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Trends in and determinants of South African maize exports in the post-deregulation era

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Orientation: Agricultural plays a key role in South Africa's economy, but its exports are constrained by inadequate transport infrastructure, logistical bottlenecks and high production costs. Therefore, most agricultural products are transported to ports by road instead of the more economical rail. Product prices fluctuate with erratic domestic and international supply and demand, which affects competitiveness.

Research purpose: The study investigates how transport cost and logistical shortcomings have impacted South African maize exports and competitiveness.

Motivation for the study: Little prior research focused on the impact of transport and logistics on the competitiveness of agricultural exports in Africa. Maize, one of South Africa's leading agricultural products with still-to-be-tapped export potential, was used as an example.

Research approach/design and method: Trends in global maize exports and logistics performance are described, as well as South Africa's share and rankings. Domestic trends in rail and road transport are investigated together with historic costs. Regression analysis investigates determinants of South African maize export volumes.

Main findings: South Africa's logistics-related competitiveness is declining. Rising domestic transport cost has a statistically significant negative effect on maize export volumes while international prices show the expected positive effect. Separate equations for exports through harbours and border posts rendered different results.

Practical/managerial implications: Valuable insights are provided into the critical role of logistics efficiency in maize export competitiveness.

Contribution/value-add: Empirical findings provide a starting point for more in-depth studies in this area and more informed policy discussions on how the competitiveness of South Africa's agricultural exports can be enhanced.

Keywords: transport infrastructure; logistics; agriculture; maize; exports; competitiveness.

Introduction

Globalisation and the general interconnectedness of the world economy have not only produced great efficiencies but also heightened vulnerabilities. One such vulnerability is supply bottlenecks (or supply constraints) – a multifaceted phenomenon that can have a very adverse effect on global production networks. A well-publicised example was the Ever Given, the largest container ship in the world, running aground and blocking the Suez Canal for 6 days in March 2021. In less than a week, 370 ships were affected, resulting in an estimated loss of trade in the amount of $54 billion (Lee & Wong 2021). This excluded the cost to insurance companies and the political cost of the catastrophe.

Logistics make a significant contribution to a country's economy through investments in road, rail, sea and air transport operations, particularly for export purposes (Closs & Bolumole 2015). International maritime transport accounts for 90% of total freight volumes in the world, which means that any inefficiencies in or disruptions to this critical sector could have dire consequences for countries (Lin, Chang & Hsiao 2019; Zhang et al. 2019). The onset of the COVID-19 pandemic had a dramatic effect on the cost of logistics globally and the availability of traded goods. Initially, demand plummeted and some shipping companies even cancelled certain shipping routes to reduce costs (Menhat et al. 2021). However, surging demand from the second half of 2020 onwards created bottlenecks as governments continued to regulate export and import flows (Cullinane & Haralambides 2021).

South Africa is a significant player in the international shipping market, and because of the country's ideal location between the west, including parts of Europe, and the Middle East and China, any disruption to the international maritime transport industry will impact South Africa's logistics industry. The logistics industry supports and feeds into innumerable economic sectors, including retail, manufacturing and agriculture. In 2020, the transport sector contributed almost R319 billion to the South African economy (Stats SA 2022).

South Africa's agricultural sector is extremely reliant on efficient logistics, with large volumes of agricultural products, such as grain and oil seeds, being exported and imported annually. The grain industry, comprising barley, maize, oats, sorghum and wheat, is one of South Africa's leading agricultural sub-sectors, contributing over 30% to the country's total agricultural production (ITAC 2022). In 2020, the value of maize exports alone exceeded R9 billion, contributing to the substantial total agricultural exports that reached R168 billion (Department of Agriculture, Land Reform and Rural Development [DALRRD] 2023). Despite South Africa's potential to become a major agricultural producer, there are various constraints that are preventing the country from fully realising its potential and enhancing its agricultural competitiveness. Two of the main impediments are neglected transport infrastructure and high production costs. Not only are infrastructural shortcomings eroding the sector's export competitiveness but also the burden and cost of the resulting inefficiencies are often passed on to producers, putting additional strain on their profitability and long-term sustainability.

This article attempts to assess transportation obstacles within the South African maize export industry. This involves analysing the correlation between maize production volumes and exports, exploring port limitations, assessing the dynamics between road and rail transportation of maize and evaluating the responsiveness of South African maize exports regarding transport costs. The article will also discuss the impact of transport industry failures on the competitiveness of South African maize.

Background to South Africa's agricultural policy: From regulation to deregulation

South Africa's agricultural sector has undergone a series of legislative changes since the early 1930s, with maize exports having been subject to government regulatory control since the promulgation of the *Mielie Control Act No. 39 of 1931*. Under this Act, individuals, merchants and co-operatives were required to export a percentage of their maize purchases during a particular season, which was determined annually by the Maize Board.

The compulsory export of maize resulted in higher international demand, which boosted domestic maize prices. The higher domestic prices, in turn, had a positive effect on production levels and, because of fertiliser usage and better weed control, South Africa was in a strong position with respect to food security. However, producers had very little control over the price of their maize and had no say in any matters pertaining to the maize sector. This changed with the passing of the *Marketing Act of 1937*, which gave producers a voice through the establishment of the Mealie Industry Control Board. Originally, the *1937 Marketing Act* was an enabling Act, aimed mainly at stabilising producer prices in the wake of overproduction and low international prices. The Act was a significant milestone in the agricultural sector, as it laid the foundation for the creation of control boards[1] that determined who produced, handled, processed and traded agricultural commodities (Dreyer 2019). These boards also determined the prices that producers and processors would receive and even the profit margin that they could expect.

Following a transition period between 1937 and 1944/45, the Mealie Industry Control Board gave way to the Maize Board and the single-channel marketing system was introduced (Brits 1969). The Maize Board became the only buyer and seller of maize, acting through its co-operative agents throughout South Africa. Under the Board's direction, maize production volumes increased, which created a need for maize storage facilities. In 1952, the Minister of Agriculture announced the implementation of a long-term loan scheme for the building of grain silos, where the Land Bank would provide loans to prospective silo owners and/or operators (Van der Merwe 2012). Many agribusinesses took advantage of this opportunity to build silos in the maize-producing areas. These silos were constructed next to functioning railway lines as the Maize Board stipulated that bulk maize had to be transported via rail if the intended distance was more than 80 km (Uys 2015).

The single-channel marketing system, however, proved to be flawed and was eventually abandoned. During the 1970s and 1980s, the macroeconomic pressure that South Africa was facing led to the liberalisation of the financial system, which put the government's efforts to sustain control board subsidy arrangements in jeopardy (Dreyer 2019). Transformation initiatives and ongoing pressure from various quarters led to the formation of the Kassier Committee in 1992, which proposed the deregulation of the various control boards (Vink, Van Zyl & Kirsten 2000). As a result, agricultural marketing controls were reformed, and the passing of the *Marketing of Agricultural Products Act of 1996* paved the way for the closure of all control boards. Under the new Act, implemented in 1996 and still in force today, a free market pricing mechanism replaced control boards. Prices are now determined predominantly by both domestic and international supply and demand, import and export parity prices and tariffs (Bayley 2000) and not by the various control boards.

1.Control boards, established for each type of commodity (e.g. the Maize Board managing all maize-related issues), are regulatory bodies overseeing the agricultural sector. They play an important role in determining production, pricing and resource allocation to stabilize the market.

Major changes accompanied the passing of the *Marketing of Agricultural Products Act of 1996*. Notably, the Maize Board was abolished, which allowed prices to be determined by market forces, and the South African Futures Exchange (SAFEX) was established to facilitate the trading of standardised agricultural commodity contracts within a new free market structure. The first maize contracts were concluded in 1996 enabling price discovery and risk management in the post control board era.

Literature

Transport challenges in South Africa's maize export sector

By investigating recent trends in South Africa's maize exports, this article offers both theoretical and practical insights, with particular attention being paid to how transport-related shortcomings and challenges have impacted the export competitiveness of South Africa's maize sector.

To understand the dynamics in the country's maize export sector, it is important to examine the role of transport infrastructure in the South African context. A few studies have considered South Africa's maize export performance in the period following the dismantling of the Maize Board in 1996. In a 2014 publication, the Bureau for Food and Agricultural Policy (BFAP) observed that domestic maize prices were much more stable when they were still set by the Maize Board and for many years were at levels higher than export parity. These high prices encouraged increased production, surpluses and exports (albeit sometimes at a loss), with the Board following a surplus-removal approach. Since the adoption of a free market system, market forces – influenced by both local and international supply and demand – have resulted in market prices that reflect a reaction to production surpluses through increased exports or production shortfalls through increased imports. Market prices therefore move between export parity and import parity depending on local supply and demand, with export parity and import parity determined by international market prices based on international supply and demand (BFAP 2014).

Apart from the impact of market forces and new competition on agricultural exports, Sihlobo (2016) examined the competitiveness of the South African maize sector specifically. He found that maize producers are not competitive and compare unfavourably to other maize producers, such as Argentina, Ukraine and the United States. The high cost of production in South Africa's maize sector is mainly because of large volumes of fertilisers, pesticides and fuel being imported at relatively high prices. Van der Merwe et al. (2016) echoed these findings. They similarly observed that South African wheat producers are not competitive internationally, which is ascribed to the dismantling of the Wheat Board and diminishing land area under production.

Although on a different continent, a South American study underlined the importance of a factor not mentioned in the aforementioned South African studies – that of logistics (Fuller et al. 2003). The authors explain how Argentinian exports of maize and soybean were constrained by inefficiencies and a lack of maintenance of transport infrastructure in that country. In the face of these problems, Argentina lost market share in the United States, a competing export supplier. However, the deliberate steps that Argentina took to privatise and modernise its export facilities resulted in a reduction in transport costs, which compared favourably with those in the United States and increased grain export volumes.

South African maize exports

Port constraints and global maize export landscape

South Africa has two deep-sea grain ports – Durban (with three bulk grain export or import terminals) and East London (with one terminal). South Africa can, at maximum capacity, export seven supermax vessels of 55°000 tonnes each per month through the three Durban terminals (Van der Vyver 2022). The port of East London resumed maize exports during the 2021/22 marketing season. Prior to that, no maize exports had been shipped from East London since the 2011/12 marketing season (SAGIS 2022). Two factors have contributed to this.

The first (most significant) factor, which has prevented South Africa from fully realising its agricultural potential and capitalising on the port of East London, is the draft in the port, which is only 10.4 m. This means that the facility can accommodate only what are known as 'handysize' vessels, with a carrying capacity of around 40°000 tonnes. To compete in the export of bulk grains, the port needs to expand its facilities to accommodate larger vessels. The second factor is that, despite the terminal being operational, it still needs a major upgrade to accommodate the increasing numbers of vessels that are expected to arrive at the port. Among the necessary investments that the port should make are the construction of a permanent weighbridge, an overhead gantry and a road offloading facility.

To contextualise South Africa's maize exports against those of its global competitors, data were sourced from Comtrade. According to the International Trade Centre's (ITC) Harmonized System, maize is classified in product line 'HS100590', which treats maize as a homogeneous product and does not distinguish between white and yellow maize. Table 1 presents the share of global maize exports per country, ranked according to each country's individual contribution in 2020.

For example, in 2020, South Africa was responsible for 1.46% of global maize exports. Since 2007, this share has fluctuated between 0.09% (in 2007) at its lowest point and 2.65% (in 2011) at its highest point. In 2020, the United States was responsible for 26.99% of global maize exports. The country's lowest

TABLE 1: Shares in global maize exports per country (%).

Exporter	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007
United States	26.99	27.34	45.70	46.02	36.50	31.21	36.16	22.59	33.30	43.13	47.26	52.14	57.34	53.55
Argentina	17.40	20.93	15.17	-	15.10	11.39	11.25	19.32	16.64	13.34	14.65	8.72	14.47	11.85
Brazil	16.79	25.54	14.24	22.76	13.36	18.39	13.08	21.74	18.71	8.24	10.22	7.41	5.60	10.18
Ukraine	14.13	-	-	-	9.64	11.15	11.22	-	-	6.17	-	-	-	-
Romania	3.10	4.22	3.09	3.28	2.19	3.35	2.41	2.58	2.13	2.03	2.05	1.74	0.61	0.40
France	2.65	2.59	3.61	4.08	3.63	4.72	4.47	6.38	6.18	5.91	6.31	7.82	7.37	6.14
European Union	2.59	2.80	1.52	1.54	1.53	2.36	1.44	2.80	1.89	2.01	1.71	1.36	1.26	0.77
Hungary	1.97	1.88	1.60	2.90	1.58	2.62	1.80	1.98	3.81	3.09	3.34	4.06	3.56	5.30
Yugoslavia	1.80	1.79	0.84	1.32	1.23	1.25	1.52	0.56	1.89	1.36	1.49	1.54	0.41	0.37
South Africa	1.46	0.90	1.54	2.21	1.11	0.63	1.52	2.42	1.71	2.65	1.82	2.39	1.98	0.09
Bulgaria	1.45	1.63	0.96	0.90	0.88	0.78	1.26	1.68	0.76	0.83	0.75	0.53	0.17	0.20
Russian Federation	1.13	2.17	3.08	4.18	3.13	2.23	2.36	2.05	2.03	0.50	0.20	1.10	0.13	0.06
India	1.02	0.36	0.70	0.61	0.39	0.74	2.73	4.28	-	3.35	2.46	2.97	-	-
Paraguay	0.94	1.42	0.81	1.22	1.24	1.64	1.20	1.61	1.95	1.09	1.14	1.38	0.73	1.46
Poland	0.83	0.77	0.83	0.97	0.53	0.47	0.60	0.88	1.00	0.27	0.15	0.18	0.06	0.07
Myanmar	0.72	0.32	-	-	0.69	1.27	1.20	0.99	0.33	0.16	-	-	-	-
Croatia	0.61	0.53	0.35	0.40	0.29	0.33	0.23	0.10	0.10	0.14	0.17	0.37	0.14	0.02
Netherlands	0.56	0.83	0.71	0.86	0.39	0.50	0.54	0.49	0.45	0.27	0.14	0.28	0.44	0.34
Canada	0.52	0.71	1.25	1.20	1.03	0.40	1.24	1.66	0.71	0.95	0.94	0.29	0.80	0.42

Source: Comtrade, 2022, *UN Comtrade database*, viewed 14 June 2022, from https://comtrade.un.org/

TABLE 2: Rankings in global maize exports (%).

Exporter	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007
United States	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Argentina	2	3	2	-	2	3	3	3	3	2	2	2	2	2
Brazil	3	2	3	2	3	2	2	2	2	3	3	4	4	3
Ukraine	4	-	-	-	4	4	4	-	-	4	-	-	-	-
Romania	5	4	5	5	7	6	7	7	6	9	7	8	12	14
France	6	6	4	4	5	5	5	4	4	5	4	3	3	4
European Union	7	5	9	8	9	8	12	6	9	10	9	11	7	9
Hungary	8	8	7	6	8	7	9	10	5	7	5	5	5	5
Yugoslavia	9	9	12	9	12	12	11	18	10	11	10	9	16	15
South Africa	10	12	8	7	13	16	10	8	11	8	8	7	6	24
Bulgaria	11	10	11	14	15	13	13	11	14	14	14	15	21	19
Russian Fed	12	7	6	3	6	9	8	9	7	16	22	12	25	27
India	13	18	16	16	22	14	6	5	-	6	6	6	-	-
Paraguay	14	11	14	10	11	10	15	13	8	12	11	10	11	7
Poland	15	14	13	12	19	19	18	16	13	24	28	28	30	25
Myanmar	16	19	-	-	17	11	16	14	23	27	-	-	-	-
Croatia	17	16	18	19	24	22	24	33	31	29	25	21	24	32
Netherlands	18	13	15	15	21	18	19	19	20	23	29	24	15	16
Canada	19	15	10	11	14	21	14	12	15	13	13	23	9	13

Source: Comtrade, 2022, *UN Comtrade database*, viewed 14 June 2022, from https://comtrade.un.org/

share was in 2013 at 22.58%, while its highest share was in 2008 at 57.34%.

Table 2 ranks the countries according to their contribution to global exports. In 2020 and 2014, South Africa was the 10th biggest maize exporter in the world. The country's highest ranking during these 14 years was 6th place in 2008, with a few 7th and 8th places as well. During this period, the top rankings were quite stable.

Although various factors such as distance from an importing country, the exchange rate and domestic prices all play a role in a country's export performance, logistics remains a crucial factor. Since 2007, the World Bank has published a Logistics Performance Index (LPI) covering 160 countries. The index is based on the reported experiences of operators on the ground, both in the country in which they are based and the countries with which they trade. The LPI consists of an overall index value as well as indices for its different components: customs (CUSTOMS), infrastructure (INFRA), international shipment (SHIP), logistics quality and competence (LOGIS), tracking and tracing (TRACK) and timeliness (TIME). The LPI shows values of between 1 and 5, where 1 is low (poor) and 5 is high (good).

Table 3 provides a summary of the various LPI index values for South Africa and South Africa's corresponding rankings (out of 160 countries) for each of the years in question (in brackets).

In respect of some of the indicators, the 2016 values seem to be outliers when viewed against the general trend. However,

TABLE 3: South Africa: Logistics Performance Index components and rankings.

Year	LPI	CUSTOMS	INFRA	LOGIS	SHIP	TIME	TRACK
2007	3.53 (24)	3.22 (28)	3.42 (26)	3.54 (25)	3.56 (22)	3.78 (31)	3.71 (18)
2010	3.46 (28)	3.22 (31)	3.42 (29)	3.59 (25)	3.26 (31)	3.57 (57)	3.73 (24)
2012	3.67 (23)	3.35 (26)	3.79 (19)	3.56 (24)	3.50 (20)	4.03 (20)	3.83 (16)
2014	3.43 (34)	3.11 (42)	3.20 (38)	3.62 (24)	3.45 (25)	3.88 (33)	3.30 (41)
2016	3.78 (20)	3.60 (18)	3.78 (21)	3.75 (22)	3.62 (23)	4.02 (24)	3.92 (17)
2018	3.38 (33)	3.17 (34)	3.19 (36)	3.19 (39)	3.51 (22)	3.74 (34)	3.41 (35)

Source: World Bank, 2022, *Logistics performance index*, viewed 11 April 2022, from https://lpi.worldbank.org/
LPI, Logistics Performance Index; INFRA, infrastructure.

apart from SHIP (international shipments), all the index values were lower in 2018 than in 2007 and all the rankings were worse. Transport costs make up the bulk of logistics costs, with fuel contributing more than 28% (based on 2014 values) to transport costs. These are expected to increase in the wake of the higher fuel prices. The unfortunate picture, based on international indices, painted in Table 3 is of a country losing ground in the international logistics arena.

Shifting transportation trends: From rail to road

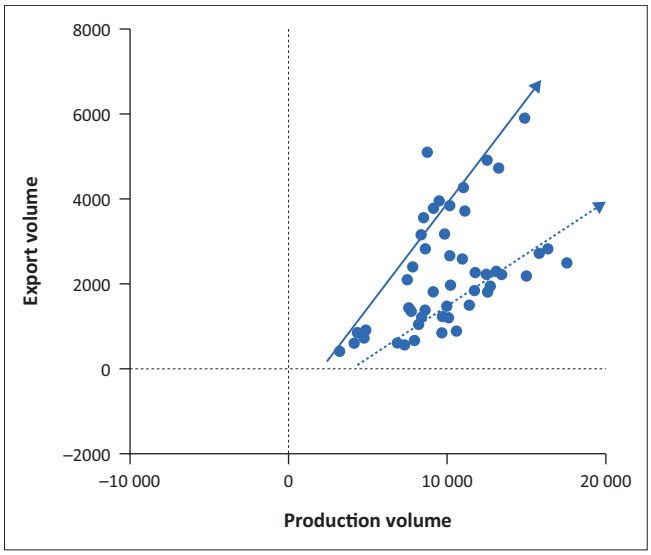
Figure 1 shows a positive relationship between domestic maize production and exports – as would be expected. The figure is based on data from Comtrade for the period 1971–2021. The vertical axis shows maize exports measured in thousands of tonnes while the horizontal axis shows total production measured in thousands of tonnes.

A closer inspection of Figure 1 reveals two distinct relationships. The solid line connects data points in the period before 1994 when a larger proportion of production was exported. The dashed line relates to data after 1994 and after the disbanding of the Maize Board. The latter is therefore more representative of the relationship between exports and production which is mainly determined by local and international market forces. It indicates that a smaller proportion of total production was exported after 1994.

Figure 2 confirms the relationship observed in Figure 1. Export volumes have been substantially lower since 1994, even though production volumes have continued to increase. One possible explanation for this, according to the BFAP (2014), is high domestic prices in the post-1994 period, whereas prior to that, the Maize Board followed a surplus-removal approach to ensure price stability.

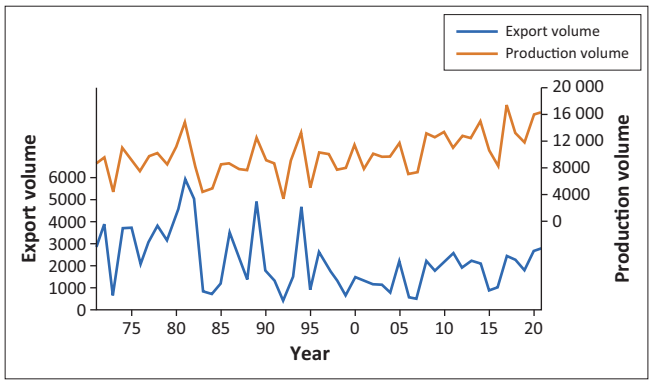
Established in 1997, the South African Grain Information Service (SAGIS) gathers and publishes monthly data pertaining to grain production in South Africa. Their database, which was launched in 2001, has provided valuable information on the performance of South African grain markets since the dismantling of the control boards. Data are available on production, demand, supply, stock levels, certain cost items, imports and exports, and related topics.

Figure 3 sheds some light on two cost components: the rand per tonne financing cost (RPERTFINANCE) and the rand per tonne loading cost (RPERTLOADCOST) for the period 2001–2020. The financing cost in 2020 was still lower than in



Source: Comtrade, 2022, *UN Comtrade database*, viewed 14 June 2022, from https://comtrade.un.org/

FIGURE 1: South African maize production and trading volumes, 1971–2020.

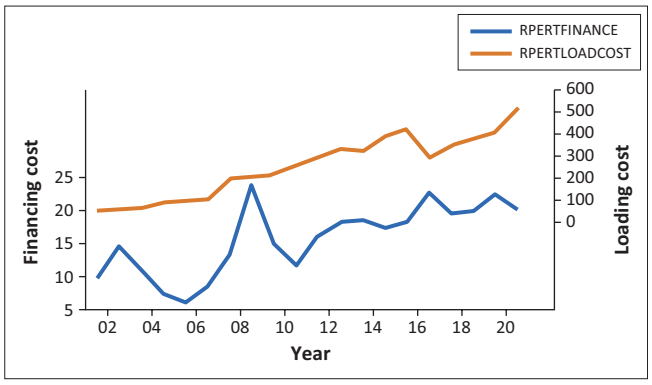


Source: Comtrade, 2022, *UN Comtrade database*, viewed 14 June 2022, from https://comtrade.un.org/

FIGURE 2: Trends in maize production and trading volumes (measured in tonnes), 1971–2021.

2008 – because of a lower interest rate. The loading cost, however, had increased almost 10 times from R55.55 in 2001 to R517.52 in 2020. Another striking, but related, trend is evident in Figure 4.

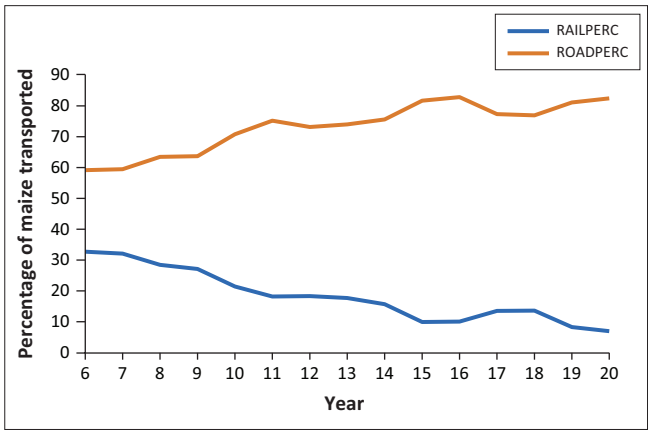
Figure 4 shows the percentage of maize transported by rail (RAILPERC) for each of the years in question as well as the residual percentage of maize transported by road (ROADPERC). These figures have only been available since 2006, but the trend is alarming. In 2007, 32.67% of South African maize was still being transported by rail and 59.15% by road. By 2020, the contribution of rail transport had decreased to a mere 6.71%,



Source: South African Grain Information Service (SAGIS), 2022, *Historical price data*, viewed 06 May 2022, from https://www.sagis.org.za/historical%20prices%20local.html

RPERTFINANCE, rand per tonne financing cost; RPERTLOADCOST, rand per tonne loading cost.

FIGURE 3: Financing and loading costs in Rand per tonne, 2001–2020.



Source: South African Grain Information Service (SAGIS), 2022, *Historical price data*, viewed 06 May 2022, from https://www.sagis.org.za/historical%20prices%20local.html

RAILPERC, percentage of maize transported by rail; ROADPERC, residual percentage of maize transported by road.

FIGURE 4: Percentages of maize transported by rail and road, 2006–2020.

with 82.44% of maize being transported by road. As was to be expected, there was a high positive correlation between the rising cost of transport in Figure 3 and the increasing burden on road transport in Figure 4.

According to Van der Vyver (2022), road transport costs about R220 per tonne more from Reitz (an ideal export location and on a main railway track to Durban) than rail transport. The average load size for maize transported by road is about 32 tonnes per truck. About 1700 trucks are needed to load one supermax vessel of 55°000 tonnes for export. If the share of rail transport could once again rise to 35% (which is the maximum rail capacity of one terminal in Durban), a cost saving of R4235°000 per supermax vessel could be achieved. This cost saving would exclude the opportunity cost of moving the load by road.

Regression analysis on maize export volumes

Although current SAGIS data are available for only 20 years, they are the only data capturing the dynamics in South Africa's maize export sector since the closure of the Maize Board, when market forces came into play. An added advantage of this source of data is that export

TABLE 4: Regression results.

Explanatory variable	Dependent variables for maize exports		
	Regression 1 Log (TotalExports)	Regression 2 Log (ExportsHarbours)	Regression 3 Log (ExportsBorderposts)
Constant	-48.52	-215.86	-5.59
	(-4.84)	(-5.14)	(-0.46)
Log (TotalSupply)	3.68	13.32	1.23
	(6.02)	(5.19)	(1.67)
Log (SAFOB)	1.08	5.09	-0.05
	(3.37)	(3.78)	(-0.12)
Log (RperTLoadcost)	-0.63	-3.20	-0.16
	(-3.32)	(-3.99)	(-0.69)
Observations	20	20	20
R^2	0.7574	0.6804	0.1759
DW	1.910	1.774	2.041

Note: All estimated coefficients in regressions 1 and 2 are statistically significant at 1%. None of the estimated coefficients in regression 3 is statistically significant, not even at 10%.

SAFOB, South African Free On Board; DW, Durbin-Watson; RperTLoadcost, rand per tonne loading cost.

volumes are reported separately for white and yellow maize, which does not happen with the Comtrade data (as mentioned earlier) and is a major weakness. There are distinct differences between the export destinations of white and yellow maize, respectively. In 2021, only 24% of white maize exports did *not* go to Africa (Botswana, Eswatini, Lesotho, Mozambique, Namibia, Zimbabwe and Angola), with 24% of all exports going to Italy (SAGL 2022). It was the complete opposite for yellow maize exports. Eswatini absorbed 3% of exports and the bulk went to other non-African destinations: Taiwan (29%), Japan (28%), Vietnam (17%), Korea (14%) and Spain (4%).

For the purpose of empirically investigating the potential influence of various factors on maize export volumes since 2001, three regression equations were estimated, the results of which are reported in Table 4. Unit root tests were performed for all the variables – see Appendix 1. All three dependent variables can be regarded as stationary. The null hypotheses of unit roots can be rejected with probabilities of between 0.0070 and 0.0665. The explanatory variables appear to be non-stationary. The mixture of stationary and non-stationary variables ideally would be dealt with in an ARDL specification. However, the small sample size ruled out the use of traditional time series estimation techniques. The significant results obtained with relatively few degrees of freedom are nevertheless encouraging. The reported Durbin-Watson (DW) values close to the required value of 2 are a crude indication of the absence of spurious regression results. A DW smaller than the R-squared value provides an early indicator of spurious regressions – something that is not present in the reported results. In a final attempt to informally test for spurious regression, the residuals of all three regressions were found to be stationary.

Three different indicators of export volumes were employed as dependent variables in each of the three equations reported in Table 4. Equation 1 dealt with total export volumes, while equations 2 and 3 dealt with exports through South African ports and border posts, respectively. The explanatory variables are listed in the first column. It was

expected that export volumes would increase as the total production and supply of maize in South Africa increased. The Free on Board (FOB) price obtained by South African exporters was also expected to show a positive relationship. As the only included cost item, the loading cost per tonne was expected to have a negative impact on export volumes.

All the estimated coefficients in regression 1 displayed the correct *a priori* sign and were statistically significant at 1%. Higher domestic production volumes therefore lead to increased exports, higher prices encourage exports, and increased transport costs discourage exports. Regression 2 focused only on maize exports through South African ports. The reported relationships observed from equation 1 are confirmed for port exports – with even larger coefficients in absolute terms and potentially stronger relationships. For every 1% increase in FOB, export volumes through ports are expected to increase by 5.09% – a very elastic relationship. By contrast, a 1% increase in loading costs would reduce exports through ports by 3.20%. In a surprising finding, none of the estimated coefficients in regression 3 was statistically significant and FOB even displayed a coefficient with a wrong sign. The low adjusted R^2 of regression 3 provides further evidence that maize exports through South African border posts cannot be explained by expected market forces. Higher FOB and lower loading costs do not lead to higher export volumes. This is because logistical impediments at the ports are limiting more exports. For example, the port of Durban has a maximum maize export capacity of between 200°000 and 250°000 tonnes per month.

Lower transport cost will either result in earlier export opportunities at a higher domestic price or an improved farm margin at a lower domestic price. Exports to neighbouring countries are less sensitive to transport costs. Neighbouring countries need to procure maize from an overseas source, ship it to the closest port and then transport it to their country. If they import from South Africa, the only costs that are added are transport, bagging, insurance, financing and other administrative costs. This results in a higher export price for South African exporters to Africa – not reflected in the FOB price. Many countries have restrictions on genetically modified crops which limits South Africa's export opportunities in those countries. Clearly, then, maize exports shipped through ocean ports are influenced by a different set of factors from maize exports transported through inland border posts.

The researchers attempted to arrive at regression estimates, similar to those in Table 4, for separate sub-samples of white and yellow maize. However, the results were less significant than for overall maize exports. One possible explanation for this is the absence of exports through ports in some of the years in the sample. This is an avenue to explore in future studies when more data become available.

Discussion and conclusion

Given rising production volumes and a near-constant domestic demand for maize, it is imperative that exportable surpluses are generated year on year. Rising export volumes imply that South African prices will trade at export parity for longer periods. Prior research, as indicated by Fuller et al. (2003), underlines the importance of exportable surpluses in maintaining domestic prices at export parity. This not only means higher export volumes but also that maize is made available to the domestic market at the lowest possible price. This is beneficial for industries depending on commodities as their major input, such as maize millers and feed manufacturers, while also promoting food security.

The ability of South Africa to compete in the global grain market is becoming more and more important. South Africa must ensure high-quality products at competitive prices to be able to play in the international market. While there are no question marks over the quality of South African maize, this study confirms the results of a study by Kapuya and Sihlobo (2014) and Havenga et al. (2014) that transport costs (shipping costs included) directly impact South Africa's ability to compete against other maize-exporting countries. The higher the transport cost, the lower the domestic price must be to remain competitive. High transport costs will harm the financial position of grain farmers who find themselves in an escalating cost–price squeeze.

South Africa's logistics-related competitiveness is on the decline, as seen by the weaker LPI in Table 3, with LOGIS and TRACK showing significant changes. These findings align with results from a study by Bogetic and Fedderke (2005). The shift towards road transport and the decline in rail usage contribute to increased costs, negatively impacting export volumes. South African producers have come to rely more heavily on road transport, with the percentage of grain moved by rail declining from 35% to a current low of about 7%. Road transport is substantially more expensive than rail transport (also excluding the cost of maintaining the road surface). The higher cost of road transport has a direct impact on South Africa's export volumes which show a negative and statistically significant relationship with transport costs.

Harbours serve as a gateway for South Africa's exports, a study by Petterson (2021) stresses their role in linking various economic sectors. Deep-sea exports take place through Durban and East London ports. The overland movement of exports to and from the port of East London is limited to road transport as there is no working railway line from Springfontein (a major railway junction between Gauteng, Port Elizabeth and East London) in the Free State province to East London. This puts a further damper on South Africa's ability to export surplus volumes. Research by Mlambo (2021) indicated the direct link between poor efficiency in ports and adverse economic performance in South Africa. If South Africa is not able to move enough surplus volumes to export markets, future maize prices may trade even lower than export parity. This will have a negative effect on the sustainability of the maize sector and food security in South Africa. Similar conclusions were drawn from a study by van

der Vyver (2022) emphasising the direct impact of inefficient transport on the overall growth and productivity of the grain industry. However, if South Africa could follow the example of Argentina (Fuller et al. 2003) and improve its transport infrastructure, it will go a long way towards boosting export performance and competitiveness.

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Competing interests

The authors have declared that no competing interest exists.

Authors' contributions

M.G. was responsible for the conceptualisation and writing of the article. A.P. was responsible for the conceptualisation, data download and data analysis of the article. A.F. was responsible for the conceptualisation and writing of the article.

Ethical considerations

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Data availability

The data that support the findings of this study are not openly available due to confidentiality and are available from the corresponding author, A.P., upon reasonable request.

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Appendix starts on the next page →

Appendix 1

TABLE 1-A1: Unit root tests.

Variables	Lag length (AIC)	Probability
Dependent variables		
Log(TotalExports)	0	0.0665
Log(ExportsHarbours)†	1	0.0070
Log(ExportsBorderposts)†	1	0.0173
Explanatory variables		
Log(TotalSupply)	0	0.2750
Log(SAFOB)†	0	0.3595
Log(RperTLoadcost)†	0	0.5525

†, Warning: probabilities and critical values calculated for 20 observations may not be accurate for a sample size of 19.