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

HSRC
Human Sciences Research Council

POLICY BRIEF

GLENDA KRUSS, AMY KAHN AND IL-HAAM PETERSEN

JANUARY 2025

Mapping modes of firm innovation: new indicators for South African STI policy

Key messages

- South African science, technology and innovation (STI) and industrial policy actors, and business or industry organisations, increasingly recognise the need for a contextually appropriate mix of policy interventions aiming to build and strengthen firms' innovation capabilities, aligned with the priorities of the STI Decadal Plan (2022).
- New kinds of indicators can add value to inform design, implementation and monitoring of a policy mix.
- This policy brief draws on analysis of national business innovation datasets to identify and profile the distinctive South African spread of firms' modes of innovation.
- The empirical analysis identifies four main innovation pathways, so that policy strategies and mechanisms are oriented to incentivise the full range of firm innovation capabilities: (1) strengthening the dynamic innovation capabilities of high capability firms operating on global or domestic markets, (2) building the innovation capabilities of moderate capability firms, for technology modification, (3) broadening the innovation capabilities of low capability firms to access and absorb technologies, and (4) supporting the conditions for non-innovating firms' market entry and growing demand.

The challenge: a policy mix to strengthen firm capabilities, technological upgrading and participation in global value chains

An old problem, not unique to South Africa, is the dominance of an STI policy mix that is overly focused on supply-side interventions to grow scientific institutions, R&D and knowledge production. Researchers have long highlighted a gap in South African STI policy models, arguing that they were not sufficiently informed by demand-side evidence on the determinants of technological learning and upgrading in local firms, which 'made for a veritable black box hiding the engines of innovation'[1]. Policy makers need to understand the scope and nature of South African firms' technological capabilities, which span both their production capabilities – their ability to operate effectively in local and global value chains, and their innovation capabilities – their ability to develop new and improved products and processes.

The White Paper on STI (2019) and the Decadal Plan (2022) prioritise the need for new policy instruments to grow firm innovation capabilities, which require a better understanding of how South African firms currently innovate. For instance, research by the Centre for Science, Technology and Innovation Indicators (CeSTII) shows that, in South Africa, like many other middle-income countries, few firms report modes of innovation that are R&D-led, or require novel locally developed technologies[2]. Instead, most South African firms innovate through training staff and adopting new ICT, machinery and equipment acquired from elsewhere. Such innovation activities require different kinds of learning, knowledge and technology transfer than for R&D-led innovation, particularly because new technology is often acquired from global innovation and production networks. To use new technologies efficiently requires firms to develop innovation capabilities and technological, management and workforce skills that may be missing. If these are not present, learning is hindered, and firms may lack the ability to make further modifications to grow productivity and markets[3]. While relatively low technological capabilities are not the only obstacle to strengthening South African firms' productivity and competitiveness in domestic or international markets, their development across the national system of innovation is key[4].

This policy brief proposes a new set of indicators that can illuminate how South African firms innovate. First, the 'modes of innovation' employed by South African firms are identified. Second, patterns of innovation activity are mapped to discern profiles of sets of firms with similar innovation capabilities. Third, these insights are used to inform a framework for designing a new mix of policy instruments that can support the Decadal Plan (2022) goals of inclusive and sustainable growth and development.

The evidence: mapping and profiling firms' innovation capabilities

New kinds of analysis

The evidence is based on producing new indicators from existing data obtained from the South African Business Innovation Survey (BIS) 2014-2016. The new indicators classify firms according to their **product** innovation outcomes, based on three business traits[5]:

- **Market reach**: whether the firm operates in international markets or in domestic markets only
- The **novelty** of their product innovations, whether **goods** and/or **services**
- Whether product and/or process innovations were developed **in-house** or **adopted** from other businesses or organisations.

This way of classifying firms is based on the work of Anthony Arundel and Hugo Hollanders at UNU-MERIT[6] in the Netherlands and Kieran O'Brien from the Australian Innovation Research Centre[7]. They proposed new indicators for innovation profiling that capture *how* firms innovate, using data collected by innovation surveys following the OECD's Oslo Manual guidelines. The premise is that classifying firms based on how they innovate provides insights into the range of firm-level innovation capabilities. The South African government has sanctioned national business innovation surveys that follow the Oslo Manual since the 2002-2004 period. Yet, to date, the analyses of South African survey data have only provided limited aggregate evidence on firm-level capabilities, particularly for the large proportion of firms whose innovations are not R&D-based.

Classifying firms using the three business traits yielded five mutually exclusive groups (Table 1 and Figure 2), providing a map of the spectrum of firm-level innovation at a specific point in time, and, a basis for comparison with other country experiences. There is, of course, a sixth group – those firms that do not report any innovation.

The policy evidence can be used to highlight where there are emergent firm strengths to be nurtured, or major gaps that require systemic interventions to address market failures. In this way, analyses of firm innovation profiles enable critical consideration of the likely reach of well-established STI policy instruments, and of potential spaces for new instruments and strategies to drive change.

Table 1: Firm-level classification based on innovation outcomes

Indicators based on innovation outcomes (innovation modes)		Description
1	New to market international innovators	Firms operate on international markets, develop innovations in-house and implement new-to-world product innovations.
2	New to market domestic innovators	Firms operate at the national/local level only, develop innovations in-house and implement new-to-market product innovations.
3	International modifiers	Firms operate on international markets, develop innovations in-house, but resulting products are only new to domestic markets or to the firm.
4	Domestic modifiers	Firms operate at the national/local level only, develop innovations in-house, but resulting products are only new to the firm.
5	Adopters	Innovations are primarily developed by external organisations, indicating that firms do not have internal capabilities (irrespective of resulting novelty).

Source: Adapted from Arundel and O'Brien (2009)[8]

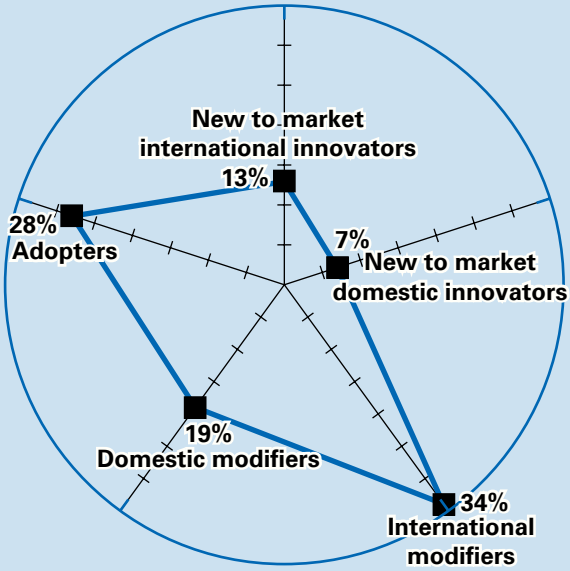
Predominantly adoption and modification innovation capabilities

Figure 1 shows the distribution of the five modes of product innovation across South African firms. This excludes the 33% of firms that reported no innovation, as well as firms that had only process, organisational, or marketing innovations, with no product innovation.

The group of product innovator firms with cutting-edge innovation capabilities ('new to market international innovators') is relatively small (accounting for 13% of firms), and the group of 'new to market domestic innovators' (7%) is even smaller. Just over one quarter of product innovators are classified as 'adopters', with low innovation capabilities and whose innovations are developed by external organisations (28%). Interventions with these relatively significant groups may need to build capabilities to access and modify innovations developed by other actors in the first instance.

Of policy interest is the significant set of firms with some internal innovation capabilities. 'International modifiers' (34%) are firms that operate on international markets, and are able to develop innovations in-house, but the resulting products have low degrees of novelty, either only new to domestic markets or to the firm itself. Interventions to support these firms to engage in global value chains in ways that link back into and drive local-level technological upgrading could be important to structural transformation. 'Domestic modifiers' (19%) operate at the national or local levels only, and develop innovations in-house, but the resulting products are only new to the firm. Interventions to strengthen learning and capabilities for adapting, adjusting and modifying technologies in this set of firms may also strengthen capacity for domestic value-added and employment generation. With the opportunities created by the African Continental Free Trade Area, implemented in 2019, developing innovation capabilities to operate on regional markets may also be significant.

Figure 1: Modes of innovation in South African firms reporting product innovation



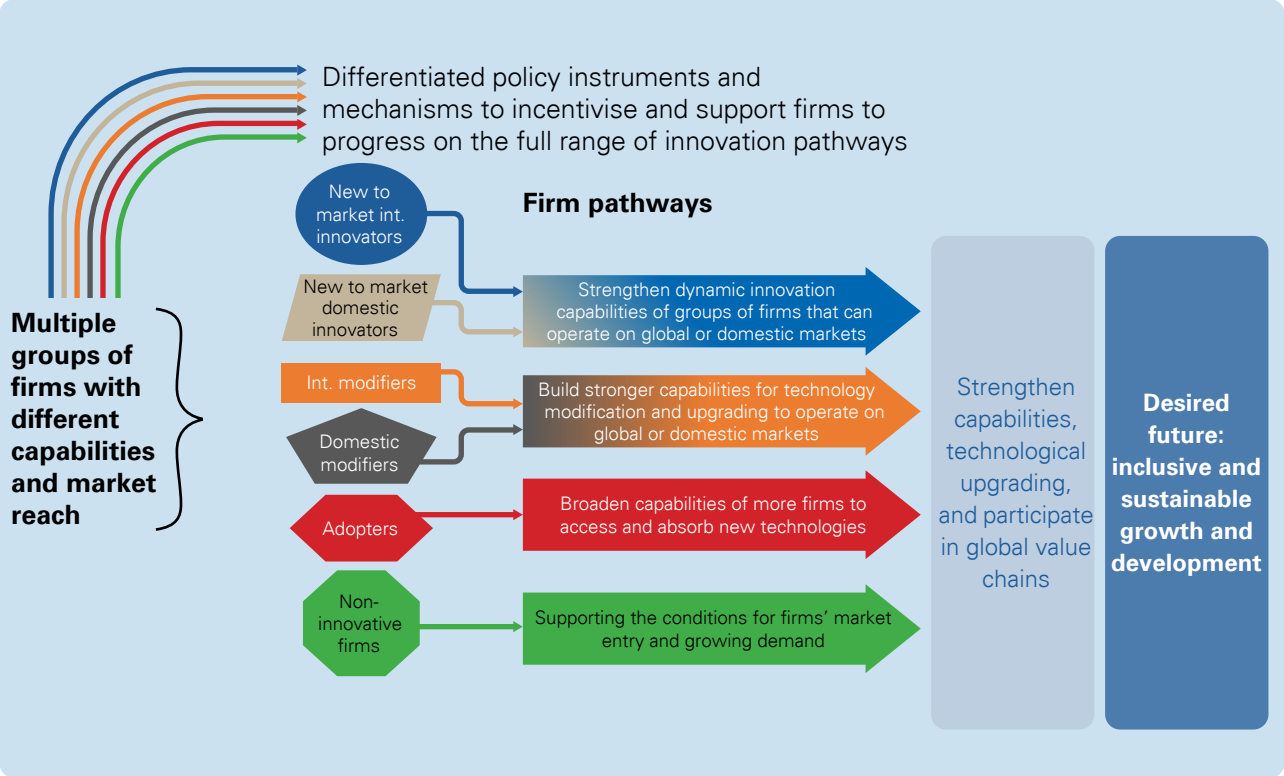
Source: Authors' calculation from CeSTII. 2020. South African Business Innovation Survey 2014-2016. Survey weights have been used such that the data are representative of the South African business population.

The insights: evidence towards STI policy mixes strengthening firm-level innovation capabilities

A model of indicators oriented to differentiated policy pathways

The research guided the development of a generic stylised model (Figure 2), depicting how new indicators can be used to inform the design, implementation and monitoring of new policy mixes. In this case, the policy process is oriented to the Decadal Plan (2022) goals to strengthen firm capabilities and technological upgrading, to contribute to the desired future of innovation-led inclusive and sustainable growth and development.

Figure 2: A conceptual model to inform the design and implementation of a contextually specific policy mix



Source: Authors, adapted from CeSTII (2024)[9] and Kruss et al. (2024)[10]

The five mutually-exclusive groups of firms with varying innovation capabilities identified in Figure 2 above are represented by the shapes on the left-hand side, with the non-innovators represented as a sixth group.

Horizontal policy instruments may improve the environment for all firms' productive capabilities, such as policies to supply and train skilled workers, or the competitive environment, such as intellectual property rights (IPR) or export regulation. For example, based on emergent trends in other countries, organisational economist David Teece and colleagues[11] recommended the establishment of a competitive funding pool in South Africa, to build firm-level productivity 'through a programme aimed at identifying, acquiring and widely diffusing existing best-practice *ordinary capabilities* and technologies'.

However, a range of vertical interventions targeted to specific firm innovation capabilities are required. If the policy focus is primarily on the set of firms that use advanced technologies to build export capabilities or operate at the technological frontier, policy will fail to support the large number of firms using other innovation modes. In contrast, a differentiated innovation policy mix would incentivise and support these other firms to advance along a variety of pathways (depicted by the horizontal arrows and discussed further below), to achieve the Decadal Plan (2022) policy goals. To strengthen the national system of innovation, a mix of strategies and interventions, including policy instruments adopted from elsewhere, should support relevant pathways for all innovation modes.

The challenge is to create and use indicators as evidence of the range of firm innovation capabilities, and of firms' progress along each of the pathways.

Profiling and using evidence on firms' innovation capabilities

To inform the design of a more targeted mix of diverse policy instruments and mechanisms, we investigated the profiles of each of the five groups of firms and the non-innovators. Are there distinct patterns in firms in different sectors or size of classes? Are there differing degrees of technological intensity? How do firms with different modes of innovation report their most significant barriers to innovation: cost, market, knowledge and/or institutional factors?

Empirical analysis of how South African firms innovate yields four main innovation policy pathways, as depicted in the horizontal arrows in Figure 2 above, and with their main features and related policy strategies elaborated in Table 2 below.

Pathway 1: strengthening dynamic innovation capabilities of high capability firms operating on global or domestic markets

The policy priority to strengthen dynamic innovation capabilities of firms that can operate on global or domestic markets is relevant to firms in the profile 'new to market international' and 'new to market domestic innovators' with high to moderate technology intensity. Firms with international markets tend to have higher technology intensity than those with domestic markets. Policy interventions, such as competitive research and innovation funds, could focus on addressing the wide range of significant cost and market barriers reported by most of these firms. These firms are more likely to have the capabilities to access currently available commercialisation and localisation funding instruments, such as tax incentives or venture capital funds. The sectoral and size profiles of firms with these capabilities may be used to inform further targeting of instruments proposed in sectoral innovation strategies.

Table 2: Main features and related policy strategies of South African firms

Policy priority to inform mix of strategies and interventions	Mode of innovation capabilities	Sectoral spread	Firm size class	Technology intensity[12]	Barriers	Examples of policy interventions to build innovation capabilities
Strengthen dynamic innovation capabilities of groups of firms that can operate on global or domestic markets	New to market international innovators	Similar proportion of manufacturing and services	More likely to be small firms	High technology intensity	Cost and market barriers important	• Competition/IPR policy regulation • Competitive research funds/tax incentives/tech transfer support/ incubators • Venture/seed capital • Sector specific
	New to market domestic innovators	More manufacturing than services	Spread over small, medium, large	Moderate technology intensity	Cost and market barriers important	
Build stronger capabilities for technology modification and upgrading to operate on global or domestic markets	International modifiers	Similar proportion of manufacturing and services	Spread over small, medium, large and micro	Moderate technology intensity	Cost and market barriers important Knowledge and institutional factors more important	• Sector specific economic and financial and other incentives, positive or negative • Regulatory social and market interactions • Quality standards • Public support to higher education and public research institutes
	Domestic modifiers	More services than manufacturing	More likely to be micro firms	Moderate technology intensity	Knowledge and institutional factors less important	• SME incentives and support services • Digital services
Broaden capabilities of more firms to access and absorb new technologies	Adopters	Similar proportion of manufacturing and services	Spread over micro, medium and small size firms	Low technology intensity	Cost and market barriers more strongly important Knowledge and institutional factors less important	• Voluntary, non-coercive 'soft' tools: campaigns, codes of conduct • Information exchange global/sectoral/HE/ PRIs • Public procurement/public private partnerships with innovation conditions • SME incentives/support services/legal advice • Skills, education and training to build competences
Supporting the conditions for firms' market entry and growing demand	Non-innovators	Two thirds are services sector firms	More likely to be small and micro firms	Very low technology intensity	Market and cost barriers more strongly important Legislation and standards important	• Competition policy • Alignment with industrial policy • Private demand for innovation • Innovation support to economic clusters • Diffusion of digital technologies

Pathway 2: building innovation capabilities of moderate capability firms for technology modification

A second policy priority is to build the innovation capabilities of firms for technology modification on global or domestic markets – oriented to the demands of the 'international modifiers' and the 'domestic modifiers'. These firms have moderate technology intensity, and cost and market barriers are important. Knowledge and institutional barriers are less important for the domestic modifiers, who are more likely to be micro firms, and more in services than manufacturing sectors. Hence, additional interventions are required to stimulate innovation capabilities in specific sectors that are identified in the Decadal Plan (2022) as critical to economic growth trajectories. Policy instruments should support and drive collaboration across relevant sectors to share the costs and benefits of new technologies among firms, and to promote technological acquisition and learning.

Coordinated innovation, sectoral and industrial policy interventions are required to nurture the development and use of basic advanced technologies, as they are enablers for firms to absorb and modify a wider range of advanced technologies to local conditions.

To address the significant market barriers reported by these firms requires coordination between innovation, trade and industry and competition policies, and partnerships with and between industry and sectoral associations. Market barriers can also be addressed by programmes to build firm-level capabilities to enable the search for suitable technologies and adaptation for use inside the firm. Knowledge barriers were identified as more significant for the 'international modifiers', and interventions for this set of firms could include investment in technical, engineering, design and managerial skills development and research in general and in specific directions, but equally, by strengthening capabilities for learning at firm-level.

Pathway 3: broadening the innovation capabilities of more low capability firms to access and absorb technologies

The third policy priority has not been a strong focus for intervention thus far in South African STI policy, nor for sectoral industry associations: to broaden the innovation capabilities of more firms to access and absorb technologies for productive efficiency. These firms tend to have low technology intensity, and view knowledge and institutional factors as less important.

Building capabilities and stimulating demand from 'adopters' can strengthen a national system of innovation. The aim is not for all firms to develop capabilities to operate at the technological frontier through R&D and science driven modes of innovation, or on global markets. Rather, firms need to be able to innovate in ways that can stimulate market demand within existing economic conditions, with varying levels of technological intensity. This may require voluntary, non-coercive 'soft' policy tools, such as sectoral innovation campaigns. To broaden capabilities of more firms – notably small, medium and micro – requires different kinds of funding incentives, and addressing barriers to market entry. Public procurement and public-private partnerships including innovation conditionalities are typically used for this purpose, for example.

Pathway 4: supporting the conditions for non-innovator firms' market entry and growing demand

The majority of non-innovator firms have not adopted any advanced technologies, and most of these are in services sectors. In a rapidly digitalising world, this trend points to a major gap that requires creative public policy solutions, as well as programmatic responses from sectoral and industry associations, to diffuse and build capabilities.

For these non-innovative firms, the main reason not to innovate is a lack of demand. The most important barriers were market competition and uncertain demand, as well as cost factors related to lack of access to finance for innovation, within the firm and externally. These stem from structural constraints on the economy, such as the strong market concentration of large firms. Closer alignment of innovation and industrial policy to stimulate competition, facilitate market entry and support to catalyse new markets may be a necessary framework condition for building firm-level capabilities, together with incentives to encourage these firms to continually look for opportunities to innovate through adoption or modification.

The value of new STI indicators to inform STI policy mixes

The analysis in this policy brief points to the potential value of new kinds of indicators to inform public and private sector funding and policy mechanisms aimed at building technological capabilities across the full range of firms, including those displaying no, very low or moderate innovation capabilities.

Defining and profiling firm innovation capabilities can provide greater nuance to inform policy interventions than is possible from the limited number of indicators that are typically used in South Africa. The new indicators feed into a generic model that can be used to track change pathways towards desired policy goals over time, or for comparison and learning from other country experiences.

Acknowledgements

The Business Innovation Survey (BIS), on which this policy brief is based, was funded by the South African Department of Science and Innovation (DSI). The survey was conducted by the Centre for Science, Technology, and Innovation Indicators (CeSTII) at the Human Sciences Research Council (HSRC). The ideas, opinions, conclusions or policy recommendations expressed in this brief are strictly those of the authors and do not necessarily represent, and should not be reported as, those of the DSI. Access to innovation survey reports: https://hsrc.ac.za/about-cestii/measuring-innovation-capacity/

Contact

Dr Glenda Kruss, Executive Head, CeSTII, GKruss@hsrc.ac.za

Dr Amy Kahn, Research Specialist and BIS Project Lead, CeSTII, AKahn@hsrc.ac.za

Dr Il-haam Petersen, Chief Research Specialist, CeSTII, IPetersen@hsrc.ac.za

Endnotes

1. Lorentzen, J. 2009. Learning by firms: the black box of South Africa's innovation system. *Science and Public Policy* 36(1): 33-45.

2. Centre for Science, Technology and Innovation Indicators (CeSTII). 2020. *Innovation performance in South African businesses 2014-2016: activities, outcomes, enablers, constraints*. Cape Town: Human Sciences Research Council.

3. Marcelle, G.M. 2004. *Technological learning: a strategic imperative for firms in the developing world*. Cheltenham: Edward Elgar Publishing.

4. National Advisory Council on Innovation. No date. *Review of the White Paper on Science and Technology*. Pretoria: National Advisory Council on Innovation; Walwyn, D. and Cloete, L. 2018. Draft White Paper on Science, Technology and Innovation neglects to prioritise issues of performance and human capability. *South African Journal of Science* 114(11-12): 1-6.

5. Refer to Kruss, Kahn and Petersen (2024) for more technical details on the grouping of firms. Kruss, G., Kahn, A. and Petersen, I. 2024. Where innovations may come to life: evidence to inform a new policy mix to build firm capabilities across the national system of innovation. In Z. Mazibuko-Makena and T. Pogue (eds), *Why innovations live or die: South Africa's innovation system*. Johannesburg: Mapungubwe Institute for Strategic Reflection.

6. Hollanders, H.J.G.M. and Arundel, A.V. 2004. *European Innovation Scoreboard* – EXIS: an exploratory approach to innovation scoreboards. European Commission, Enterprise Directorate-General.

7. Arundel, A. and O'Brien, K. 2009. *Innovation Metrics Framework Project*. Australian Government.

8. Ibid.

9. Centre for Science, Technology and Innovation Indicators (CeSTII). 2024. Innovation in South African businesses, 2019-2021: activities, practices and capabilities. Cape Town: Human Sciences Research Council.

10. Kruss, G., Kahn, A. and Petersen, I. 2024, op. cit.

11. Teece, D., Brown, K., Alves, P., Mthombeni, M., and Mondliwa, P. 2020. *Firm-level capabilities: the missing link in South African industrial growth strategy*. BRG Institute and Gordon Institute of Business Science, University of Pretoria. Available at https://repository.up.ac.za/bitstream/handle/2263/82700/Teece_Firm_2020.pdf?sequence=1

12. Technological capabilities are measured by the number of advanced technologies developed or used by a firm.