
	(0.007)	(0.020)	(0.031)	(0.029)	(0.022)	(0.040)	(0.014)	(0.039)	(0.051)	(0.017)	(0.022)
Capital/Labour	0.022**	0.002	0.020	0.067*	0.020	0.001	0.021*	-0.008	0.004	0.006	0.045**
	(0.005)	(0.022)	(0.024)	(0.026)	(0.013)	(0.035)	(0.010)	(0.025)	(0.036)	(0.013)	(0.017)
Constant	12.032**	10.534**	12.681**	11.346**	11.613**	12.424**	12.458**	12.849**	13.182**	12.313**	12.221**
	(0.069)	(0.277)	(0.323)	(0.310)	(0.182)	(0.446)	(0.127)	(0.303)	(0.459)	(0.150)	(0.218)
Observations	41,579	3,543	2,088	2,470	6,035	1,345	10,013	884	649	5,723	5,994
Adjusted R-squared	0.466	0.374	0.297	0.364	0.196	0.288	0.284	0.238	0.453	0.266	0.258

*Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. The dependent variable is TFP estimated by Kreuser and Brink (2021). Estimates cover the period 2010 to 2018. All estimates include SIC three-digit industry by financial year fixed effects. Employment and the capital/labour ratio are in natural logarithms, while the remaining variables are categorical variables. Foreign ownership is defined according to the strict definition of Kilumelume et al. (2021), i.e. firms declaring themselves to "being ultimately foreign-controlled". The dummy variable "Importer of high-tech products" denotes firms that import high-technology products as defined by Lall (2000). Robust standard errors clustered at the firm level are presented in parentheses. ** p<0.01, * p<0.05, + p<0.1.*

Table 16: Testing complementarity/substitutability effects of R&D and in-licencing on manufacturing firm TFP, 2018-2019

	(1) Base	(2) Interact with Royalty firm	(3) Categorise royalty and R&D firms
R&D firm	0.167**	0.218**	
	(0.028)	(0.023)	
Royalty/licence fee firm	0.201**	0.180**	
	(0.023)	(0.011)	
(R&D firm) x (Royalty/licence firm)		0.152**	
		(0.049)	
Exporter	0.123**	0.146**	0.123**
	(0.017)	(0.010)	(0.017)
Importer	0.055**	0.119**	0.055**
	(0.018)	(0.011)	(0.018)
Importer high-tech products	0.243**	0.216**	0.243**
	(0.016)	(0.011)	(0.016)
Foreign ownership	-0.191*	-0.114**	-0.185*
	(0.079)	(0.043)	(0.078)
Multinational enterprise	0.642**	0.709**	0.638**
	(0.074)	(0.038)	(0.073)
Employment	-0.302**	-0.403**	-0.302**
	(0.007)	(0.004)	(0.007)
Capital/Labour	0.022**	0.118**	0.022**
	(0.005)	(0.003)	(0.005)
Royalty only firm			0.185**
			(0.024)
R&D only firm			0.133**
			(0.031)
R&D and Royalty firm			0.468**
			(0.057)
Constant	12.032**	12.961**	12.036**
	(0.069)	(0.035)	(0.069)
Observations	41,579	224,501	41,579
Adjusted R-squared	0.466	0.456	0.466

*Notes: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. The dependent variable is TFP estimated by Kreuser and Brink (2021). Estimates cover the period 2010 to 2018. Variables exclude foreign related expenditures on R&D and royalty/license fees. All estimates include SIC three-digit industry by financial year fixed effects. Employment and the capital/labour ratio are in natural logarithms, while the remaining variables are categorical variables. Foreign ownership is defined according to the strict definition of Kilumelume et al. (2021), i.e. firms declaring themselves to "being ultimately foreign-controlled". The dummy variable "Importer of high-tech products" denotes firms that import high-technology products as defined by Lall (2000). Robust standard errors clustered at the firm level are presented in parentheses. ** p<0.01, * p<0.05, + p<0.1.*

Annex C: R&D and other sources of knowhow as drivers of GDP growth

To study how R&D and other indicators of knowhow affect future growth, we estimate a simple growth convergence model using an unbalanced panel of data for 104 countries over the period 2003 to 2021. The model is specified as follows

$$\Delta_2 \ln \left(\frac{GDP}{capita}\right)_{i,t} = \alpha + \beta \ln \left(\frac{GDP}{capita}\right)_{i,t-2} + \delta_1 RD_{i,t-2} + \delta_2 IP_{i,t-2} + \delta_3 I_{i,t-2} + \delta_4 F_{i,t-2} + \mathrm{l}_t + \varepsilon_{i,t}$$

Where the dependent variable is the two-year growth in GDP per capita and explanatory variables include initial period levels of R&D (RD), foreign assets (F), payments for foreign IP (Ip) and gross fixed capital formation (I) (all as % of GDP). The initial GDP per capita is also included to control for convergence effects, with the expectation that indicating that poorer countries grow faster. Time fixed effects are included to deal with global macroeconomic trends affecting growth in all countries. The data are obtained from the World Development Indicator database.

Several versions of this model are estimated with the results presented in Table 17. The first three columns present results that include country-fixed effects. These estimates capture the within-country dynamics between future growth and initial GDP per capita, R&D and other variables. Columns (4) and (5) present cross-country regression results where the sample is split into eight two-year intervals (2004-06, 2006-08, 2008-10, and so on up to 2018-20). While country fixed effects are not included, trends in growth by income status (high, upper-middle, lower-middle, and low-income) are controlled with the inclusion of dummy variables for income status interacted with year-fixed effects. The estimated coefficients are, therefore, identified by the cross-country variation of the data within each income status group. The estimates include a dummy variable for South Africa interacted with year-fixed effects. The purpose of including these interactions is to identify whether South Africa's growth performance differs from other upper-middle-income countries after considering the influence of its initial levels of R&D, investment, foreign IP payments, etc. Finally, as we are particularly interested in how business enterprise R&D affects growth, columns (3) and (5) include a variable for business R&D as a share of GERD. The data are obtained from the OECD. Stat, but only cover a narrow selection of 38 countries from 2013 to 2020.

Several key findings emerge from the estimates.

- Gross expenditure on R&D is positively and significantly associated with future growth within a country. A one percentage point increase in R&D as percent of GDP is associated with a 1.4 percentage point increase in the two-year growth rate of GDP per capita (Column 2).
- Higher levels of foreign ownership, as measured by foreign assets (% of GDP), are also predicted to raise future GDP per capita growth.
- Higher levels of investment and purchases of foreign IP as shares of GDP are associated with higher GDP per capita growth.
- The composition of R&D expenditure matters, with rising shares of business R&D in total R&D positively associated with future growth. However, the sample size is small and the coefficients are imprecisely estimated for most variables. Countries with higher initial shares of business R&D in total R&D grew faster in the following two years than in countries with low initial shares.
- GDP per capita growth in South Africa lagged other upper-middle-income countries, even after accounting for the country's initial level of R&D, purchases of foreign IP, investment and foreign assets (see column (4) results). Further, the growth divergence has increased over time.

Table 17: Simple growth model estimates

VARIABLES	(1) GERD within country	(2) GERD within country	(3) BERD within country	(4) GERD between country	(5) BERD between country
ln(GDP per capita$_{t-2}$)	-0.1920**	-0.2015**	-0.1424*	-0.0156+	-0.0068
	(0.023)	(0.024)	(0.064)	(0.009)	(0.008)
R&D/GDP$_{t-2}$	0.0146*	0.0142*	-0.0065	0.0103	-0.0014
	(0.006)	(0.006)	(0.010)	(0.008)	(0.007)
Fixed investment/GDP$_{t-2}$		0.0019**	-0.0033*	0.0020**	0.0008
		(0.001)	(0.001)	(0.000)	(0.001)
Foreign IP payments/GDP$_{t-2}$		0.0070*	-0.0002	0.0045**	0.0050**
		(0.003)	(0.005)	(0.002)	(0.001)
Initial Foreign assets/GDP$_{t-2}$		0.0005**	0.0004+	0.0000*	-0.0000
		(0.000)	(0.000)	(0.000)	(0.000)
Share business R&D in total R&D$_{t-2}$			0.0008*		0.0009*
			(0.000)		(0.000)
DSA x 2004				-0.0173+	
				(0.010)	
DSA x 2006				-0.0372**	
				(0.013)	
DSA x 2008				-0.0261*	
				(0.012)	
DSA x 2010				-0.0346**	
				(0.009)	
DSA x 2012				-0.0392**	-0.0358**
				(0.007)	(0.012)
DSA x 2014				-0.0489**	-0.0620**
				(0.009)	(0.012)
DSA x 2016				-0.0449**	-0.0570**
				(0.008)	(0.014)
DSA x 2018				-0.0463**	-0.0545**
				(0.009)	(0.018)
Constant	1.8069**	1.8331**	1.4981*	0.1191+	0.0215
	(0.216)	(0.212)	(0.641)	(0.070)	(0.080)
Observations	1,231	1,231	281	573	141
R-squared	0.513	0.538	0.808	0.405	0.662
Adj. R-squared	0.460	0.486	0.767	0.355	0.616
Fixed effects					
Year	Y	Y	Y	Y	Y
Country	Y	Y	Y	N	N
Income group x year	N	N	N	Y	Y

*Notes: The sample comprises an unbalanced panel of 104 countries. Within country estimates cover the period 2003 to 2021, while the cross-country estimates cover two-year intervals from 2006 to 2020. All estimates include year and country fixed effects. Robust standard errors in parentheses. ** p<0.01, * p<0.05, + p<0.1.*

Annex D: R&D status and firm characteristics: Simple regression analysis[32]

To test for significance in the difference in characteristics across importer status we adopt the approach of Bernard & Jensen[33] and estimate regressions of the form:

$$(DV)_{ikt} = \alpha + \beta_1 RD_{ikt} + \mu_k + \mu_t + \mu_r + \varepsilon_{ikt} \quad (1)$$

where: DV refers to the characteristics of the firm at period operating in industry k and RD is a firm-level indicator of whether the firm is investing in R&D (equals for an R&D firm, zero otherwise). The regression also includes time-fixed effects ((µk), province fixed effects (µt) and 2-digit industry (µr) fixed effects to control for aggregate year shocks and time-invariant industry effects. The coefficient of interest is the that β indicates whether specific characteristics of the firms within an industry are systematically related to their R&D status. The regressions are estimated from 2018 to 2019 using the firm panel based on the R20 million in turnover in April 2013 prices sales cut-off.
The results are presented in Table 18.

Table 18: Difference between R&D firms and non-R&D firms, 2018-2019

	R&D firm	Observations	R-squared	% difference
Sales	0.631**	66,226	0.085	88%
Value added	0.876**	66,226	0.154	140%
Value added/worker	0.111**	58,997	0.128	12%
Employment	0.698**	58,997	0.106	101%
Capital	1.029**	62,336	0.176	180%
Wage	0.133**	58,097	0.151	14%
Export status	0.251**	66,226	0.263	29%
Exporter high tech products	0.181**	66,226	0.153	20%
Export destinations per product	0.206**	17,729	0.104	23%
Export value	1.039**	17,729	0.092	183%
Importer	0.263**	66,226	0.265	30%
Importer high-tech products	0.213**	66,226	0.180	24%
Export products per destination	-1.433**	17,729	0.085	-76%

Note: Firm panel based on cut-off of R20 million in turnover in April 2013 prices. Excludes R&D and royalty/licence fees from related foreign firms. The estimates include fixed effects for 3-digit industry, financial year and province. The percentage difference is calculated as the exponent of the coefficient minus 1.

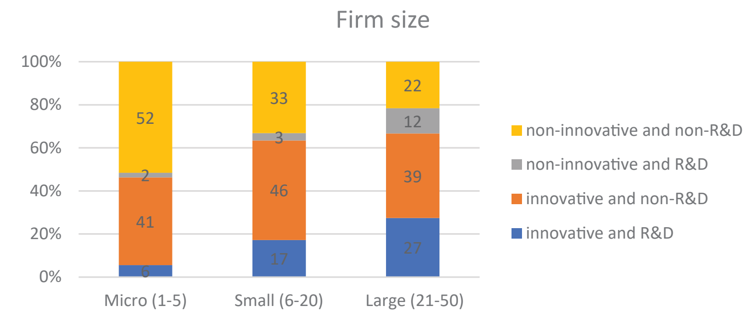
32 The explanation of the regression model in this section draws heavily on Edwards, Ismail and Venter (2022).
33 (Bernard & Jensen, 1995)

Annex E: Characteristics of small R&D firms

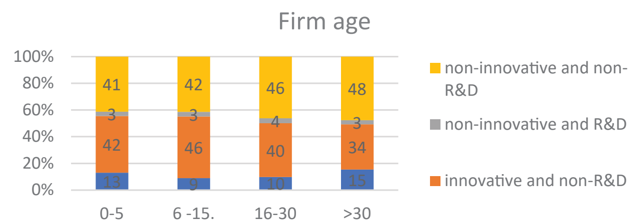
Characteristics of small R&D firms

This small firm analysis draws on the firm-level innovation survey dataset for South African small and micro enterprises firms collected in 2019 in Johannesburg. In the survey, innovation refers to a new or improved product or process that significantly differs from previous products or processes done in this establishment, while R&D refers to creative work undertaken on a systematic basis to increase the stock of knowledge and use it for innovation. Therefore, the definition of R&D differs from and is broader than the definition used in the tax data.

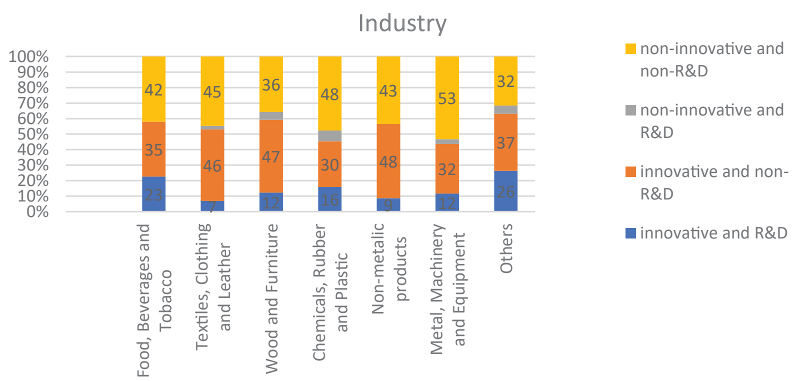
Firm size: Larger firms are more likely to report innovation and R&D than smaller counterparts. Six percent of micro firms (those with at most five workers) are actively involved in both innovation and R&D. The majority of micro firms (52%) are neither involved in innovation nor R&D. A significant proportion (17%) of small firms (those with 6-20 workers) compared to micro firms are actively participating in both innovation and R&D while only 33% are not. Compared to small and micro firms, a large share (27%) of larger firms embark on both innovation and R&D. Only 22% of large firms are not involved in both innovation and R&D.



Firm age: A non-linear relationship between the age of the firm and engaging in innovation and R&D. Younger and older firms are more likely to be both innovative and engage in R&D. Across the age spectrum, a relatively high proportion of firms engaging in both innovation and R&D are within the 0-5 years (13%) and the 30+ years (15%) age bands.



Firm industry: Looking at industry composition, Food, Beverages and Tobacco have the highest proportion (23%) of firms engaging in both R&D and innovation, with the lowest proportion (7%) recorded in the Textiles, Clothing and Leather industry. However, it seems that firms in the Metal, Machinery and Equipment industry have the highest likelihood of not involved in any kind on innovation and R&D. 53% of firms in this industry are neither involved in innovation nor R&D, contrary to only 35% of firms in the Wood and Furniture industry.



Other firm attributes

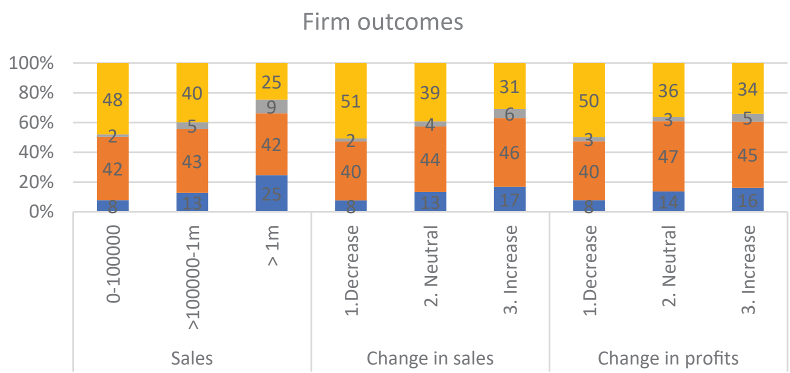
– The sector in which the firm is operating is associated with R&D and innovation. Only 7% of informal sector firms both engage in innovation and R&D, while 48% are engaged in none of these. This can be contrasted with formal firms, where 14% are involved in both innovation and R&D, and only 30% are involved in neither.

Financially constrained firms are less likely to be involved in R&D or innovation activities, while domestically owned firms are more likely to innovate and engage in R&D than foreign-owned firms.

Innovation, R&D and firm outcomes

Sales: A large proportion of innovative and R&D firms are more likely to have higher sales values, while firms with lower sales values are less innovative and engage in R&D. For example, only 8% of firms within the lower sales value category (0-100000 Rands) are both innovative and engage in R&D while 40% of them did not engage in any innovation or R&D activities. On the contrary, firms with large sales values (above 1 million Rands) are more likely to innovate and engage in R&D. 25% of firms with large sales engage in R&D and innovative firms, while only 34% did not engage in either of these.

Change in sales and profits: Firms that engage in both innovation and R&D tend to report increases in sales and profits. Non-innovative firms, especially those without R&D, appear more susceptible to sales and profit decreases.



Types and sources innovation for small and micro firms

85% of innovative firms engage in solely product innovation, while only 3% focus on process innovation. Twelve % of innovative firms implement both product and process innovation.

The majority of firms (43%) have external sources of innovation, compared to 39% that source internally. 18% of firms have both external and internal sources of innovation.

- The significant share of firms that have to external sources of innovation highlights a willingness to collaborate with external entities. This openness can lead to diverse perspectives, access to new technologies, and a faster pace of innovation.

Annex F – Policies and empirical evidence

Table 19: Summary of empirical evidence on effectiveness of R&D policies internationally and in South

Policy	Literature	International	South Africa
Accelerated depreciation on R&D assets	Abel, 1982. Li et al., 2020. Childs and Triantis, 1999. Calitz et al., 2013. Pouris, 2003.	Research on the effectiveness of accelerated depreciation policies for R&D investment yields mixed results. Abel (1980) suggests that temporary tax cuts, which can be achieved through accelerated depreciation, may reduce investment. However, Li et al. (2020) find that accelerated depreciation, particularly with shorter depreciation periods, can promote economic growth. Childs and Triantis (1999) emphasise the importance of balancing the costs and benefits of accelerating R&D projects.	The efficacy of this policy can be influenced by factors such as the age profile of depreciation deductions and inflation (Abel, 1980). In the context of R&D investment, firms may need to balance the costs and benefits of accelerating projects, especially in the presence of budget constraints (Childs, 1999). Pouris (2003) argues that the effectiveness of accelerated depreciation policies for R&D investment remains an area for further research. Calitz (2021) argues that accelerated depreciation, as a policy instrument for R&D investment stimulation in South Africa, has become less common, and its potential is quite limited.
Cash grants	Boeing, 2016. Becker, 2015. Klette and Møen,, 2012. Hottenrott, et al., 2017. Howell, 2017. Tsvakirai et al., 2018. Barbour, 2005.	Research on the effectiveness of cash grants for R&D investment yields ambiguous results. Boeing (2016) found that while R&D subsidies in China initially crowd out business R&D investment, they are neutral in the long term. However, this crowding-out effect is not prevalent for certain types of firms. Becker (2015) offers a more positive view, noting that R&D subsidies typically stimulate private R&D investment, as do R&D tax credits, university research support, and high-skilled human capital. Klette (2012) found that Norway's R&D subsidies (matched grants) do not crowd out privately financed R&D, and may even have a positive long-term effect. Hottenrott (2014) also found positive effects of R&D subsidies in Belgium, particularly for research grants. Howell's 2017 study, suggests these cash grants do work, especially when considering financially constrained firms.	Little has been done on the effect of cash grants on R&D investment in South Africa. However, research on the effectiveness of cash grants in spurring R&D investment in South Africa suggests that it can lead to significant economic growth, with a marginal internal rate of return of 55.9% in the peach and nectarine industry (Tsvakirai, 2018).
Expedited government approval process	Macklin, 2012. Godlewskiet al., 2020. Rittberg et al., 2020.	Expedited government approval policies, such as the FDA's Accelerated Approval Program, have been criticised for their potential to lead to the approval of drugs with limited evidence of efficacy (Rittberg, 2020; Godlewski, 2020). This is particularly concerning in the context of R&D investment, as it may lead to the allocation of resources to less effective treatments. However, there are also arguments in favour of such policies, particularly in urgent situations such as the need for HIV prevention products (Macklin, 2012).	

Policy	Literature	International	South Africa
Financial support	Mohnen, P., 2017. Hottenrott and Veugelers, 2017. Brown et al., 2017. Carboni, 2017. Cincera and Ravet, 2010. Bah and Dumontier, 2001.	Financial support can be in the form of subsidies or improved access to financial instruments in the markets. Research on the effectiveness of financial support policies for R&D investment has yielded mixed results. Hottenrott and Veugelers (2012) found that targeted R&D subsidies can accelerate R&D spending, particularly in small and medium-sized firms, and can lead to marketable product innovations. Mohnen (2017) noted that subsidies can also result in a deadweight loss, suggesting the need for a policy mix of R&D tax incentives and subsidies. Carboni (2017) further supported the positive impact of public grants on investment and R&D expenditure, particularly in financial constraints. From the financial instruments angle, studies have highlighted the importance of financial access policies in driving R&D investment. Brown et al., (2017) highlighted the importance of domestic policies that address appropriability and financing problems, such as financial market rules. Cincera and Ravet (2010) emphasised the role of external capital in financing R&D activities, particularly in European firms. Bah and Dumontier (2001) highlighted the unique financial policies adopted by R&D-intensive firms, including lower debt levels and higher cash reserves.	
Infrastructure/land preferential price	Brown et al., 2017. Liu et al., 2021.	Infrastructure or Preferential land policies for R&D investment can be effective. Still, their impact may vary across industries and regions, Liu et al., (2021) highlighted the potential negative impact of land supply on fiscal incentives for R&D, suggesting that the effectiveness of preferential land policies may be limited in certain contexts. Brown et al., (2017) further emphasised the importance of domestic policies that address appropriability and financing problems, indicating that a combination of measures may be necessary to maximise the effectiveness of preferential land policies for R&D investment.	
Patent-related incentives	Czarnitzki and Toole (2011), Encaoua et al. (2006); Chu (2007); Gao et al. (2016); Mani (2001); Pouris and Pouris (2011); Makhoba and Pouris, (2019)	Patent policies can be effective in stimulating R&D investment by reducing the impact of market uncertainty (Czarnitzki and Toole, 2006). However, the impact of patent length on R&D investment is limited, with little increase beyond 20 years (Chu, 2007). The effectiveness of patents also depends on the stringency of patentability requirements and the trade-off between length and breadth (Encaoua and martinez, 2006). Furthermore, the success of R&D investment, as measured by patent output, is not associated with tax avoidance (Gao et al., 2016).	Pouris and Pouris (2011) argue that the current patent system does not support the national innovation system and can lead to exploitation by foreign interests. Makhoba and Pouris (2019) present a more positive view, noting that South Africa has the highest R&D efficiency among BRICS countries, particularly in nanotechnology. Despite this, the country's patenting profile does not always align with its R&D priority areas, as identified by government policy (Makhoba and Pouris, 2019).

Policy	Literature	International	South Africa
Reduced tax rates/ preferable tax rates Tax allowances and tax credits Tax deductions (including super deductions) Tax exemptions	Hemphill, 2009. Crespi et al., 2016. Guceri and Liu, 2019. Lokshin, B. and Mohnen, 2012. Baghana and Mohnen, 2009. Pouris, 2003. T Marire, 2022. E	Research on the effectiveness of tax incentive policies for R&D investment yields mixed results. Hemphill (2009) found that the US R&E tax credit had a negligible effect on increasing industry applied research investment. However, Crespi et al., (2016) reported that a tax credit scheme in Argentina was effective in increasing firms' innovation efforts, with varying effects based on the type of innovation investment, industrial sector, and firm size. Guceri and Liu (2019) provided evidence of the positive impact of tax credits for R&D in the UK, with an estimated user-cost elasticity of around -1.6. Lokshin and Mohnen (2012) found level-based fiscal tax incentives effective but can bring about crowding out for medium to large firms. However, incremental tax credits may be less susceptible to deadweight loss than the level-based ones, especially in small firms (Baghana and Mohnen, 2009).	Marire (2021) argues that the reallocation of business R&D expenditure from experimental to applied research, influenced by tax incentives, harmed the productivity of the national system of innovation. Firm-level analysis by Kreuser and Newman (2018) finds a positive, positive correlation between R&D tax allowances and total factor productivity. James (2017) estimated that companies benefiting from the incentive spend an additional R4 million on R&D (cited in National Treasury, 2021: 19). Tregenna et al. (2020) use the SARS-NT data for manufacturing firms and find significant positive effects associated with the R&D tax incentive. Companies that received the R&D tax allowance increased in-house R&D expenditure and intensity but reduced technology in-licensing. Finally, the World Bank (2019) conducted an impact evaluation study and found some evidence that the incentive increased firm expenditure on R&D (more than doubled expenditure) and increased the remuneration of R&D employees in beneficiary companies. However, their findings were based on a very limited set of data (18 treated companies, 14 control companies).

R&D Success Stories from Comparator Countries

Table 20 displays 11 potential research and development (R&D) incentives based on the 2023 Ernst & Young report for South Africa and three comparable nations: Türkiye, Malaysia, and Thailand. These countries were selected due to their effective R&D initiatives, increasing their Gross Expenditure on Research and Development (GERD) and Business Expenditure on Research and Development (BERD). These nations have adopted R&D policies similar to those of South Africa. For instance, all the presented countries have instituted a tax deduction policy to attract R&D investments. South Africa, Turkey, and Thailand have implemented the 'Accelerated Depreciation on R&D Assets' policy, while all countries, except Thailand, have introduced the 'Cash Grants' R&D policy. However, there are additional R&D policies shared among the comparator countries that South Africa has not embraced. For instance, Turkey and Malaysia have implemented 'Patent-related Incentives' and 'Tax Exemptions' policies. Consequently, South Africa could gain policy insights from the R&D success stories of these comparator countries.

Table 20: R&D policies applied by Türkiye, Malaysia, Thailand and South Africa

	South Africa	Türkiye	Malaysia	Thailand
Accelerated depreciation on R&D assets	X	X		X
Cash grants	X	X	X	
Financial support			X	
Income tax withholding incentives		X		
Loans				X
Patent-related incentives		X	X	
Reduced social security contributions		X		
Tax allowance			X	
Tax deduction (including super deductions	X	X	X	X
Tax exemptions		X	X	
Tax holiday			X	X

Ernst & Young (2023) Worldwide R&D Incentives Reference Guide.

Türkiye

The Turkish Government, aiming to transition into an innovation-driven, high-tech economy, implemented an extensive support package for research and development (R&D) starting on March 1, 2016. As shown in Table 20, Turkey has implemented 7 R&D incentives out of the 16 possible compared to South Africa. Key components of this: The creation of design centres that enjoy incentives on par with R&D centres; tax deduction and grants for pre-competition cooperation projects to encourage joint projects; exemptions from customs duties on materials acquired from abroad for R&D, innovation, and design projects; the establishment of specialised technology development zones (TDZs) dedicated to priority and strategic sectors such as ICT, healthcare, biotech, and nanotech (this aims to facilitate concentrated R&D efforts); tax deductions for companies providing venture capital to start-ups through the Techno-Initiative Capital Support Program within (TDZs).

The utilisation of R&D tax incentives as an indirect funding mechanism in Turkey originated from the enactment of the Technology Development Zone Law in 2001. Subsequently, it was strengthened and rendered more supportive by implementing the R&D Activities Support Law in 2008. This legal framework continues to serve as the foundation for R&D tax incentives. In 2016, it underwent revisions, incorporating design activities and introducing additional regulations that favor small and medium-sized enterprises (SMEs). According to (Tas and Erdil, 2023), the major drive of increase in R&D in Turkey was legal regulations governing R&D tax incentives that led the share of R&D tax incentives in business enterprise expenditures on R&D (BERD) to rise to 14.8% in 2018 from 6.94% in 2008. In addition, and more importantly, total government allocation for R&D increased more than one and a half-fold over the last 20 years in the OECD (Turkey included). Because R&D investments require profit opportunities for businesses enterprises, the government of Turkey implemented policies aimed at reducing the relative cost and uncertainty of R&D investments. The support policies included public-private R&D partnerships, direct subsidies, and fiscal incentives.

Malaysia

Several types of incentives and financial assistance are offered to attract investments in R&D activities. Key to this are the multiple local government funding programmes aimed at supporting businesses in various industries (see 2023 Ernst and Young Report). In addition, significant policy endeavours have been directed towards attracting and supporting business research and development (R&D) endeavours, with a specific focus on the "high" and "medium-technology" sectors. Additionally, attention has been given to resource-based production segments, leveraging Malaysia's robust comparative advantages in areas such as palm oil and rubber.

Thailand

Thailand is emphasising fostering an innovation-driven economy, urging both the public and private sectors to increase investments in research and development (R&D) activities. In pursuit of this goal, the Thai government has introduced various tax incentive programs to provide additional support in science, technology, R&D, and innovation. These initiatives align with the nation's strategy to elevate Thailand from a middle-income status to a high-income status by 2027. The government offers tax holidays and non-tax incentives to businesses engaged in research and development (R&D) services or incurring qualifying R&D expenditures. The Thai government has set up a fund to subsidise R&D investment projects, target startup businesses, and engage in the targeted industries that involve the use of new high technology. In addition, the Thai National Science and Technology Development Agency (NSTDA) provides additional financial assistance to businesses through soft loans.

South Africa can, therefore, draw several lessons from other successful countries' R&D policies. First, compared to Turkey, Malaysia and Thailand, South Africa uses fewer incentives (3 out of 16). In general, comparator countries are more likely to use a wider range of incentives. For example, Turkey and Malaysia uses seven incentives out of a possible 16. Second, for the above comparator countries, there is effective government involvement in funding and creating opportunities for R&D. Policies have been implemented to streamline bureaucratic processes associated with R&D funding.

1 The export estimates do not include productivity which is an indirect channel through which R&D can influence firm export performance. This indirect effect will partially be captured by the coefficient on the R&D dummy variable.

DEPARTMENT OF SCIENCE AND INNOVATION

Building No. 53 (CSIR South Gate Entrance)
Meiring Naudé Road
Brummeria
Pretoria
www.dsi.gov.za
@dsigovza
www.facebook.com/dsigovza