Policy mixes and overcoming challenges to innovation in developing countries: Insights from a mixed methods study of South Africa's manufacturing sector

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Abstract

Although innovation policy mix as an analytical framework has been widely used and reported for developed countries, its application to developing countries has been minimal. In this study, an exploratory sequential approach has been followed in order to initially profile the policy mix in South Africa and then develop an understanding of how the policy mix could be rebalanced, and hence more effective, in addressing the requirements within its manufacturing sector. The characterisation followed the typology as used by the Organisation for Economic Cooperation and Development in order to allow a cross-case comparison with two other countries (India and Canada). This analysis has concluded that South Africa's policy mix is dominated by supply-side measures which support early stage research with more limited assistance for market development. Rebalancing the innovation policy mix towards the use of more demand-side instruments, combined with generic rather than population targeted policies, could address these deficiencies and improve the prospects for the sector. It is further proposed that the methodology be routinely applied in developing countries, particularly as a means of ensuring policy cohesion and synergy.

Keywords: Innovation Policy Mix; Developing Country; Demand-Side Measures; Mixed Methods

1. Introduction

Whilst the importance of innovation policy, and particularly policy instruments with which to support or stimulate innovation, are widely recognised by practitioners and discussed in the literature, the shaping of innovation policy mix for sector- or country-specific contexts is comparatively under-acknowledged and reported. Moreover much of the existing literature on policy mix considers only the developed countries (Borrás and Edquist, 2013; Cunningham et al., 2013; OECD, 2012) and there is limited analysis or discussion of policy mixes which may be more relevant to developing countries.

In this article, we report on cross comparison case study of innovation policy mix which includes an analysis of such policies in South Africa, Canada and India. The study begins from the premise that policy instruments are widely used as a means of incentivising firm-level innovation. Moreover in each country there is generally a broad range of such instruments covering different sectors, or size of firm, or means of support (Borrás and Edquist, 2013). Given the complexity of this policy landscape, its characterisation and customisation to specific contexts becomes an open and interesting question (Meuer et al., 2015).

In this discussion, it is useful to state what may be considered as the normative principles which describe innovation and hence define the structure of innovation policy. Without attempting to be comprehensive, this study adopts several such principles as follows:

- Technological change, as a consequence of innovation, is an important driver of productivity gains and economic growth, thereby increasing social welfare (Gries et al., 2017)
- Innovation takes place mainly and perhaps most importantly at firm level
- In developed countries, firm-level innovation is linked to private/public research and development (R&D) within an environment of strong competition; in developing countries, the most important path for technical change is technology transfer and diffusion, although the gains in all countries are highly uneven (Gries et al., 2017)
- Innovation can also be a means of addressing critical social and environmental problems, although this result requires government intervention
- The analytical framework of evolutionary economics has heavily influenced innovation policy; for instance, an appropriate balance for policy is considered to be the establishment of an environment which allows experimentation and hence variety without weakening the overall competitive environment, thereby ensuring that only sustainable or effective firms survive (Malerba and Orsenigo, 1996)

Given these principles, the importance of the appropriate balance, rather than the individual instruments, becomes apparent. The design of this balance goes to the core of the discussion around effectiveness, especially in resource-constrained settings where being able to cover all eventualities is impractical or too expensive. Important choices must be made including, for instance, the weighting between support for incremental innovation as a consequence of technology transfer and radical innovation arising from research and development; direct and indirect incentives; sector-specific and generic policies; support for large firms vs. small firms; and competitive vs. non-competitive grants (Guerzoni and Raiteri, 2015).

The discussion around policy choices to stimulate innovation is highly opportune for all countries in this study but particularly for South Africa, which has experienced a weakening of its manufacturing sector over the last 10 years. For instance, this sector accounted for 13.3% of the Gross Domestic Product (GDP) in the fourth quarter of 2015, a contraction of 0.8% vs. the fourth quarter of 2014 (Statistics South Africa, 2015b). Innovation within the manufacturing sector is crucial for its development, yet the process itself is highly complex and requires a range of instruments, including strong competition policy, adequate financial support and support for internationalisation (Becheikh et al., 2006).

Characterising South Africa's policy mix in the manufacturing sector and comparing it to other countries may provide relevant and useful insight into an approach towards innovation policy instruments to be employed as a means of achieving national objectives. Such a characterisation and comparison are now reported.

2. Theory of Innovation Policy Mix

Innovation policy mix is generally described using a typological framework which allows for the grouping of instruments into a limited number of well-defined categories. Various approaches have been adopted in terms of this typological framework. For instance, Borrás and Edquist (2013) adopt a three-fold typology, namely regulatory instruments, financial and economic instruments, and soft instruments, which are referred to as the "sticks, carrots and sermons" of public policy, as shown in Table 1 (Bemelmans-Videc et al., 2003).

INSERT TABLE 1 HERE

Other typologies include those developed by the Organisation for Economic Cooperation and Development (OECD, 2012) and Cunningham et al. (2013). The OECD typology, which has been used in this study, is summarised in Table 2.

INSERT TABLE 2 HERE

The rationale for considering policy mix, as opposed to individual policies, is several-fold; in the first place, firms are highly heterogenous, requiring different forms and levels of support depending on their sector, their maturity, the way in which they absorb technology, and their geographical context. Secondly, policies themselves interact and show levels of interdependence which influence their impact (Flanagan et al., 2011). Finally, different policies are often hosted by separate government departments whose policy objectives may not overlap or even act in conflict.

The latter issue touches on the broader discussion of policy alignment within government and is a significant cause of policy failure. For instance, the pursuance of policies favouring foreign direct investment may disadvantage the development of local industries and firms which result from local R&D programmes. The debate on alignment also raises another important question which is the evolutionary nature of policy environments. Policy mixes are rarely the consequence of portfolio design in which a government will *ab initio* establish a national policy mix through purposive action and co-ordination (Flanagan et al., 2011). Mixes

are emergent processes which exhibit a high level of pathway dependency. It is indeed this aspect which make the discussion on policy mix so important; countries need to continuously assess the policy portfolio to ensure that it remains broadly coherent and relevant to the innovation context.

The literature contains several reports of policy mix evaluations which have sought to address this issue of coherence and balance. For instance, Borrás and Edquist (2013) argue that innovation policy is too ad-hoc and lack the overview perspectives that arise from a proper understanding of the actual problems. In a study of supply-side instruments, Guerzoni and Raiteri (2015) conclude that innovation policy practitioners exaggerate the impact of supply-side instruments, and should place more emphasis on demand-side instruments, particularly the use of public procurement. Flanagan et al. (2011) argue that insufficient attention has been focussed on the time aspects of policy analysis and that introducing policy instrument A before policy instrument B may not necessarily provide the same result as policy instrument B before policy instrument A. The implication on this for policy making is that policy makers need to consider the temporal interaction of policy instruments with each other.

Fagerberg and Srholec (2008) explore how differences in capabilities between different countries cause some countries to excel and other to lag. The differences between country's innovation positioning can be attributed to differences in "social capabilities" (Fagerberg & Srholec, 2008). Fagerberg and Srholec (2008) analyse the work of Alexander Gerschenkron where the performance of different countries was evaluated and the challenge of technological "catch up" was noted. It was concluded that countries have to develop policy instruments that are capable of exploiting the opportunities that are presented.

Robin and Schubert (2013) examine the impact of public-private partnerships on a firm's innovation activities by using survey data to benchmark the innovation activities of firms in France and Germany. According to their approach, the interaction between institutions and industry is a fundamental driver of innovation activity. They conducted a study to examine the formal collaborations between firms and public research institutions. The study concluded that increasing the level of public-private collaboration was not likely to improve all forms of innovation intensity. This result contradicts the perspectives outlined by Johnson et al. (2003) who suggest that larger countries tend to favour the narrow perspective by growing the science and technology base through an emphasis on supply-side policy instruments. An explanation for the contradiction could be the different contexts of each study, with the latter study being conducted on firms in Denmark, and the former on firms in France and Germany.

Instruments are chosen to address a specific problem, and therefore exist within a context that is determined by the social, political and economic objectives and policies of the government at that period of time (Borrás & Edquist, 2013). As a result, the choice of policy instruments is highly contextual and unique to a country.

3. Research Objectives and Methodology

The overall objectives of this project were to characterise South Africa's innovation policy mix, as applied to the manufacturing sector, in order to understand what policies are available for the sector and then, through a qualitative engagement with private firms in the sector, to understand how the policies could be improved. The four research questions were as follows:

- What is the current innovation policy mix in South Africa as per the OECD typology?
- How does this mix compare to the policies in India and Canada (the former an example of a developing country and the latter a developed country, both following a similar approach to innovation policy as South Africa)?
- How effective has South Africa's approach been in addressing economic growth?
- How should a future innovation policy mix for South Africa be configured in order to improve the outlook for manufacturing in particular?

The study followed a mixed methods approach with an initial set of quantitative questions relating to actual policy expenditure and policy mix, followed by a qualitative phase in which the experiences of firms in accessing policy instruments were elicited and examined, a combination of approaches which can be described as exploratory sequential (Creswell, 2013). An overview of the approach is shown in Figure 1.

INSERT FIGURE 1 HERE

3.1 Characterising the Policy Mix

Data for policy mix profiles and expenditure were obtained from various secondary sources, depending on the country. In the case of South Africa, data were obtained from published annual reports of the relevant government department for each instrument as identified in Table 3. As already noted, the OECD typology has been used to characterise and compare country-level innovation policy mix. In the case of South Africa, it was necessary to calculate the allocations per category since the OECD data was not available.

INSERT TABLE 3 HERE

Data for India and Canada were obtained from existing publicly available databases as reported by the Innovation Policy Platform (World Bank and OECD, 2017).

3.2 Policy Effectiveness

Research questions 3 and 4 covered firm-level experiences of the effectiveness of policy mix, and how future policy mix could be configured. An interview-based approach with a purposive sampling strategy was used to explore these questions, with the interviewees being identified using the two criteria of firstly being representative of firms operating broadly within South Africa's manufacturing sector; and secondly their experience/seniority within the firm (greater than five years work experience within the company and preferably at senior management level). The reason for the latter selection criterion was two-fold; firstly, to ensure that the participants had sufficient experience with the company to provide meaningful feedback on the topic; and secondly, to provide an element of internal validity,

with the premise being that senior management should be able to better evaluate the overall impact of policy, rather than other factors, on the firm's performance.

Saunders et al. (2016) describe several varieties of purposive sampling, and define a heterogeneous sample as having sufficiently diverse characteristics to provide maximum variation in the collected data. The underlying premise is that patterns that emerge from such a sample will represent the key themes. Participants were therefore targeted from different sub-sectors of manufacturing, and also from firms that spanned a range from new emerging small enterprises to large automotive manufacturers.

Eleven interviews were conducted with participants meeting the above criteria. Fifteen interviews were targeted, but by the end of the tenth interview no new concepts were emerging from the interviews. Fusch and Ness (2015) highlight that no new codes mean that no new themes are emerging, and therefore it is likely that data saturation has been reached. It was therefore decided that no more interviews were necessary, and no further interviews were sought.

The interviews made use of a semi-structured questionnaire to reveal the effectiveness of present innovation policy and to explore how future policy mix could be configured. The interview guide was designed to cover whether the company used any of the innovation policy instruments; if so, which ones were used; how effective were these instruments; and what, in the participants view, should be changed to make innovation policy more effective. On the basis that experience of policy could be sector-specific, the company's sector was recorded in each case. In most cases, more experienced personnel were approached on the assumption that such respondents would be more qualified to answer the questions.

Table 4 shows the description of each participant in terms of the sector in which their company operates, the participants' position and the participants' experience levels. With the permission of the participants, the interviews were digitally recorded and later transcribed, with the exception of one interviewee who declined permission to be recorded. In this case, notes were taken during the interview and then sent back to the participant to confirm that the interview had been captured as intended. All interview transcripts were imported into a computer-aided qualitative data analysis software (CAQDAS) tool for subsequent analysis. ATLAS.ti was used as the tool to perform qualitative data analysis.

INSERT TABLE 4 HERE

4. Results

4.1 South Africa's Innovation Policy Mix

The categorisation of South African innovation policy instruments according to the OECD typology has been shown in Table 3. These allocations were made on the basis of public information covering the scope of each instrument and the authors' understanding of the OECD typology. For instance, the automotive investment scheme was considered to be a demand-side instrument (aimed at growing market opportunities to increase the demand for

innovation) whereas the Support Programme for Industrial Innovation was treated as a supply-side instrument (designed to promoting knowledge growth through support for R&D). For each instrument, the reported expenditure was extracted from annual reports of the relevant government department and then summed to calculate the overall expenditure or policy weighting within the separate categories. The three main government departments considered for this study are the Department of Trade and Industry (the dti), the Department of Science and Technology (DST) and the Department of Higher Education and Training (DHET). In the case of DHET, only R&D output was considered for this study. R&D output can be regarded as contributing directly towards the manufacturing sector, as a large portion of R&D output is intended to create the seed for the development of new products and services.

It is noted that this profiling of the South African instruments was not undertaken at a sector level, but across the whole economy. Although the focus of the study pertained to manufacturing, it was assumed that the latter sector would use the available instruments in equal proportion to other sectors. The same consideration applies to the data for Canada and India.

Based on the policy instruments listed in Table 3, the total expenditure across the three government departments is approximately $1.4 billion[1].

Figure 2 shows the aggregated expenditure per category within the OECD framework, with supply-side instruments making up approximately 96% of the mix. Figure 3 shows how South Africa's policy mix is currently configured. South Africa employs more generic rather than sector based instruments. The policy mix also favours population targeted instruments and is heavily dominated by supply-side instruments.

INSERT FIGURE 2 AND FIGURE 3 HERE

4.2 India's Innovation Policy Mix

India and Canada were used as comparator countries for this study. India is regarded as a fast-growing emerging economy, and Canada is considered a large economy with a well-developed science, technology and innovation (STI) system. India has a policy mix that is mostly sector or technology specific, non-competitive, generic and non-financial (see Figure 4). There appears to be a balance between supply-side instruments and demand-side instruments, with the balance slightly on the supply-side.

4.3 Canada's Innovation Policy Mix

Generic rather than sector or technology specific instruments dominate Canada's innovation policy mix (see Figure 4). Financial and supply-side instruments are also favoured. There appears to be a balance between population targeted and generic instruments, with generic instruments slightly favoured over population-targeted instruments.

[1] All currency values in this article have been converted from South African Rands to US dollars using the average 2014/15 exchange rate of R11.06/$.

INSERT FIGURE 4 HERE

Figure 5 shows the comparison of innovation policy mix between South Africa, Canada and India. The profile of South Africa is very similar to that of Canada, whereas India's policies place more emphasis on the use of non-financial, demand-side and sector/technology-targeted instruments.

INSERT FIGURE 5 HERE

4.4 Policy Effectiveness

Research question 3 examined how effective South Africa's approach has been in addressing economic growth within the manufacturing sector. The interview participants were asked to provide their view on how effective South Africa's innovation policy instruments have been for their organisations, and the economy at large. The meaning of effectiveness within the context of this study was clarified for all the participants as the "benefit of the policy instrument outweighing the cost of implementing the policy instrument".

The analysis of the answers to research question 3 was structured using the framework as shown in Figure 6. Firstly, the main points of the positive elements within the current innovation policy environment, to which the majority of the participants agreed, were identified. Secondly the institutional challenges around policy implementation and the major gaps were defined. Finally, the answers were used to provide feedback on proposals for future changes to the policy mix. Each theme is now discussed.

INSERT FIGURE 6 HERE

4.4.1 Positive Aspects of the Policy Environment

An important aspect which emerged from the interviews related to how firms understand and manage the new product development or science and technology-based innovation process. The respondents generally viewed the process as consisting of a series of distinct steps stretching from initial research to commercialisation or introduction to the market, which aligns with the now generic stage/gate architecture (Cooper, 1990) or technology readiness levels (Mankins, 1995). For example, one respondent described this value chain as:

> *"Maybe if I were to segment it, you get research, then you get development and then you get manufacturing. So that development component that sits in the middle creates overlap. So you find that research would generally go into development, and you'd find that manufacturing would go into development."*

Moreover, the firms expect policy instruments to cover the full spectrum of level and there was general consensus that some of the aspects of that process are well covered by the existing instruments, whereas some are neglected. One area that is addressed is the early development of products and technologies, primarily through tax incentives but also through agencies such as the Technology Innovation Agency.

The R&D tax incentive scheme (an example of an indirect, supply-side policy instrument; further details on the scheme are available from Department of Science and Technology

(2017)) was identified as one of the most effective mechanisms in place to incentivise innovative activities within the sector. Among the reasons given for this positive assessment of the instrument was that it was either well understood by the participants, or its administration could easily be outsourced to consulting firms. Various comments on this scheme follow.

> *"It's working well for us. That's a brilliant incentive. So, what that one allows you is that you can essentially claim 1.5 times your R&D investment as a tax deductible. It's an on-going one. We are still making use of it. I think it works well. And it has an impact. We actually budget for R&D because this incentive is there. So, there's on-going R&D in our business. I would not say primarily, but this assists us in growing and having a higher R&D budget. We would take this tax incentive into account when we invest."*

> *"We used it for the last three or four years. It's working well. It does not refund us as much as we would like, but it works. I think it's difficult if you don't have a consultant helping you."*

> *"The tax incentive has worked very well. Finance submits for us based on our R&D spending."*

> *"Actually, very effective. Very, very effective, because it did not take money out of the budget that was allocated to the main programme. Because these technologies were key and were meant to become part of the mainstream programme, there was a strong drive to actually turn those technology programmes into applied technologies and then into applicable technologies on the actual aircraft."*

Similarly, the Support Programme for Industrial Innovation, which is an example of a direct, supply-side instrument received positive feedback.

> *"The one project is our commercial of the shelf products. We currently have a product range, which we sell globally that was sort of seeded by a SPII project. So that helped to seed this business. If I look at our product ranges and the history of our business and our COTS products, that was a nice impact from SPII."*

Other positive comments related to the Export Marketing and Investment Assistance (EMIA) scheme, which is an example of an instrument which was designed to assist firm in accessing international markets. A respondent noted:

> *"I think it is a very good programme. We used that we used extensively over the years in all our businesses. We're part of the electro-technical export council and I think the link with the Export Council and the Department of Trade and Industry export funding works. We would probably do one or two international trips or exhibitions a year through EMIA funding."*

The Automotive Incentive Scheme (AIS) was also found to be particularly effective in supporting large volume manufacture.

> *"In general, within the automotive sector the benefits outweigh the cost, otherwise the automotive sector will not be using the incentive schemes. They are still using the incentive schemes."*

4.4.2 Major Policy Challenges

A major issue that was raised by the majority of participants is the discontinuity on policy instruments between R&D and product launch including the final phases of development which result in products that can generate revenue for the firm. While the evidence from the interviews show that there is general satisfaction with the instruments that deal with the early phases of development, there is consensus that a funding gap exists to cover market development and product launch.

It is considered that this gap is the consequence of the poor coordination between the two departments that manage the innovation policy mix. The Department of Science and Technology (DST) incentivises early stage R&D efforts, whereas the Department of Trade and Industry (dti) promotes the development of industry capability. Despite their overlapping goals, there seems to be an area that remains largely unaddressed.

> *"A lot of these policies however sit under the dti jurisdiction or ambit. Basically, we were still not taken into the dti fold or transferred into the dti. That was a major dilemma. We proposed that we fit into the dti arena, but could not get government to do that. We were still in the phase of the design and development; however, the reality was that because we changed our strategy we should have had a very strong handover framework between the seed funding which primarily came out of the DST, moved over to TIA, then basically the IDC who did the venture capital."*

> *"… so, we split the project into phases: Developing, industrialising, and then introducing it into the field. They will consider the development, and maybe the industrialising for funding. But the other part is missing."*

One participant indicated that they were unable to bridge this gap despite attempting to engage in a risk sharing co-funding arrangement.

> *"But we did not actually get the money. We did not qualify for it even though in our minds it was something that was there. The reason that we did not get it was that they found that the risk of the technology was too immature. It was too far away from a level of maturity to take to industry, it was too far away from being a product. So, in that scenario we proposed that we pay 50% of the technology and they pay 50% of the technology so they would help fund us. Even in that scenario they would not assist us."*

Surprisingly, one firm had used policy instruments to develop production capabilities, but could not access the R&D funding instruments.

> *"The real issue on the table is that policy is primarily driven for production related organisations. What dti has not catered for is the earlier stages. If we are to play as a competitive player in the local or global phase, the policy must be altered, or new policy introduced for the earlier phases, which really don't exist. So, they should have a policy framework that allows design and development to take place, even if it is completely innovative. Policies that incentivise new product development, rather than getting into what I call the industrialisation and production. Because you can only use that if you have a design that you can produce."*

The participants expressed that there appears to be insufficient coordination between the policy instruments that deal with R&D and those that deal with manufacturing and

production. Despite a policy framework based on a National System of Innovation (NSI) (DACST, 1996), there is still a misalignment in the implementation of the policy instruments offered by each of these departments.

"I personally believe that although there is good intent by dti and government at large, there is strong chasm that is missing. That is for SA to grow the cake, we cannot only be involved in the manufacturing sector. We have to be involved in the design and development arena."

While the gap between R&D and production was an overwhelming area of concern for the majority of participants, there was also consensus that a much deeper problem existed. The poor administration of the policy instruments emerged in all of the interviews conducted. Many of the participants expressed extreme frustration regarding the administrative procedures.

"You cannot believe that one person can generate so much paper. And the dti just does not respond. Five Years. Five years, that's what it takes. We applied for R2.5m We wanted to put a bunch of machines in here, wanted to really upgrade. Eventually we got R530k five years later. It's so frustrating, it's unbelievable. Is it effective? It is. But don't expect it to happen anytime soon."

"I think that the biggest stumbling block was the administration, so I think that it needs to be a lot clearer in terms of what the requirement is…"

"We've actually looked at this but have not had much success. The other challenge we've had in terms of getting funding from government is that it's not as simple as going to them and saying "please can I have money". That whole process is in itself not conducive to the intent."

It is also evident from the interviews that the industry does not have a basic awareness of the entire policy mix. They are able to get to understand some of the different instruments in isolation, but there is not a holistic view of how these instruments interact with each other to achieve the overall goals of government. This emerged in the interviews as a communication failure between government and industry. Participants view the lack of awareness of the policy mix as simply an issue of lack of communication from the side of government.

"No, because firstly we are unaware that they even exist, and even if we did we have no idea how to initiate or engage with the people that are involved with these policy instruments." – (when questioned about why they did not apply any of the policy instruments in their business to date.)

"One of the key organisational drives is to find out the rules and understand it and try to use it to the best of our advantage. We've been largely self-funded in terms our research and development to date. But I think there are opportunities to exploit other sources of funding"

Each participant was aware of the existence and the intent of specific instruments, but they were not aware of the interplay between these instruments to enable them to apply the policy instruments to gain the maximum benefit out of the synergy between the various instruments. Awareness of the policy mix emerged as a key theme from the interviews.

Participants have realised that they need to have an understanding of the complete policy mix, rather than just isolated instruments in order to effectively utilise them.

> *"So, we've put together research and development processes, and part of the process is to understand funding and look into government funding instruments. I think that part of the problem is how do you learn about it. How do you know about it? So that is one of the tasks that I've given the CTO. Go find out what is available in what institutes, and then learn the rules around that and do we fit into these rules? I spoke to someone from [another company], and he said that they received a million here and a million there, and managed to fund some work. And I though wow, that's brilliant. Why don't we access some of this funding? But we have not been able to get our hands on this and understand the rules around this."*

One participant, P1, who was not yet using any of policy instruments stated that they would rather see more emphasis on instruments that aided them in gaining access to a market, rather than instruments that helped develop new products. This was a key theme that featured among the participants from companies that considered themselves "small businesses".

> *"A lot of the manufacturing sector at this level is private and it's not very regulated with no real market access. As a young company prototyping, you don't really have access to a market. Government wants to boost employment in the country, and the best way to do that is for more business to grow and develop so that you can create more jobs. That speaks to the small businessman, and hopefully you can scale up and employ more people. But accessibility to those small businesses is not great."*

Participants who did manufacturing within the defence sector also noted the exclusionary nature of some of the instruments on defence related activities.

> *"Much of these incentives do not apply to the defence industry."*

4.5 Future Innovation Policy Mix

The final research question examined how future innovation policy mix could be configured in order to improve the outlook for the South African manufacturing sector and the interviewees were requested to make recommendations in this regard. This discussion took place subsequent to the questions regarding the effectiveness of policy, and as a result the participants ended up primarily focussing their recommendations to address the problems and gaps as identified earlier in the interview.

Replies to this question are now presented; firstly, proposals to address the funding gap are covered, followed by how to improve firm-level awareness of innovation instruments, how to resolve administrative issues between departments, and how to promote inclusivity. Finally, proposals to increase national levels of innovation through the enhancement of human resources are briefly mentioned.

4.5.1 Addressing the Funding Gap

There was a general feeling amongst the participants that there needs to be more access to instruments that allow companies to innovate across the full product development cycle from

R&D to full-scale production. Many of the participants had used R&D incentive schemes, without being able to access any of the instruments that allowed them to take the product into a production phase. The participants therefore all expressed similar recommendations for policy to cover the full spectrum of the development process.

"The current R&D policy is actually for R&D work, but there is not really much that takes that R&D towards full-scale production. There is a chasm between R&D and production. This is where design and development incentives will bridge the gap between R&D and production."

"And where we battled with is… we do a lot of development on products. We develop it in phases. We put out the product and then add more features. That part we cannot claim."

There was general consensus among the participants' responses that the objectives of the DST and the dti need to be linked through formulating policy that overlaps and complements, rather than conflicts, in this critical innovation stage or readiness level.

4.5.2 Policy Communication and Networking

Participants identified that a large contributor to the administrative challenges experienced arose from either a lack of communication or awareness of how policy intent was implemented. Participants recommended that this be better communicated, not just in terms of the administration of single instruments, but also in terms of how the various policy instruments were intended to support each other. Participants felt that this would enable companies to make use of a basket of instruments, rather than a single favoured instrument.

"Communication of the instruments is also a hurdle. Not everyone is aware of it. I know I mentioned that my background is defence manufacturing, but I also got a little bit of exposure into mining equipment manufacture. From the dti cluster meetings that I sat in, very few, especially the smaller companies have visibility or have awareness of the policy instruments that are available although they could probably benefit the most. So I think communication on the availability of these instruments and how to make use of it is something that we can improve on."

"Innovation policy as a whole... If we were aware of the opportunities for funding… Communication would be the biggest impact. Inform us what options there are and what avenues there are and secondly relieve us of the bureaucracy. That in itself will allow us to focus on innovation rather than compliance."

There is general consensus among the participants' responses that the objectives of the DST and the dti need to be linked through formulating policy that overlaps and complements, rather than conflicts, in the innovation area.

Participants also recommended improved networking between various actors within the NSI. For instance, one respondent stated:

"For me that is the key to getting collaboration between research and industry if you can solve that in-the-middle block."

Similarly, inclusivity in the policy making process was viewed by participants as an important contributor towards effective policymaking. The participants perceived government as making and implementing policy without a real knowledge of the industry. It was strongly suggested that industry be involved in the formulation of innovation policy, with one participant providing a tangible example of where has previously worked.

"[Company name removed] played a crucial role in writing the Industrial Policy Action Plan for South Africa. That is because we played in that space and understood the aspects of electric vehicles. Policies can only be written by companies, or individuals, or departments within government that fully understand the technical aspects of how that sector needs to operate, even if it is a sub-sector. Otherwise policies are not effective."

"People who make decisions on behalf of business haven't the slightest clue what it takes. They don't understand. The people who make the policy decisions should actually interact with business. And I'm talking about the people at our level. Have people empowered and knowledgeable develop the policy."

"Firstly, to understand the landscape of the way businesses – I can only speak for new businesses because that is what I know – the way that businesses are starting up are very different to the way businesses have been starting up 5 to 10 years ago. I don't think government has caught up to accessing business owners in a way that is simple to them."

4.5.3 Policy Communication and Networking

Participants also observed that many of the policy instruments were focused on developing technology, or on developing infrastructure through capital equipment procurement. Participants noted that the development of skills was as important for capability building as technology or equipment. Participants expressed a desire that skills development needs to be integrated into the policy framework as part of the policy mix, rather than implemented as a separate initiative.

"We need the skill set. That's what's lacking. Not just capital infrastructure. I currently cannot bring all of our manufacturing into the country. We don't have the skills. We don't have the manpower. And I can go down that road, but we don't have the skills. But skills is not a degree or technikon diploma. Skills is real skills. It needs to be real. It's about being able to do real things. Things like soldering skills needs to be developed."

"We don't have tradesmen. Apprenticeships should be given more stature through policy. Companies used to be given a tax incentive to train artisans. More policy instruments to incentivise training of artisans and tradesmen."

5. Discussion

Studies of this nature clearly have interest to policy makers and public servants who work within national departments that are attempting to stimulate innovation across an economy. In the context of this study, South Africa has adopted various instruments over the last 20 to 30 years which have been designed individually to address specific problems or opportunities. For instance, the R&D tax incentive was designed to boost business expenditure on R&D, and

the Technology Innovation Agency was established to provide direct grants for product development.

Most, if not all, of these instruments have arisen on an ad hoc basis, without the perspective of the overall policy mix. Such an evolution of innovation policy is not unique to South Africa; it is common to many national systems (Cunningham et al., 2013). This ad hoc tinkering with policy environments may address specific problems but will overlook systemic issues which require a broad front of instruments to address.

Examples of such system issues include the appropriate balance between the fundamental policy questions, where the latter include supply- vs demand-side instruments; the pursuance of niche management strategies.; and sector/population specific incentives, which may encourage inefficiencies in these populations vs. competitive/generic instruments (Kamp et al., 2017). In this case study of South Africa, issues have been surfaced which are relevant only to South Africa, such as the administration of specific schemes. At the same there are a general set of observations which have wider relevance; much of the following discussion covers the latter items.

One of the most surprising results is that compared to India and Canada, South Africa's innovation policy mix contains more supply-side instruments rather than demand-side instruments. Indeed, it can be stated that supply-side instruments dominate South Africa's innovation policy mix. Similarly, there are more generic rather than population targeted or technology specific instruments. India has a policy mix that is mostly sector or technology specific, non-competitive, generic and non-financial. Generic rather than sector or technology specific instruments dominate Canada's innovation policy mix. Financial and supply-side instruments are also favoured.

Some of the results from the cross-case comparison were mentioned in the interviews with firms on their experiences of innovation policy. For instance, a key theme that emerged from the participants was that there is a gap between R&D (supply-side) and manufacturing/producing a product (often demand-side). The participants have either very effectively used the R&D incentives offered by the DST, or they have used the manufacturing and production incentives offered by the dti. There is a general agreement among the participants that the policy offerings by these departments do not synergise effectively.

Participants expressed the need for policy instruments to complement each other allowing a firm to take a product from R&D towards a manufacturing and production. Generally, it was reported that policy instruments are effective for the early R&D phases of product development, but instruments that support taking that product to a market and developing that market are lacking. One participant, captured this by stating:

> *"They [government] see it as product support, but actually we are still developing the product. That's where we lose out a bit. That's something they need to look at."*

The comparative analysis showed that India has adopted a set of demand-side measures which are complementary to their supply-side measures and support the goal of stimulating the market, thereby creating a favourable environment for innovation. Canada has a more

pronounced focus on STI and growing R&D. Despite this focus, Canada employs some demand-side measures. A key learning from the comparative analysis is that supply-side and demand-side policies should be used in combination with each other, and a shift in the balance towards demand-side measures could aid in creating favourable conditions for innovation.

The need for a holistic view of the various policy instruments and how they interacted with each other was apparent. The coordinated administration of the entire basket of policy instruments emerged as strong recommendation for government.

Proposals for an adjustment to the innovation policy mix, based on the OECD typology are shown in Figure 7. The most significant is a shift in supply-side to demand-side funding, and from population (mainly small, medium and micro enterprises to generic funding).

INSERT FIGURE 7 HERE

6. Conclusion

Studies on suitable innovation policy mix(es) for developing countries have not been widely reported in the literature. While there may be some agreement on how to analyse this question and what mix may be suitable for a developed country, the critical question of policy mix for a developing country remains largely unanswered.

In this study, an exploratory sequential approach has been followed in order to initially profile the policy mix in South Africa and then develop an understanding of how the policy mix could be rebalanced, and hence more effective, in addressing the requirements within its manufacturing sector. The characterisation followed the typology as used by the Organisation for Economic Cooperation and Development in order to allow a cross-case comparison with two other countries (India and Canada).

This analysis concluded that South Africa's policy mix is dominated by supply-side measures which support early stage research with more limited assistance for market development. The two main departments that manage South Africa's innovation policy mix are the DST and the dti. The experiences of firms in terms of the innovation instruments suggest that the objectives and instruments of each department are not well coordinated or aligned.

This experience seems to differ between South Africa and the comparator countries. India has a system which favours inclusiveness within the NSI, and therefore a policy mix that is more non-financial, non-competitive and generic rather than population targeted. Demand-side measures form a significant portion of India's policy mix. On the other hand, Canada has prioritised entrepreneurial growth and strengthening the country's R&D base. More supply-side measures together with generic instruments are therefore used by Canada.

The choice of innovation policy instruments should be determined by consideration of a country's goals, as well as its current economic and technological positioning. South Africa has set dual goals of addressing its socio-economic challenges whilst simultaneously

transforming towards a knowledge economy, which together suggest that the country's policy mix needs to move towards using more demand-side instruments. Furthermore, it needs to address issues of industry awareness and knowledge of the policy interventions.

The following recommendations to policymakers are made based on the findings in this study:

- Innovation policy mix assessments should be routinely conducted across government departments within developing countries
- There is a need to shift towards using more demand-side instruments as opposed to supply-side instruments.
- The knowledge and awareness different policy instruments, including how they link with each other and support different phases of product development, needs to be improved within private firms generally.

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Tables

Table 1. Typology of innovation policy instruments

Type of Instrument	Description	Examples
Regulatory	Specific legislation covering actors within the NSI in order to achieve the optimal market conditions for the development of innovative products and processes	Organisational mandates; tax legislation
Financial and economic	Broad spectrum of instruments that provide financial incentives or disincentives for innovation activities	R&D grants
Soft	Non-coercive voluntary instruments that encourage transformative initiatives between actors	Incubation, business advice and support

Source: Bemelmans-Videc et al. (2003)

Table 2. OECD typology of innovation policy instruments

Type of Instrument	Description
Population targeted versus generic instruments	Population targeted instruments are aimed at specific sectors, or specific types of firms, especially SMEs or technology based firms
Technology targeted versus generic instruments	Technology targeted instruments favour specific types of sectors or technology. Examples of sectors and technologies favoured by technology-targeted instruments are renewable energy, biotechnology and additive manufacturing.
Financial versus non-financial instruments	Non-financial instruments are instruments that do not involve the exchange of funds, but are based on other benefits. Examples of such benefits may include access to infrastructure, training, information or markets.
Direct versus indirect financing instruments;	Direct financing instruments include instruments such as loans, grants, repayable advances and innovation vouchers. Indirect financial instruments include instruments such as tax incentives for innovation activity.
Competitive versus non-competitive instruments	Competitive instruments allocate funding based on the evaluation of competitive proposals against a set of criteria, with allocations based on the quality of the application and the available funding.
Supply-side versus demand-side instruments	Supply-side instruments focus on the generation of knowledge, while demand-side instruments incentivise the growth of market opportunities to increase the demand for innovation

Source: OECD (2012)

Table 3. Characterisation of policy instruments

Incentive Scheme or Support	Population vs Generic	Sector or Technology vs Generic	Financial vs Non-Financial	Direct vs Indirect	Competitive vs Non Competitive	Supply-Side vs Demand-Side
Automotive Investment Scheme	Generic	Sector	Financial	Indirect	Non Competitive	Demand-Side
Capital Projects Feasibility Programme	Generic	Generic	Financial	Direct	Non Competitive	Supply-Side
Clothing and Textile Competitiveness Improvement Programme	Generic	Sector	Financial	Direct	Non Competitive	Supply-Side
Critical Infrastructure Programme	Population	Sector	Financial	Direct	Non Competitive	Supply-Side
Manufacturing Competitiveness Enhancement Programme	Generic	Generic	Financial	Direct	Non Competitive	Supply-Side
Section 12I Tax Allowance Incentive	Generic	Generic	Financial	Indirect	Non Competitive	Supply-Side
Support Programme for Industrial Innovation	Generic	Generic	Financial	Direct	Competitive	Supply-Side
Black Business Supplier Development Programme	Population	Generic	Financial	Direct	Non Competitive	Supply-Side
Co-operative Incentive Scheme	Population	Generic	Financial	Direct	Non Competitive	Supply-Side
Technology and Human Resources for Industry Programme	Generic	Generic	Financial	Direct	Competitive	Supply-Side
Incubation Support Programme	Population	Generic	Financial	Direct	Non Competitive	Supply-Side
Export Marketing and Investment Assistance	Generic	Generic	Financial	Direct	Non Competitive	Supply-Side
Special Economic Zones and Industrial Development Zones	Population	Generic	Financial	Direct	Non Competitive	Supply-Side
Sector-Specific Assistance Scheme	Population	Generic	Financial	Direct	Non Competitive	Supply-Side
Higher Education Institutions (R&D)	Population	Generic	Non-Financial	Indirect	Non Competitive	Supply-Side
Small Enterprise Development Agency: Technology Programme (Tech Transfer)	Population	Sector	Financial	Direct	Non Competitive	Supply-Side
Small Enterprise Development Agency	Population	Sector	Financial	Indirect	Non Competitive	Supply-Side
Research, Development and Innovation	Population	Generic	Financial	Indirect	Non Competitive	Supply-Side

Incentive Scheme or Support	Population vs Generic	Sector or Technology vs Generic	Financial vs Non-Financial	Direct vs Indirect	Competitive vs Non Competitive	Supply-Side vs Demand-Side
Internal Resources & Cooperation	Population	Generic	Non-Financial	Indirect	Non Competitive	Supply-Side
Human Capital and Knowledge Systems	Population	Generic	Non-Financial	Indirect	Competitive	Supply-Side
Socio-Economic Partnerships	Population	Generic	Non-Financial	Indirect	Non Competitive	Supply-Side
Research outputs	Population	Generic	Non-Financial	Indirect	Competitive	Supply-Side
Earmarked Funds	Population	Generic	Non-Financial	Indirect	Non Competitive	Supply-Side

Table 4. Profiles of the interviewees

No	Sector	Position	Experience in that organisation
1	Manufacturing	Co-Founder and CEO	A start-up, so less than one year
2	Defence, Aerospace Manufacturing	Executive Manager	Just under 30 years
3	Automotive	Executive Manager for Production	Just under 5 years
4	Defence, Manufacturing	Programme Manager	14 years
5	Defence, Manufacturing	Engineering Manager	Just over 5 years.
6	Engineering	Head, Business Unit	9 Years
7	Defence Manufacturing and production	Engineering Manager	7 years
8	ICT	CEO	21 years
9	Defence, Manufacturing	Founder and Co-owner	15 years
10	Defence, Manufacturing	CEO	9 Months
11	Manufacturing for the Mining Industry	Chief Operations Officer	14 years

Figures

Figure 1. Overview of methodology and research questions

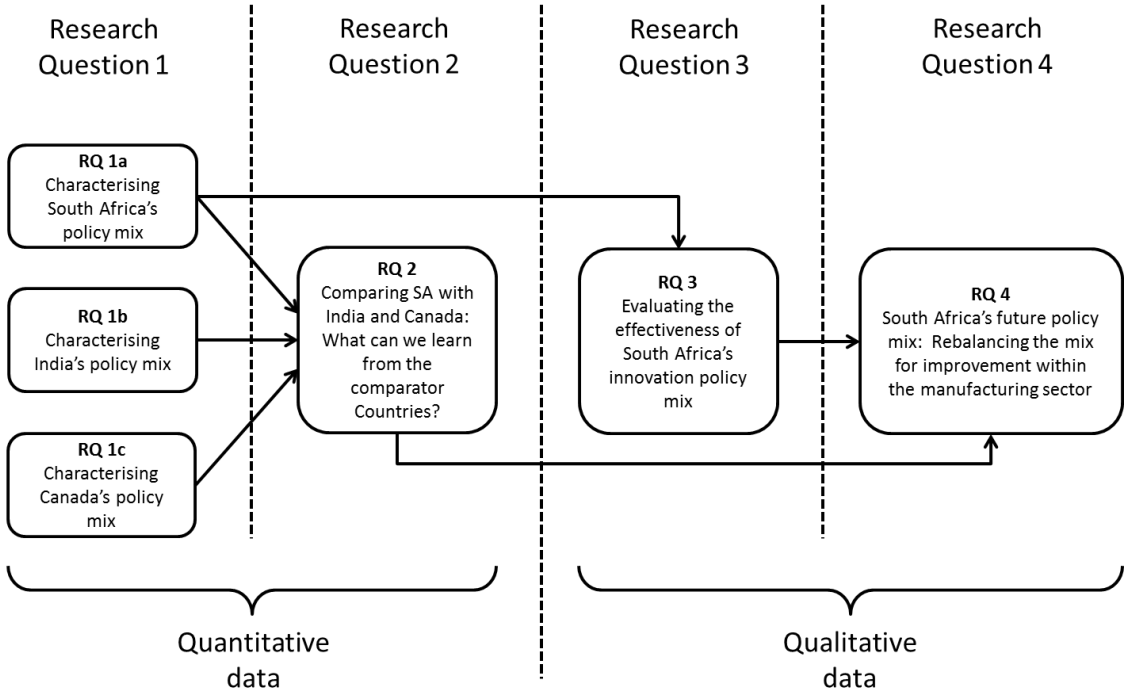


Figure 2. South Africa's expenditure on Innovation (2014/15)

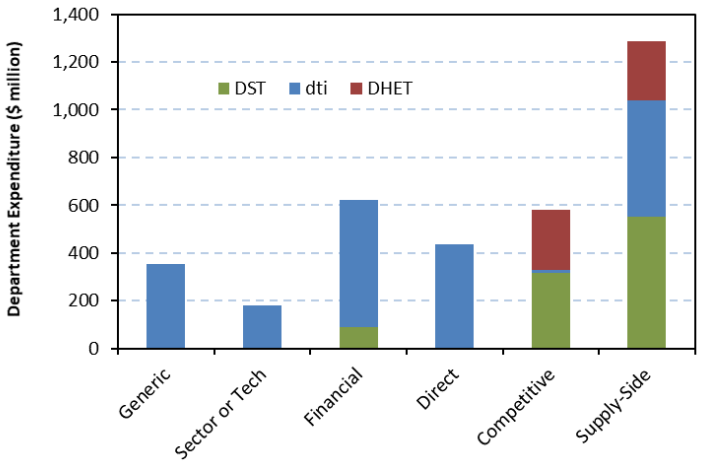


Figure 3. South Africa's innovation policy mix (total public expenditure)

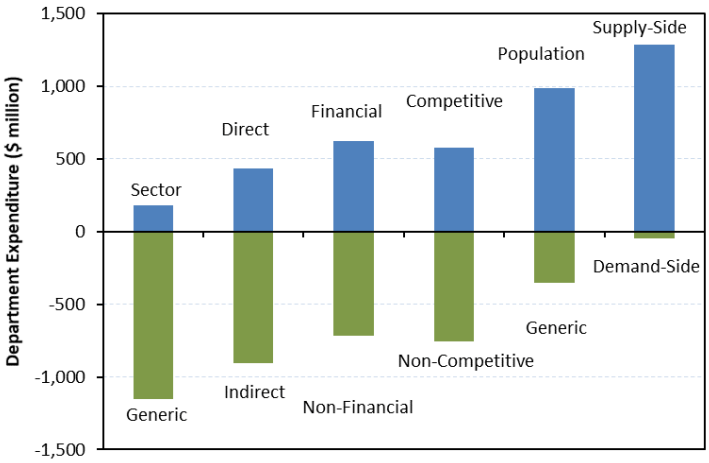


Figure 4. Balance of innovation policy mix for India and Canada

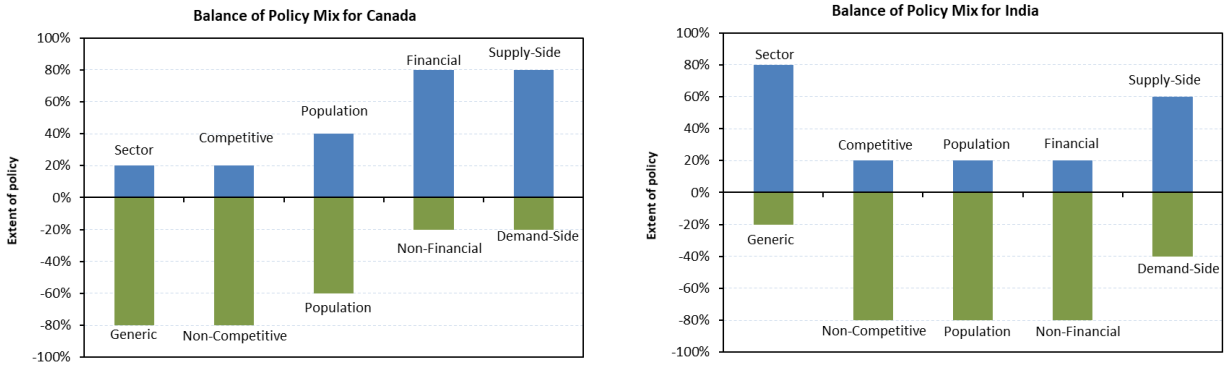


Figure 5. Innovation policy mix comparison between countries

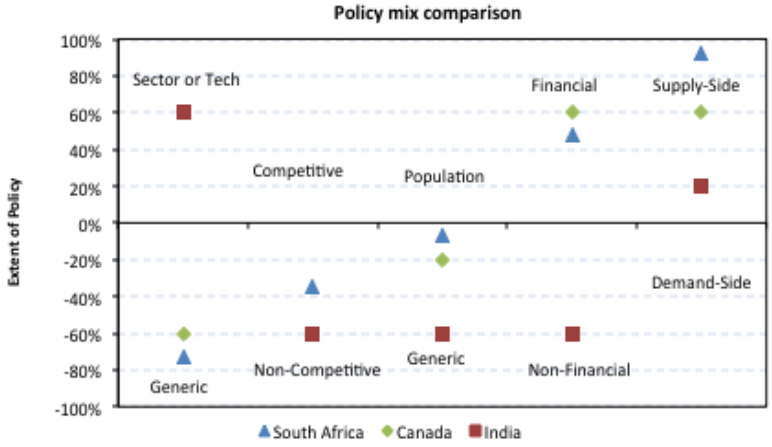


Figure 6. Framework for presentation of data

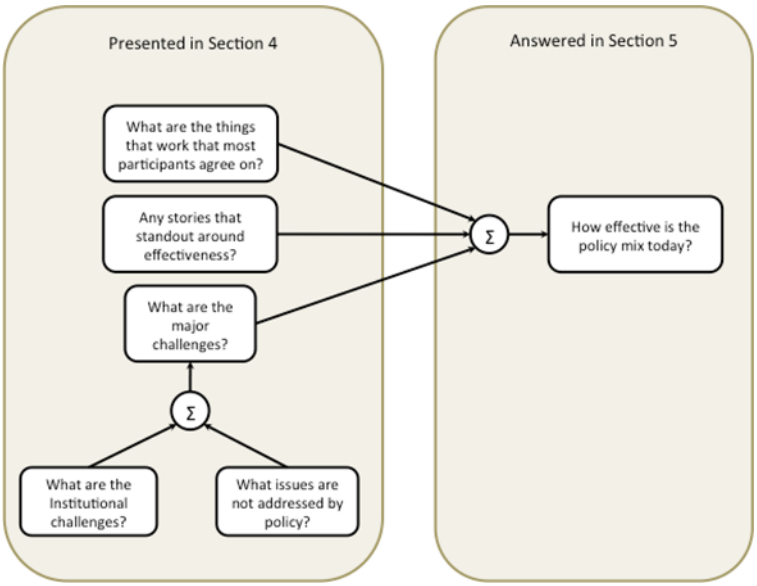
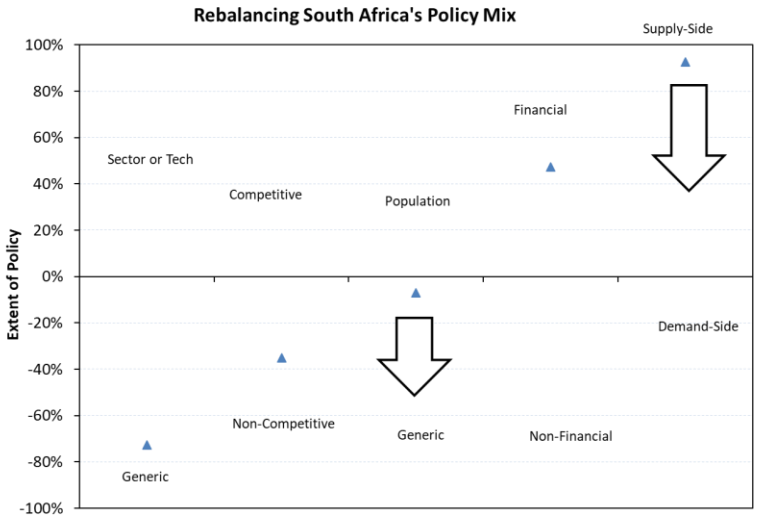


Figure 7. Proposed adjustments to the policy mix in South Africa



An Exploratory Sequential Study of Innovation Policy Mix in South Africa

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Abstract

Although innovation policy mix as an analytical framework has been widely used and reported for developed countries, its application to developing countries has been minimal. In this study, an exploratory sequential approach has been followed in order to initially profile the policy mix in South Africa and then develop an understanding of how the policy mix could be rebalanced, and hence more effective, in addressing the requirements within its manufacturing sector. The characterisation followed the typology as used by the Organisation for Economic Cooperation and Development in order to allow a cross-case comparison with two other countries (India and Canada). This analysis has concluded that South Africa's policy mix is dominated by supply-side measures which support early stage research with more limited assistance for market development. Rebalancing the innovation policy mix towards the use of more demand-side instruments, combined with generic rather than population targeted policies, could address these deficiencies and improve the prospects for the sector. It is further proposed that the methodology be routinely applied in developing countries, particularly as a means of ensuring policy cohesion and synergy.

Keywords: Innovation Policy Mix; Developing Country; Demand-Side Measures; Mixed Methods

1. Introduction

Whilst the importance of innovation policy, and particularly policy instruments with which to support or stimulate innovation, are widely recognised by practitioners and discussed in the literature, the shaping of innovation policy mix for sector- or country-specific contexts is comparatively under-acknowledged and reported. Moreover much of the existing literature on policy mix considers only the developed countries (Borrás and Edquist, 2013; Cunningham et al., 2013; OECD, 2012) and there is limited analysis or discussion of policy mixes which may be more relevant to developing countries.

In this article, we report on cross comparison case study of innovation policy mix which includes an analysis of such policies in South Africa, Canada and India. The study begins from the premise that policy instruments are widely used as a means of incentivising firm-level innovation. Moreover in each country there is generally a broad range of such instruments covering different sectors, or size of firm, or means of support (Borrás and Edquist, 2013). Given the complexity of this policy landscape, its characterisation and customisation to specific contexts becomes an open and interesting question (Meuer et al., 2015).

In this discussion, it is useful to state what may be considered as the normative principles which describe innovation and hence define the structure of innovation policy. Without attempting to be comprehensive, this study adopts several such principles as follows:

- Technological change, as a consequence of innovation, is an important driver of productivity gains and economic growth, thereby increasing social welfare (Gries et al., 2017)
- Innovation takes place mainly and perhaps most importantly at firm level
- In developed countries, firm-level innovation is linked to private/public research and development (R&D) within an environment of strong competition; in developing countries, the most important path for technical change is technology transfer and diffusion, although the gains in all countries are highly uneven (Gries et al., 2017)
- Innovation can also be a means of addressing critical social and environmental problems, although this result requires government intervention
- The analytical framework of evolutionary economics has heavily influenced innovation policy; for instance, an appropriate balance for policy is considered to be the establishment of an environment which allows experimentation and hence variety without weakening the overall competitive environment, thereby ensuring that only sustainable or effective firms survive (Malerba and Orsenigo, 1996)

Given these principles, the importance of the appropriate balance, rather than the individual instruments, becomes apparent. The design of this balance goes to the core of the discussion around effectiveness, especially in resource-constrained settings where being able to cover all eventualities is impractical or too expensive. Important choices must be made including, for instance, the weighting between support for incremental innovation as a consequence of technology transfer and radical innovation arising from research and development; direct and indirect incentives; sector-specific and generic policies; support for large firms vs. small firms; and competitive vs. non-competitive grants (Guerzoni and Raiteri, 2015).

The discussion around policy choices to stimulate innovation is highly opportune for all countries in this study but particularly for South Africa, which has experienced a weakening of its manufacturing sector over the last 10 years. For instance, this sector accounted for 13.3% of the Gross Domestic Product (GDP) in the fourth quarter of 2015, a contraction of 0.8% vs. the fourth quarter of 2014 (Statistics South Africa, 2015b). Innovation within the manufacturing sector is crucial for its development, yet the process itself is highly complex and requires a range of instruments, including strong competition policy, adequate financial support and support for internationalisation (Becheikh et al., 2006).

Characterising South Africa's policy mix in the manufacturing sector and comparing it to other countries may provide relevant and useful insight into an approach towards innovation policy instruments to be employed as a means of achieving national objectives. Such a characterisation and comparison are now reported.

2. Theory of Innovation Policy Mix

Innovation policy mix is generally described using a typological framework which allows for the grouping of instruments into a limited number of well-defined categories. Various approaches have been adopted in terms of this typological framework. For instance, Borrás and Edquist (2013) adopt a three-fold typology, namely regulatory instruments, financial and economic instruments, and soft instruments, which are referred to as the "sticks, carrots and sermons" of public policy, as shown in Table 1 (Bemelmans-Videc et al., 2003).

INSERT TABLE 1 HERE

Other typologies include those developed by the Organisation for Economic Cooperation and Development (OECD, 2012) and Cunningham et al. (2013). The OECD typology, which has been used in this study, is summarised in Table 2.

INSERT TABLE 2 HERE

The rationale for considering policy mix, as opposed to individual policies, is several-fold; in the first place, firms are highly heterogenous, requiring different forms and levels of support depending on their sector, their maturity, the way in which they absorb technology, and their geographical context. Secondly, policies themselves interact and show levels of interdependence which influence their impact (Flanagan et al., 2011). Finally, different policies are often hosted by separate government departments whose policy objectives may not overlap or even act in conflict.

The latter issue touches on the broader discussion of policy alignment within government and is a significant cause of policy failure. For instance, the pursuance of policies favouring foreign direct investment may disadvantage the development of local industries and firms which result from local R&D programmes. The debate on alignment also raises another important question which is the evolutionary nature of policy environments. Policy mixes are rarely the consequence of portfolio design in which a government will *ab initio* establish a national policy mix through purposive action and co-ordination (Flanagan et al., 2011). Mixes

are emergent processes which exhibit a high level of pathway dependency. It is indeed this aspect which make the discussion on policy mix so important; countries need to continuously assess the policy portfolio to ensure that it remains broadly coherent and relevant to the innovation context.

The literature contains several reports of policy mix evaluations which have sought to address this issue of coherence and balance. For instance, Borrás and Edquist (2013) argue that innovation policy is too ad-hoc and lack the overview perspectives that arise from a proper understanding of the actual problems. In a study of supply-side instruments, Guerzoni and Raiteri (2015) conclude that innovation policy practitioners exaggerate the impact of supply-side instruments, and should place more emphasis on demand-side instruments, particularly the use of public procurement. Flanagan et al. (2011) argue that insufficient attention has been focussed on the time aspects of policy analysis and that introducing policy instrument A before policy instrument B may not necessarily provide the same result as policy instrument B before policy instrument A. The implication on this for policy making is that policy makers need to consider the temporal interaction of policy instruments with each other.

Fagerberg and Srholec (2008) explore how differences in capabilities between different countries cause some countries to excel and other to lag. The differences between country's innovation positioning can be attributed to differences in "social capabilities" (Fagerberg & Srholec, 2008). Fagerberg and Srholec (2008) analyse the work of Alexander Gerschenkron where the performance of different countries was evaluated and the challenge of technological "catch up" was noted. It was concluded that countries have to develop policy instruments that are capable of exploiting the opportunities that are presented.

Robin and Schubert (2013) examine the impact of public-private partnerships on a firm's innovation activities by using survey data to benchmark the innovation activities of firms in France and Germany. According to their approach, the interaction between institutions and industry is a fundamental driver of innovation activity. They conducted a study to examine the formal collaborations between firms and public research institutions. The study concluded that increasing the level of public-private collaboration was not likely to improve all forms of innovation intensity. This result contradicts the perspectives outlined by Johnson et al. (2003) who suggest that larger countries tend to favour the narrow perspective by growing the science and technology base through an emphasis on supply-side policy instruments. An explanation for the contradiction could be the different contexts of each study, with the latter study being conducted on firms in Denmark, and the former on firms in France and Germany.

Instruments are chosen to address a specific problem, and therefore exist within a context that is determined by the social, political and economic objectives and policies of the government at that period of time (Borrás & Edquist, 2013). As a result, the choice of policy instruments is highly contextual and unique to a country.

3. Research Objectives and Methodology

The overall objectives of this project were to characterise South Africa's innovation policy mix, as applied to the manufacturing sector, in order to understand what policies are available for the sector and then, through a qualitative engagement with private firms in the sector, to understand how the policies could be improved. The four research questions were as follows:

- What is the current innovation policy mix in South Africa as per the OECD typology?
- How does this mix compare to the policies in India and Canada (the former an example of a developing country and the latter a developed country, both following a similar approach to innovation policy as South Africa)?
- How effective has South Africa's approach been in addressing economic growth?
- How should a future innovation policy mix for South Africa be configured in order to improve the outlook for manufacturing in particular?

The study followed a mixed methods approach with an initial set of quantitative questions relating to actual policy expenditure and policy mix, followed by a qualitative phase in which the experiences of firms in accessing policy instruments were elicited and examined, a combination of approaches which can be described as exploratory sequential (Creswell, 2013). An overview of the approach is shown in Figure 1.

INSERT FIGURE 1 HERE

3.1 Characterising the Policy Mix

Data for policy mix profiles and expenditure were obtained from various secondary sources, depending on the country. In the case of South Africa, data were obtained from published annual reports of the relevant government department for each instrument as identified in Table 3. As already noted, the OECD typology has been used to characterise and compare country-level innovation policy mix. In the case of South Africa, it was necessary to calculate the allocations per category since the OECD data was not available.

INSERT TABLE 3 HERE

Data for India and Canada were obtained from existing publicly available databases as reported by the Innovation Policy Platform (World Bank and OECD, 2017).

3.2 Policy Effectiveness

Research questions 3 and 4 covered firm-level experiences of the effectiveness of policy mix, and how future policy mix could be configured. An interview-based approach with a purposive sampling strategy was used to explore these questions, with the interviewees being identified using the two criteria of firstly being representative of firms operating broadly within South Africa's manufacturing sector; and secondly their experience/seniority within the firm (greater than five years work experience within the company and preferably at senior management level). The reason for the latter selection criterion was two-fold; firstly, to ensure that the participants had sufficient experience with the company to provide meaningful feedback on the topic; and secondly, to provide an element of internal validity,

with the premise being that senior management should be able to better evaluate the overall impact of policy, rather than other factors, on the firm's performance.

Saunders et al. (2016) describe several varieties of purposive sampling, and define a heterogeneous sample as having sufficiently diverse characteristics to provide maximum variation in the collected data. The underlying premise is that patterns that emerge from such a sample will represent the key themes. Participants were therefore targeted from different sub-sectors of manufacturing, and also from firms that spanned a range from new emerging small enterprises to large automotive manufacturers.

Eleven interviews were conducted with participants meeting the above criteria. Fifteen interviews were targeted, but by the end of the tenth interview no new concepts were emerging from the interviews. Fusch and Ness (2015) highlight that no new codes mean that no new themes are emerging, and therefore it is likely that data saturation has been reached. It was therefore decided that no more interviews were necessary, and no further interviews were sought.

The interviews made use of a semi-structured questionnaire to reveal the effectiveness of present innovation policy and to explore how future policy mix could be configured. The interview guide was designed to cover whether the company used any of the innovation policy instruments; if so, which ones were used; how effective were these instruments; and what, in the participants view, should be changed to make innovation policy more effective. On the basis that experience of policy could be sector-specific, the company's sector was recorded in each case. In most cases, more experienced personnel were approached on the assumption that such respondents would be more qualified to answer the questions.

Table 4 shows the description of each participant in terms of the sector in which their company operates, the participants' position and the participants' experience levels. With the permission of the participants, the interviews were digitally recorded and later transcribed, with the exception of one interviewee who declined permission to be recorded. In this case, notes were taken during the interview and then sent back to the participant to confirm that the interview had been captured as intended. All interview transcripts were imported into a computer-aided qualitative data analysis software (CAQDAS) tool for subsequent analysis. ATLAS.ti was used as the tool to perform qualitative data analysis.

INSERT TABLE 4 HERE

4. Results

4.1 South Africa's Innovation Policy Mix

The categorisation of South African innovation policy instruments according to the OECD typology has been shown in Table 3. These allocations were made on the basis of public information covering the scope of each instrument and the authors' understanding of the OECD typology. For instance, the automotive investment scheme was considered to be a demand-side instrument (aimed at growing market opportunities to increase the demand for

innovation) whereas the Support Programme for Industrial Innovation was treated as a supply-side instrument (designed to promoting knowledge growth through support for R&D). For each instrument, the reported expenditure was extracted from annual reports of the relevant government department and then summed to calculate the overall expenditure or policy weighting within the separate categories. The three main government departments considered for this study are the Department of Trade and Industry (the dti), the Department of Science and Technology (DST) and the Department of Higher Education and Training (DHET). In the case of DHET, only R&D output was considered for this study. R&D output can be regarded as contributing directly towards the manufacturing sector, as a large portion of R&D output is intended to create the seed for the development of new products and services.

It is noted that this profiling of the South African instruments was not undertaken at a sector level, but across the whole economy. Although the focus of the study pertained to manufacturing, it was assumed that the latter sector would use the available instruments in equal proportion to other sectors. The same consideration applies to the data for Canada and India.

Based on the policy instruments listed in Table 3, the total expenditure across the three government departments is approximately $1.4 billion[1].

Figure 2 shows the aggregated expenditure per category within the OECD framework, with supply-side instruments making up approximately 96% of the mix. Figure 3 shows how South Africa's policy mix is currently configured. South Africa employs more generic rather than sector based instruments. The policy mix also favours population targeted instruments and is heavily dominated by supply-side instruments.

INSERT FIGURE 2 AND FIGURE 3 HERE

4.2 India's Innovation Policy Mix

India and Canada were used as comparator countries for this study. India is regarded as a fast-growing emerging economy, and Canada is considered a large economy with a well-developed science, technology and innovation (STI) system. India has a policy mix that is mostly sector or technology specific, non-competitive, generic and non-financial (see Figure 4). There appears to be a balance between supply-side instruments and demand-side instruments, with the balance slightly on the supply-side.

4.3 Canada's Innovation Policy Mix

Generic rather than sector or technology specific instruments dominate Canada's innovation policy mix (see Figure 4). Financial and supply-side instruments are also favoured. There appears to be a balance between population targeted and generic instruments, with generic instruments slightly favoured over population-targeted instruments.

[1] All currency values in this article have been converted from South African Rands to US dollars using the average 2014/15 exchange rate of R11.06/$.

INSERT FIGURE 4 HERE

Figure 5 shows the comparison of innovation policy mix between South Africa, Canada and India. The profile of South Africa is very similar to that of Canada, whereas India's policies place more emphasis on the use of non-financial, demand-side and sector/technology-targeted instruments.

INSERT FIGURE 5 HERE

4.4 Policy Effectiveness

Research question 3 examined how effective South Africa's approach has been in addressing economic growth within the manufacturing sector. The interview participants were asked to provide their view on how effective South Africa's innovation policy instruments have been for their organisations, and the economy at large. The meaning of effectiveness within the context of this study was clarified for all the participants as the "benefit of the policy instrument outweighing the cost of implementing the policy instrument".

The analysis of the answers to research question 3 was structured using the framework as shown in Figure 6. Firstly, the main points of the positive elements within the current innovation policy environment, to which the majority of the participants agreed, were identified. Secondly the institutional challenges around policy implementation and the major gaps were defined. Finally, the answers were used to provide feedback on proposals for future changes to the policy mix. Each theme is now discussed.

INSERT FIGURE 6 HERE

4.4.1 Positive Aspects of the Policy Environment

An important aspect which emerged from the interviews related to how firms understand and manage the new product development or science and technology-based innovation process. The respondents generally viewed the process as consisting of a series of distinct steps stretching from initial research to commercialisation or introduction to the market, which aligns with the now generic stage/gate architecture (Cooper, 1990) or technology readiness levels (Mankins, 1995). For example, one respondent described this value chain as:

> *"Maybe if I were to segment it, you get research, then you get development and then you get manufacturing. So that development component that sits in the middle creates overlap. So you find that research would generally go into development, and you'd find that manufacturing would go into development."*

Moreover, the firms expect policy instruments to cover the full spectrum of level and there was general consensus that some of the aspects of that process are well covered by the existing instruments, whereas some are neglected. One area that is addressed is the early development of products and technologies, primarily through tax incentives but also through agencies such as the Technology Innovation Agency.

The R&D tax incentive scheme (an example of an indirect, supply-side policy instrument; further details on the scheme are available from Department of Science and Technology

(2017)) was identified as one of the most effective mechanisms in place to incentivise innovative activities within the sector. Among the reasons given for this positive assessment of the instrument was that it was either well understood by the participants, or its administration could easily be outsourced to consulting firms. Various comments on this scheme follow.

> *"It's working well for us. That's a brilliant incentive. So, what that one allows you is that you can essentially claim 1.5 times your R&D investment as a tax deductible. It's an on-going one. We are still making use of it. I think it works well. And it has an impact. We actually budget for R&D because this incentive is there. So, there's on-going R&D in our business. I would not say primarily, but this assists us in growing and having a higher R&D budget. We would take this tax incentive into account when we invest."*

> *"We used it for the last three or four years. It's working well. It does not refund us as much as we would like, but it works. I think it's difficult if you don't have a consultant helping you."*

> *"The tax incentive has worked very well. Finance submits for us based on our R&D spending."*

> *"Actually, very effective. Very, very effective, because it did not take money out of the budget that was allocated to the main programme. Because these technologies were key and were meant to become part of the mainstream programme, there was a strong drive to actually turn those technology programmes into applied technologies and then into applicable technologies on the actual aircraft."*

Similarly, the Support Programme for Industrial Innovation, which is an example of a direct, supply-side instrument received positive feedback.

> *"The one project is our commercial of the shelf products. We currently have a product range, which we sell globally that was sort of seeded by a SPII project. So that helped to seed this business. If I look at our product ranges and the history of our business and our COTS products, that was a nice impact from SPII."*

Other positive comments related to the Export Marketing and Investment Assistance (EMIA) scheme, which is an example of an instrument which was designed to assist firm in accessing international markets. A respondent noted:

> *"I think it is a very good programme. We used that we used extensively over the years in all our businesses. We're part of the electro-technical export council and I think the link with the Export Council and the Department of Trade and Industry export funding works. We would probably do one or two international trips or exhibitions a year through EMIA funding."*

The Automotive Incentive Scheme (AIS) was also found to be particularly effective in supporting large volume manufacture.

> *"In general, within the automotive sector the benefits outweigh the cost, otherwise the automotive sector will not be using the incentive schemes. They are still using the incentive schemes."*

4.4.2 Major Policy Challenges

A major issue that was raised by the majority of participants is the discontinuity on policy instruments between R&D and product launch including the final phases of development which result in products that can generate revenue for the firm. While the evidence from the interviews show that there is general satisfaction with the instruments that deal with the early phases of development, there is consensus that a funding gap exists to cover market development and product launch.

It is considered that this gap is the consequence of the poor coordination between the two departments that manage the innovation policy mix. The Department of Science and Technology (DST) incentivises early stage R&D efforts, whereas the Department of Trade and Industry (dti) promotes the development of industry capability. Despite their overlapping goals, there seems to be an area that remains largely unaddressed.

> *"A lot of these policies however sit under the dti jurisdiction or ambit. Basically, we were still not taken into the dti fold or transferred into the dti. That was a major dilemma. We proposed that we fit into the dti arena, but could not get government to do that. We were still in the phase of the design and development; however, the reality was that because we changed our strategy we should have had a very strong handover framework between the seed funding which primarily came out of the DST, moved over to TIA, then basically the IDC who did the venture capital."*

> *"… so, we split the project into phases: Developing, industrialising, and then introducing it into the field. They will consider the development, and maybe the industrialising for funding. But the other part is missing."*

One participant indicated that they were unable to bridge this gap despite attempting to engage in a risk sharing co-funding arrangement.

> *"But we did not actually get the money. We did not qualify for it even though in our minds it was something that was there. The reason that we did not get it was that they found that the risk of the technology was too immature. It was too far away from a level of maturity to take to industry, it was too far away from being a product. So, in that scenario we proposed that we pay 50% of the technology and they pay 50% of the technology so they would help fund us. Even in that scenario they would not assist us."*

Surprisingly, one firm had used policy instruments to develop production capabilities, but could not access the R&D funding instruments.

> *"The real issue on the table is that policy is primarily driven for production related organisations. What dti has not catered for is the earlier stages. If we are to play as a competitive player in the local or global phase, the policy must be altered, or new policy introduced for the earlier phases, which really don't exist. So, they should have a policy framework that allows design and development to take place, even if it is completely innovative. Policies that incentivise new product development, rather than getting into what I call the industrialisation and production. Because you can only use that if you have a design that you can produce."*

The participants expressed that there appears to be insufficient coordination between the policy instruments that deal with R&D and those that deal with manufacturing and

production. Despite a policy framework based on a National System of Innovation (NSI) (DACST, 1996), there is still a misalignment in the implementation of the policy instruments offered by each of these departments.

"I personally believe that although there is good intent by dti and government at large, there is strong chasm that is missing. That is for SA to grow the cake, we cannot only be involved in the manufacturing sector. We have to be involved in the design and development arena."

While the gap between R&D and production was an overwhelming area of concern for the majority of participants, there was also consensus that a much deeper problem existed. The poor administration of the policy instruments emerged in all of the interviews conducted. Many of the participants expressed extreme frustration regarding the administrative procedures.

"You cannot believe that one person can generate so much paper. And the dti just does not respond. Five Years. Five years, that's what it takes. We applied for R2.5m We wanted to put a bunch of machines in here, wanted to really upgrade. Eventually we got R530k five years later. It's so frustrating, it's unbelievable. Is it effective? It is. But don't expect it to happen anytime soon."

"I think that the biggest stumbling block was the administration, so I think that it needs to be a lot clearer in terms of what the requirement is…"

"We've actually looked at this but have not had much success. The other challenge we've had in terms of getting funding from government is that it's not as simple as going to them and saying "please can I have money". That whole process is in itself not conducive to the intent."

It is also evident from the interviews that the industry does not have a basic awareness of the entire policy mix. They are able to get to understand some of the different instruments in isolation, but there is not a holistic view of how these instruments interact with each other to achieve the overall goals of government. This emerged in the interviews as a communication failure between government and industry. Participants view the lack of awareness of the policy mix as simply an issue of lack of communication from the side of government.

"No, because firstly we are unaware that they even exist, and even if we did we have no idea how to initiate or engage with the people that are involved with these policy instruments." – (when questioned about why they did not apply any of the policy instruments in their business to date.)

"One of the key organisational drives is to find out the rules and understand it and try to use it to the best of our advantage. We've been largely self-funded in terms our research and development to date. But I think there are opportunities to exploit other sources of funding"

Each participant was aware of the existence and the intent of specific instruments, but they were not aware of the interplay between these instruments to enable them to apply the policy instruments to gain the maximum benefit out of the synergy between the various instruments. Awareness of the policy mix emerged as a key theme from the interviews.

Participants have realised that they need to have an understanding of the complete policy mix, rather than just isolated instruments in order to effectively utilise them.

> *"So, we've put together research and development processes, and part of the process is to understand funding and look into government funding instruments. I think that part of the problem is how do you learn about it. How do you know about it? So that is one of the tasks that I've given the CTO. Go find out what is available in what institutes, and then learn the rules around that and do we fit into these rules? I spoke to someone from [another company], and he said that they received a million here and a million there, and managed to fund some work. And I though wow, that's brilliant. Why don't we access some of this funding? But we have not been able to get our hands on this and understand the rules around this."*

One participant, P1, who was not yet using any of policy instruments stated that they would rather see more emphasis on instruments that aided them in gaining access to a market, rather than instruments that helped develop new products. This was a key theme that featured among the participants from companies that considered themselves "small businesses".

> *"A lot of the manufacturing sector at this level is private and it's not very regulated with no real market access. As a young company prototyping, you don't really have access to a market. Government wants to boost employment in the country, and the best way to do that is for more business to grow and develop so that you can create more jobs. That speaks to the small businessman, and hopefully you can scale up and employ more people. But accessibility to those small businesses is not great."*

Participants who did manufacturing within the defence sector also noted the exclusionary nature of some of the instruments on defence related activities.

> *"Much of these incentives do not apply to the defence industry."*

4.5 Future Innovation Policy Mix

The final research question examined how future innovation policy mix could be configured in order to improve the outlook for the South African manufacturing sector and the interviewees were requested to make recommendations in this regard. This discussion took place subsequent to the questions regarding the effectiveness of policy, and as a result the participants ended up primarily focussing their recommendations to address the problems and gaps as identified earlier in the interview.

Replies to this question are now presented; firstly, proposals to address the funding gap are covered, followed by how to improve firm-level awareness of innovation instruments, how to resolve administrative issues between departments, and how to promote inclusivity. Finally, proposals to increase national levels of innovation through the enhancement of human resources are briefly mentioned.

4.5.1 Addressing the Funding Gap

There was a general feeling amongst the participants that there needs to be more access to instruments that allow companies to innovate across the full product development cycle from

R&D to full-scale production. Many of the participants had used R&D incentive schemes, without being able to access any of the instruments that allowed them to take the product into a production phase. The participants therefore all expressed similar recommendations for policy to cover the full spectrum of the development process.

"The current R&D policy is actually for R&D work, but there is not really much that takes that R&D towards full-scale production. There is a chasm between R&D and production. This is where design and development incentives will bridge the gap between R&D and production."

"And where we battled with is… we do a lot of development on products. We develop it in phases. We put out the product and then add more features. That part we cannot claim."

There was general consensus among the participants' responses that the objectives of the DST and the dti need to be linked through formulating policy that overlaps and complements, rather than conflicts, in this critical innovation stage or readiness level.

4.5.2 Policy Communication and Networking

Participants identified that a large contributor to the administrative challenges experienced arose from either a lack of communication or awareness of how policy intent was implemented. Participants recommended that this be better communicated, not just in terms of the administration of single instruments, but also in terms of how the various policy instruments were intended to support each other. Participants felt that this would enable companies to make use of a basket of instruments, rather than a single favoured instrument.

"Communication of the instruments is also a hurdle. Not everyone is aware of it. I know I mentioned that my background is defence manufacturing, but I also got a little bit of exposure into mining equipment manufacture. From the dti cluster meetings that I sat in, very few, especially the smaller companies have visibility or have awareness of the policy instruments that are available although they could probably benefit the most. So I think communication on the availability of these instruments and how to make use of it is something that we can improve on."

"Innovation policy as a whole... If we were aware of the opportunities for funding… Communication would be the biggest impact. Inform us what options there are and what avenues there are and secondly relieve us of the bureaucracy. That in itself will allow us to focus on innovation rather than compliance."

There is general consensus among the participants' responses that the objectives of the DST and the dti need to be linked through formulating policy that overlaps and complements, rather than conflicts, in the innovation area.

Participants also recommended improved networking between various actors within the NSI. For instance, one respondent stated:

"For me that is the key to getting collaboration between research and industry if you can solve that in-the-middle block."

Similarly, inclusivity in the policy making process was viewed by participants as an important contributor towards effective policymaking. The participants perceived government as making and implementing policy without a real knowledge of the industry. It was strongly suggested that industry be involved in the formulation of innovation policy, with one participant providing a tangible example of where has previously worked.

"[Company name removed] played a crucial role in writing the Industrial Policy Action Plan for South Africa. That is because we played in that space and understood the aspects of electric vehicles. Policies can only be written by companies, or individuals, or departments within government that fully understand the technical aspects of how that sector needs to operate, even if it is a sub-sector. Otherwise policies are not effective."

"People who make decisions on behalf of business haven't the slightest clue what it takes. They don't understand. The people who make the policy decisions should actually interact with business. And I'm talking about the people at our level. Have people empowered and knowledgeable develop the policy."

"Firstly, to understand the landscape of the way businesses – I can only speak for new businesses because that is what I know – the way that businesses are starting up are very different to the way businesses have been starting up 5 to 10 years ago. I don't think government has caught up to accessing business owners in a way that is simple to them."

4.5.3 Policy Communication and Networking

Participants also observed that many of the policy instruments were focused on developing technology, or on developing infrastructure through capital equipment procurement. Participants noted that the development of skills was as important for capability building as technology or equipment. Participants expressed a desire that skills development needs to be integrated into the policy framework as part of the policy mix, rather than implemented as a separate initiative.

"We need the skill set. That's what's lacking. Not just capital infrastructure. I currently cannot bring all of our manufacturing into the country. We don't have the skills. We don't have the manpower. And I can go down that road, but we don't have the skills. But skills is not a degree or technikon diploma. Skills is real skills. It needs to be real. It's about being able to do real things. Things like soldering skills needs to be developed."

"We don't have tradesmen. Apprenticeships should be given more stature through policy. Companies used to be given a tax incentive to train artisans. More policy instruments to incentivise training of artisans and tradesmen."

5. Discussion

Studies of this nature clearly have interest to policy makers and public servants who work within national departments that are attempting to stimulate innovation across an economy. In the context of this study, South Africa has adopted various instruments over the last 20 to 30 years which have been designed individually to address specific problems or opportunities. For instance, the R&D tax incentive was designed to boost business expenditure on R&D, and

the Technology Innovation Agency was established to provide direct grants for product development.

Most, if not all, of these instruments have arisen on an ad hoc basis, without the perspective of the overall policy mix. Such an evolution of innovation policy is not unique to South Africa; it is common to many national systems (Cunningham et al., 2013). This ad hoc tinkering with policy environments may address specific problems but will overlook systemic issues which require a broad front of instruments to address.

Examples of such system issues include the appropriate balance between the fundamental policy questions, where the latter include supply- vs demand-side instruments; the pursuance of niche management strategies.; and sector/population specific incentives, which may encourage inefficiencies in these populations vs. competitive/generic instruments (Kamp et al., 2017). In this case study of South Africa, issues have been surfaced which are relevant only to South Africa, such as the administration of specific schemes. At the same there are a general set of observations which have wider relevance; much of the following discussion covers the latter items.

One of the most surprising results is that compared to India and Canada, South Africa's innovation policy mix contains more supply-side instruments rather than demand-side instruments. Indeed, it can be stated that supply-side instruments dominate South Africa's innovation policy mix. Similarly, there are more generic rather than population targeted or technology specific instruments. India has a policy mix that is mostly sector or technology specific, non-competitive, generic and non-financial. Generic rather than sector or technology specific instruments dominate Canada's innovation policy mix. Financial and supply-side instruments are also favoured.

Some of the results from the cross-case comparison were mentioned in the interviews with firms on their experiences of innovation policy. For instance, a key theme that emerged from the participants was that there is a gap between R&D (supply-side) and manufacturing/producing a product (often demand-side). The participants have either very effectively used the R&D incentives offered by the DST, or they have used the manufacturing and production incentives offered by the dti. There is a general agreement among the participants that the policy offerings by these departments do not synergise effectively.

Participants expressed the need for policy instruments to complement each other allowing a firm to take a product from R&D towards a manufacturing and production. Generally, it was reported that policy instruments are effective for the early R&D phases of product development, but instruments that support taking that product to a market and developing that market are lacking. One participant, captured this by stating:

> *"They [government] see it as product support, but actually we are still developing the product. That's where we lose out a bit. That's something they need to look at."*

The comparative analysis showed that India has adopted a set of demand-side measures which are complementary to their supply-side measures and support the goal of stimulating the market, thereby creating a favourable environment for innovation. Canada has a more

pronounced focus on STI and growing R&D. Despite this focus, Canada employs some demand-side measures. A key learning from the comparative analysis is that supply-side and demand-side policies should be used in combination with each other, and a shift in the balance towards demand-side measures could aid in creating favourable conditions for innovation.

The need for a holistic view of the various policy instruments and how they interacted with each other was apparent. The coordinated administration of the entire basket of policy instruments emerged as strong recommendation for government.

Proposals for an adjustment to the innovation policy mix, based on the OECD typology are shown in Figure 7. The most significant is a shift in supply-side to demand-side funding, and from population (mainly small, medium and micro enterprises to generic funding).

INSERT FIGURE 7 HERE

6. Conclusion

Studies on suitable innovation policy mix(es) for developing countries have not been widely reported in the literature. While there may be some agreement on how to analyse this question and what mix may be suitable for a developed country, the critical question of policy mix for a developing country remains largely unanswered.

In this study, an exploratory sequential approach has been followed in order to initially profile the policy mix in South Africa and then develop an understanding of how the policy mix could be rebalanced, and hence more effective, in addressing the requirements within its manufacturing sector. The characterisation followed the typology as used by the Organisation for Economic Cooperation and Development in order to allow a cross-case comparison with two other countries (India and Canada).

This analysis concluded that South Africa's policy mix is dominated by supply-side measures which support early stage research with more limited assistance for market development. The two main departments that manage South Africa's innovation policy mix are the DST and the dti. The experiences of firms in terms of the innovation instruments suggest that the objectives and instruments of each department are not well coordinated or aligned.

This experience seems to differ between South Africa and the comparator countries. India has a system which favours inclusiveness within the NSI, and therefore a policy mix that is more non-financial, non-competitive and generic rather than population targeted. Demand-side measures form a significant portion of India's policy mix. On the other hand, Canada has prioritised entrepreneurial growth and strengthening the country's R&D base. More supply-side measures together with generic instruments are therefore used by Canada.

The choice of innovation policy instruments should be determined by consideration of a country's goals, as well as its current economic and technological positioning. South Africa has set dual goals of addressing its socio-economic challenges whilst simultaneously

transforming towards a knowledge economy, which together suggest that the country's policy mix needs to move towards using more demand-side instruments. Furthermore, it needs to address issues of industry awareness and knowledge of the policy interventions.

The following recommendations to policymakers are made based on the findings in this study:

- Innovation policy mix assessments should be routinely conducted across government departments within developing countries
- There is a need to shift towards using more demand-side instruments as opposed to supply-side instruments.
- The knowledge and awareness different policy instruments, including how they link with each other and support different phases of product development, needs to be improved within private firms generally.

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Tables

Table 1. Typology of innovation policy instruments

Type of Instrument	Description	Examples
Regulatory	Specific legislation covering actors within the NSI in order to achieve the optimal market conditions for the development of innovative products and processes	Organisational mandates; tax legislation
Financial and economic	Broad spectrum of instruments that provide financial incentives or disincentives for innovation activities	R&D grants
Soft	Non-coercive voluntary instruments that encourage transformative initiatives between actors	Incubation, business advice and support

Source: Bemelmans-Videc et al. (2003)

Table 2. OECD typology of innovation policy instruments

Type of Instrument	Description
Population targeted versus generic instruments	Population targeted instruments are aimed at specific sectors, or specific types of firms, especially SMEs or technology based firms
Technology targeted versus generic instruments	Technology targeted instruments favour specific types of sectors or technology. Examples of sectors and technologies favoured by technology-targeted instruments are renewable energy, biotechnology and additive manufacturing.
Financial versus non-financial instruments	Non-financial instruments are instruments that do not involve the exchange of funds, but are based on other benefits. Examples of such benefits may include access to infrastructure, training, information or markets.
Direct versus indirect financing instruments;	Direct financing instruments include instruments such as loans, grants, repayable advances and innovation vouchers. Indirect financial instruments include instruments such as tax incentives for innovation activity.
Competitive versus non-competitive instruments	Competitive instruments allocate funding based on the evaluation of competitive proposals against a set of criteria, with allocations based on the quality of the application and the available funding.
Supply-side versus demand-side instruments	Supply-side instruments focus on the generation of knowledge, while demand-side instruments incentivise the growth of market opportunities to increase the demand for innovation

Source: OECD (2012)

Table 3. Characterisation of policy instruments

Incentive Scheme or Support	Population vs Generic	Sector or Technology vs Generic	Financial vs Non-Financial	Direct vs Indirect	Competitive vs Non Competitive	Supply-Side vs Demand-Side
Automotive Investment Scheme	Generic	Sector	Financial	Indirect	Non Competitive	Demand-Side
Capital Projects Feasibility Programme	Generic	Generic	Financial	Direct	Non Competitive	Supply-Side
Clothing and Textile Competitiveness Improvement Programme	Generic	Sector	Financial	Direct	Non Competitive	Supply-Side
Critical Infrastructure Programme	Population	Sector	Financial	Direct	Non Competitive	Supply-Side
Manufacturing Competitiveness Enhancement Programme	Generic	Generic	Financial	Direct	Non Competitive	Supply-Side
Section 12I Tax Allowance Incentive	Generic	Generic	Financial	Indirect	Non Competitive	Supply-Side
Support Programme for Industrial Innovation	Generic	Generic	Financial	Direct	Competitive	Supply-Side
Black Business Supplier Development Programme	Population	Generic	Financial	Direct	Non Competitive	Supply-Side
Co-operative Incentive Scheme	Population	Generic	Financial	Direct	Non Competitive	Supply-Side
Technology and Human Resources for Industry Programme	Generic	Generic	Financial	Direct	Competitive	Supply-Side
Incubation Support Programme	Population	Generic	Financial	Direct	Non Competitive	Supply-Side
Export Marketing and Investment Assistance	Generic	Generic	Financial	Direct	Non Competitive	Supply-Side
Special Economic Zones and Industrial Development Zones	Population	Generic	Financial	Direct	Non Competitive	Supply-Side
Sector-Specific Assistance Scheme	Population	Generic	Financial	Direct	Non Competitive	Supply-Side
Higher Education Institutions (R&D)	Population	Generic	Non-Financial	Indirect	Non Competitive	Supply-Side
Small Enterprise Development Agency: Technology Programme (Tech Transfer)	Population	Sector	Financial	Direct	Non Competitive	Supply-Side
Small Enterprise Development Agency	Population	Sector	Financial	Indirect	Non Competitive	Supply-Side
Research, Development and Innovation	Population	Generic	Financial	Indirect	Non Competitive	Supply-Side

Incentive Scheme or Support	Population vs Generic	Sector or Technology vs Generic	Financial vs Non-Financial	Direct vs Indirect	Competitive vs Non Competitive	Supply-Side vs Demand-Side
Internal Resources & Cooperation	Population	Generic	Non-Financial	Indirect	Non Competitive	Supply-Side
Human Capital and Knowledge Systems	Population	Generic	Non-Financial	Indirect	Competitive	Supply-Side
Socio-Economic Partnerships	Population	Generic	Non-Financial	Indirect	Non Competitive	Supply-Side
Research outputs	Population	Generic	Non-Financial	Indirect	Competitive	Supply-Side
Earmarked Funds	Population	Generic	Non-Financial	Indirect	Non Competitive	Supply-Side

Table 4. Profiles of the interviewees

No	Sector	Position	Experience in that organisation
1	Manufacturing	Co-Founder and CEO	A start-up, so less than one year
2	Defence, Aerospace Manufacturing	Executive Manager	Just under 30 years
3	Automotive	Executive Manager for Production	Just under 5 years
4	Defence, Manufacturing	Programme Manager	14 years
5	Defence, Manufacturing	Engineering Manager	Just over 5 years.
6	Engineering	Head, Business Unit	9 Years
7	Defence Manufacturing and production	Engineering Manager	7 years
8	ICT	CEO	21 years
9	Defence, Manufacturing	Founder and Co-owner	15 years
10	Defence, Manufacturing	CEO	9 Months
11	Manufacturing for the Mining Industry	Chief Operations Officer	14 years

Figures

Figure 1. Overview of methodology and research questions

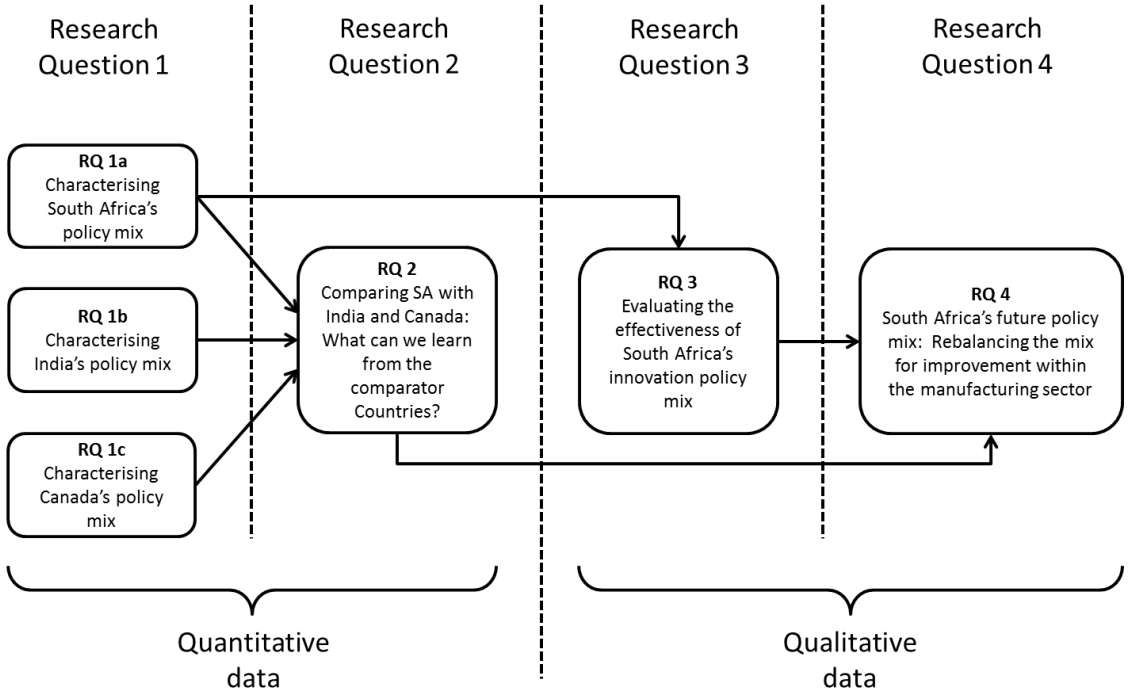


Figure 2. South Africa's expenditure on Innovation (2014/15)

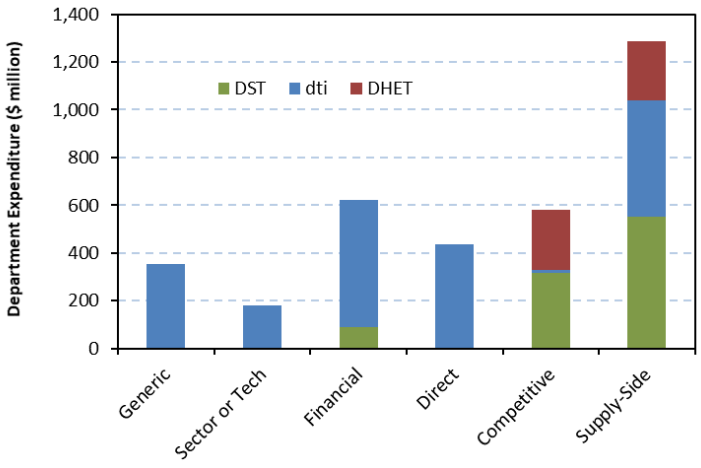


Figure 3. South Africa's innovation policy mix (total public expenditure)

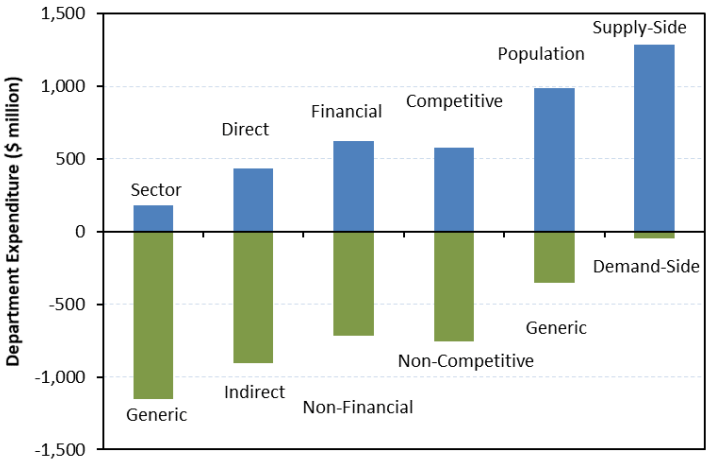
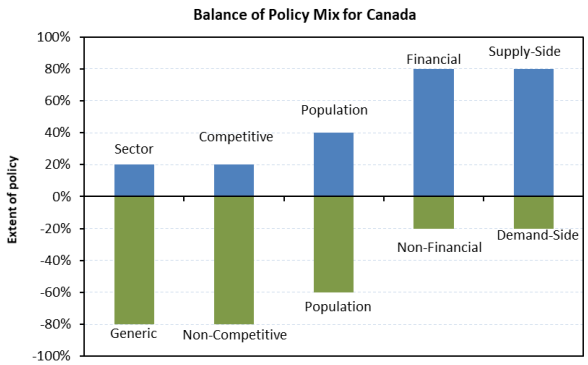


Figure 4. Balance of innovation policy mix for India and Canada



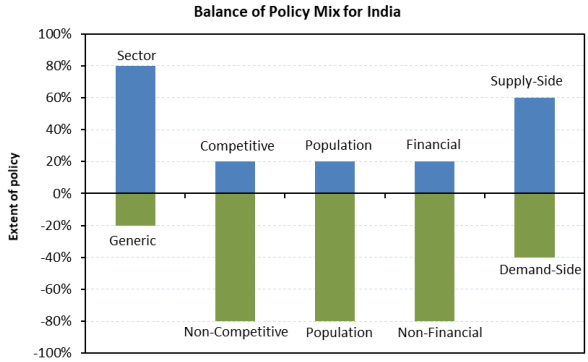


Figure 5. Innovation policy mix comparison between countries

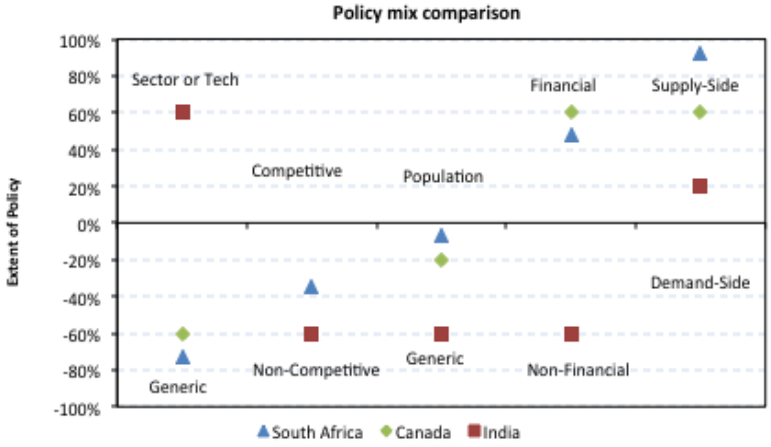


Figure 6. Framework for presentation of data

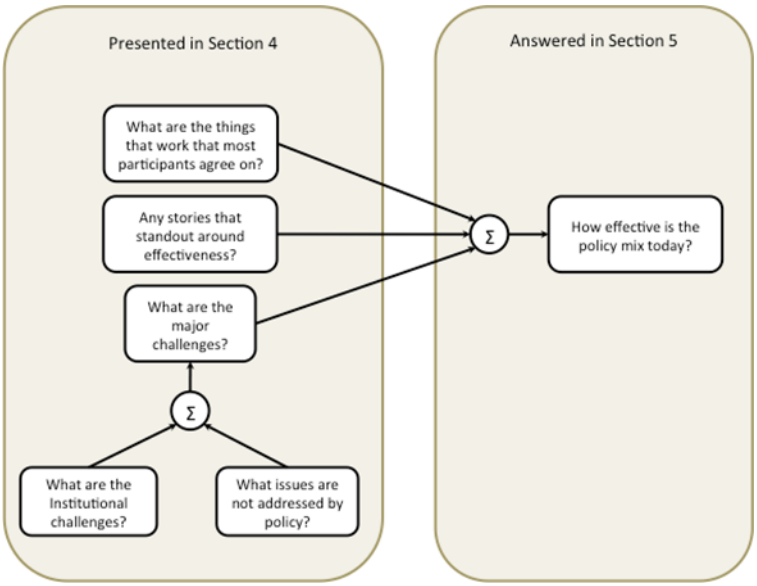


Figure 7. Proposed adjustments to the policy mix in South Africa