EVALUATING OPPORTUNITIES FOR FURTHER DEVELOPING THE MEDICAL TECHNOLOGY INDUSTRY IN SOUTH AFRICA: A PRODUCT SPACE ANALYSIS

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ABSTRACT

Despite recent gains, South Africa is yet to fully develop its economic potential in the medical technologies industry. Yet it remains uncertain which parts of the extended medical technologies industry South Africa should prioritise. This paper uses the input-output product space (IO-PS) methodology to identify key areas in the medical technologies industry that are likely to unlock the industry's potential in South Africa. The analysis involved using a hierarchical mapping of the industry as input to the IO-PS analysis. Thereafter, the outputs of the methodology were analysed and interpreted. The most promising products for further development under various scenarios were identified.

OPSOMMING

Ten spyte van onlangse voortuigang, moet Suid-Afrika nog sy ekonomiese potensiaal in die mediese tegnologie bedryf ten volle ontwikkel. Tog bly dit onseker watter dele van die uitgebreide mediese toestelbedryf Suid-Afrika moet prioritiseer. Hierdie artikel gebruik die inset-uitset produkruimte (IO-PS) metodologie om sleutelareas binne die mediese toestelbedryf te identifiseer wat die bedryf se potensiaal sal ontsluit in Suid-Afrika. Die analise het die gebruik van 'n hiërargiese kartering van die industrie as inset tot die 'IO-PS'-analise, behels. Daarna is die uitset van die metode ontleed en geïnterpreteer. Die mees belowende produkte vir verdere ontwikkeling onder verskeie scenario's was geïdentifiseer.

1. INTRODUCTION

The medical-related technologies industry is expansive, encompassing many products, from biological substances such as blood to hospital furniture. Medical technologies are also intricate products that demand a wide range of complex capabilities across various technological domains [1]. These technologies play a pivotal role in the healthcare industry, and comprise a critical sector for economic growth in many countries. The production of medical technologies not only holds significant promise for economic development, but also offers substantial opportunities for job creation [2]. The COVID-19 pandemic also highlighted the benefits of self-sufficiency when a shortage of the supply of such technologies arises. Globally, South Africa holds 0.071% of the export market share and 0.41% of the import market share for medical technologies. The United States is the largest exporter and the largest importer of medical technology, with 20.1% and 21.3% of the global market, respectively [3]. According to 2021 trade data, South Africa holds 20.2% of the market share among exporters of medical instruments in Africa, second only to Tunisia, holding 51% of the market share [3]. With regard to the importers of medical instruments in Africa, South Africa is at the forefront, holding 23% of the market share [3]. As a developing country, South Africa has made significant strides in its healthcare sector over the years. Still, the country has yet to leverage fully its potential to compete globally in the medical technology market [4]. The government, in collaboration with stakeholders in the industry, has identified the need to improve the country's competitiveness in the production of medical technologies [4].

In this paper, we use the input-output product space (IO-PS) methodology to generate an overview of the performance of the (sub)sectors in the extended medical technologies industry that are likely to support economic growth in South Africa. We then suggest ideal industry development paths to guide policy decision-making.

The product space (PS) approach inherently considers a country's production structure in identifying potential development paths. Despite its usefulness, the PS literature has largely operated independently of the value chain literature, making it difficult to seamlessly connect PS outcomes with particular industries or value chains. Bridging these perspectives, the IO-PS approach offers an integrated solution that leverages a value chain lens on PS results. In a study conducted by [15], this IO-PS methodology was applied to analyse the steel sector in South Africa. However, its application to the medical technologies industry remains unexplored. Leveraging PS metrics, this analytical approach enables an assessment of specific segments in the industry that could yield optimal benefits for the country through local production.

This article begins with a literature review (Section 2) that sheds light on South Africa's medical technologies industry and introduces the IO-PS methodology. Section 3 details the data used and the methodology employed. Section 4 dissects the outcomes of the IO-PS analysis. Section 5 concludes the article by highlighting the key insights from the results and proposing avenues for future research.

2. LITERATURE REVIEW

In this section, the literature on the medical technologies industry in South Africa is reviewed. Section 2.1 defines the industry and South Africa's position, followed by the industry's forecasts and developments, the regulatory framework, and the competitive landscape. Section 2.2 provides more detailed information on the theoretical foundation of the IO-PS approach.

2.1. The medical technologies industry in South Africa

The medical technologies industry can be defined as the collection of companies, organisations, and professionals involved in the research, development, production, and distribution of various medical devices, instruments, consumables, pharmaceuticals, and equipment used in the healthcare industry. Medical technologies are designed to diagnose, treat, monitor, or prevent medical conditions [5]. The medical technologies industry is a large, competitive industry with many challenges and opportunities. The industry covers almost all technological fields, including medicine, applied mathematics and computation, manufacturing technology, (bio)physics, (bio)chemistry, and biology technology [1]. The difficulties faced in the technological field are not the only obstacles. Industrialisation to cost-effective solutions, customer compliance, clinical evidence, regulatory filing, and marketing are some of the other challenges this industry faces [1]. Table 2.1 below highlights the country's strong fundamentals and drivers as well as its weak fundamentals and barriers in the economic landscape that have a substantial effect on the medical technologies industry [6].

Table 1: South Africa's medical and economic position [6]

Strong fundamentals	Independent and relatively strong institutions; South Africa being the financial hub for Africa; rich mineral resources; stable banking sector; efficient transport infrastructure; good intellectual property rights
Healthcare drivers	Large population; increased funding from the government; expansion of the HIV treatment program; National Health Insurance (NHI) scheme; strong private sector; growth in the medical public-private partnership
Market drivers	SAHPRA, South Africa's newly established medical and health regulator
Weak fundamentals	Very high levels of unemployment; high levels of corruption; high crime rate; vulnerability to global demand shifts
Healthcare barriers	Insufficient medical infrastructure; substantial amount of poverty and rural areas; poor organisation of public health systems; large economic gap between public and private healthcare systems; risks associated with the NHI scheme's implementation; national electricity crisis
Market barriers	Dispersed and complicated purchasing processes

Table 2 below shows the key ratios of the medical devices industry market in South Africa. While the underdeveloped nature of the market presents a lot of growth opportunities, it is currently hindered by funding problems, inadequate infrastructure, and a shortage of skilled personnel [6].

Table 2: Medical device market: Key ratios (2021) [6]

Market size (USD Million)	1265.8
% Health expenditure	3.6
% GDP	0.3
% World market	0.3
% Supplied by imports	95
% Projected Compound Annual Growth Rate	4.2

The medical technologies industry is influenced by factors such as technological advancements, regulatory environment, market dynamics and competition, economic factors, research and development, and demographic and epidemiological trends. These areas also interact with and influence one another, creating a complex and dynamic environment for the medical technologies industry. Owing to the susceptible nature of change in the industry, there are many developments and trends within it. Recent developments and forecasts in South Africa's medical technologies industry include the following:

1. Although South Africa initiated the process of establishing the National Health Insurance programme more than a decade ago, uncertainties persist about its funding and the successful delivery of critical targets [7].

2. The government health expenditure budget is expected to grow from R259.2 billion in 2023 to 281.3 billion in 2025. Although an increased budget would suggest positive growth in the market, Fitch Solutions Group Limited [6] is of the opinion that additional delays in South Africa's National Health Insurance programme would have an unfavourable impact on the long-term appeal of the country's medical device market.

3. The global COVID-19 pandemic had a devastating effect on key economic areas such as labour, tourism, private consumption, and the medical technologies industry. When the national state of disaster was announced in South Africa, various COVID restrictions inhibited the growth of these economic areas, and had an extreme effect on the medical technologies industry. With the national state of disaster lifted, it is expected that South Africa's medical tourism will be revived, as South Africa is one of the countries with the highest medical tourism in Africa [8].

The medical devices industry is forecast to grow steadily to the year 2027 [6]. It is forecast that consumables will grow by 25%, diagnostic imaging by 17%, dental products by 25%, orthopaedics and prosthetics by 24%, patient aids by 6%, and other medical devices by 16% by 2027 [6,9].

The South African Health Products Regulatory Authority (SAHPRA) replaced the Medicines Control Council (MCC) in 2018 [6]. SAPHRA made significant changes in managing responsibilities for medical devices and pharmaceuticals. This includes introducing a robust governance framework [10]. Alongside state funding, the agency has the capacity to generate its revenue from industry sources, augmenting available resources and facilitating enhanced operational efficiency to expedite the process of product approvals. SAHPRA has also issued new guidelines for medical devices and in vitro diagnostic device (IVD) manufacturers that are expected to increase standards and compliance in the market [6].

2.2. The input-output product space

We aim to identify and evaluate the (sub)sectors in the extended medical technologies industry that would support sustainable economic growth in South Africa. The IO-PS methodology developed by [15] was chosen as the most applicable framework, since it has the capacity swiftly to offer a normative assessment of an extensive array of activities in a value chain. This framework also allows for more targeted policy decisions, particularly for developing countries, and provides a specific approach to industries and their development pathways.

The product space concept can be defined as a heterogeneous network of globally traded products, based on their relatedness inferred from co-export. The more products are co-exported, the more related they are assumed to be, and the closer they are to each other in the product space. Therefore, by targeting and developing a sector, the economic potential of other related sectors or subsectors can be unlocked. The product space developed by Hidalgo *et al.* [11] and the related economic complexity literature employ a number of foundational metrics. These include *revealed comparative advantage (RCA), proximity, density* [11], *complexity* [12], and *distance* [13]. These metrics are defined mathematically in Appendix A and explained conceptually below.

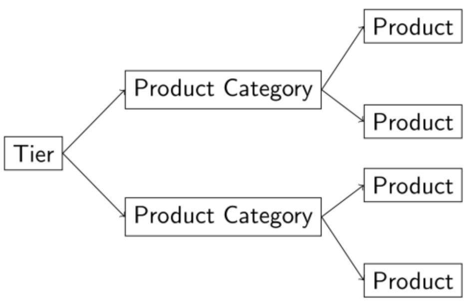
A country has an RCA if the country's share of exports for a specific product is greater than the average global share of exports of that product. The measure of proximity gives an indication of how close two products are to each other in the product space. If all countries that exported a product *i* also exported product *j*, and vice versa, these products would have the maximum proximity of 1. If no country that exported product *i* exported product *j*, these products would have a proximity of 0. Using the concept of proximity, density provides a measure of how related a product is to the other products that a country already exports with an RCA. The metric density (and its mathematical complement *distance*) is used to evaluate a country's position in the product space relative to a certain unoccupied product. It could, therefore, be seen as an indicator of how realistically attainable it is to produce and export a specific product – given a country's export basket and revealed capabilities.

The strategic value of a specific product or area can be assessed using three important metrics from the product space literature: the product complexity (anticipated impact on the economic growth prospects of the nation), the distance, and the RCA. Underdeveloped areas (with an RCA of less than 1) that can be expected to be realistically attainable to produce and export (low average distance/high density) while likely having valuable embedded productive knowledge and skills (high economic complexity) would be the ideal candidates for economic development.

3. DATA AND METHODOLOGY

The IO-PS framework requires a mapping of the product trade codes relevant to the focal industry into a value chain structure. This involves gaining a deep understanding of the industry. For the medical technologies industry, we built on the classification provided by Fitch Solution Group Limited [6] to create a hierarchical framework of medical technologies. This procedure involved categorising all products in the industry, alongside their corresponding descriptions, into three distinct levels. The general terminology of the IO-PS (as its usual application is to value chains) is 'tier', 'category' and 'product code', as illustrated in Figure 3.1. In our case, the 'tier' column represented the primary category to which each medical device belongs. This categorisation was refined into the following overarching tiers: biological products, pharmaceutical products, instruments and appliances, diagnostic imaging, dental products, orthopedics and prosthetics, patient aids, and other medical devices. The 'category' column served to subdivide the data further into their respective, more specific categories. Finally, the 'product code' column explicitly signified the unique codes assigned to each categorised product, providing a clear reference for identifying individual items in their respective tiers and categories.

Figure 1: Mapping of medical technologies



This mapping had to be linked with international trade codes. We used the CEPII BACI database (version 202301 HS17, with a focus on the data for 2021, updated on February 1st, 2023, on the six-digit level) to construct the product code column and to link the mapping with international trade codes. The resulting harmonised system (HS) trade-codes-linked mapping was then verified through interviews with subject-matter experts in the medical technologies industry. The final mapping, consisting of 80 products, 18 product categories, and eight tiers, is contained in Appendix C.

The open-source Python package developed by [17] was then used to calculate the required IO-PS metrics detailed in Appendix A. Its functionality relied on the input of a CSV file that provided the hierarchical mapping. The code's output provided a variety of metrics, facilitating a comprehensive analysis. These metrics could be analysed and interpreted to identify tiers, categories, and products that would support sustainable economic growth in South Africa's medical device industry. The analysis and interpretation process is expanded upon in Section 4.

4. IO-PS RESULTS

The IO-PS simulation generated multiple outputs for analysis. These served as the basis for generating three distinct tables: 'Metrics aggregated at tier level', 'Metrics aggregated at product category level', and 'Metrics aggregated at the product level'. To enhance ease of comprehension, the information in these tables is visually distinguished using a colour-coded spectrum, with green indicating favourable results and red indicating unfavourable outcomes.

In this section, the methodology and thought process for analysing and interpreting the information presented in these tables are discussed.

Table 3: Case-specific metrics aggregated at the tier level

Tier #	Average RCA	Average distance	Average product complexity	Average RCA of products with RCA < 1	Average distance of products with RCA < 1	Average complexity of products with RCA < 1
1	0.215	0.860	0.845	0.102	0.866	0.938
2	0.772	0.852	0.303	0.206	0.858	0.337
3	0.211	0.858	0.572	0.211	0.858	0.572
4	0.096	0.875	1.041	0.096	0.875	1.041
5	0.182	0.876	0.936	0.182	0.876	0.936
6	0.057	0.863	0.551	0.057	0.863	0.551
7	0.052	0.867	0.536	0.052	0.867	0.536
8	0.134	0.880	0.860	0.134	0.880	0.860

In Table 3, a comprehensive overview of the metrics aggregated at the tier level is presented, representing the highest classification of medical technologies. The first column in the table provides the relative comparative advantage (RCA) for each tier. As discussed earlier, according to Hidalgo *et al.* [11], a country is considered to possess a comparative advantage when its RCA exceeds 1. In the analysis, none of the tiers exhibits a comparative advantage, although Tier 2, focusing on 'pharmaceutical products', shows much better performance. Column 2, which presents the average distance metrics ranging from 0 to 1, reveals the greatest density to Tier 2, with Tier 1 and 3 following it. When considering only the distance to 'opportunity products' (products with an RCA < 1) (Column 5), Tiers 2 and 3 stand out for their relative closeness, with Tier 6 following. In Column 3, the average product complexity is assessed. High complexity values signal areas with substantial economic potential that embody valuable skills and knowledge. Notably, Tier 4, specialising in 'diagnostic imaging', boasts the highest economic complexity, while Tiers 1, 5, and 8 also have complexity values above 0.8. Furthermore, all average complexity values are above 0.3, indicating the relatively high complexity of the medical device industry (compared with the average PCI of products for which South Africa has an RCA > 1 of -0.428). Column 6 indicates the complexity of products for which South Africa has an RCA < 1. Interestingly, the values in Column 6 are all equal to or larger than the corresponding values in Column 3. This indicates that, where South Africa has achieved an RCA for products in tiers, these have had an average complexity lower than the average complexity of the tier. Thus South Africa has been unable to compete in the higher complexity goods in any tier. Importantly, for Tiers 3, 4, 5, 6, 7, and 8, no products exhibit an RCA greater than 1, which shows the low level of development of the industry in South Africa. However, Tier 1, 'biological products', and Tier 2, 'pharmaceutical products', consist of products with an RCA exceeding 1, signifying their relative competitiveness in the global landscape. This comprehensive analysis guides an understanding of the economic landscape in each tier, shedding light on areas with promising potential for growth and development.

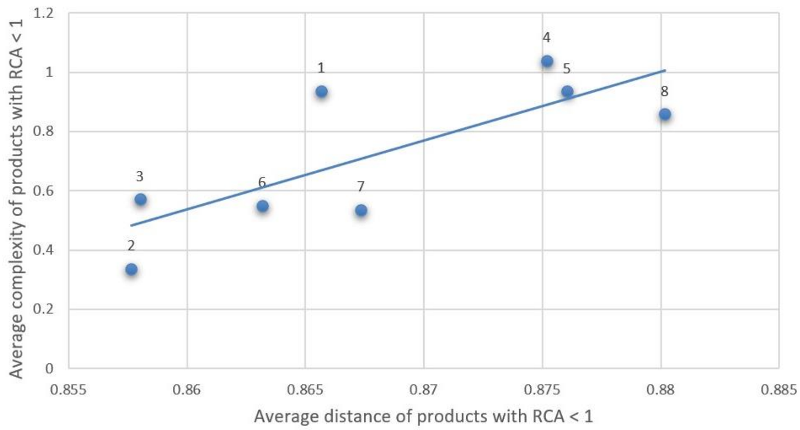


Figure 2: Distance vs complexity at tier level

Figure 4.1 visually represents the relationship between the average distance and the average complexity among various product tiers, specifically for products with an RCA lower than 1. Each tier is denoted by a label ranging from 1 to 8. Upon closer examination, it becomes evident that there is a discernible correlation between the average distance separating products in specific tiers and the corresponding average complexity of products in those tiers. The higher the average distance between products in specific tiers, the higher the average complexity of the products in the tiers, as indicated by the trend line running through the data points. Ideally, strategic development efforts should prioritise product tiers that are characterised by both low average distances and high average complexities; but, as discussed, there is a trade-off between distance and complexity.

From a distance perspective, the opportunities can be divided into three groups. The first has a distance < 0.86. The second group has distances between 0.86 and 0.87. The third has distances larger than 0.875. When considering complexity, the opportunities in each group that have higher complexity than the trendline are clearly more desirable. Thus Tier 3 (instruments and appliances), Tier 1 (biological products), and Tier 4 (diagnostic imaging) and 5 (Dental Products) are more desirable in each group. Given that the complexity of Tier 1 is only slightly less than that of Tier 4 and more than that of Tier 5 while having a lower distance, it appears to be a particularly promising opportunity relative to those in distance group 3. In summary, if a conservative approach (minimising distance) is followed, Tier 3 (instruments and appliances) seems most promising. If an intermediate approach is followed, Tier 1 (biological products) is promising. If complexity is prioritised at all costs, Tier 4 (diagnostic imaging) could be promising.

Table 4: Case-specific metrics aggregated at the product category level

Category #	Average RCA	Average Distance	Average product complexity	Average RCA of products with RCA<1	Average distance of products with RCA<1	Average complexity of rproducts with RCA<1
Tier 1						
1	0.139	0.856	0.429	0.139	0.856	0.429
2	0.234	0.861	0.949	0.091	0.868	1.083
Tier 2						
3	0.896	0.851	0.306	0.217	0.857	0.342
4	0.381	0.853	0.293	0.171	0.860	0.324
Tier 3						
5	0.090	0.860	0.650	0.090	0.860	0.650
6	0.171	0.857	0.926	0.171	0.857	0.926
7	0.428	0.855	0.324	0.428	0.855	0.324
Tier 4						
8	0.076	0.872	0.892	0.076	0.872	0.892
9	0.076	0.878	1.480	0.076	0.878	1.480
10	0.130	0.877	0.955	0.130	0.877	0.955
Tier 5						
11	0.202	0.883	0.997	0.202	0.883	0.997
12	0.168	0.871	0.891	0.168	0.871	0.891
Tier 6						
13	0.038	0.866	0.498	0.038	0.866	0.498
14	0.067	0.862	0.577	0.067	0.862	0.577
Tier 7						
15	0.041	0.866	0.750	0.041	0.866	0.750
16	0.067	0.870	0.217	0.067	0.870	0.217
Tier 8						
17	0.101	0.888	0.926	0.101	0.888	0.926
18	0.199	0.864	0.726	0.199	0.864	0.726

Table 4 offers a detailed breakdown of the same metrics presented in Table 3, but this time the analysis is conducted at the product category level. When examining the average RCA, a few conclusions can be drawn. Category 3, 'medicaments' in Tier 2, 'pharmaceutical products,' is the only category with an RCA value above 0.5, while Categories 4 (pharmaceutical goods) and 7 (consumables) (in Tiers 2 and 3 respectively) also have RCA values above 0.3. Another visible feature in this table is the lower distance values of all product categories in the first three tiers compared with the categories in other tiers. Finally, some tiers have significant heterogeneity in their complexity. For example, the average complexity of products with RCA < 1 in product categories in Tier 1 varies from 0.429 to 1.083 and from 0.324 to 0.926 in Tier 3.

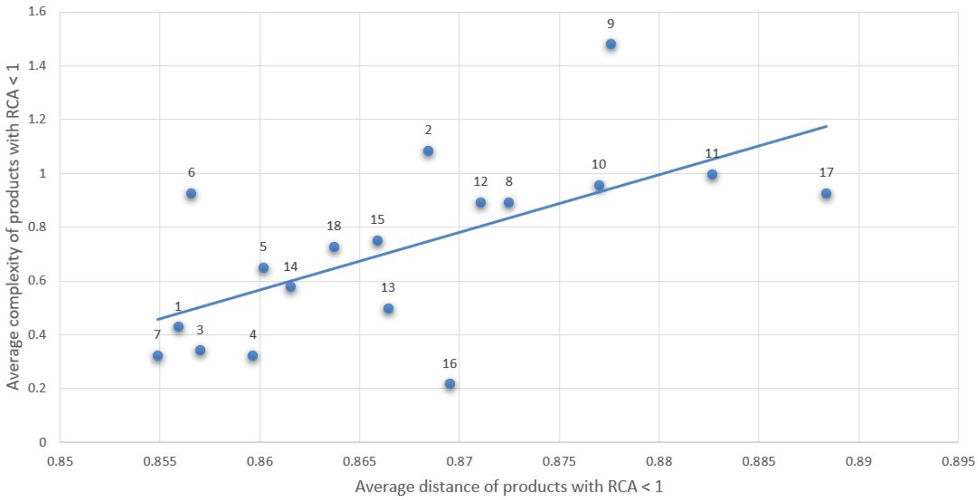


Figure 3: Distance vs complexity at product category level

We can consider the trade-off between distance and complexity for products with RCA < 1 in the various product categories as illustrated in Figure 4.2. In this analysis, three product categories clearly stand out in respect of their complexity, given their distance. These are product Categories 6 (medical and surgical sterilisers), 2 (biological and immunological products), and 9 (radiation apparatus). From the analysis, Category 6 appears to be the most attainable; Category 2 would be an intermediate choice; while Category 9 would be an ideal (in complexity) but less attainable choice. These categories also represent each of the three tiers identified in the tier level analysis (Tiers 3, 1, and 4 respectively).

In Table 5, the metrics aggregated at the product level are provided. When analysing the RCA column, the product with the code '300443' (*Medicaments: containing alkaloids or their derivatives, containing* norephedrine *or its salts, for therapeutic or prophylactic uses, packaged for retail sale* under the category *'medicaments'*, and in the tier *'pharmaceutical products')* has an outlying high value, while only four other products have an RCA value of more than 1. To analyse the distance and complexity metrics meaningfully, we turn to Figure 4.3.

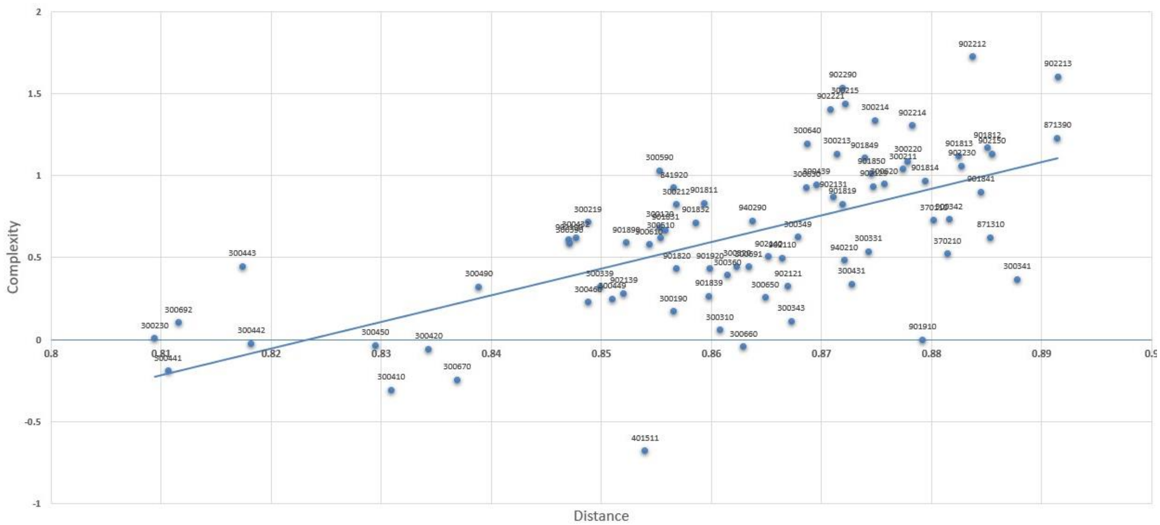


Figure 4: Distance vs complexity at product level

Figure 4.3 illustrates the intricate relationship between distance and complexity at the product level. In this representation, every data point signifies a distinct product in the medical technologies industry, identified by its corresponding trade code. In this graph, a number of products can be identified as seeming particularly promising under different scenarios. These are summarised in Table 6

Table 5: Metrics aggregated at product level

Tier	Category	Code	RCA	Distance	Complexity
1	1	300120	0.165	0.855	0.685
1	1	300190	0.113	0.857	0.173
1	2	300211	0.071	0.877	1.040
1	2	300212	0.008	0.857	0.826
1	2	300213	0.037	0.871	1.135
1	2	300214	0.000	0.875	1.337
1	2	300215	0.019	0.872	1.440
1	2	300219	0.096	0.849	0.717
1	2	300220	0.408	0.878	1.086
1	2	300230	1.230	0.809	0.006
2	3	300310	0.522	0.861	0.058
2	3	300320	0.300	0.862	0.447
2	3	300331	0.136	0.874	0.537
2	3	300339	0.299	0.850	0.321
2	3	300341	0.021	0.888	0.367
2	3	300342	0.445	0.882	0.734
2	3	300343	0.000	0.867	0.112
2	3	300349	0.500	0.868	0.625
2	3	300360	0.043	0.861	0.394
2	3	300390	0.814	0.847	0.588
2	3	300410	0.304	0.831	-0.307
2	3	300420	0.110	0.834	-0.056
2	3	300431	0.009	0.873	0.340
2	3	300432	0.050	0.848	0.622
2	3	300439	0.019	0.870	0.948
2	3	300441	1.728	0.811	-0.192
2	3	300442	2.182	0.818	-0.024
2	3	300443	11.674	0.817	0.447
2	3	300449	0.092	0.851	0.249
2	3	300450	0.150	0.829	-0.035
2	3	300460	0.186	0.849	0.230
2	3	300490	0.129	0.839	0.322
2	4	300610	0.079	0.854	0.580
2	4	300620	0.032	0.876	0.949
2	4	300650	0.435	0.865	0.258
2	4	300660	0.056	0.863	-0.043
2	4	300670	0.330	0.837	-0.245
2	4	300691	0.097	0.863	0.445
2	4	300692	1.635	0.812	0.105
3	5	901831	0.078	0.856	0.667
3	5	901832	0.068	0.859	0.713
3	5	901839	0.032	0.860	0.266
3	5	901890	0.157	0.852	0.591
3	5	901850	0.113	0.875	1.013
3	6	841920	0.171	0.857	0.926
3	7	300590	0.329	0.855	1.031
3	7	300510	0.584	0.855	0.621
3	7	401511	0.369	0.854	-0.679
4	8	901811	0.056	0.859	0.832
4	8	901812	0.036	0.885	1.169
4	8	901813	0.041	0.882	1.120
4	8	901814	0.204	0.879	0.970
4	8	901820	0.042	0.857	0.433
4	8	901819	0.080	0.872	0.828
4	9	902212	0.074	0.884	1.726
4	9	902214	0.078	0.878	1.307
4	9	902221	0.074	0.871	1.406
4	10	300630	0.031	0.869	0.930
4	10	370110	0.175	0.880	0.728
4	10	370210	0.048	0.881	0.524
4	10	902230	0.215	0.883	1.059
4	10	902290	0.184	0.872	1.536
5	11	901841	0.176	0.884	0.902
5	11	940210	0.176	0.872	0.483
5	11	902213	0.254	0.891	1.605
5	12	300640	0.021	0.869	1.196
5	12	901849	0.153	0.874	1.107
5	12	902121	0.045	0.867	0.325
5	12	902129	0.452	0.875	0.935
6	13	902110	0.038	0.866	0.498
6	14	902131	0.066	0.871	0.870
6	14	902139	0.068	0.852	0.284
7	15	902140	0.051	0.865	0.507
7	15	902150	0.020	0.885	1.134
7	15	902190	0.053	0.847	0.608
7	16	901910	0.043	0.879	-0.001
7	16	901920	0.091	0.860	0.434
8	17	871310	0.043	0.885	0.623
8	17	871390	0.160	0.891	1.230
8	18	940290	0.199	0.864	0.726

Table 6: Summary of promising products

Scenario	Product code	Product description	Category	Tier	RCA
Conservative (Distance < 0.82; Complexity > 0)	300230	Vaccines: for veterinary medicine	2	1	1.23
	300692	Waste pharmaceuticals	4	2	1.635
	300443	Medicaments: containing alkaloids or their derivatives, containing norephedrine or its salts, for therapeutic or prophylactic uses, packaged for retail sale	3	2	11.674
Intermediate I (Distance < 0.85; Complexity > 0.5)	300390	Medicaments: (not containing antibiotics, hormones, alkaloids or their derivatives), for therapeutic or prophylactic uses (not packaged for retail sale)	3	2	0.814
	902190	Appliances: worn, carried, or implanted in the body, to compensate for a defect or disability	15	7	0.053
	300432	Medicaments: containing corticosteroid hormones, their derivatives or structural analogues (but not containing antibiotics), for therapeutic or prophylactic uses, packaged for retail sale	3	2	0.05
	300219	Blood, human or animal, antisera, other blood fractions and immunological products: n.e.c. in heading 3002.1	2	1	0.096
Intermediate II (Distance < 0.86 Complexity > 0.75)	300590	Wadding, gauze, bandages, and similar articles: (excluding adhesive dressings), impregnated or coated with pharmaceutical substances, packaged for retail sale	7	3	0.329
	300212	Blood, human or animal, antisera, other blood fractions and immunological products: antisera and other blood fractions	2	1	0.008
	841920	Sterilisers: for medical, surgical, or laboratory use, not used for domestic purposes	6	3	0.171
	901811	Medical, surgical instruments and appliances: electro-cardiographs	8	4	0.056
Ambitious (Distance < 0.875 Complexity > 1.25)	902290	Apparatus based on use of x-rays and similar: parts and accessories (x-ray generators, tubes, high tension generators, control panels and desks, screens, examination or treatment tables, chairs, and the like	9	4	0.184
	300215	Blood, human or animal, antisera, other blood fractions and immunological products: immunological products, put up in measured doses or in forms or packings for retail sale	2	1	0.019

Scenario	Product code	Product description	Category	Tier	RCA
	902221	Apparatus based on the use of alpha, beta, or gamma radiations, including radiography or radiotherapy apparatus: for medical, surgical, dental, or veterinary uses	10	4	0.074

From Table 6, it becomes clear that South Africa already has an RCA > 1 for the three most promising products (from a complexity perspective) that are closely related to its production structure (conservative scenario). When the next closest group of promising products is considered (Intermediate I), then only one product has any meaningful exports (above RCA > 0.1) – 'Medicaments: (not containing antibiotics, hormones, alkaloids or their derivatives), for therapeutic or prophylactic uses, (not packaged for retail sale)', with an RCA of 0.814. Given its emerging status and established base, the products included under this trade code might be a specifically interesting target for further analysis.

The next closest group of promising products (Intermediate II), contains two product codes with an RCA > 0.1. These are 'Wadding, gauze, bandages, and similar articles: (excluding adhesive dressings), impregnated or coated with pharmaceutical substances, packaged for retail sale' (RCA = 0.329), and 'Sterilisers: for medical, surgical or laboratory use, not used for domestic purposes' (RCA = 0.171). Both of these thus hold potential for further analysis.

Finally, in the ambitious group of promising products, South Africa has an RCA > 0.1 for 'Apparatus based on use of x-rays and similar: parts and accessories (x-ray generators, tubes, high tension generators, control panels and desks, screens, examination or treatment tables, chairs, and the like'. Given its high complexity, this trade code also warrants further analysis.

From Table 6, the products in each scenario with an RCA value greater than 0.1 but less than 1 seem to be of particular interest. These are products that the country is already exporting, so basic capabilities for their production already exist. Furthermore, they have not reached their apparent potential, as they have not yet achieved the global average portion of the country's export basket. In addition, from the product space analysis, they appear to hold significant potential for increasing the complexity of the country's production structure while building on its existing capabilities.

However, this quantitative study would need to be taken further through an in-depth analysis of each product that has been identified in order to unpack the global competitive landscape and the factors driving competitiveness and to be able to establish the feasibility of further developing these export opportunities [15,18].

5. CONCLUSION

In conclusion, this project has successfully addressed the overarching objective of identifying strategic areas in South Africa's medical technologies industry that have the potential to foster the growth of the industry. The identified products should be viewed as a shortlist of products that appear to hold particular promise and that warrant further in-depth analysis of the competitive landscape that is linked to the products traded under each trade code.

Beyond its immediate implications, this project contributes to the broader societal landscape by providing a valuable tool for assessing and understanding different segments in the medical technologies industry. The insights generated through the IO-PS analysis framework offer a systematic approach to identifying industry areas with the greatest potential for economic growth. The use of this framework, pioneered by [15], underscores its relevance in guiding strategic decision-making.

Looking ahead, several promising avenues for future research and expansion emerge. A more detailed analysis of specific categories in the medical technologies industry, focusing on top-performing sectors, could provide more precise insights. Expanding the study to include countries in the Southern African Development Community would offer a holistic view of the broader healthcare landscape in the region. Moreover, the application of the IO-PS framework to different industries in South Africa could inform resource allocation and decision-making across sectors. Finally, an exploration of the interplay between disease burdens and technological advancements could yield valuable insights into the complex dynamics shaping healthcare outcomes.

The recommendations and insights presented herein lay the foundation for informed decision-making, in the hope that they will inspire further exploration and contribute to the continued advancement of both the healthcare industry and the broader economy.

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