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Identifying vulnerable and priority manufacturing sectors for economic recovery in South Africa: An empirical approach

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Abstract

The South African manufacturing sector has been in steady decline throughout the post-apartheid period, and its current path made more turbulent by the Covid-19 pandemic. Based on Leontief input-output modelling, this paper measures and quantifies the degree of vulnerability in South African manufacturing and identifies key industries for prioritisation post-Covid-19. Using input-output matrices between 2010 and 2019 for 22 sub-sector 2-digit and 91 industry 3-digit ISIC classifications, we formulate our sector prioritisation-vulnerability index based on five key components. Assuming equal preference for all components of the index, our results show petroleum products, chemicals, rubber and plastic [QSIC 33], metals, metal products, machinery and equipment [QSIC 35], and food, beverages and tobacco [QSIC 30] as the highest ranked and high-priority industries, while other non-metal mineral products [QSIC 34], and radio, TV, instruments, watches and clocks [QSIC 37] are identified as low-priority manufacturing industries. Our results suggest that to achieve quick industrial recovery and development in the short and medium term, policy could focus on accelerating rapid growth in the highest ranked and high-priority manufacturing sub-sectors in South Africa. These findings provide guidance for industrial policy formulation and efficient resource allocation in the context of a South African economic recovery programme, post-Covid-19.

Key words: Manufacturing; Vulnerability; Input-Output Modelling; South Africa
JEL Codes: L6; O14; O25; R15

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1. Introduction

The Covid-19 pandemic has disrupted and upended the supply-chain dynamics of global production and trade. In the face of the pandemic, coupled with particularly limited fiscal space in developing and emerging economies, policymakers are aiming to identify sectors that can be prioritised to drive recovery and growth in the post Covid-19 era. In this paper, we examine the evolution of South Africa's economic structure and identify key manufacturing sub-sectors that have the potential to drive industrial recovery and sustainable growth.

There has been a great deal of popular and scholarly debate on measures taken by governments in response to the Covid-19 pandemic, and on the difficult trade-offs involved for policymakers (Jenny, 2020). Restrictions on "non-essential" social activities designed to manage the spread of the virus have induced unique and simultaneous supply and demand shocks across the global economy. The medium- to long-term economic effects of these shocks are likely to vary a great deal across different countries and regions, as well as for different social groups within a particular country. Outcomes are expected to be shaped by multiple factors. These include the relative effectiveness of virus containment measures, varying levels of access to vaccines and other medical treatments, and the differential quality of economic recovery programmes and how they are financed, particularly in developing economies, where fiscal capacity may be more limited (Behuria, 2020).

The "shape" that economic recoveries take – both between different countries and within national borders – is influenced by differences in economic structure. Analysis of economic structure, particularly in regard to interdependencies between sectors and industries, can help to guide policymakers to make critical decisions relating to the allocation and reallocation of productive resources in the recovery phase to guide the economy towards structural transformation. A key challenge is how to preserve existing productive assets in general, while also directing support toward specific manufacturing sub-sectors and industries that are critical for driving recovery and building a post-Covid-19 economy (Mehrling, 2020).

Industrialisation has been widely identified as a key source of economic growth and sustainable development. However, the manufacturing sector in South Africa is susceptible to a range of economic conditions and external shocks, making it a vulnerable sector. As a result, identifying priority vulnerable sub-sectors is essential for better industrial policy decision making for the highest possible economy-wide impact. In this paper we focus specifically on manufacturing. This is due to the strong linkages and interdependencies that exist among the different manufacturing sub-sectors, and because manufacturing is still considered to be the engine of growth for middle-income economies (see Su & Yao, 2017). As such, the key contribution of this paper is the analysis of manufacturing at a sub-sectoral level, and its relevance to targeted policymaking in South Africa in the post-Covid-19 recovery phase to come. We note that the measurement of key interdependencies and their change over time, at a granular level, has been a notable gap in the growing literature analysing the effects of economic shocks. In addition, this approach helps us to graphically visualise the evolution of the industrial structure and how these industries are interlinked in the production system of South Africa. Subsequently, we explore the impact of the pandemic on manufacturing sub-sectors, including the identified priority sub-sectors, in

2020. The potential value of such an exercise in the context of the Covid-19 pandemic is clear, especially in a fiscally constrained developing country such as South Africa.

Our analysis centres on the concept of economic vulnerability, which is defined as the exposure of an economy to exogenous shocks arising out of economic openness (Organisation of Economic Co-operation and Development, 2020). We use the term in two different senses here. First, we identify several sub-sectors that are "vulnerable" in themselves; that is, sectors within manufacturing that have performed poorly over the last decade or so on a number of key metrics and are in need of strategic intervention to preserve economic output, market share and productive capacities. Second, adapting a model designed to guide post-disaster economic recovery and sector prioritisation, we identify sub-several sectors which are potential sources of vulnerability for the economy more broadly, in the event of a major shock. The model generates a measure of manufacturing's sub-sectors' interdependencies with other parts of the economy, and thus helps to determine which investments are likely to maximise benefits for the economy as a whole in the context of an economic recovery programme.

While evidence analysing the vulnerability of an economy to external shocks exists, the analysis is done mostly at an aggregated economic sector level (primary, secondary, tertiary) (see, for instance, Go et al., 2019, Yu et al., 2014, etc.). Given that sectors are directly or indirectly related, economic shocks experienced by one sector are likely to propagate across the entire production system (Dietzenbacher et al., 2005). In this paper, we develop a sector prioritisation index following Go et al. (2019) and Yu et al. (2014), to identify priority manufacturing sub-sectors over the period, 2010–2019. The application of this approach in the literature includes Khalid and Ali (2019). In their study of the Phillipines economy, for instance, Yu et al. (2014), employ three main components (average propagation length, size of the sector, and economic significance). Go et al. (2019) provide a further elaboration of this approach of post-disruption sector prioritisation in the Phillipines. We extend the analysis in Go et al. (2019) by employing a more disaggregated sectoral analysis for South African manufacturing.

Following Go et al. (2019), our index incorporates five main components, measuring: the relative influence of a given sector's demand conditions for overall economic output; structural significance as measured by relative output; the degree of interconnectedness through the extent of backward and forward linkages with other sub-sectors; the degree of dependence on domestic inputs and vulnerability to domestic shocks; and the relative contribution to overall production failure and economic loss in the event of a shock (Go et al., 2019, pp.3-5). The index ranges between 0 and 1, with sectors having higher index values being associated with higher levels of vulnerability. Our results show that, between 2010 and 2019, petroleum products, chemicals, rubber and plastic [QSIC 33], metals, metal products, machinery and equipment [QSIC 35], and food, beverages and tobacco [QSIC 30] are the top three priority manufacturing sub-sectors within the South African manufacturing sector that need immediate intervention on the part of policymakers.

The paper is structured as follows. Section 2 provides a critical contextual analysis on the South African economy. We discuss the performance of the manufacturing sector before the Covid-19 pandemic and argue that the sector can be a critical driver of economic recovery in the aftermath of the current crisis. The methodology and data underlying the vulnerability index we have constructed are laid out in detail in Section 3. Section 4 presents

the results of our analysis, leading on to Section 5, where we investigate changes to key variables on the manufacturing sub-sectors as a result of the Covid-19 pandemic. Section 6 concludes with proposed areas for further research.

2. Overview of the South African economy and the manufacturing sector

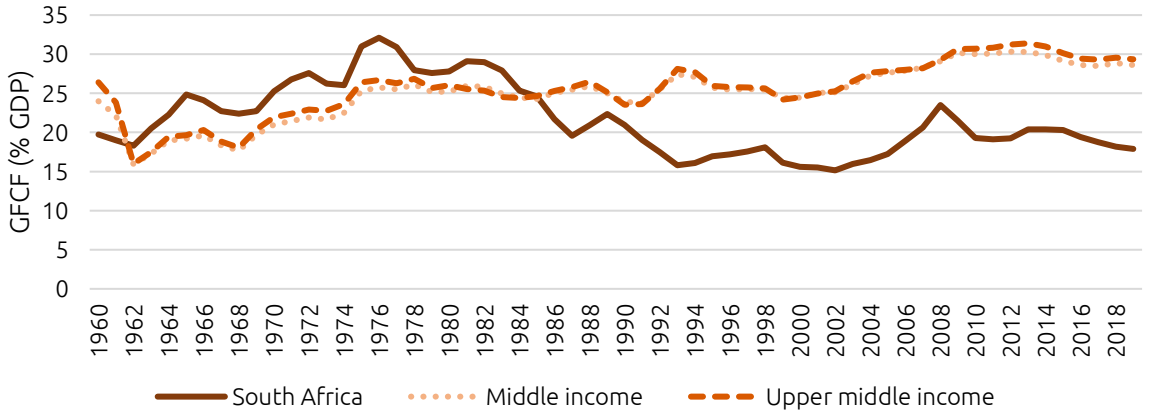
The decade before the Covid-19 pandemic in South Africa (2010–2019) was the weakest in terms of GDP growth since the transition to democracy in 1994. Average GDP growth was 2.9% from 1994–2000, 4.2% from 2000–2008, and 1.7% from 2010–2019 (Sachs, 2021). While the country's GDP per capita has fallen each year since 2014 (a trend likely to be accelerated by the pandemic) and fell below the upper-middle-income country benchmark in 2015/16, it had been weak relative to middle-income comparators for years before. While South Africa has remained stuck in what has been described as the "middle-income trap" from 1994 until the present day, a range of other developing countries have successfully escaped this trap to achieve high-income status in this period[1] (Andreoni & Tregenna, 2021). Further, while countries such as Malaysia have remained in the middle-income category, they appear to be "catching up" with high-income countries while South Africa continues to fall behind (Andreoni & Tregenna, 2021, pp. 384-5).

2.1. South Africa's poor economic performance

The poor performance of the South African economy is caused by multiple and interrelated issues. A longstanding failure to translate consistently high profitability across key economic sectors (Bosiu et al., 2017) into productive investment is arguably among the key drivers of the country's poor economic performance. Extensive failures in government policy and implementation, the exercise of economic power, and extraction of rents by influential fractions of domestic capital, long-standing and unsolved structural challenges, and a range of new challenges emerging from a hierarchical, financialised and volatile global economy have all had a role to play (Bhorat et al., 2017; Isaacs & Kaltenbrunner, 2018; Marais, 2020; Goga & Mondliwa, 2021; Mondliwa & Roberts, 2021). Data on gross fixed capital formation highlight that since the early 1980s, South Africa has consistently lagged fellow middle-income countries and that the gap has grown significantly since this marked delinking between South Africa and other major developing economies (Figure 1). This is again indicative of both long-standing structural issues and major deficiencies in a post-1994 growth strategy, which has failed to raise levels of investment, and which is a major puzzle for policymakers (Andreoni et al., 2021; Mondliwa & Roberts, 2021).

[1] These countries include: Chile, Greece, Hungary, Uruguay, and Saudi Arabia.

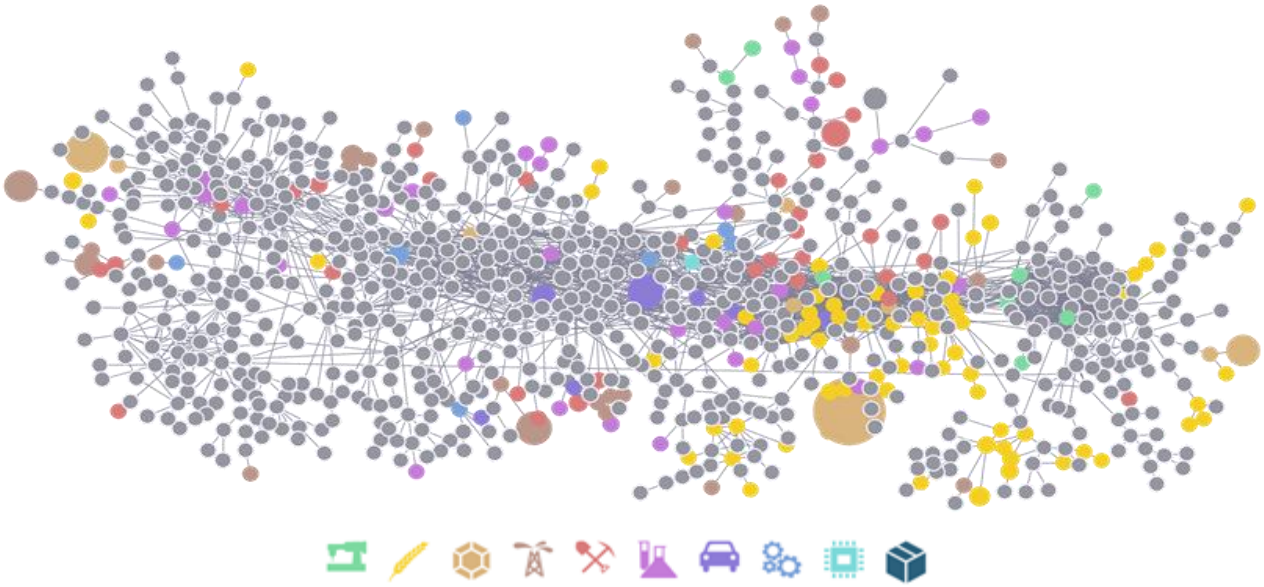
Figure 1: Gross fixed capital formation, 1960–2019



Source: World Development Indicators

South Africa has also performed poorly in terms of diversification compared to other upper middle-income countries (Andreoni & Tregenna, 2020). Figure 2 shows South Africa's export basket in 2018, using the product space approach. The product space is premised on the idea that industrial development is path dependent – i.e., that countries will grow by building on their existing capabilities and expanding production into areas that require similar capital requirements, knowledge, skills, and institutions to what they already possess. In this approach, a country's capabilities are embodied in the products exported and thus the evolution of the product space over time provides an indication of the ways in which countries have leveraged existing capabilities to develop increasingly sophisticated ones (Hausmann, et al., 2007, Hidalgo, et al., 2007).

Figure 2: South Africa's export basket, 2018



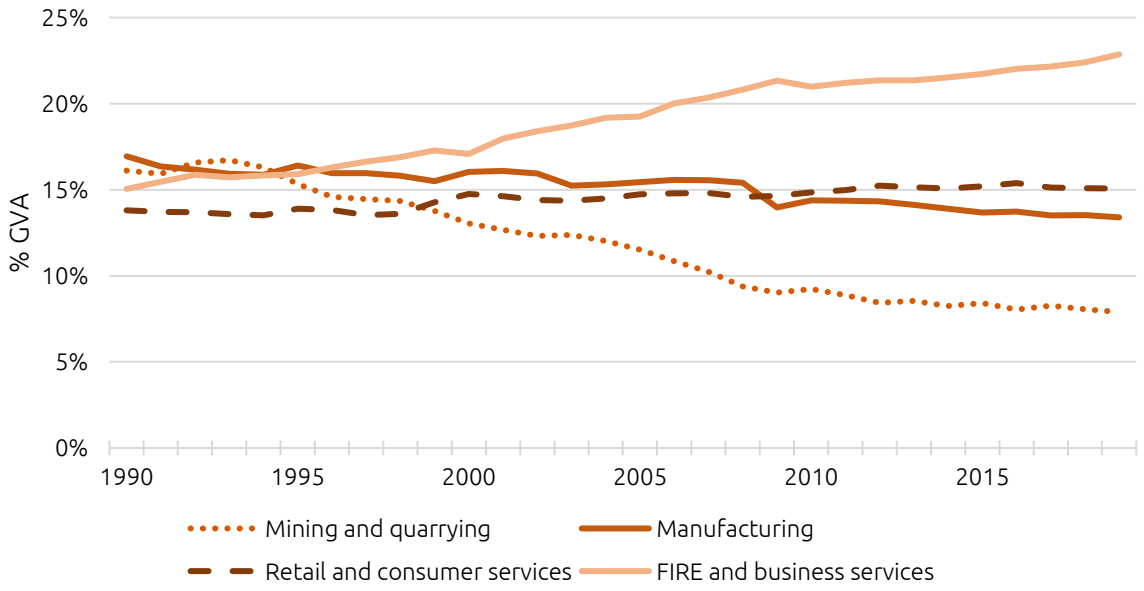
Source: Atlas of Economic Complexity

The figure shows that South Africa continues to depend on a relatively small group of isolated industries, especially in relation to export earnings, which are dominated by extractive and resource-based industries. South Africa's exports of mineral (brown dots for coal and oil), stone and glass (gold dots for gold, diamonds, and platinum), vegetable and

foodstuff (yellow dots), metal (red dots), and chemical (pink dots) products make up most of its export basket. The relative lack of product clusters as well as the degree to which minerals such as gold and platinum still feature as South Africa's top exported products have implications that go beyond the costs of a downturn in the commodity cycle. Indeed, South Africa's product space indicates also that the economy remains essentially undiversified. The country exports a small number of products that are largely used as primary or intermediate inputs, with little value added; the export basket consists of isolated industries producing products of low complexity that lack close linkages to other manufactured products. These weak linkages and lack of product clusters reflect missed opportunities to improve industrial capabilities and build backward and forward linkages from established firms.

While the export basket has shown a concerning lack of transformation since 1994, there have been important structural changes in the South African economy over the same period. Figure 3 shows the rapid rise of finance, insurance and real estate (FIRE) industries over the past three decades, while the core of the "real" economy in mining and manufacturing have declined significantly in their contribution to gross value added (GVA).

Figure 3: Share of gross value added by sector, 1990–2019



Source: South African Reserve Bank, authors' calculations.

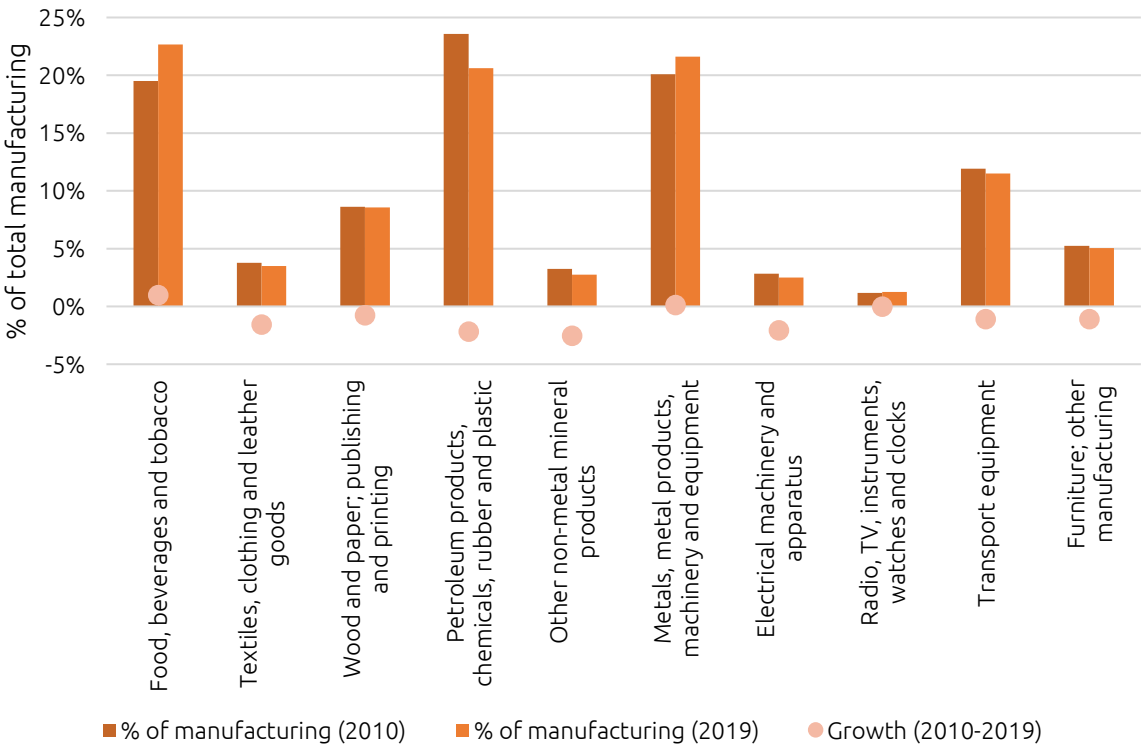
The relative decline in the contribution of manufacturing to GVA is a worrying development in light of the role played by the sector in driving sustained growth in developing countries (Rodrik, 2006; Andreoni & Tregenna, 2021). The production of tradable goods for export, the enhancement of productive capabilities, the development of linkages in the local production system, and the provision of relatively well-paid jobs are a few of the critical channels through which a robust manufacturing sector can drive development. On the latter point, Bell et al. (2018) show that jobs in manufacturing have consistently paid higher real wages and achieved higher labour productivity throughout the post-apartheid era; it is therefore concerning that manufacturing employment as a share of the labour force has declined alongside fixed investment. This figure was almost 15% in the late 1970s, dropping

to below 8% by the late 1990s and remaining below 8% until the end of 2019 and the cusp of the pandemic (Rodrik, 2006 p.31; Statistics South Africa 2021).

2.2. South African manufacturing at a sub-sectoral level

Here, we offer a brief exploration of South African manufacturing at a sub-sectoral level by considering four main macroeconomic indicators: output, employment, value added, and import leakage. In terms of output, three sub-sectors have remained dominant in their shares of manufacturing output across the 2010–2019 period, each accounting for around 20% of the total:[2]these are food & beverages; petroleum & chemicals; and metals & machinery. With the exception of transport equipment, all other sub-sectors have maintained single-figure shares of output. Output for manufacturing as a whole declined over the decade, decreasing at an average 0.7% each year, while the food & beverages sector led growth at sub-sector level at around 1% per annum (Figure 4).

Figure 4: Manufacturing sub-sector output share and growth, 2010–2019



Source: Quantec

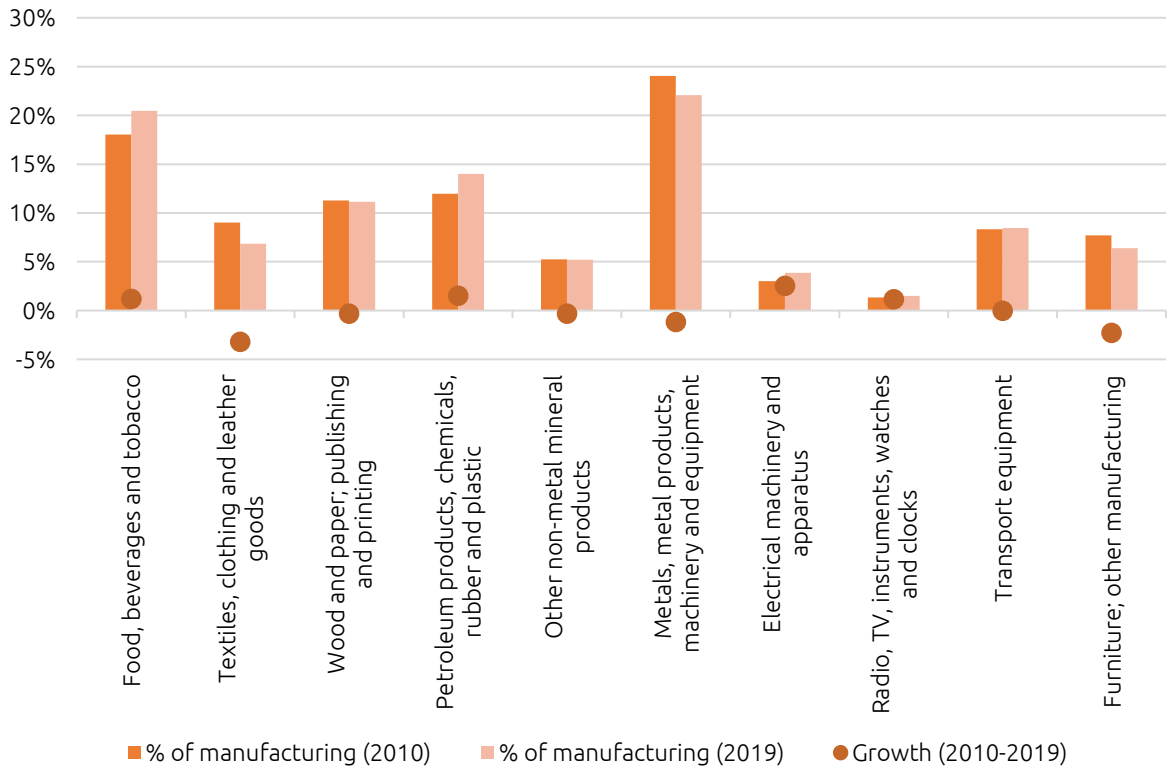
Note: Growth rates are all calculated as compound annual average growth rates.

Figure 5 shows that the manufacturing employment shares of the food & beverages, and petroleum & chemicals sub-sectors have increased significantly between 2010 and 2019, largely at the expense of textiles & clothing and furniture & other. Actual employment increased only in food & beverages, petroleum & chemicals, electrical machinery, and radio & TV, with other sectors in decline or stagnant. Employment in textiles & clothing, in particular,

[2] Sub-sectors referred to in shorthand henceforth, are named as follows: food & beverages, textiles & clothing, wood & paper, petroleum & chemicals, other minerals, metals & machinery, electrical machinery, radio & TV, transport equipment, furniture & other.

declined by 3% per year on average between 2010 and 2019 – a decline in employment of 25% in simple terms – with total manufacturing employment declining 0.23% on average each year.

Figure 5: Manufacturing sub-sector employment share and growth, 2010–2019

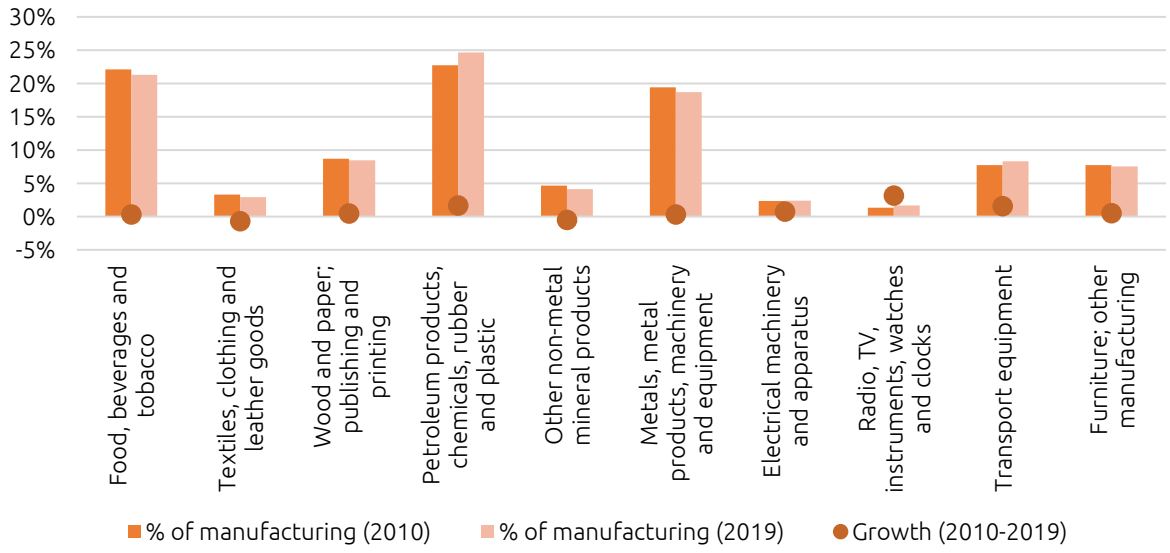


Source: Quantec

Note: Total employment inclusive of formal and informal employment. All growth rates are calculated as compound annual average growth rates.

The value-added performance of manufacturing sub-sectors for the period 2010–2019 indicates that upstream, resource-based sub-sectors have outperformed those that rely on more sophisticated capabilities, indicating failures of diversification and capabilities upgrading in the post-apartheid period (Figure 6). Additionally, where there are domestic linkages between upstream, resource-based sub-sectors and downstream sub-sectors, dominant upstream firms have tended to capture the lion's share of value, squeezing profits and further dampening growth (and even viability in some cases) in downstream manufacturing (see Mondliwa & Roberts, 2019).

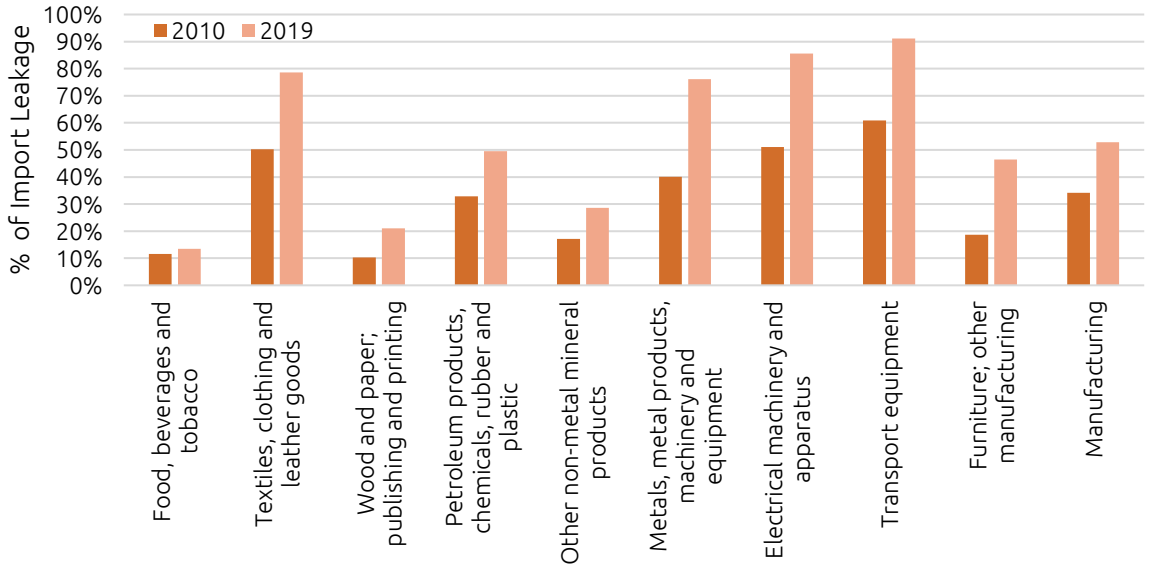
Figure 6: Manufacturing sub-sector value-added share and growth, 2010–2019



Source: Quantec.

In relation to the threat posed by imported manufactures, the period 2010–2019 has seen import leakage increase in every sub-sector except radio & TV. Import leakage is an indicator of the proportion of domestic demand that is directed toward imports in a given sector, rather than locally manufactured goods. For the manufacturing sector as a whole, import penetration rose from 34.1% in 2010 to 52.8% in 2019 – a major loss of domestic market shares for local manufacturers (Figure 7).

Figure 7: Import leakage by manufacturing sub-sector, 2010–2019



Source: Quantec

Note: Radio & TV sub-sector excluded from Figure 7

South Africa's main imports are machinery (23.5 percent of total imports), mineral products (15.1 percent), vehicles and aircraft vessels (10 percent), chemicals (10.9 percent), equipment components (8.1 percent) and iron and steel products (5.3 percent) (Statistics South Africa, 2020). However, increasing import penetration across the manufacturing sector is clearly a threat to the industrial base more generally. That import penetration has increased across both labour- and capital-intensive sub-sectors is a challenge for both employment and capital accumulation.

2.3. Summary

In summary, South Africa has failed to achieve a positive model of structural transformation; the structural changes that have taken place have been growth-reducing rather than growth-enhancing. This is in stark contrast to other developing countries that have successfully industrialised such as China and Malaysia. They have managed to achieve strong and sustained growth through major changes in the sectoral composition of output, through the reallocation of labour and capital towards higher productivity activities, and through capabilities upgrading within sectors and industries that have increasing growth in tradable goods *and* services (McMillan et al., 2017; Bell et at., 2018).

This section has shown that the South African economy, and the manufacturing sector, in particular, entered the Covid-19 pandemic after a prolonged period of weakness. Declining employment and output, sluggish growth in value-added, and increasing loss of domestic market share to imported manufactures all point to a need for interventions across multiple manufacturing sub-sectors, in terms of both short-term responses to the current crisis and a long-term strategy for revitalising South African manufacturing. In the short term, and in light of constraints on the fiscus and state capacity, it is crucial from a policymaking perspective to be able to identify manufacturing sub-sectors that ought to be prioritised for immediate government support. This paper aims to inform this process, applying an empirical framework to identify priority manufacturing sub-sectors using I-O methodology and a sectoral vulnerability index.

3. Methodology and data

In this section we discuss the methodology, data and the empirical strategy of our study.

3.1. Methodology

We draw on quantitative methods that model how shocks spread through interdependent economic systems. These methods have been applied in a range of contexts including tsunamis (Kajitani and Tatano, 2014), climate change (see Kowalewski, 2009 for helpful case studies), and other disaster scenarios. They are also employed in studies of supply chain resilience (see Hosseini et al., 2019 for a review of quantitative methods), recovery strategies (Dolgui et al., 2018), inventory policies in the context of supply chain disruptions (Barker and Santos, 2010) and in exploring the impacts of the Covid-19 pandemic on global supply chains (Ivanov and Das, 2020).

A subset of these methods is built on the input-output model pioneered by Wassily Leontief (1936), adaptations of which are commonly employed in the assessment of post-disruption economic damage (Kowalewski, 2009; Okuyama & Santos, 2014; Galbusera & Giannopoulos,

2018).[3] Input-output analysis is built on the construction of input-output tables, which are published by many government statististical agencies around the world, including Statistics South Africa (Stats SA). Input-output tables record transactions between economic sectors, often at a highly disaggregated level, as well as value added by each sector and sales to the "final demand sector", comprising household consumption, government consumption, exports and imports (Kowalewski, 2009, p.3). The manipulation of input-output (I-O) tables allows researchers to investigate a range of phenomena, including the impact of changes in economic variables in a given sector on the sectors that are upstream and downstream from it, inclusive of feedback effects to the initial sector.

Despite its usefulness, the I-O framework has several limitations that are based mainly on three crucial assumptions (see Munroe & Biles, 2005). Firstly, I-O analyses assume a fixed proportion of consumption of inputs by each sector. Secondly, the I-O model assumes constant returns to scale, thus negating differences in returns to different sectors due to size. Lastly, I-O models assume that no substitution can occur between different inputs. The results from our analyses are interpreted with these caveats in mind.

3.2. The data

As we have noted, the paper aims to examine the evolution of South Africa's economic structure and to identify key manufacturing sub-sectors and industries that have the potential to drive industrial recovery in South Africa. To do this as well as determine how these industries have evolved in the last decade (2010–2019), we use the input-output (I-O) tables, with input referring to supply and output referring to use. Table 1 shows the general structure of an I-O table (see Liu and He (2016) for elaboration).

For our analysis, we employ I-O tables from Quantec, spanning the 2010–2019 period. The Quantec database covers the period 1993–2019, with three-digit Quantec Standard Industrial Classification (QSIC) level by industry. The analytical supply and use tables (SUT) are imputed using Stats SA data published as part of the GDP National Accounts publication. The Quantec I-O data is also based on additional sources such as Stats SA's Annual Financial Survey to estimate the more detailed SUT structure that is not published every year, but in intervals. The methodology used is standard to the computation of Analytical SUT Tables. Uniquely, the Quantec I-O database generates and provides a disaggregated and standardised time-series dataset for industry-by-industry perspective of the South African economy. This is key given the interest of this research on sub-sector-specific nuances and idiosyncrasies.

[3] See these authors for overviews of the input-output method, case studies of various applications, and discussion of its main strengths and weaknesses.

Table 1: Structure of an input-output table

		Production sector					Intermediate Output	Final demand	Total output
		1	…	j	…	n			
Production Sector	1								
	…								
	i			X_{ij}			X_i	Y_i	X_i
	…								
	n								
Intermediate input				X_j					
Value added				V_i				Y=V	
Total input				X_j					

Source: Liu and He (2016, p. 58)

Our analyses use data spanning the 2010–2019 decade. This is to enable us to identify trends across the South African economic structure, specifically across the manufacturing sub-sectors of the South African economy. At the first level, we use data for the 22 sub-sector classification at the 2-digit QSIC level including (1) Food, beverages and tobacco [QSIC 30]; (2) Textiles, clothing and leather goods [QSIC 31]; (3) Wood and paper; publishing and printing [QSIC 32]; (4) Petroleum products, chemicals, rubber and plastic [QSIC 33]; (5) Other non-metal mineral products [QSIC 34]; (6) Metals, metal products, machinery and equipment [QSIC 35]; (7) Electrical machinery and apparatus [QSIC 36]; (8) Radio, TV, instruments, watches and clocks [QSIC 37]; (9) Transport equipment [QSIC 38]; (10) Furniture; and Other manufacturing [QSIC 39].

This level of aggregation of manufacturing industries enables us to identify key manufacturing sub-sectors that have the potential to drive industrial recovery in South Africa. Based on this, we use the disaggregated 91 industry classification at the 3-digit SIC level to identify specific manufacturing industries that could be essential in driving industrial recovery in the key sub-sectors identified in the first stage. All analyses use I-O tables with values in 2010 constant prices.

3.3. The empirical strategy

In a context of increasing complexity and interdependency in the South African economy, economic disruptions in a single sector, sub-sector or industry can have powerful ripple effects that impair production and dampen demand in other sectors (Khalid and Ali, 2019). Such disruptions can arise from natural sources (such as hurricanes or floods), human action (such as policy change, political instability, wars, and accidents), or from a combination of both. This is the premise of our empirical strategy.

To identify priority sub-sectors for industrial recovery and the growth of South African manufacturing, we adapt the sector prioritisation index approach, popular in the literature, based on five indicators (see Go et al., 2019; Yu et al., 2014). These indicators are: (1) relative degree of sector's influence on the rest of the economy; (2) relative structural significance or contribution to overall output production; (3) degree of interconnectedness (producer

and consumer) with other economic sub-sectors; (4) dependence on the domestic economy (inputs); and (5) contribution to the economy's risk of inoperability or production failure.

Following Dietzenbacher et al. (2005) and Go et al. (2019), we model sub-sector interdependencies in South Africa based on I-O model (Leontief, 1936) model as:

$$\mathrm{x} = \mathrm{Ax} + \mathrm{f} = (\mathrm{I} - \mathrm{A})^{-1}\mathrm{f} \tag{1}$$

with $\boldsymbol{x}$ denoting a vector of total output produced by each sub-sector and A is the standard technical coefficients matrix, with a_{ij} as the number of inputs sub-sector i contributes to sector j. f refers to the vector of final demand corresponding to each sub-sector's output. Finally, $(I - A)^{-1}$ measures the increase in the total output of sub-sector i, resulting directly and indirectly from an increase in the final demand of sector j – the so-called Leontief inverse matrix.

Go et al. (2019) identified five key components/indicators of the sector prioritisation index as:

(1) The relative degree of sector's influence on the rest of the economy measured by the power of the dispersion index (PDI);

From equation (1), the PDI is formulated as:

$$\ddot{p}_i = \frac{p_i}{\sum_{i=1}^{n} p_i} \tag{2}$$

where the relative change in the overall production of the economy due to changes in the final demand by sector i, is defined as:

$$p_i = \frac{\sum_{j=1}^{n}(\mathrm{I}-\mathrm{A})^{-1}{}_{ij}}{\frac{1}{n}\sum_{j=1}^{n}\sum_{i=1}^{n}(\mathrm{I}-\mathrm{A})^{-1}{}_{ij}} \tag{3}$$

From equation (3), higher $\ddot{p}_i$ indicates that a sector has a higher number of inter-sector linkages with other sectors with an increase in the final demand (f) in sector i resulting in a relatively larger increase in overall economic output. That is, sector i has a strong inter-sector linkage and induces a larger positive spillover effect relative to other sectors in the economy, thus making it a key economic sector (Go et al., 2019).

(2) The relative structural significance or contribution to overall output production measured by sector size:

The relative size of the sector is measured following Yu et al. (2014) as:

$$\ddot{x}_i = \frac{x_i}{\sum_{i=1}^{n} x_i} \tag{4}$$

where x_i is the overall output produced by sector i. The higher the value of $\ddot{x}_i$, the more economically significant sector i is compared to the rest of the economy. Given that sector i is more structurally significant to the economy, it implies that it requires a higher level of prioritisation.

(3) The degree of interconnectedness (producer and consumer) with other economic sectors measured by average propagation length (APL):

(4)

Sectors of an economy are interdependent, that is, linked directly or indirectly (Dietzenbacher et al., 2005). The APL measures the length of inter-sector linkages (direct or indirect) between industries in an economy (Dietzenbacher et al., 2005; Yu et al., 2014; Chen, 2014). Following Chen (2014), we formulate a revised APL matrix as:

$$APL_{ij} = \frac{(\mathrm{I}-\mathrm{A})^{-1}{}_{ij}[(\mathrm{I}-\mathrm{A})^{-1}{}_{ij}-\mathrm{I}]}{[(\mathrm{I}-\mathrm{A})^{-1}{}_{ij}-\mathrm{I}]} = \frac{L(L-I)}{(L-I)} \quad (5)$$

where APL_{ij} measures the length or the average number of steps it takes for sector j's final product to affect the overall output of sector i. $L = (\mathrm{I}-\mathrm{A})^{-1}{}_{ij}$ refers to the Leontief inverse.

$$A\ddot{P}L_{\iota} = \frac{\sum_{j=1}^{n} APL_{ij}}{\sum_{j=1}^{n}\sum_{i=1}^{n} APL_{ij}} \quad (6)$$

Given that the APL is also a measure of "upstreamness of a sector in the production chain of the whole economy" (Chen, 2014: p.5), a higher $A\ddot{P}L_{\iota}$ for sector i means that it is closer to the upstream of the entire production chain compared with other sectors. This implies that sector i is a major economic player and has a larger scope of influence on the rest of the economy.

(5) The dependence on the domestic economy (inputs) measured by the sectoral purchase coefficient (SPC):

The relative degree of dependence of a sector on the domestic economy is measured as:

$$\ddot{D}_{\iota} = \frac{D_i}{\sum_{i=1}^{n} D_i} \quad (7)$$

where Okuyama and Yu (2018) measure sector i's domestic input use in the production of its overall output as $D_i = 1 - M_i = \frac{m_i}{\sum_{j=1}^{n} a_{ji}x_j + f_i^d}$, m_i measures sector i's total import requirement, $\sum_{j=1}^{n} a_{ji}x_j$ measures the total amount of input sector i supplies to other economic sectors, f_i^d is the sum total of sector $i's$ output supplies for final domestic consumption, and M_i measures sector i's import requirement relative to its output production. Higher $\ddot{D}_{\iota}$ values indicate that sector i has a relatively larger domestic input requirement for its output production. That is, higher dependence on local inputs may suggest lower levels of external shock/border closures. Given that the Covid-19 pandemic led to the shutdown of international supply and production chains, we argue that manufacturing sub-sectors that source a large proportion of inputs domestically are less vulnerable compared with those sub-sectors that depend solely on imported inputs. That is, industry i is less vulnerable to the impact of Covid-19 shocks as it impended less the supply of domestic inputs, thus leading to lower production losses.

(6) The contribution to the economy's risk of inoperability or production failure measured by the inoperability multiplier (IM):

$$\ddot{g}_\iota = \frac{g_i}{\sum_{i=1}^{n} g_i} \tag{8}$$

where g_i measures the increase in economic losses due to perturbation in the final demand of sector i. Santos and Haimes (2004) derive g_i by taking the column sums of $(\mathrm{I} - A^*)^{-1}{}_{ij}$, where I is the identity matrix. Following Yu et al. (2014), we define $A^* = (\hat{x})^{-1} A \hat{x}$, where A^* is the interdependency matrix, A the technical coefficients matrix, and $\hat{x}$ as the diagonalised output vector. A^* , therefore, measures the 'degree of coupling' between two industries and the production failure sector i contributes to sector j (Santos & Haimes, 2004: p.1441). Given this, $\ddot{g}_\iota$ quantifies economic losses with higher values suggesting that sector i causes a larger degree of production failure and negative spillover effects across the entire economy. As a result, it can be prioritised for available resources (Santos and Haimes, 2004; Go et al., 2019).

To generate the composite sector prioritisation index, we follow Go et al. (2019) and Yu et al. (2014) to combine the five components/indicators of the economy as:

$$V_i^* = W_{\ddot{p}} \ddot{p}_\iota + W_{\ddot{x}} \ddot{x}_\iota + W_{\ddot{s}} \ddot{s}_\iota + W_{\ddot{D}} \ddot{D}_\iota + W_{\ddot{g}} \ddot{g}_\iota \tag{9}$$

where $0 \leq W_{\ddot{p}}, W_{\ddot{x}}, W_{\ddot{s}}, W_{\ddot{D}}, W_{\ddot{g}} \geq 1$, and $W_{\ddot{p}} + W_{\ddot{x}} + W_{\ddot{s}} + W_{\ddot{D}} + W_{\ddot{g}}$=1.

To normalise the addition of the various dimensions of the index into the range of 0-1, with 0 indicating the least vulnerable sub-sector while 1 indicates the most vulnerable/priority sub-sector, Eichhorn's (1976) was adopted in Yu et al. (2014) and Go et al. (2019) as:

$$\ddot{e} = \frac{e_i}{\sum_{i=1}^{n} e_i} \tag{10}$$

For easier interpretation, Equation (10) normalises V_i^* between 0 and 1, with higher V_i^* indicating that a sub-sector is important for the recovery of the economy. W are weights indicating the importance of each indicator to the economy. While Go et al. (2019) assigned weights based on experts' views on the importance of each indicator to the Philippines economy, we followed Yu et al. (2014) to assume equal weights of 0.20 for each indicator. The baseline empirical results reported in this paper are based on this weight.

4. The empirical results

This section presents and discusses the empirical results from our analysis of the vulnerability of South African manufacturing sub-sectors. South Africa continues to experience premature deindustrialisation (Tregenna, 2016), putting the sustainable development of the economy as a whole at risk. Our analysis shows the structural changes that have occurred across the South African economic structure and identifies key manufacturing sub-sectors that have the potential to drive industrial recovery in South Africa, using the sector prioritisation index approach. In Section 4.1, we present and discuss the prioritisation indices for all manufacturing sub-sectors reported in the 22 sub-sector 2-digit ISIC level. Given that variations may exist across each indicator, in Section 4.2, we report on and discuss possible dynamics across manufacturing industries by each component of the sector prioritisation index. To provide more fine-grained and nuanced evidence, we go a step further by conducting analyses at a more disaggregated 3-digit ISIC industry level, of

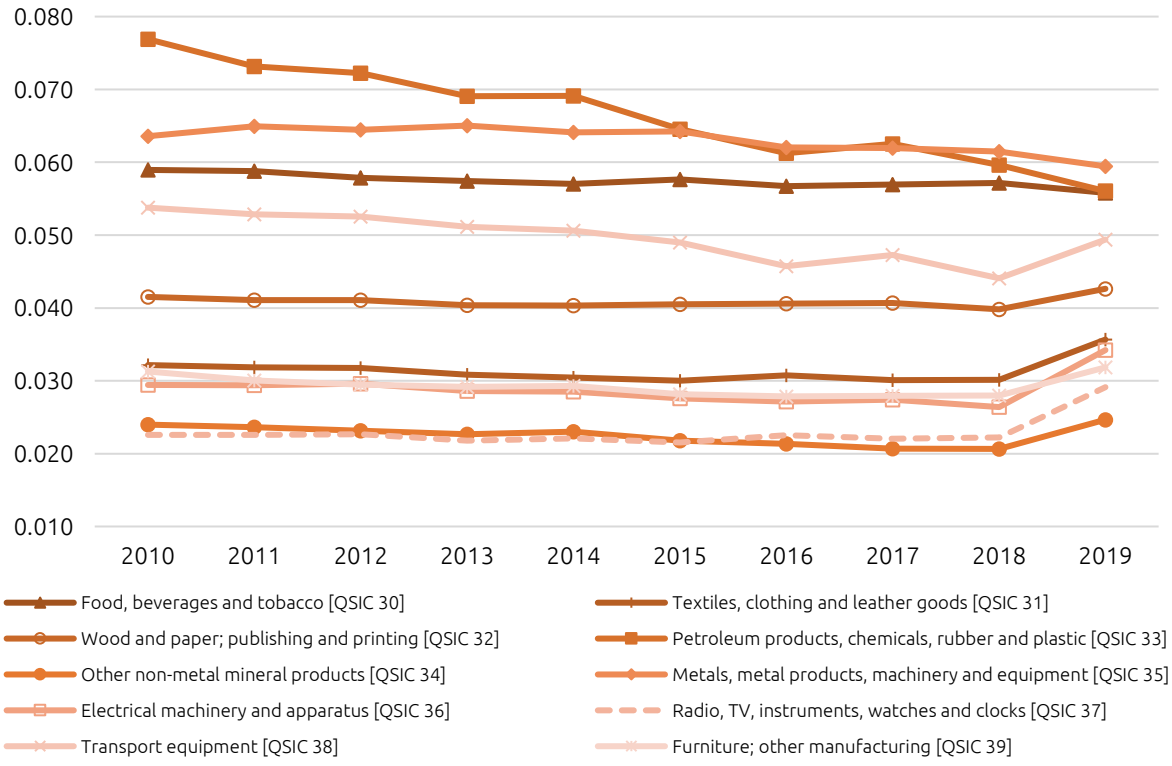
the key priority sub-sectors identified in Section 4.1. Based on these findings, we predict and discuss possible scenarios during and post-Covid-19 in Section 5.

4.1. The main results

Figure 8 represents the sub-sector prioritisation indices based on each component (see equations 1–10) for all manufacturing sub-sector for 22-sector I-O matrices at the 2-digit ISIC level between 2010–2019 (see Appendix 1 for values). As noted, the sub-sector prioritisation indices measure a sub-sector's vulnerability to induced shocks and the effect of the propagation of the shock on the overall economy.

Figure 8 identifies trends across all manufacturing industries. The figure shows that petroleum & chemicals, metals & machinery, and food & beverages are the top three key manufacturing industries in the South African economy between 2010 and 2019. The figure shows that petroleum & chemicals was the most important manufacturing sub-sector in South Africa from 2010 until 2017, with metals & machinery becoming the most important manufacturing sub-sector from 2017. Meanwhile, food & beverages has remained the third most important sub-sector over the focal period (2010–2019).

Figure 8: Manufacturing sub-sector prioritisation (vulnerability) indices, 2010–2019

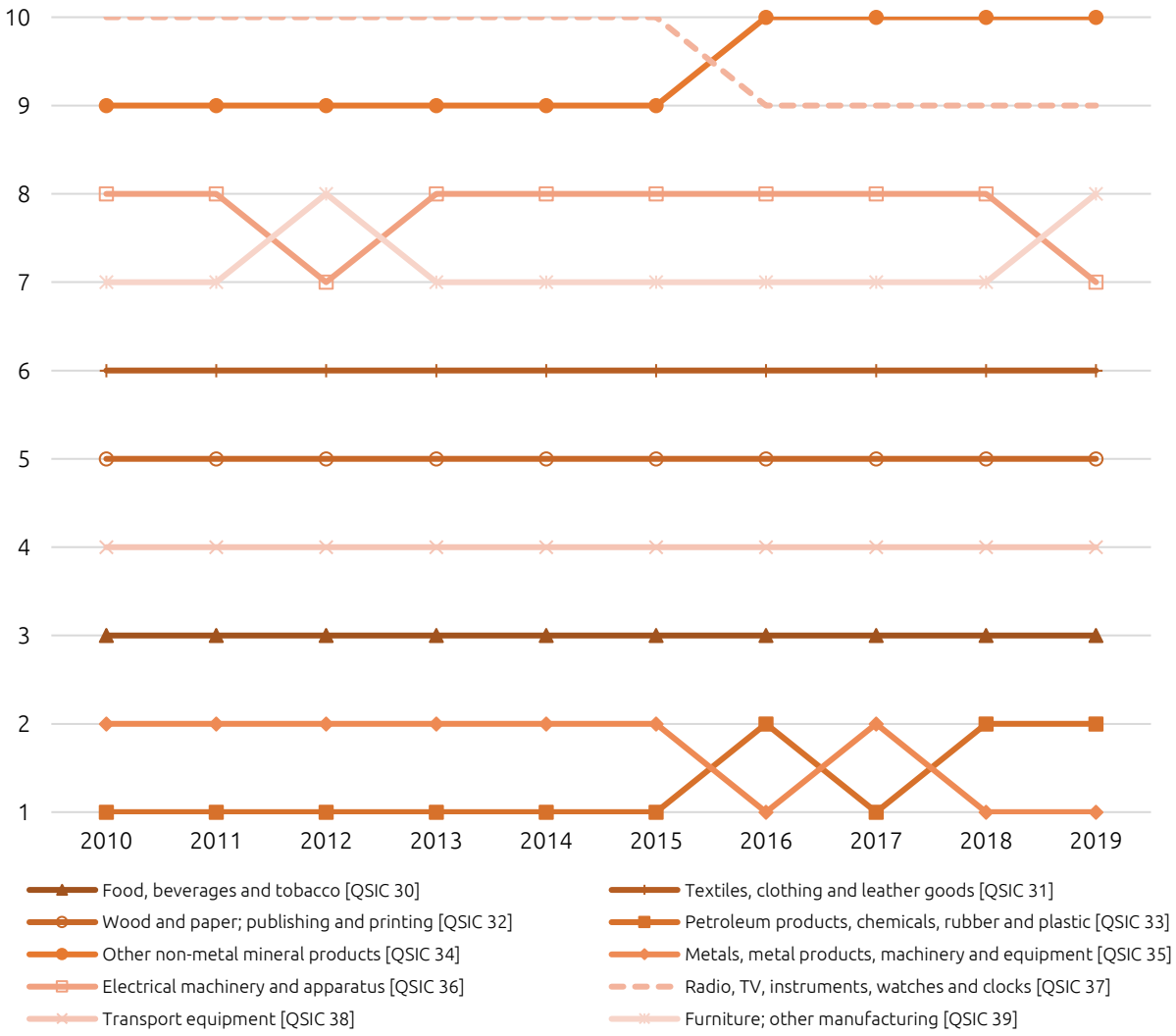


Source: Authors

The ranking of all manufacturing sub-sectors in descending order confirms the importance of petroleum & chemicals, metals & machinery, and food & beverages sub-sectors as the three priority sub-sectors in South African manufacturing for South Africa's industrial recovery and growth (Figure 9). This is explained by the reasoning that these three priority

sub-sectors have the highest total output contributions to the economy, higher effects in terms of spillovers and linkages across the rest of the economy, and they rely significantly on domestic inputs and run a lower risk of production failure. As a result, the prioritisation of these sub-sectors through, for instance, industrial policy and resource allocation decisions, will generate higher overall positive effects on industrial development and the recovery of the entire South African economy.

Figure 9: Manufacturing sub-sector prioritisation (vulnerability) indices ranked, 2010–2019



Source: Authors

Given the importance of these three sub-sectors, the declining trend observable in all three prioritised sub-sectors after 2018, could be explained by the declining industrial activities in South Africa's manufacturing or the effect of broad-based industrial policy. The decline may also be a result of a deliberate shift in policy focus towards the diversification of the product space to other non-traditional drivers of industrial performance. However, a deeper exploration of the priority sub-sectors, particularly the food sector, highlights the presence of concentration of a few large and lead firms in a number of key value chains (Nhundu, et al., 2017). Market structures of this type, as well as the strategies employed by the lead

firms within them, make the manufacturing sector and these sub-sectors vulnerable to the financial health of these large and lead firms. Similar evidence has been noted in the metals & machinery (Bell, et al., 2017), and Petroleum products, chemicals value chains (Mondliwa, et al., 2021).

We see little variation in the trends of other manufacturing sub-sectors. Both figures 10 and 11 also show the transport equipment and wood & paper industries to be semi-priority sub-sectors, while the low-priority manufacturing sub-sectors include textiles & clothing, Other minerals, Electrical machinery, radio & TV, and furniture & other manufacturing. These findings suggest that these manufacturing sub-sectors are not priorities for industrial recovery, and that industrial policy should target these sub-sectors less, particularly low-priority sub-sectors: they have relatively low linkages with other sectors, contribute less to overall output, and pose a low risk to the entire economy should production activities fail.

4.2. Prioritisation (vulnerability) indices by indicator

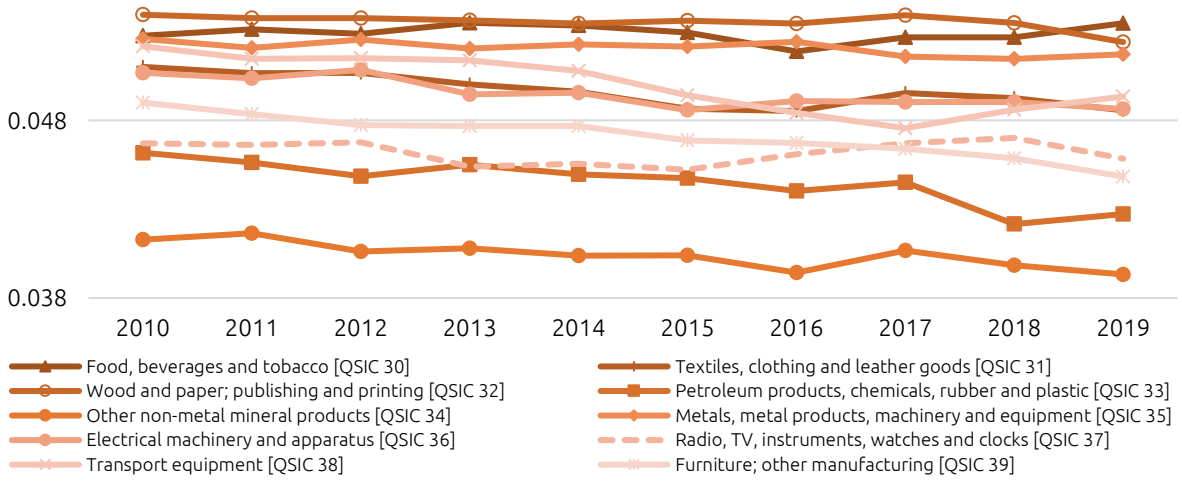
In order to understand the drivers of our priority rankings by sub-sector, we examine each component/indicator across all manufacturing industries. A sub-sector may have a high power of the dispersion index but a low structural significance in the entire economy, for instance – leading to a lower average. This section aims to identify and explain these possible observable dynamics and variations in terms of rankings across the five indicators as well as manufacturing sub-sectors (Appendices 3 to 7 present the values and rankings of each industry across the five sector prioritisation components.)

(1) Power of the dispersion index

The power of the dispersion index (PDI), computed using the Leontief inverse, shows the relative change in overall production of the economy as a result of a change in the final demand by sector i. Appendix 3 shows the sub-sector prioritisations based on the PDI. This is further elaborated in Figure 10. Our results show wood & paper, food & beverages, and metals & machinery sub-sectors as priorities within the manufacturing sector with the largest positive spillovers and influence on other sub-sectors of the economy. This suggests that a change in the final demand in wood & paper has the highest impact on the entire economy, followed by food & beverages, and metals & machinery. That is, inducing final demand in these industries will produce significant improvement in overall output of the economy. This may be due to the role these sub-sectors play as sources of primary inputs for other sub-sectors. In 2019, the metals & machinery sub-sector accounted for the largest source of formal employment in manufacturing, contributing a total of 284,000 direct jobs, of which 228,000 were in the machinery and equipment, and fabricated metal products sub-sectors (Kaziboni, et al., 2019).

The lowest ranked manufacturing sub-sectors here include Other minerals; Petroleum and chemicals; and radio & TV. While this result suggests that these sub-sectors have the least influence over other sub-sectors, it is important to note that the petroleum and chemical sub-sector remains a key strategic sector in all economies. This is because the prices of most goods and services are directly or indirectly driven by changes in fuel costs (Paelo, et al., 2014).

Figure 10: Distribution of power of the dispersion index across manufacturing sub-sectors, 2010–2019

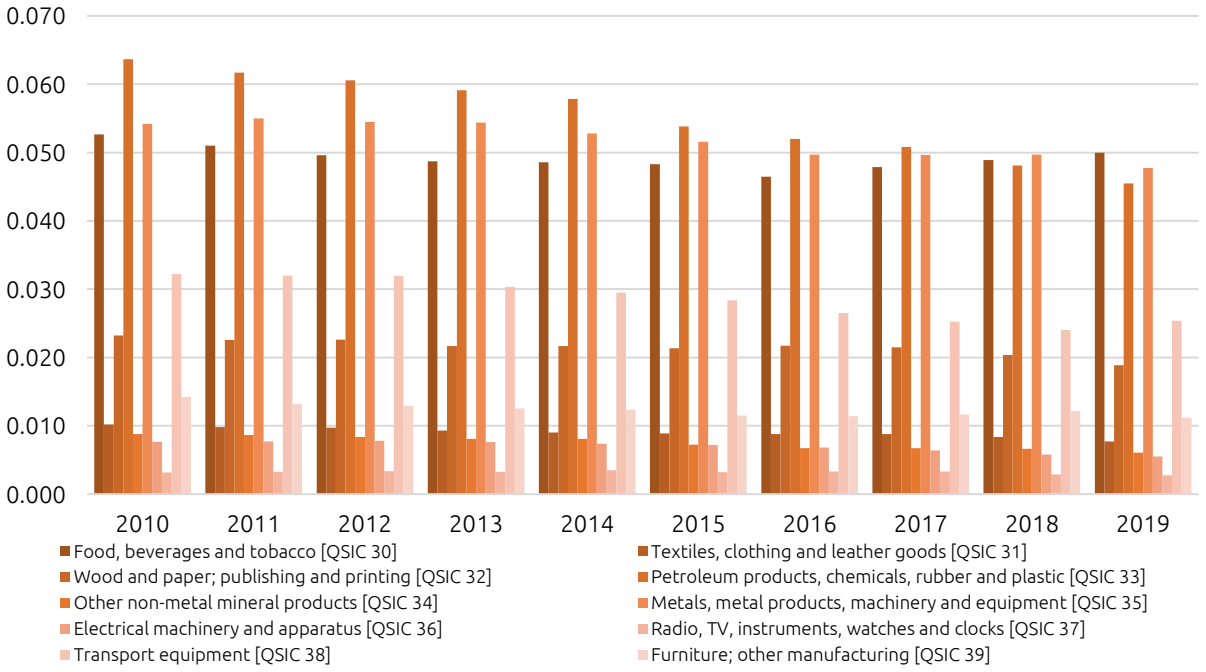


Source: Authors

(2) The relative structural significance of each sub-sector

This component of the sector prioritisation index measures the relative contribution of each manufacturing sub-sector to total output. Figure 11 shows the evolutions of the relative importance of all manufacturing sub-sectors between 2010 and 2019. The figure shows that the highest ranked sub-sector with significant structural importance are petroleum & chemicals, metals & machinery, and food & beverages. The lowest-ranked sub-sectors are transport equipment, radio & TV, and other minerals.

Figure 11: Distribution of relative structural significance of manufacturing sub-sectors, 2010–2019



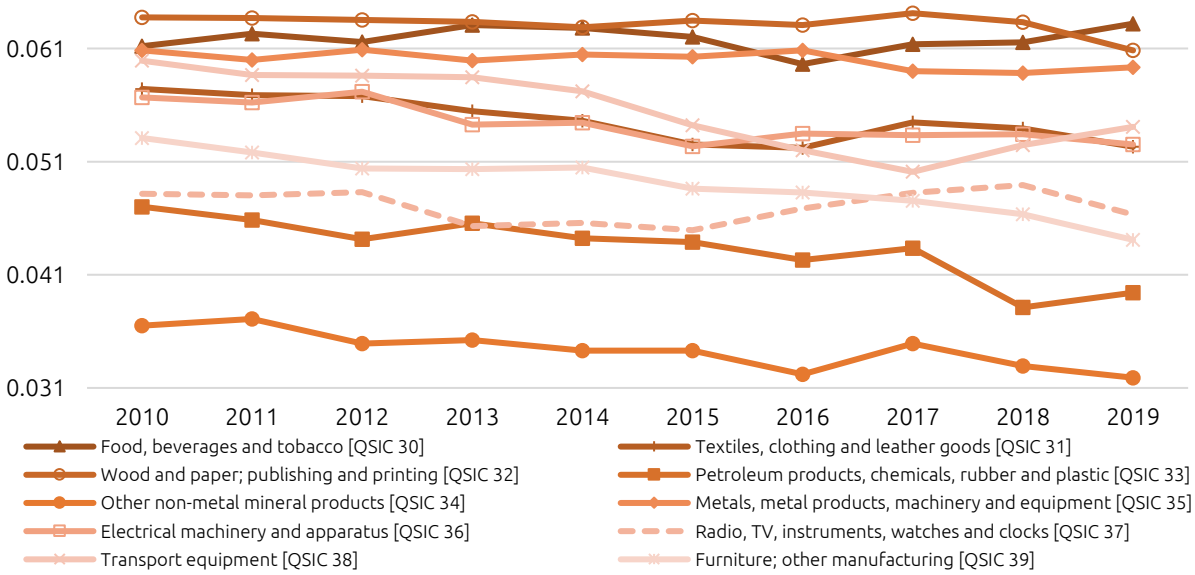
Source: Authors

We observe declining importance of petroleum & chemicals across the period under consideration, with metals & machinery, and food & beverages becoming the two highest ranked manufacturing sub-sectors from 2018. In fact, food & beverages ranked highest as the most significant contributor to overall output in 2019, suggesting a recent upsurge in the growth of this sub-sectors. The food and beverages sub-sector remains a core focus for the country's economic growth accounting for approximately 20% of total manufacturing output (Dube, et al., 2018).

(3) Average propagation length

The average propagation length (APL) indicator measures the degree of interconnectedness of one sub-sector to other sub-sectors of the economy (Santos and Haimes, 2004). In this paper, it shows the extent to which a sub-sector influences other sub-sectors in the entire economy both as a producer of final goods and consumer of outputs from other sub-sectors (Yu et al., 2014). The higher the propagation length, the greater the interconnectedness of a sub-sector. In terms of the average propagation length, our index shows that wood & paper, followed by food & beverages and metals & machinery are high-priority sub-sectors, while petroleum & chemicals and other minerals are low-priority sub-sectors (Figure 12).

Figure 12: Average propagation length in manufacturing sub-sectors, 2010–2019



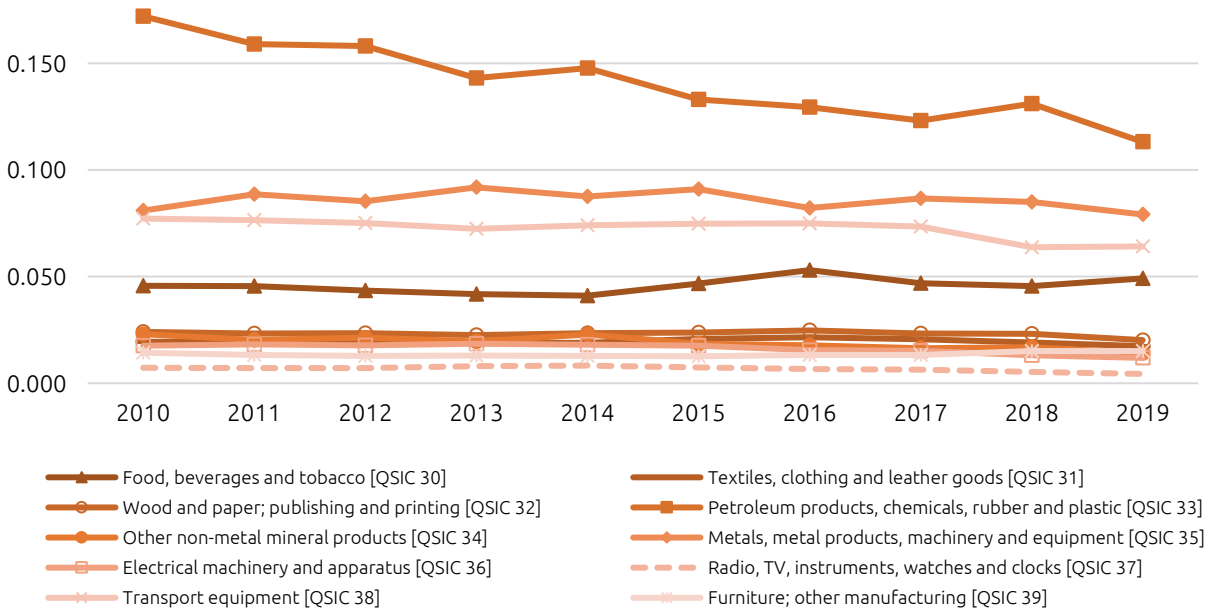
Source: Authors

The metals & machinery industry has been at the heart of South Africa's industrial ecosystem due to the long-term importance of mining activities and the extensive demand- and supply-side linkages of the mining sector (Andreoni, et al., 2021, forthcoming). Similarly, the food, beverages and tobacco industry (agro-processing) exhibits strong backward and forward linkages to agriculture, forestry and fishing and manufacturing level (Dube, et al., 2018). The empirical results are consistent with the earlier analysis that food & beverages, and metals & machinery enjoy a high degree of interconnectedness, as shown by their strong backward and forward linkages, while petroleum & chemicals and other minerals have weaker interconnectedness. This can be attributed to the fact that there are still significant differences in terms of manufacturing capabilities development within the sector, which limits the potential for collaborations (Monaco, et al., 2019).

(4) Sectoral purchase coefficient

The sectoral purchase coefficient of the sector prioritisation index measures a sub-sector's dependence on the domestic economy and inputs. The literature suggests that sub-sectors with a heavy reliance on domestic inputs may face higher risks in the face of domestic shocks. In the face of the Covid-19 pandemic and the resulting shutdown of supply chains, we argue that manufacturing sub-sectors with a higher domestic product content are less likely to face complete supply chain shutdowns during external shocks. Our results show the three priority sub-sectors with the highest sectoral purchase coefficient are petroleum & chemicals, metals & machinery, and transport equipment (see Figure 13).

Figure 13: Distribution of sectoral purchase coefficient in manufacturing, 2010–2019



Source: Authors

This result suggests the need to prioritise these sub-sectors due to their dependence on the domestic economy and inputs. The petroleum & chemicals sub-sector in 2019 sourced from within the manufacturing industry 10% of its input while the metals & machinery sub-sector accounted for 12%.[4] A possible justification for why the sub-sectors (for example, metals & machinery, and transport equipment) rank highly in this measure is the nature of their products: both the transport equipment and metals & machinery sub-sectors utilise inputs from a large number of other sub-sectors while themselves also being inputs into other sub-sectors.

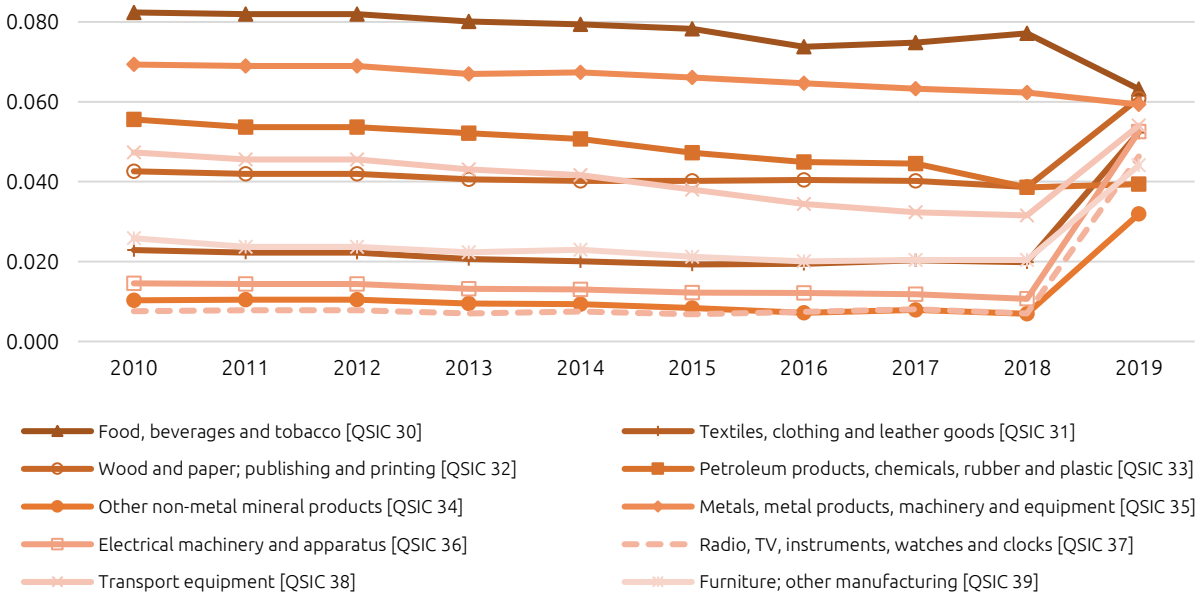
(5) The inoperability multiplier

Negative disruptions in certain sub-sectors could have cascading multiplying negative effects on other sectors and the entire economy. The inoperability multiplier (IM) component identifies and ranks sub-sectors with the highest risk of production failure and negative spillovers based on their degree of interconnectedness to other sub-sectors in the economy. The interdependence between sub-sectors is identified as a possible source of vulnerability (Yu, et al., 2014). As a result, a higher IM indicates a higher degree of

[4] Quantec, 2019. Structural Table -Manufacturing

vulnerability and negative implications for the entire economy. Our results show that the sub-sectors that must be prioritised to prevent the risk of negative spillover effects from failure in production are food & beverages, metals & machinery, and petroleum & chemicals (see Figure 14). What is of interest, however, is the noticeable rise between 2018 and 2019 in the inoperability multiplier of the non-priority sub-sectors (according to the index). The results appear to suggest evidence of diversification away from the three priority sub-sectors identified in our earlier results. The non-priority sub-sectors, it appears, are gaining prominence in the economy while the downward trend of food and beverages and metals, machinery and equipment likewise suggests that these sub-sectors may be becoming less depended on. This diversification is key to fostering economic resilience to shocks of the nature of Covid-19.

Figure 14: Distribution of the inoperability multiplier in manufacturing, 2010–2019



Source: Authors

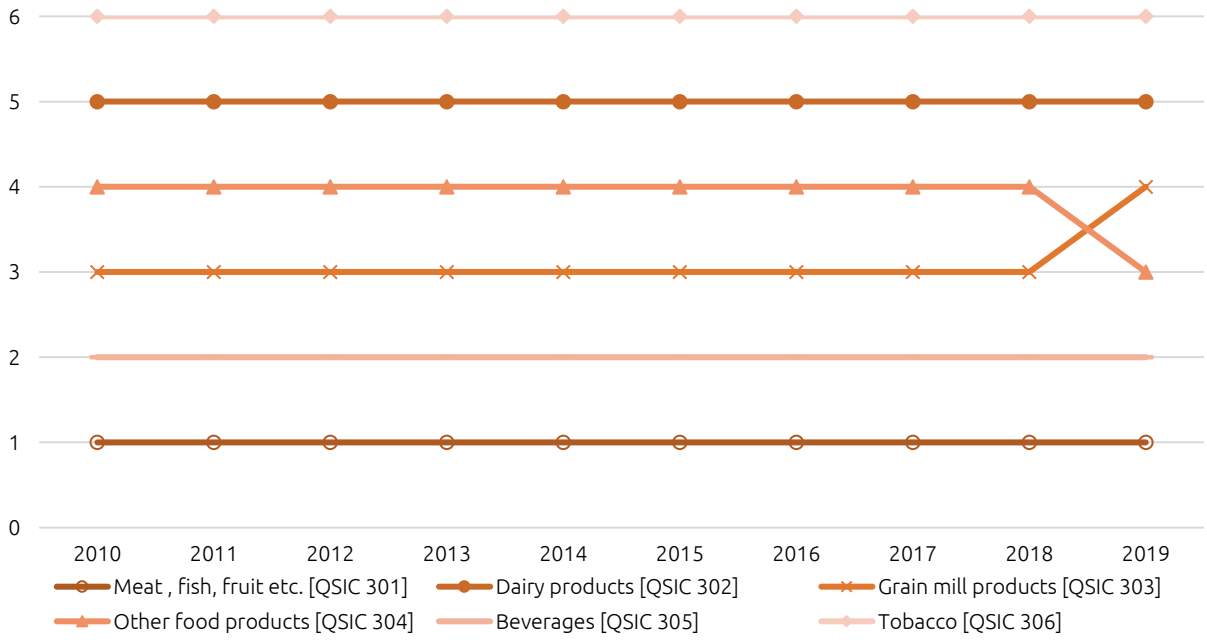
In summary, our results show that there exist disparities in manufacturing sub-sectors across the five components of our sub-sector prioritisation index. While the overall sub-sector prioritisation index shows the petroleum & chemicals, metals & machinery, and food & beverages sub-sector as the three crucial industries in need of prioritisation, the analysis of these individual components of the vulnerability index presents contrasting findings. For instance, the power of the dependence index suggests that the wood & paper sub-sector should be prioritised. However, the high level at which these results are presented may not fully be capturing, at the industry-level, the true nature of the vulnerabilities described above. Therefore, the following section looks at the industry rankings within the three-priority manufacturing sub-sectors.

4.3. Ranking of industries within the priority manufacturing sub-sectors

Using more disaggregated data of 91 industries at the 3-digit QISIC level, this section further examines the industries that make up the three key priority manufacturing sub-sectors

identified above. Figures 15, 16, and 17 show the evolution of the priority indices across and within our three priority sub-sectors. The analysis of the food & beverages sub-sector identifies the meat, fish and fruit [QSIC 301] and beverages [QSIC 305] industries as those driving the high vulnerability levels in this sub-sector and therefore in need of prioritisation (Figure 15). However, the reasons for the vulnerability of these two industries require more research.

Figure 15: Industry vulnerability ranking in the food, beverages, and tobacco sub-sector, 2010–2019

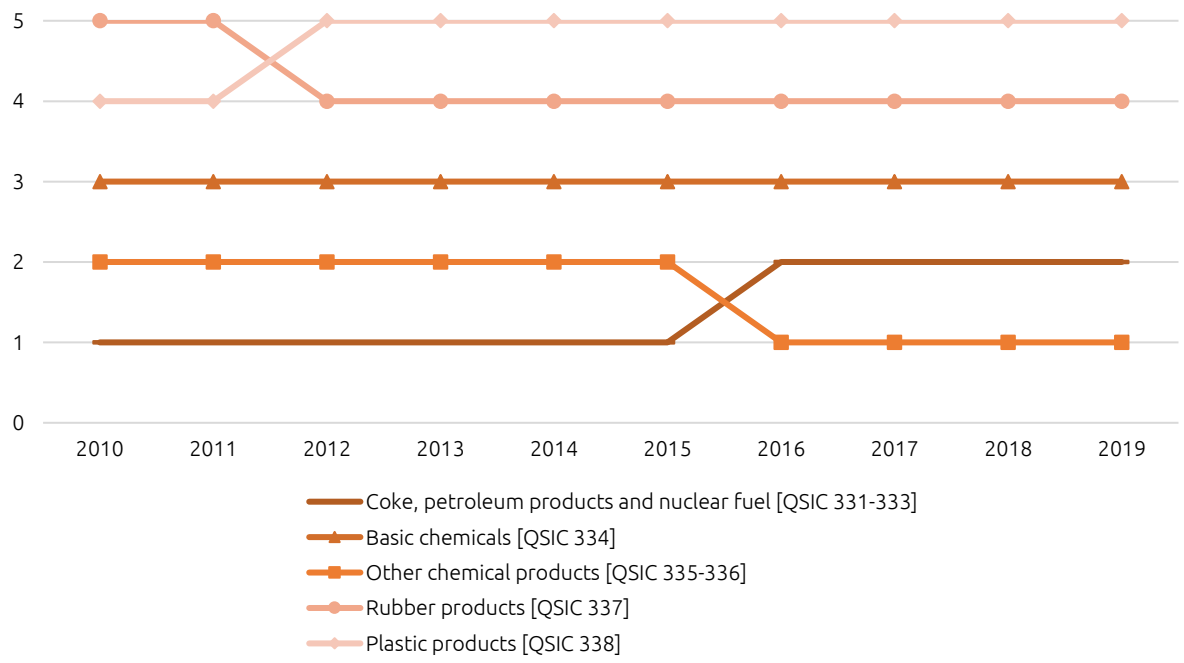


Source: Authors

In terms of the petroleum & chemicals sub-sector, our results identify coke, petroleum products and nuclear fuel [QSIC 331-333] and Other chemical products [QSIC 335-336] as the industries that industrial policy should prioritise for industrial recovery (Figure 16). The concentrated nature of the coke, petroleum products and nuclear fuel industry (due to South African Synthetic Oil Limited (SASOL))[5] enjoying a near-perfect monopoly) is a possible reason for the vulnerability of the sub-sector. Political economy issues of this nature introduce complexity to the design of policies needed to correct long-standing problems that exist in the industry and broader sub-sector. Therefore, there will need for a concerted effort on the part of policymakers to address the power imbalances (in the form of concentration of large and lead firms) and shape better developmental outcomes in the sub-sector and wider economy. Furthermore, there is a need for further research on the vulnerabilities within these industries. This can assist in the formulation of industry-specific policies that address the specific vulnerabilities.

[5] SASOL is a global integrated chemicals and energy company spanning 30 countries. The Company develops and commercializes technologies, and builds and operates facilities to produce a range of product streams, including liquid fuels, chemicals and low-carbon electricity

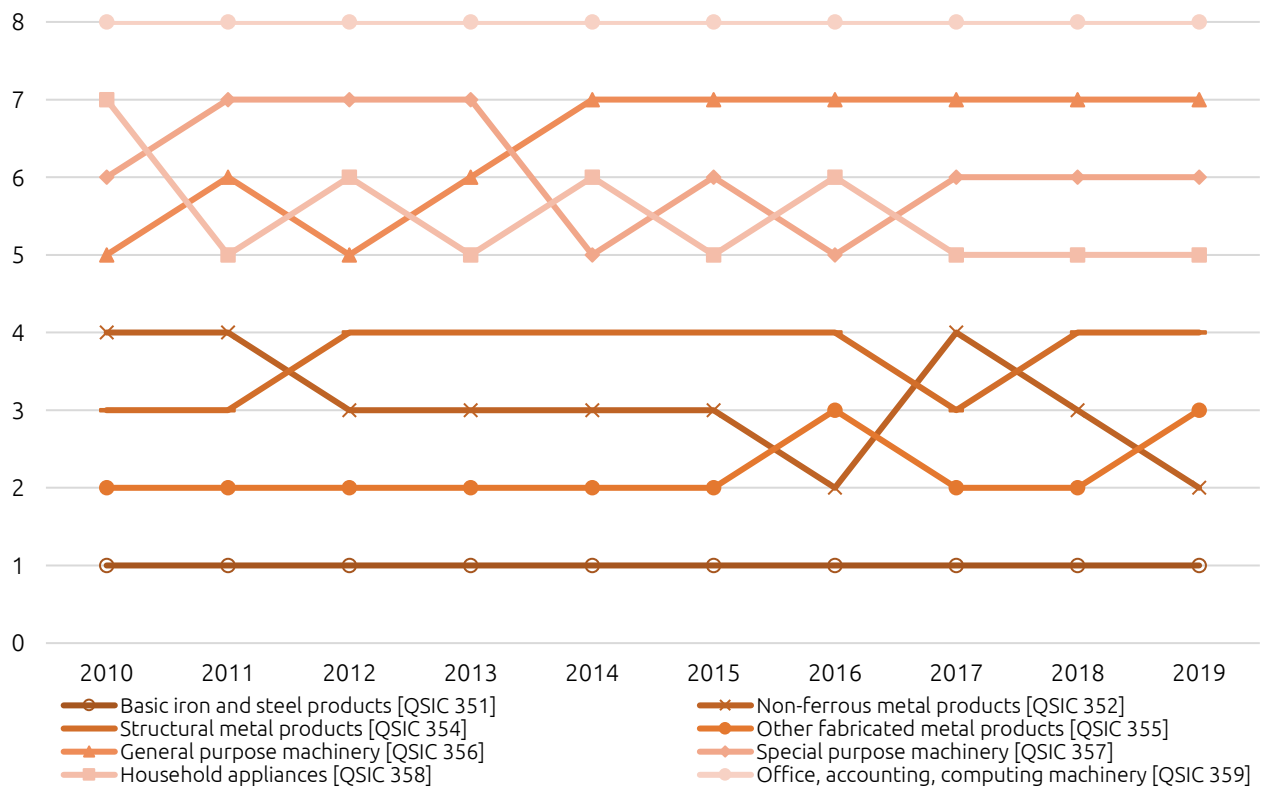
Figure 16: Industry vulnerability ranking in the petroleum products, chemicals, rubber and plastics sub-sector, 2010–2019



Source: Authors

Within the metals & machinery sub-sector, a number of industries have seen changes in terms of their relative vulnerability, but the basic iron and steel products industry has consistently ranked as the most vulnerable (Figure 17). This is possibly due, in large part, to the fragile nature of the industry despite being the recipient of favourable electricity tariffs, and investment and logistics support aimed at promoting its competitiveness during the apartheid regime (Rustomjee, et al., 2018). Additionally, the closure of ArcelorMittal-SA steel plants in the past few years, which together held the monopoly over steel production in South Africa, may have driven the sector to a near collapse. Moreover, further downstream, firms involved in the manufacture of products requiring basic iron and steel as inputs have been forced to import from international companies (Rustomjee, et al., 2018). This puts them at a distinct disadvantage compared to other firms that source their inputs from their respective domestic suppliers (Goga, et al., 2020).

Figure 17: Industry vulnerability ranking in the metals, machinery and equipment sub-sector, 2010–2019



Source: Authors

While instructive in identifying sub-sectors and industries that require prioritisation due to their inherent vulnerabilities, following Go et al. (2019) over the 10-year span from 2010 to 2019, these results do not account for the drastic economic impact caused by the Covid-19 pandemic. In order to take account of this crucial factor, the next section explores the performance of key indicators across the manufacturing sector as a whole at the sub-sectoral level. This is to see whether the priority sub-sectors identified above have also registered the largest declines and slowest recoveries, hence reiterating their prioritisation as per our empirical results. If they have, it suggests that an urgent and broader recovery policy package is required on top of a prioritisation of the three sectors discussed throughout this section. This also suggests that some sub-sectors and industries have been more vulnerable to the pandemic than others, and therefore identifying a clear path to recovery is made more difficult.

5. The effect of Covid-19 on manufacturing sub-sectors in 2020

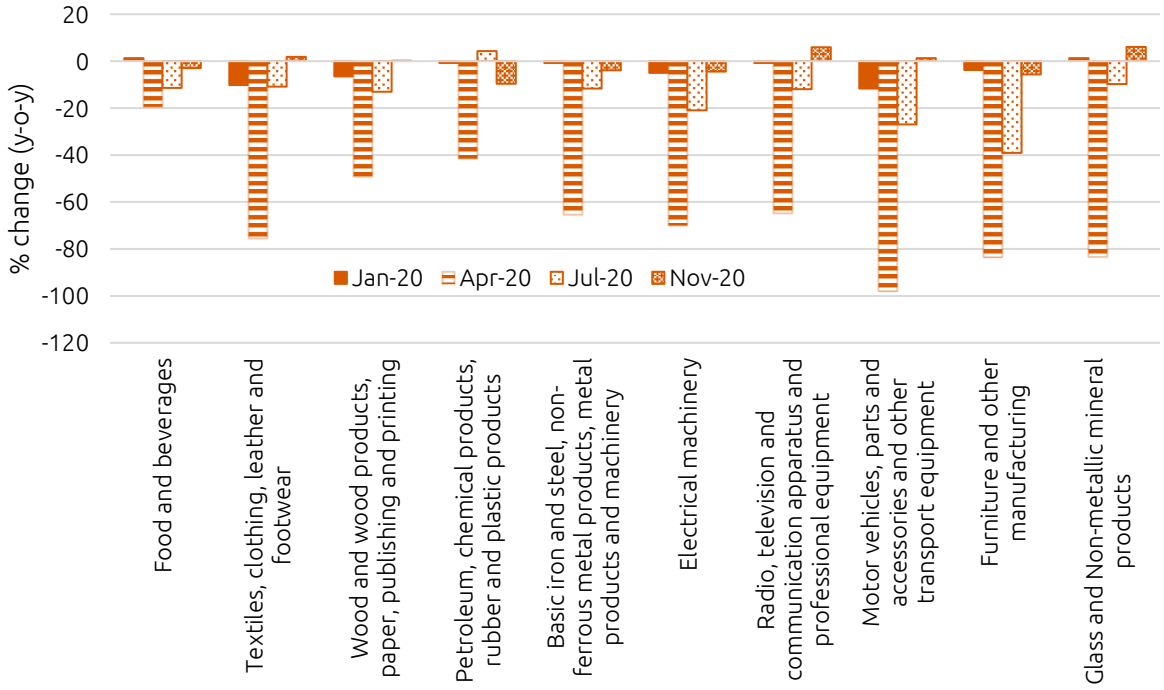
Covid-19 has presented an unprecedented shock to the global economic system. Within South Africa's manufacturing sector, Covid-19 and its resultant impacts have affected the sector in its entirety (Telukdarie, et al., 2020). This section extends our earlier analysis by looking at the effects of the Covid-19 pandemic on the manufacturing sub-sectors in South Africa. The pandemic has given rise to unprecedented demand- and supply-side shocks in the local and global economy. These have had, and continue to have, a major impact on domestic spending, production, and investment activities. At the start of the pandemic, most segments of the economy went into complete shutdown, with providers of essential services being the exception. The consequences of the lockdown on economic activities are reflected in poor sectoral performance along a range of measures. The adverse impact has been severe, with declines being registered in output levels, employment, and trade.

The empirical results reported and discussed in Section 4 identified the three priority manufacturing sub-sectors in the South African economy as Petroleum products, chemicals, rubber and plastic [QSIC 33], Metals, metal products, machinery and equipment [QSIC 35], and Food, beverages and tobacco [QSIC 30]. These were identified as priority manufacturing sub-sectors due to their having the highest total output contributions to the economy; accounting for a vast majority of jobs; having stronger spillovers; and greater number of linkages across the rest of the economy, while also relying significantly on inputs from other domestic sub-sectors. However, these results, due to data being available only until 2019, do not take into account the effects of the Covid-19 pandemic.

4.1. The impact of the pandemic on output levels

Figure 18 shows the change in manufacturing output by sub-sector during 2020. The transport equipment (including motor vehicles and parts) sub-sector was the hardest hit as output plummeted 97.9% (year-on-year) in April, followed by furniture and other industries (-84.4%), non-metallic mineral products (-82.5%), and clothing, textiles, leather and footwear (-76.3%). The automotive industry was extremely affected by the lockdown; as new passenger vehicle sales came to a standstill in April (-99.6% y-o-y). Although vehicle dealers were allowed to reopen from May, new passenger car sales of 18 905 in July were below the March levels and 35.8% lower than a year earlier (IDC, 2020). Considering the size and importance of the automotive industry for supplier industries, its downturn has extensive implications.

Figure 18: Change in manufacturing output by sub-sector in 2020



Source: Compiled using Stats SA data

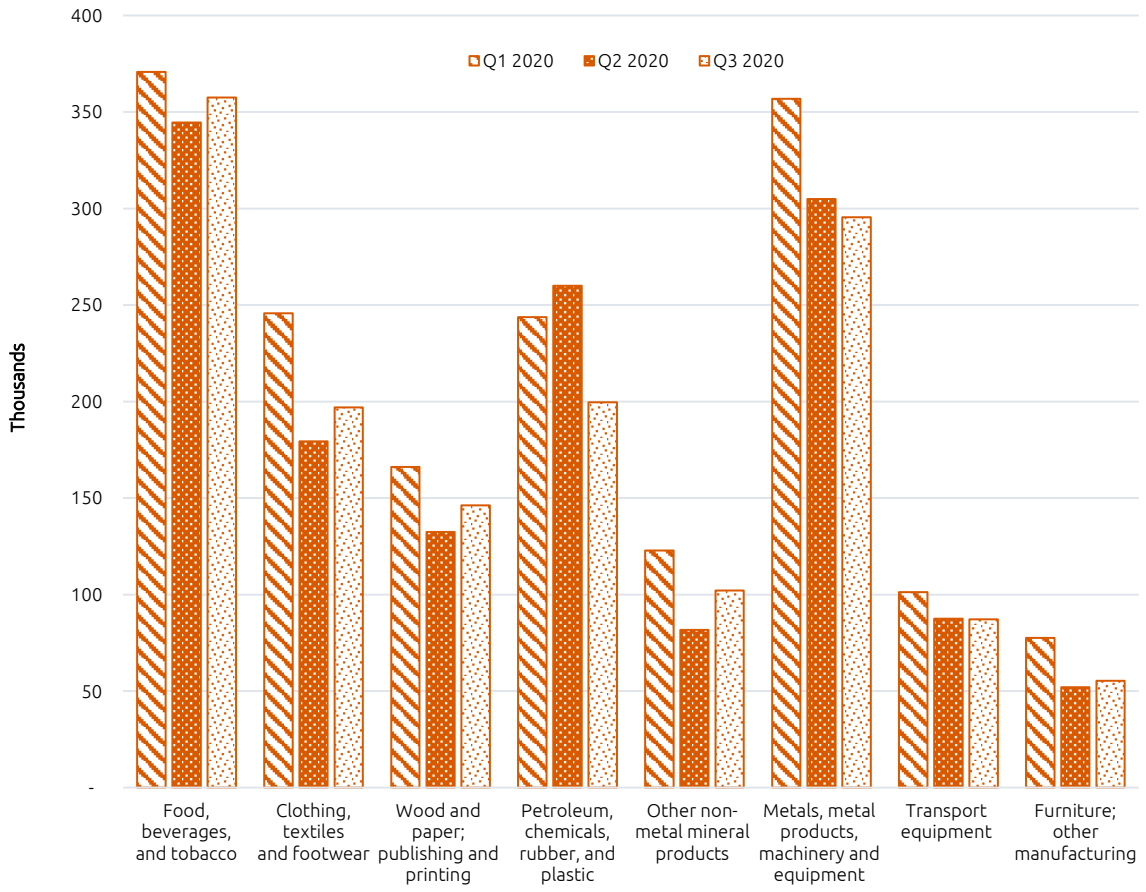
The easing of restrictions resulted in improved manufacturing performances in May and June, and the pace of contraction moderated. With the continued easing of the lockdown regulations, production activity in the manufacturing sector rebounded, with output levels having risen sharply almost across all broad sub-sectors, albeit off very low bases. Overall

manufacturing output expanded by 32.9% (q-o-q) in the third quarter of 2020, following the 29.4% contraction recorded in the preceding quarter. For the period January to September 2020, manufacturing output was still 14.4% lower compared to the corresponding period in 2019.

4.2. The impact of the pandemic on employment

Through the examination of the levels of employment in manufacturing, the data show that food & beverages, textiles & clothing, petroleum & chemicals, and metals & machinery account for the majority of jobs in the manufacturing sector. When looking at employment trends for 2020, the textiles & clothing and metals & machinery sub-sectors recorded the sharpest declines from the first to the second quarter, shedding more than 50,000 jobs each, while petroleum & chemicals and metals & machinery reported marginal increases of 16,000 and 10,000 jobs respectively.

Figure 19: Employment numbers in selected manufacturing sub-sector in 2020



Source: Compiled using Stats SA data

This period coincided with the first measures of restrictions, which meant some services had to be shut down while those deemed as "essential services", such as petroleum and machinery equipment, had to be strengthened in the face of an increase in demand. Food processing was comparatively stable, reflecting its position as an essential sub-sector. By the

third quarter there had been some recovery in both textiles & clothing, and metals & machinery, although employment remained significantly lower than in the first quarter. However, in the petroleum & chemicals the opposite occurred, with an increase from the first to the second quarter and a sharp fall in the third quarter.

4.3. The impact of the pandemic on trade

The impact of the pandemic on trade was significant, with a massive decline in the nominal value of South African exports, which tumbled by 55.2% (month-on-month) in April 2020, due to significantly weaker demand in key export markets and restrictions to domestic production and logistics constraints. The balance of trade consequently posted its worst monthly deficit on record, at R53 billion (IDC, 2020). The automotive industry and motor trade services sector have been clear victims of the damaging demand-side effects of global and domestic lockdowns (IDC, 2020). Manufactured goods were severely affected, with exports to the EU decreasing by 77.4%, followed by the USA (-69.2%), Africa (-61.5%) and Japan (-56.9%). Combined, these markets accounted for roughly 70% of South Africa's total manufactured exports in April 2020.

Among the import categories, there was a sharp drop of 47.9% (or R3.7 billion) in the import bill for refined petroleum products in April 2020, whereas imports of motor vehicles, parts and accessories declined by 25.7% or R4.3 billion.[6] In sharp contrast, imports of textiles rose 372% (or R3.4 billion) compared to March. This was perhaps associated with the increased demand for personal protective equipment to combat the spread of Covid-19. Imports of wearing apparel declined by 22.1% to R1.5 billion. In the third quarter, signs of economic recovery were emerging, but the environment remains very challenging. Production activity in the manufacturing sector rebounded in recent months, with output levels having risen sharply almost across all broad sectors.

4.4. Summary

The above discussions build on from the empirical analysis undertaken in Section 4. The drastic costs of the pandemic have spilled over to the entire economy. Within manufacturing, the results showed that all sectors were hard hit, in terms of output, employment, and trade. However, what is clear is that the priority manufacturing sub-sectors, food & beverages, petroleum & chemicals, and metals & machinery suffered significantly in terms of their respective declines in output, employment and trade. Moreover, these sub-sectors' recoveries have been sluggish compared to the rest of the manufacturing sub-sectors. A reason for this may be precisely because of the number of linkages that these sub-sectors have throughout the manufacturing sector as well as the broader economy.

6. Conclusions and the way forward

The role of manufacturing in driving sustained economic growth and development is well established in industrialisation literature. With the dual challenges of de-industrialisation and declining economic activities due to the Covid-19 pandemic, coupled with increasing unemployment, inequalities and extensive poverty, there is a critical need to examine and

[6] IDC, June 2020. Economic Overview.

identify key industrial sectors that have the potential to drive South Africa's re-industrialisation and economic recovery. While evidence exists on the need to prioritise manufacturing for an industrialisation-driven economic recovery, there is limited evidence on the specific industrial sub-sectors that should be prioritised to drive this objective. This paper fills this evidence gap using Input-Output data from South Africa, from 2010 to 2019, to identify priority sub-sectors within the larger manufacturing sector.

Following the literature, we computed a sub-sector prioritisation index based on five key components: 1) the relative degree of sector's influence on the rest of the economy measured by the power of the dispersion index (PDI); 2) the relative structural significance or contribution to overall output production measured by sector size; 3) the degree of interconnectedness (producer and consumer) with other economic sectors measured by average propagation length (APL); 4) the dependence on the domestic economy (inputs) measured by the sectoral purchase coefficient (SPC) and; 5) the contribution to the economy's risk of inoperability or production failure measured by the inoperability multiplier (IM). We examined the evolution of manufacturing industries across these five components for the entire South African economy at both 2- and 3- digit Standard Industrial Classification (QSIC) levels for 22 and 91 sector classifications. Based on these, we then identified key sub-sectors that significantly impact the South African economy and have the potential to generate overall industrial drive and recovery.

Our results suggest that over a 10-year span, between 2010 and 2019, petroleum products, chemicals, rubber and plastic [QSIC 33], metals, metal products, machinery and equipment [QSIC 35], and food, beverages and tobacco [QSIC 30] are the three priority manufacturing sub-sectors in the South African economy in terms of their share of contribution to the economy; their relatively greater number of linkages with other sub-sectors in the economy; the significantly larger number of inputs they derive from the local economy; and their overall importance in the South African economy. These finding suggests that these sub-sectors should be prioritised for intervention by policymakers as they are well-entrenched within South Africa's current industrial structure. This means that failure within these sub-sectors will spill over and have drastic consequences for the rest of the manufacturing sector and the economy at large.

We then examined the specific components that are driving these three key priority manufacturing sub-sectors, as well as which sub-sectors rank highest as a priority across the five components. At the second level of analysis, we focused on these three key priority sub-sectors identified at the first stage of analysis, and then examined specific industries that may be driving the high priority rankings in these industries. Our analysis showed that within these three sub-sectors, specific industries are overwhelmingly represented, in terms of key economic variables over the 2010–2019 period. This conclusion suggests that there is a need for a more targeted policy response – at the industry level. We believe this exercise has been vital for identifying sub-sectors to ensure more targeted and nuanced policy interventions that have the potential to assist in alleviating the vulnerabilities within the manufacturing sector and the South African economy as a whole.

Moreover, the Covid-19 pandemic has presented an unprecedented shock to the global economic system. South Africa has felt the brunt in its entire economy. For the 2020 period, where data was available, the analysis showed that the priority manufacturing sub-sectors, owing to their inherent vulnerability, relative significance, and linkages within the larger

economy, should remain priority sub-sectors in the policymaking space. A crucial caveat, however, is that the arrival of the second and subsequent waves of Covid-19 infections may introduce a new level of complexity and uncertainty across broad economic and industrial sectors and hence affect this finding. Despite this, our results show that South Africa is at a crossroads. The country is at a place where there is a critical need for tailored industrial policies that have the highest potential to generate positive spillovers and the ability to drive other sectors' growth while contributing significantly to the overall growth of the economy.

The evidence presented in this paper shows the evolution of manufacturing sectors and sub-sectors in South Africa, and identifies which sub-sectors should be prioritised in future industrial policies. We believe that this provides an important resource for more refined policymaking at this crucial time. We argue that, over the short and medium term, policies to rehabilitate and accelerate growth in the identified priority sub-sectors are necessary and fundamental in achieving immediate economic recovery in South Africa. This is because the nature of these "traditional" manufacturing sub-sectors, the strong linkages that exist between them and the rest of the manufacturing sub-sectors, and their contribution to aggregate growth requires policy responses that shape clear objectives, orientate firms within them, and ensure that these sub-sectors grow rapidly. Policy interventions should be innovative and reaffirm the importance of establishing a development coalition for the manufacturing sector. This is to make an industrialisation-led recovery a reality, while also boosting prospects and confidence throughout the manufacturing sector and the entire economy.

But South Africa's recovery policy should also have an eye on the long term. South Africa's product space, for instance, shows that there is lack of diversification within the basket of manufactured goods currently exported. This makes the economy particularly vulnerable to specific downturns in economic performance. Policies that are developed in the immediate aftermath of the pandemic must prioritise the identification of new sub-sectors that have the potential to grow rapidly and diversify the product space in the long term. This is crucial and necessary in the process of the industrialisation-led recovery and growth of the South African economy towards a more sustainable and inclusive development path. Also, the data on the inoperability multiplier (see Figure 14) appeared to show a convergence between the priority and non-priority manufacturing sub-sectors in terms of their importance in the economy. This indicates a degree of increased diversification within the broader manufacturing sector. However, we note that the validity of this conclusion is hampered by the fact that, at the time of writing, we do not have access to 2020 data to see the effects of the pandemic. More research into this apparent diversification of South Africa's product space is needed.

Furthermore, despite the novel findings of our research, the analysis could be extended by using more disaggregated data whenever it becomes available. For instance, more work on is needed to identify the specific vulnerabilities within each identified priority sub-sector. The literature may also benefit from a focused analysis of the agricultural and service sectors. This is because the agricultural sector, for instance, is a key component in South Africa's current economic structure and a key source of inputs for manufacturing industries. From the perspective of services, South Africa's service industry contributes over two-thirds of the economy's output. The evidence also highlights that the majority of jobs within

services (or the tertiary industry) are in retail (31% in 2019), and finance (23% in 2019)[7].This skewed nature of South Africa's current economic structure makes the understanding of these sectors critical for economic recovery and growth. Furthermore, we also assume components have equal preference with weight of 0.20. Different weights may change the ranking of industries. As a result, a systematic generation of weights through available procedures such as the fuzzy set approach may improve this paper. Despite this, we believe the baseline findings discussed in this paper add to the literature and can inform and redirect policy discussions, particularly with respect to industrial policy and strategies at the sub-sector manufacturing level.

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8. Appendices

Appendix 1: Manufacturing sub-sector prioritisation (vulnerability) indices, 2010–2019

	Year									
Manufacturing industries	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Food, beverages and tobacco [QSIC 30]	0,059	0,059	0,058	0,057	0,057	0,058	0,057	0,057	0,057	0,056
Textiles, clothing and leather goods [QSIC 31]	0,032	0,032	0,032	0,031	0,030	0,030	0,031	0,030	0,030	0,036
Wood and paper; publishing and printing [QSIC 32]	0,042	0,041	0,041	0,040	0,040	0,040	0,041	0,041	0,040	0,043
Petroleum products, chemicals, rubber and plastic [QSIC 33]	0,077	0,073	0,072	0,069	0,069	0,065	0,061	0,063	0,060	0,056
Other non-metal mineral products [QSIC 34]	0,024	0,024	0,023	0,023	0,023	0,022	0,021	0,021	0,021	0,025
Metals, metal products, machinery and equipment [QSIC 35]	0,064	0,065	0,064	0,065	0,064	0,064	0,062	0,062	0,061	0,059
Electrical machinery and apparatus [QSIC 36]	0,029	0,029	0,030	0,029	0,029	0,028	0,027	0,027	0,026	0,034
Radio, TV, instruments, watches and clocks [QSIC 37]	0,023	0,023	0,023	0,022	0,022	0,022	0,023	0,022	0,022	0,029
Transport equipment [QSIC 38]	0,054	0,053	0,053	0,051	0,051	0,049	0,046	0,047	0,044	0,049
Furniture; other manufacturing [QSIC 39]	0,031	0,030	0,029	0,029	0,029	0,028	0,028	0,028	0,028	0,032

Source: Authors, based on Quantec I-O table in 2010 constant prices

Appendix 2: Prioritisation index rankings of manufacturing sub-sectors, 2010–2019

	Year									
Manufacturing industries	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Food, beverages and tobacco [QSIC 30]	3	3	3	3	3	3	3	3	3	3
Textiles, clothing and leather goods [QSIC 31]	6	6	6	6	6	6	6	6	6	6
Wood and paper; publishing and printing [QSIC 32]	5	5	5	5	5	5	5	5	5	5
Petroleum products, chemicals, rubber and plastic [QSIC 33]	1	1	1	1	1	1	2	1	2	2
Other non-metal mineral products [QSIC 34]	9	9	9	9	9	9	10	10	10	10
Metals, metal products, machinery and equipment [QSIC 35]	2	2	2	2	2	2	1	2	1	1
Electrical machinery and apparatus [QSIC 36]	8	8	7	8	8	8	8	8	8	7
Radio, TV, instruments, watches and clocks [QSIC 37]	10	10	10	10	10	10	9	9	9	9
Transport equipment [QSIC 38]	4	4	4	4	4	4	4	4	4	4
Furniture; other manufacturing [QSIC 39]	7	7	8	7	7	7	7	7	7	8

Source: Authors, based on Quantec I-O table in 2010 constant prices

Appendix 3: Distribution of power of the dispersion index across manufacturing sub-sectors, 2010–2019

	Year									
Manufacturing industry	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Food, beverages and tobacco [QSIC 30]	0,053	0,053	0,053	0,053	0,053	0,053	0,052	0,053	0,053	0,053
Textiles, clothing and leather goods [QSIC 31]	0,051	0,051	0,051	0,050	0,050	0,049	0,049	0,050	0,049	0,049
Wood and paper; publishing and printing [QSIC 32]	0,054	0,054	0,054	0,054	0,053	0,054	0,053	0,054	0,053	0,052
Petroleum products, chemicals, rubber and plastic [QSIC 33]	0,046	0,046	0,045	0,045	0,045	0,045	0,044	0,045	0,042	0,043
Other non-metal mineral products [QSIC 34]	0,041	0,042	0,041	0,041	0,040	0,040	0,039	0,041	0,040	0,039
Metals, metal products, machinery and equipment [QSIC 35]	0,053	0,052	0,053	0,052	0,052	0,052	0,052	0,052	0,051	0,052
Electrical machinery and apparatus [QSIC 36]	0,051	0,050	0,051	0,049	0,050	0,049	0,049	0,049	0,049	0,049
Radio, TV, instruments, watches and clocks [QSIC 37]	0,047	0,047	0,047	0,045	0,046	0,045	0,046	0,047	0,047	0,046
Transport equipment [QSIC 38]	0,052	0,051	0,051	0,051	0,051	0,049	0,048	0,048	0,049	0,049
Furniture; other manufacturing [QSIC 39]	0,049	0,048	0,048	0,048	0,048	0,047	0,047	0,046	0,046	0,045

Source: Authors, based on Quantec I-O table in 2010 constant prices

Appendix 4: Relative structural significance across manufacturing sub-sectors, 2010–2019

	Year									
Manufacturing industry	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Food, beverages and tobacco [QSIC 30]	0,053	0,051	0,050	0,049	0,049	0,048	0,046	0,048	0,049	0,050
Textiles, clothing and leather goods [QSIC 31]	0,010	0,010	0,010	0,009	0,009	0,009	0,009	0,009	0,008	0,008
Wood and paper; publishing and printing [QSIC 32]	0,023	0,023	0,023	0,022	0,022	0,021	0,022	0,021	0,020	0,019
Petroleum products, chemicals, rubber and plastic [QSIC 33]	0,064	0,062	0,061	0,059	0,058	0,054	0,052	0,051	0,048	0,045
Other non-metal mineral products [QSIC 34]	0,009	0,009	0,008	0,008	0,008	0,007	0,007	0,007	0,007	0,006
Metals, metal products, machinery and equipment [QSIC 35]	0,054	0,055	0,054	0,054	0,053	0,052	0,050	0,050	0,050	0,048
Electrical machinery and apparatus [QSIC 36]	0,008	0,008	0,008	0,008	0,007	0,007	0,007	0,006	0,006	0,006
Radio, TV, instruments, watches and clocks [QSIC 37]	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003
Transport equipment [QSIC 38]	0,032	0,032	0,032	0,030	0,030	0,028	0,027	0,025	0,024	0,025
Furniture; other manufacturing [QSIC 39]	0,014	0,013	0,013	0,013	0,012	0,012	0,011	0,012	0,012	0,011

Source: Authors, based on Quantec I-O table in 2010 constant prices

Appendix 5: Average propagation length across manufacturing sub-sectors, 2010–2019

	Year									
Manufacturing industry	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Food, beverages and tobacco [QSIC 30]	0,061	0,062	0,062	0,063	0,063	0,062	0,060	0,061	0,062	0,063
Textiles, clothing and leather goods [QSIC 31]	0,057	0,057	0,057	0,055	0,055	0,053	0,052	0,054	0,054	0,052
Wood and paper; publishing and printing [QSIC 32]	0,064	0,064	0,064	0,063	0,063	0,063	0,063	0,064	0,063	0,061
Petroleum products, chemicals, rubber and plastic [QSIC 33]	0,047	0,046	0,044	0,046	0,044	0,044	0,042	0,043	0,038	0,039
Other non-metal mineral products [QSIC 34]	0,036	0,037	0,035	0,035	0,034	0,034	0,032	0,035	0,033	0,032
Metals, metal products, machinery and equipment [QSIC 35]	0,061	0,060	0,061	0,060	0,060	0,060	0,061	0,059	0,059	0,059
Electrical machinery and apparatus [QSIC 36]	0,057	0,056	0,057	0,054	0,054	0,052	0,053	0,053	0,053	0,053
Radio, TV, instruments, watches and clocks [QSIC 37]	0,048	0,048	0,048	0,045	0,046	0,045	0,047	0,048	0,049	0,046
Transport equipment [QSIC 38]	0,060	0,059	0,059	0,058	0,057	0,054	0,052	0,050	0,052	0,054
Furniture; other manufacturing [QSIC 39]	0,053	0,052	0,050	0,050	0,050	0,049	0,048	0,048	0,046	0,044

Source: Authors, based on Quantec I-O table in 2010 constant prices

Appendix 6: Sectoral purchase coefficient across manufacturing sub-sectors, 2010–2019

	Year									
Manufacturing industry	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Food, beverages and tobacco [QSIC 30]	0,046	0,046	0,043	0,042	0,041	0,047	0,053	0,047	0,046	0,049
Textiles, clothing and leather goods [QSIC 31]	0,019	0,020	0,019	0,019	0,019	0,021	0,022	0,021	0,019	0,017
Wood and paper; publishing and printing [QSIC 32]	0,024	0,023	0,024	0,023	0,023	0,024	0,025	0,023	0,023	0,020
Petroleum products, chemicals, rubber and plastic [QSIC 33]	0,172	0,159	0,158	0,143	0,148	0,133	0,129	0,123	0,131	0,113
Other non-metal mineral products [QSIC 34]	0,023	0,020	0,021	0,020	0,023	0,019	0,018	0,016	0,017	0,014
Metals, metal products, machinery and equipment [QSIC 35]	0,081	0,089	0,085	0,092	0,088	0,091	0,082	0,087	0,085	0,079
Electrical machinery and apparatus [QSIC 36]	0,018	0,018	0,018	0,019	0,018	0,018	0,016	0,015	0,013	0,012
Radio, TV, instruments, watches and clocks [QSIC 37]	0,007	0,007	0,007	0,008	0,008	0,007	0,007	0,006	0,005	0,004
Transport equipment [QSIC 38]	0,077	0,077	0,075	0,072	0,074	0,075	0,075	0,074	0,064	0,064
Furniture; other manufacturing [QSIC 39]	0,014	0,013	0,013	0,013	0,013	0,013	0,013	0,013	0,015	0,015

Source: Authors, based on Quantec I-O table in 2010 constant prices

Appendix 7: Inoperability measure across manufacturing sub-sectors, 2010–2019

	Year									
Manufacturing industry	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Food, beverages and tobacco [QSIC 30]	0,082	0,082	0,082	0,080	0,079	0,078	0,074	0,075	0,077	0,063
Textiles, clothing and leather goods [QSIC 31]	0,023	0,022	0,022	0,021	0,020	0,019	0,019	0,020	0,020	0,052
Wood and paper; publishing and printing [QSIC 32]	0,043	0,042	0,042	0,041	0,040	0,040	0,040	0,040	0,039	0,061
Petroleum products, chemicals, rubber and plastic [QSIC 33]	0,056	0,054	0,054	0,052	0,051	0,047	0,045	0,045	0,039	0,039
Other non-metal mineral products [QSIC 34]	0,010	0,010	0,010	0,009	0,009	0,008	0,007	0,008	0,007	0,032
Metals, metal products, machinery and equipment [QSIC 35]	0,069	0,069	0,069	0,067	0,067	0,066	0,065	0,063	0,062	0,059
Electrical machinery and apparatus [QSIC 36]	0,015	0,014	0,014	0,013	0,013	0,012	0,012	0,012	0,011	0,053
Radio, TV, instruments, watches and clocks [QSIC 37]	0,008	0,008	0,008	0,007	0,008	0,007	0,007	0,008	0,007	0,046
Transport equipment [QSIC 38]	0,047	0,046	0,046	0,043	0,042	0,038	0,034	0,032	0,032	0,054
Furniture; other manufacturing [QSIC 39]	0,026	0,024	0,024	0,022	0,023	0,021	0,020	0,020	0,020	0,044

Source: Authors, based on Quantec I-O table in 2010 constant prices