



Research Article

Socio-economic impact assessment of CBAM on the South African economy

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Abstract

The European Union's Carbon Border Adjustment Mechanism (CBAM) is a regulatory framework aimed at pricing carbon emissions embedded in imported goods. This presents substantial risks for South Africa's carbon-intensive industries. The study aims to determine the potential socio-economic effects of CBAM on South Africa's export industries, with an emphasis on the iron & steel, aluminium, cement, and fertiliser industries. Using the macroeconomic impact model (MEIM), the socio-economic effects were quantified. Three scenarios were explored, and under the mid-case scenario, the results reveal an estimated total loss of approximately R10.2 billion (0.21% of real GDP) in GDP, R20.3 billion in capital formation, R7.0 billion in household income, R2.7 billion in government revenue and R4.8 billion in net exports as a result of the imposition of CBAM across four industries (iron & steel, aluminium, fertiliser and cement). About 18 100 FTE jobs are also estimated to be lost. The decline in government revenue is estimated to leave about 26 251 grant beneficiaries, 599 educators, 126 hospital beds, 21 doctors and 134 low-cost houses unfunded. The iron & steel industry is estimated to be the most impacted, followed by aluminium, due to its large export base to the EU. These results highlight the need to decarbonise the production processes of these industries by 2030 to mitigate these impacts. Enhancing decarbonisation strategies in South Africa, such as improving energy efficiency, material efficiency and substitution, and investing in clean energy technologies, is crucial in the face of changing global trade flows.

Keywords: Carbon Border Adjustment Mechanism (CBAM), South Africa, Decarbonisation, Export industries, Socio-economic effects

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1 Introduction

As the world contends with the challenges created by climate change, international regulatory frameworks such as the Carbon Border Adjustment Mechanism (CBAM) in Europe, the carbon pricing border adjustments in the United States and the output-based pricing system (OBPS) in Canada are gaining traction. Of these international regulatory frameworks, the European Union (EU) CBAM, which became fully operational in January 2026, is the most developed and formalised. CBAM is a regulatory measure that aims to price carbon emitted during the production of carbon-intensive goods exported to the EU countries (European Commission, 2024). The mechanism encourages countries that export to the EU to adopt low-carbon practices in their production processes while levelling the playing field for domestic industries in the EU (Monkelbaan & Figures, 2022). In addition, the mechanism aims to prevent carbon leakages (European Commission, 2024; Monkelbaan & Figures, 2022). These leakages occur when companies relocate their production to countries with less stringent emissions regulations. Therefore, CBAM intends to impose a carbon price on these imported products.

The CBAM applies to products with a high risk of carbon leakage, such as iron & steel, cement, fertiliser, aluminium, hydrogen, and electricity (European Commission, 2024; International Carbon Action Partnership, 2023; KPMG, 2023). The CBAM transitional phase from 2023 to 2025 initially required importers to report carbon emissions data in a simplified system. The transitional phase of the CBAM was designed to (1) serve as a pilot and learning phase for the importers, producers, and authorities involved, (2) collect information on the emissions to refine the methodology for calculating the embedded emissions, and (3) align the price of carbon produced in the EU with the price of carbon-intensive goods imported into the EU. Since entering its definitive regime in January 2026, CBAM requires the purchase of certificates that are priced based on the carbon market price in the EU Emissions Trading System (ETS) to ensure compliance with international trade laws. Companies that fail to provide acceptable emissions data will face punitive default emissions values, increasing the cost of trading with the EU.

The CBAM could impact the trade competitiveness of various countries based on each country's emission intensity of its production process and trade intensity (Durant et al., 2021). In addition, this regulatory measure can lead to significant changes in trade effects and employment, especially in developing countries. For South Africa, the implications of the CBAM are particularly concerning for critical carbon-intensive export industries, such as iron & steel, aluminium, cement, and fertiliser, which are vital to the country's economy. These selected industries are critical industries that contribute significantly to employment, industrial production, and foreign exchange earnings in South Africa. However, the carbon-intensive nature of their production processes puts them at risk under the new international trade landscape shaped by the CBAM. As global markets increasingly demand lower-carbon products, South African exports could face competitive disadvantages, potentially leading to reduced market access and economic losses. To mitigate the adverse effects of CBAM and remain competitive in trade, carbon-intensive sectors are required to consider measures to reduce emissions, such as investing in clean energy technologies, technology innovation, and energy efficiency upgrades (Li et al., 2026).

Given this context, this study aims to quantify the socio-economic impacts of export reductions of carbon-intensive industries due to the implementation of CBAM. This study

assumes that failure to decarbonise the selected industries (iron & steel, aluminium, cement, and fertiliser) by 2030 would lead to penalisation and, ultimately, to the reduction of South African exports to countries that implement instruments such as the CBAM.

The study is structured as follows: Section 2 covers the empirical literature review on the impacts of CBAM. Section 3 presents an overview of South Africa's trade with the European Union in the selected commodities expected to be impacted by the CBAM. Section 4 covers the methodology, which summarises the macroeconomic impact model (MEIM) adopted by the study. Section 5 summarises the results of the study, and their implications are discussed in Section 6. Lastly, Section 7 covers the conclusion of the study.

2 Empirical literature review

Many studies have confirmed that the implementation of the CBAM will result in export reductions for EU trading partners, particularly developing countries characterised by high carbon-intensive production processes (Aarrestad & Nytrøen, 2021; AFC & LSE, 2023; Baker et al., 2022; Eicke et al., 2021; Gergondet, 2021; Gu et al., 2023; Magacho et al., 2023; Perdana & Vielle, 2022).

These studies adopted different models to assess the impacts of CBAM. For example, Baker et al. (2022) used the partial equilibrium model to analyse the impact of CBAM and found that South Africa, followed by Egypt and Morocco, will be the most affected by the CBAM, with the most affected sectors being iron & steel, aluminium and fertiliser. Magacho et al. (2023) used trade data and a Multi-Regional Input-Output (MRIO) model. Their findings are similar to those of Baker et al. (2022) where it was found that South Africa and other countries such as Turkey, the USA, South Korea, Ukraine and BRICS will be the most impacted by the implementation of CBAM, particularly on iron & steel exports. The study further indicated that the impact of the implementation of CBAM will be proportional to the exports of each country to the EU, with many developing countries facing a loss of approximately 2% and 1% of their export and production capacities, respectively.

AFC & LSE (2023) used a set of models, including the Computable General Equilibrium (CGE), the New Trade Quantitative Model (NTQM) and the Ricardian models, for their analysis. They found that African countries will be the most affected in terms of export reductions. For instance, the exports of aluminium, iron & steel, fertiliser, and cement from Africa to the EU are estimated to decrease by 13.9%, 8.2%, 3.9% and 3.1%, respectively, resulting from the implementation of CBAM. In addition, the CBAM is estimated to reduce Africa's GDP by 0.91% and will render the production of these industries less competitive. Perdana & Vielle (2022) also used the CGE model, but the GEMINI-E3 version, to assess and quantify the implications of the EU CBAM on EU trading partners. The implications will be detrimental to Less Developed Countries (LDCs) in particular, and the analysis confirmed a significant welfare loss for LDCs resulting from declining exports.

Merven et al. (2023) used the SATIM-GE model to assess the impacts of CBAM on GDP and inequalities in South Africa. They found that South Africa's GDP will decrease by 0.3% in 2030 and 0.9% in 2050, and inequalities will be exacerbated due to reduced exports as a result of the implementation of CBAM. Gu et al. (2023) used the Global Trade Analysis Project (GTAP) to explore the economic effects of the EU CBAM on China, India, Brazil, and South Africa, and found that the policy will negatively impact economic development,

welfare, trade levels, and the output of energy-intensive industries in these countries.

Studies which also assessed the impacts of the CBAM but whose assessment models were not clear include Aarrestad & Nytrøen (2021), Eicke et al. (2021), Durant et al. (2021) and Leukers (2022). Aarrestad & Nytrøen (2021) found that reduced imports of cement and aluminium products by Norway will severely affect South Africa, as well as countries such as Canada, Japan, those in Asia and the Pacific, and those in the Middle East. Eicke et al. (2021) found that African countries, including South Africa, are at high risk of being the most impacted by CBAM. Durant et al. (2021) assessed several types of impacts of the implementation of CBAM and found that it will lead to reduced CO₂ emissions, carbon leakage, employment, welfare, and exports. The trade patterns will also shift in favour of countries where production is relatively carbon efficient. Additionally, a welfare gap will be created through the imposition of a \$44 carbon tax per tonne of CO₂, which is expected to result in a \$2.5 billion increase in income for developed countries and a \$5.9 billion decrease in income for developing countries. Exports from the sectors targeted by CBAM will also fall by 1.4% for developing countries. The countries to experience a significant export reduction in energy-intensive sectors include the Russian Federation, Serbia, Bosnia, Herzegovina, Ukraine, Central Asia, Egypt, and South Africa. The highest reductions in GHG emissions are expected to be observed in countries such as China, India, Russia, and, to a lesser extent, in South Africa, Serbia, Bosnia and Herzegovina (Durant et al., 2021). Similar to Merven et al. (2023), Leukers (2022) also found that the introduction of the CBAM will exacerbate inequalities in South Africa due to reduced exports and increased unemployment.

Other grey qualitative literature includes TIPS' published series of policy briefs related to CBAM. For example, a policy brief on the implications of the CBAM proposal for South Africa notes that CBAM will impose significant compliance costs and disrupt trade flows for South Africa (TIPS, 2023b). TIPS (2023a) argues that beyond trade disruptions, there is going to be a fragmentation of the multilateral systems across countries within the Global South. Consequently, governments and exporters need to start evaluating the administrative and financial implications for businesses and industries, as well as increasing efforts to align their business models with a low-carbon future. Reforms to the carbon tax are also necessary to reflect international carbon pricing (TIPS, 2023b). The absence of such reforms risks South Africa paying more in CBAM charges to the EU compared to what it collects domestically through its carbon tax, resulting in significant revenue leakage (Gasealahwe et al., 2024; TIPS, 2026).

In summary, despite having applied different models, these studies discovered that the implementation of CBAM will result in export reductions in the iron & steel, aluminium, fertiliser, and cement sectors. Other negative implications related to CBAM include GDP losses, job losses, increased poverty levels, inequalities, and welfare losses. However, there are also positive implications, including reduced carbon emissions. These risks compel carbon-intensive industries to consider decarbonising their production processes to maintain their export market share in the EU. The risks will be severe, particularly for developing countries, which lack the requisite resources and technologies. As a result, developing countries should receive supportive measures such as climate subsidies, concessional loans, and revenue from CBAM. Furthermore, African countries must prioritise the implementation of supportive regulations designed to attract investment in clean energy technologies (Baker et al., 2022). South Africa has started amending its regulations to support the rollout of clean energy technologies, along with plans such as JET-IP that seek to mobilise public,

concessional and private funding for clean energy technologies that can be considered for decarbonising the production processes of carbon-intensive industry (South African Government, 2024; The Presidency, 2022).

Studies on the implications of CBAM exist (Gasealahwe et al., 2024; TIPS, 2023a, 2023b, 2026) in South Africa, including those that studied the impacts on GDP, employment and inequalities such as Merven et al (2023). Panel studies also exist, including Baker et al. (2022), Magacho et al. (2023), Gu et al. (2023), Durant et al. (2021) and Leukers (2022). It is against this background that the contribution of the current study to the existing body of knowledge is the examination of the socio-economic impacts at a detailed industry level. That is, examining the propagation of resulting export demand loss due to CBAM through detailed inter-industry production linkages of the economy. The study also provides the impacts on government social expenditure programmes, such as the availability of educators, hospital beds, doctors, affordable housing, and beneficiaries of grants.

3 South Africa's trade with the European Union

The European Union (EU) is the largest trading partner of South Africa (SA) and the largest foreign investor (accounting for 72% of South Africa's total FDI stock) (SA Embassy, n.d.).

Over the past twenty-four years, SA's total exports to the EU increased by about 512% from R82 billion in 2001 to R502 billion in 2025, while imports from the EU increased by 412% from R89 billion in 2001 to R456 billion in 2025. Over the same period, SA was mostly a net importer of the EU but recovered in 2025, with a positive net export value of about R47 billion. The top ten export commodities from SA to the EU include, inter alia, iron ore and concentrates, as well as unwrought aluminium (SA Embassy, n.d.; Wesgro, 2024).

Figure 1 summarises the trend in export values of SA's iron & steel, aluminium, fertiliser, and cement industries to the EU from 2001 to 2025. Iron & steel and aluminium industries accounted for a significant proportion of export values to the EU throughout the period. In contrast, the fertiliser and cement industries accounted for an insignificant proportion. For example, in 2025, the iron & steel and aluminium industries recorded export values of about R12.3 billion and R15.0 billion, while the fertiliser and cement industries recorded insignificant export values of approximately R180 million and R2.5 million, respectively. Of the four industries, the aluminium industry is the only one that recorded a consistent increase in export values to the EU between 2001 and 2025.

The implementation of the CBAM threatens these export values partly by increasing compliance costs, thereby reducing competitiveness in the EU markets (Gasealahwe et al., 2024; TIPS, 2023b). Alternatively, the decline in exports can intensify as export industries struggle to absorb the additional costs and, as a result, be forced to increase prices, which leads to reduced demand. However, industries that could adapt to the CBAM regulations and decarbonise their production processes are expected to achieve growth in exports to the EU markets.

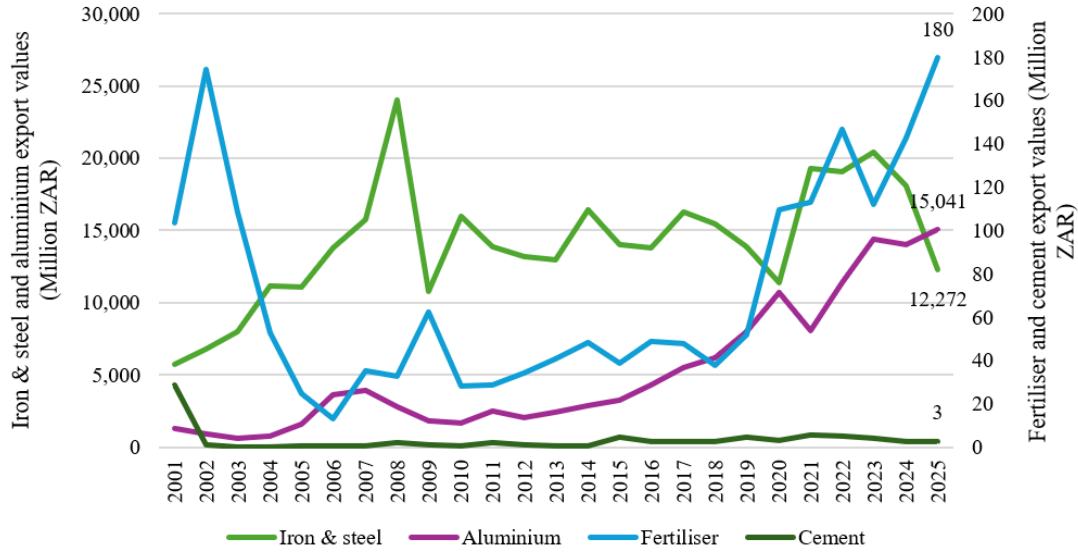


Figure 1: Export values of South Africa's carbon-intensive industries (Iron & steel, aluminium, fertiliser and cement) to the EU (Million ZAR).

Source: Compiled by the authors based on Trade Map data.

4 Methodology and data

The study used the macroeconomic impact model (MEIM) developed by Conningarth Economists to assess the economy-wide socio-economic impact of failing to decarbonise production processes in South Africa's iron & steel, aluminium, cement, and fertiliser industries. The MEIM can be described as an input-output (I-O) model that uses the standard Leontief equation represented in equation (1):

$$X = (I - A)^{-1}Y \quad (1)$$

Where X represents sectoral production (output), A represents intermediate demand technical coefficients, and Y represents the final demand. The Leontief inverse, or Leontief multiplier matrix, represented by $(I - A)^{-1}$, captures the inter-industry linkage effects in the economy (Miller & Blair, 2009; Ncube & Tregenna, 2022). I is the identity matrix ($n \times n$) consisting of ones along its main diagonal with zeros elsewhere and can be expressed as shown in equation (2):

$$I_n = \begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix} \quad (2)$$

A is the matrix ($n \times n$) for technical coefficients, which is expressed in equation (3):

$$A = \begin{bmatrix} \alpha_{11} & \cdots & \alpha_{1n} \\ \vdots & \ddots & \vdots \\ \alpha_{n1} & \cdots & \alpha_{nn} \end{bmatrix} \quad (3)$$

These technical coefficients can be defined as the units of input i required to produce a unit of output j (Mandapaka & Lo, 2023). They can be calculated as shown in equation (4):

$$\alpha_{ij} = \frac{Z_{ij}}{X_j} \quad (4)$$

Where: α_{ij} is the input-output coefficient; Z_{ij} is the intermediate demand for sector i and sector j ; X_j is the total input for sector j (Casler, 2004; Han et al., 2020).

Y which represents final demand can be expressed as a column vector as shown in equation (5):

$$Y = \begin{bmatrix} Y_1 \\ \vdots \\ Y_n \end{bmatrix} \quad (5)$$

X which represents total outputs can be expressed as a column vector as shown in equation (6):

$$X = \begin{bmatrix} X_1 \\ \vdots \\ X_n \end{bmatrix} \quad (6)$$

An increase (or decrease) in total outputs, X , can be determined by multiplying the Leontief matrix, $(I - A)^{-1}$, derived from the social accounting matrix (SAM), by an increase (or decrease) in final demand. This relationship can be expressed as shown in equation (7)

$$\Delta X = (I - A)^{-1} \Delta Y \quad (7)$$

The change in final demand represents an exogenous shock in the model. Such an exogenous shock in this study is represented by a reduction in exports for the iron & steel, aluminium, cement, and fertiliser industries.

The MEIM uses the 2019 SAM database, which aligns with the National Accounts (NA) published by the South African Reserve Bank (SARB) and captures the flow of financial and economic activities across sectors. The key features of the MEIM model include several accounts depicted in Figure 2.

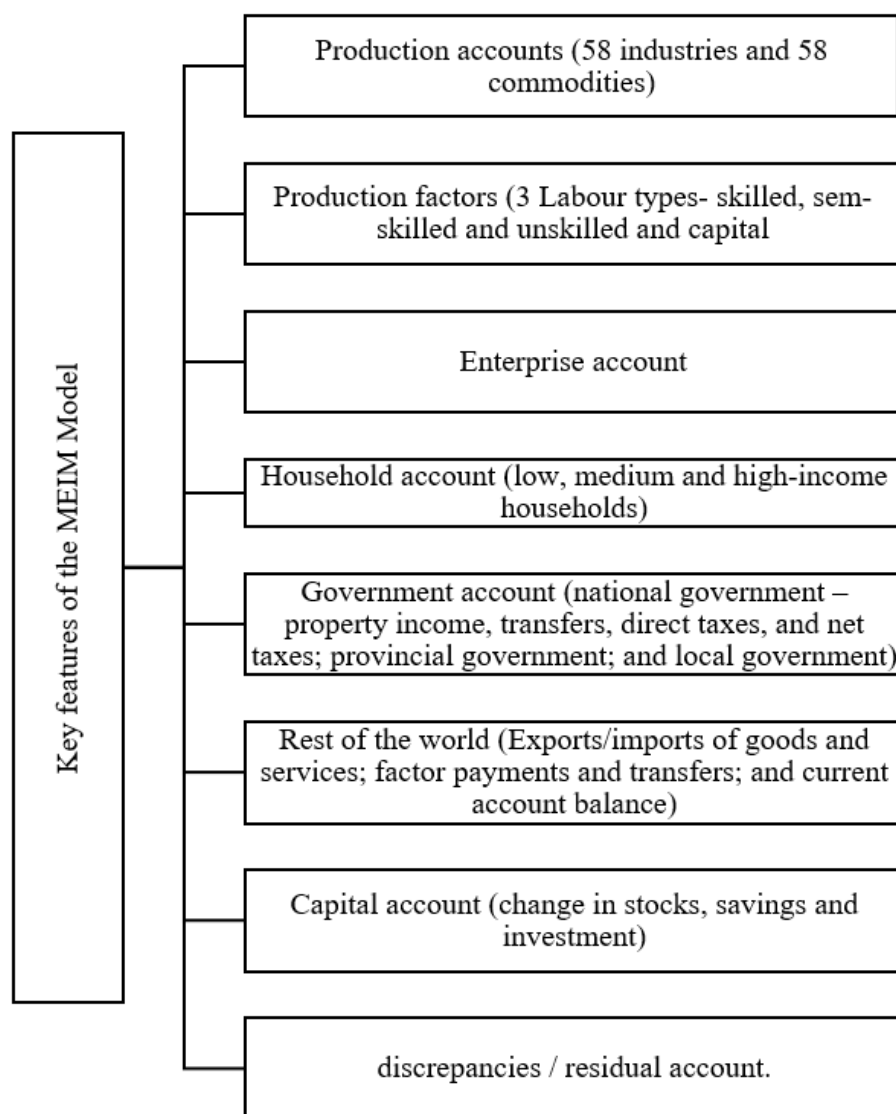


Figure 2: Key features of the MEIM model

Source: Compiled by the authors

Like the standard I-O models (Chang et al., 2014; Magacho et al., 2023; Mvelase & Ferrer, 2024; Schröder & Storm, 2020), the MEIM is based on the following key limitations and assumptions:

- i. Fixed prices, technical coefficients and expenditure shares, with zero substitution elasticity for factors and intermediate inputs.
- ii. Sufficient productive capacity and resources available to accommodate any additional demand
- iii. The results are linear estimates, giving a linear relationship between the shock and the resulting output due to fixed coefficients and expenditure shares.
- iv. The results are short-term estimates that reflect the existing economic structure rather than long-term structural adjustment.

- v. The results are upper-bound estimates, due to the model's inability to capture the behavioural, technological, and market adjustments.
- vi. The model is based on the 2019 SAM database, which does not allow for the examination of the socio-economic impacts of CBAM on current economic development.

Traditional I-O models, including the MEIM, are unable to represent structural changes such as changes in the relative cost of carbon-intensive exports due to CBAM. As a result, this study builds on the results of He et al. (2022) which quantify potential export reductions of 31% in iron and steel, 16% in aluminium, 9% in fertiliser, and 44% in cement to the EU by 2030, as illustrated in Table 1. Their simulation assumed the EU's carbon price of \$75 that is imposed on the embedded carbon content of only direct (scope 1) emissions, in line with the current EU proposal, which is the first scenario of He et al. (2022). The carbon price and emissions data for South Africa were obtained from the World Bank Carbon Pricing Dashboard. At the time of publication of the study, South Africa's carbon tax rate was R120 (or about US\$7) per tonne of CO₂e, and it has since increased to R308 (or about US\$18) per tonne of CO₂e in 2026 (SARS, 2026; World Bank, 2026). He et al. (2022) further indicate that the carbon border tax rate of a specific export product was calculated as the difference between the carbon prices paid in the EU and the carbon prices paid in the country of origin. The carbon border tax rate was multiplied by sectoral embodied carbon emissions to calculate the carbon border taxes paid by the exporting countries.

The current study also gathered the export values of the industries under examination from TradeMap and forecasted them for 2030. These projected export values, along with the estimated percentage losses from the aforementioned studies, were used to calculate the monetary value of export losses attributable to the implementation of CBAM by 2030.

The MEIM is well suited for impact assessment, which is the objective of this study, not to simulate the economy's endogenous adjustment to the EU-CBAM through changes in prices, input substitution, trade diversion, and factor and goods market equilibrium, which are more explicitly represented in the CGE models.

To quantify the socio-economic impacts of the CBAM on the South African economy, the estimated export losses of the industries under examination were introduced as an external shock to the MEIM. The socio-economic impacts that the model can quantify include GDP, household income, government revenue and net exports. The model can also quantify impacts on government expenditure for essential social programmes, such as the availability of educators, hospital beds, doctors, affordable housing, and grant beneficiaries. Besides being useful for quantifying social indicators and economic impacts at the detailed sectoral level to support better decision-making processes, other advantages of the MEIM are its ability to capture a wide range of inputs, including direct, indirect,[†] and induced impacts,[‡] which add up to economy-wide impacts.

*Direct impacts that occur in the iron & steel, Aluminium, cement, and fertiliser industries are measured through changes in production/turnover and profit generation.

[†]Indirect impacts refer to impacts on industries that provide inputs to the Iron & steel, Aluminium, cement, and fertiliser industries and other backward linkages.

[‡]Induced impacts (income effects) refer to a further round of economic activity that takes place in the economy as a result of additional consumer spending due to additional salaries and wages that occur throughout the economy.

Table 1: Baseline export values and forecasted values of export loss by 2030 (Million ZAR)

Commodity	Iron & steel	Aluminium	Fertiliser	Cement	Total
Baseline export value (2025)	12 272	15 041	180	2.50	27 495
No CBAM: Forecasted export value (2030)					
<i>Low</i>	7 100	10 403	123	0.02	17 626
<i>Mid</i>	17 349	14 973	261	1.99	32 585
<i>High</i>	27 598	19 543	400	25	47 565
Portion of export market loss (%)	31%	16%	9%	44%	
With CBAM: Estimated export value loss (2030)					
<i>Low</i>	2 201	1 665	11	0.01	3 877
<i>Mid</i>	5 378	2 396	24	0.88	7 798
<i>High</i>	8 555	3 127	36	11	11 729

Note: Forecasted export values (low, mid and high case scenarios) were calculated using the exponential triple smoothing (ETS) function in Excel. The function is useful for time series forecasting and can handle trends and seasonal patterns. The portion of export market loss (%) was obtained from He et al. (2022).

Source: Compiled by the authors from TradeMap data and He et al. (2022).

5 Empirical Results

5.1 Macroeconomic impacts

Table 2 summarises the macroeconomic impacts on the South African economy in 2030 resulting from the implementation of CBAM, which will lead to a reduction in exports to the EU. The results show a substantial economic impact of reduced exports, particularly for the iron & steel and aluminium industries, which account for a significant estimated decline in GDP, capital formation, household income, government revenue, and net exports. This can be attributed to their large export base.

Under the mid-case scenario, a reduction in iron & steel exports is estimated to lead to a loss in GDP of approximately R7.5 billion, while aluminium export reductions could lead to a decrease in GDP of approximately R2.7 billion. These changes are linked to an estimated decrease in capital formation of approximately R13.7 billion for the iron & steel industry and R6.5 billion for the aluminium industry. It is estimated that household income will decrease by approximately R5.1 billion for the iron & steel industry and R1.9 billion for the aluminium industry. It is also estimated that net exports and government revenue will decrease by approximately R3.4 billion and R1.9 billion, respectively, for the iron & steel industry. In the case of the aluminium industry, net exports and government revenue are estimated to decrease by R1.4 billion and R807 million, respectively.

In contrast, the economic impacts associated with reduced fertiliser and cement exports are comparatively low, with estimated GDP contraction of approximately R20.8 million and R1.0 million, respectively. Furthermore, it is estimated that capital formation will decrease by approximately R50.7 million for the fertiliser industry and R2.5 million for the cement industry. Household income, government revenue and net exports are estimated to decrease by approximately R14.5 million, R6.5 million and R10.5 million, respectively, for the fertiliser industry. While for the cement industry, household income, government revenue

and net exports are estimated to decline by approximately R0.70 million, R0.29 million and R0.49 million, respectively. These relatively small values reflect the limited contribution of these sectors to aggregate economic activity. Despite its small values, the cement industry remains the most vulnerable given the highest percentage of export loss of 44%.

The economic impacts increase further for all the industries under the high case scenario. For example, the GDP loss is estimated to increase to approximately R11.9 billion for the iron & steel industry, R3.6 billion for the aluminium industry, R31.9 million for the fertiliser industry and R12.7 million for the cement industry. They also decrease under the low-case scenario. The GDP loss decreases to approximately R3.1 billion for the iron & steel industry, R1.9 billion for the aluminium industry, R9.8 million for the fertiliser industry and R0.01 million for the cement industry.

Collectively, the cumulative GDP loss for all industries is estimated to be approximately R5.0 billion under the low-case scenario. It increases to approximately R10.2 billion under the mid-case scenario and increases further to approximately R15.5 billion under the high-case scenario. This translates into a real GDP decline ranging approximately between 0.10% and 0.31% for South Africa in 2030. Under the mid-case scenario, it is about a 0.21% decline in real GDP from an estimated real GDP of R5.0 trillion by the model. This estimate deviates slightly by 0.09 percentage points from the 0.3% GDP decline estimated for 2030 in the study by Merven et al (2023).

Table 2: Macroeconomic impacts attributable to the reduction in the export of iron & steel, aluminium, fertiliser, and cement industries (Millions ZAR).

	Iron & steel	Aluminium	Fertiliser	Cement	Total
Low case					
GDP	-3 062	-1 904	-9.80	-0.01	-4 975
Capital formation	-5 602	-4 536	-23.83	-0.02	-10 161
Household income	-2 093	-1 294	-6.80	-0.01	-3 394
Government revenue	-771	-561	-3.05	0.00	-1 335
Net exports	-1 387	-948	-4.95	0.00	-2 341
Mid-case					
GDP	-7 482	-2 740	-20.84	-1.01	-10 244
Capital formation	-13 687	-6 528	-50.71	-2.49	-20 269
Household income	-5 113	-1 863	-14.47	-0.70	-6 991
Government revenue	-1 885	-807	-6.49	-0.29	-2 699
Net exports	-3 390	-1 365	-10.54	-0.49	-4 766
High case					
GDP	-11 902	-3 576	-31.89	-12.72	-15 523
Capital formation	-21 773	-8 521	-77.58	-31.41	-30 403
Household income	-8 134	-2 431	-22.14	-8.77	-10 596
Government revenue	-2 999	-1 053	-9.93	-3.66	-4 065
Net exports	-5 393	-1 781	-16.13	-6.17	-7 197

Note: Capital formation, household income, government revenue, and net exports are proportions of gross output (GO), not gross domestic product (GDP). GO measures overall economic activity. It consists of value added as well as all transactions between industries for inputs (intermediate inputs). GDP measures value added created through the production of goods and services in a country in a given period of time (Callen, n.d.). Totals are computed from unrounded values and may differ slightly from the sum of the rounded components.

Source: Compiled by authors using MEIM

5.2 Social impacts

5.2.1 Employment

Table 3 presents the estimated employment losses associated with a reduction in exports by 2030. Significant employment losses are expected in the iron & steel and aluminium industries as a result of reduced export volumes. Under the low-case scenario, the employment losses amount to approximately 5 109 jobs for iron & steel and 3 865 jobs for aluminium. They increase to approximately 12 485 jobs for iron & steel and 5 562 jobs for aluminium under the mid-case scenario. Under the high case scenario, the employment losses are estimated to increase further to approximately 19 860 jobs for iron & steel and 7 260 jobs for aluminium, as shown Table 3.

In contrast, the employment impacts of reduced fertiliser and cement exports are comparatively low, with an estimated employment loss of about 24 jobs in the fertiliser industry and no job losses for the cement industry, under the low case scenario. Under the mid-case scenario, employment loss is estimated to increase to about 51 jobs for the fertiliser industry, with the cement industry estimated to lose only about 2 jobs. The employment losses are estimated to further increase, as export losses increase, under the high case scenario, to about 77 jobs for the fertiliser and 29 jobs for the cement industry.

In total, the employment loss for all industries is estimated to amount to about 8 998 jobs, 18 100 jobs and 27 227 jobs under low-case, mid-case and high-case scenarios, respectively. Consistent with the macroeconomic impact estimates, these results highlight the pivotal role of the iron & steel and aluminium industries in sustaining employment throughout the economy.

Table 3: Impact on employment attributable to reduction in the export of iron & steel, aluminium, fertiliser and cement industries (employment numbers)

	Iron & steel	Aluminium	Fertiliser	Cement	Total
Low case					
Employment (Numbers)	-5 109	-3 865	-24	-	-8 998
Mid-case					
Employment (Numbers)	-12 485	-5 562	-51	-2	-18 100
High case					
Employment (Numbers)	-19 860	-7 260	-77	-29	-27 227

Note: The employment/ job losses are measured as full-time equivalent (FTE) jobs. These are annual job losses in the year 2030. Totals are computed from unrounded values and may differ slightly from the sum of the rounded components.

Source: Compiled by authors using MEIM

5.2.2 Social indicators

Table 4 presents government expenditure losses relating to social services such as educators, hospital beds, doctors, low-cost houses, and grant beneficiaries. This suggests that export reductions in the industries under examination have implications for government social services, particularly education, healthcare, social security, and housing services.

The grant beneficiaries are estimated to be the social indicator most affected across all four industries, with iron & steel accounting for 7 504 and aluminium accounting for 5 454 individuals unable to receive their grant benefit due to reduced export values under the low-case scenario. The second most impacted social indicator will be educators, with reduced iron & steel and aluminium exports resulting in a lack of funds for the government for about 172 and 125 teaching positions, respectively. The impacted grant beneficiaries and teaching positions are estimated to increase further under both the mid-case and high-case scenarios, as shown in Table 4. The allocation of funding for hospital beds and low-cost housing will be relatively affected by the reduction in exports of the iron & steel and aluminium industries. Doctors will be the least affected, as the government will be unable to fund about 10 doctors due to the export reduction in the iron & steel and aluminium industries under the low-case scenario.

In total, about 12 988 individuals are estimated to be unable to receive their grant benefit under the low-case scenario. The number of affected individuals is estimated to increase to about 26 251 and 39 545 under the mid-case and high-case scenarios, respectively.

Table 4: Impact on social indicators attributed to reduction in the export of iron & steel, aluminium, fertiliser, and cement industries

	Iron & steel	Aluminium	Fertiliser	Cement	Total
Low case					
Grant beneficiaries	-7 504	-5 454	-30	-	-12 988
Educators	-172	-125	-1	-	-298
Hospital beds	-36	-26	-	-	-62
Doctors	-6	-4	-	-	-10
Low-cost houses	-38	-28	-	-	-66
Mid-case					
Grant beneficiaries	-18 335	-7 850	-63	-3	-26 251
Educators	-419	-179	-1	-	-599
Hospital beds	-88	-38	-	-	-126
Doctors	-15	-6	-	-	-21
Low-cost houses	-94	-40	-	-	-134
High case					
Grant beneficiaries	-29 166	-10 246	-97	-36	-39 545
Educators	-667	-234	-2	-1	-904
Hospital beds	-140	-49	-	-	-189
Doctors	-24	-8	-	-	-32
Low-cost houses	-149	-52	-	-	-201

Note: The quantification of social indicators attributable to export reduction from the industries under examination is based on a fixed government consumption expenditure ratio.

Source: Compiled by the authors using MEIM

5.3 Sensitivity analysis

Sensitivity analysis was conducted to assess the effect of changing the percentage proportion of export loss (from 5% to 80%) on macroeconomic factors, employment and social indicators. The sensitivity analysis was based on the mid-case forecasted export values for all the

industries (iron & steel, aluminium, fertiliser and cement). The analysis revealed that an increase in export losses would result in losses of GDP, capital formation, household income, government revenue and net exports, as well as employment losses, as shown in Figure 3. This suggests a positive relationship between export losses and macroeconomic factors and employment. Iron & steel is the most sensitive industry to changes in export losses, followed by the aluminium industry. This is due to the iron and steel industry having the largest export base and absolute change. Variations in export losses have a comparatively small effect on GDP, capital formation, household income, government revenue, net exports and employment contributions of the fertiliser and cement industries due to their insignificant export base.

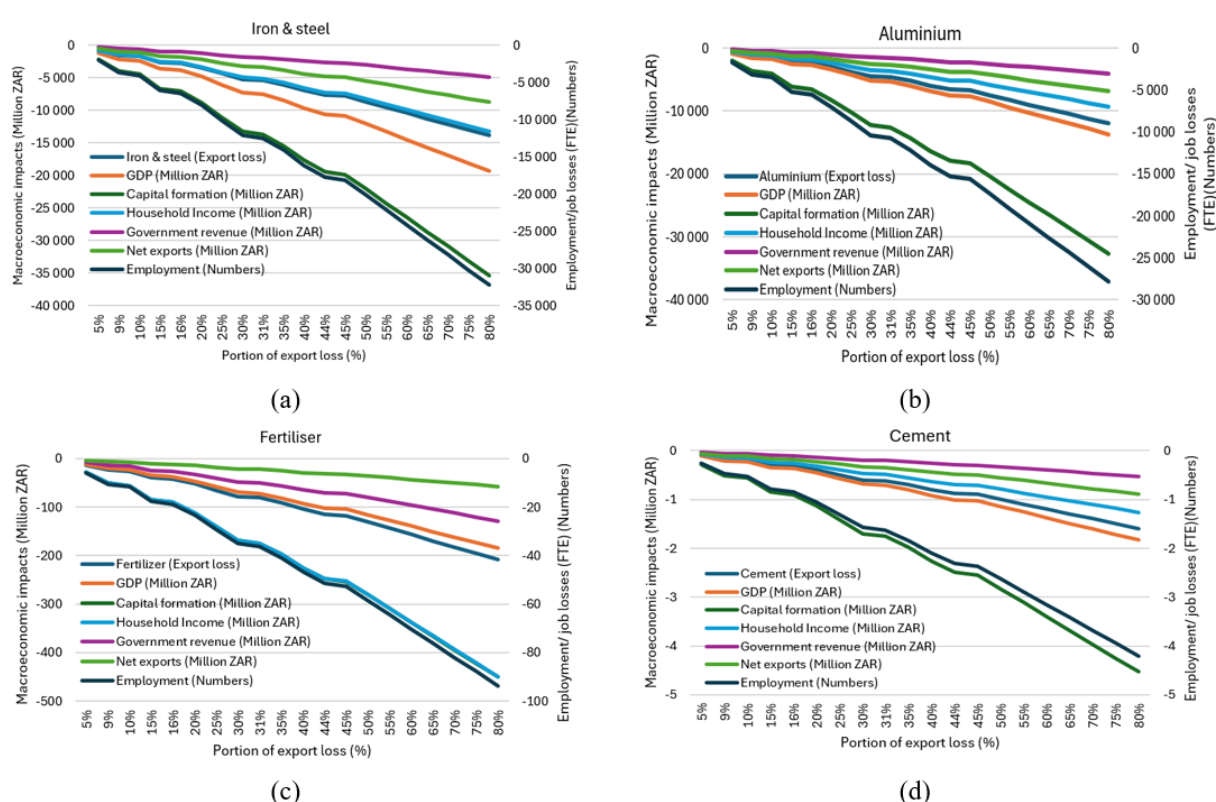


Figure 3: Sensitivity analysis of the change in the percentage proportion of export loss (%) on macroeconomic and employment indicators

Source: Compiled by the authors using MEIM

The results of the sensitivity analysis also revealed a positive relation between export loss and social indicators. As shown in Figure 4, an increase in export losses (%) results in an increase in government social programme losses, such as losses to social programmes that can cover grant beneficiaries, educators, hospital beds, doctors and low-cost houses. Similarly, iron & steel remains the most sensitive industry to changes in export losses (%), followed by the aluminium industry due to their large export base connected to large contributions to government social programmes compared to fertiliser and cement industries. Comparatively, changes in export losses have an insignificant effect on fertiliser and cement industries' contribution to government social programmes.

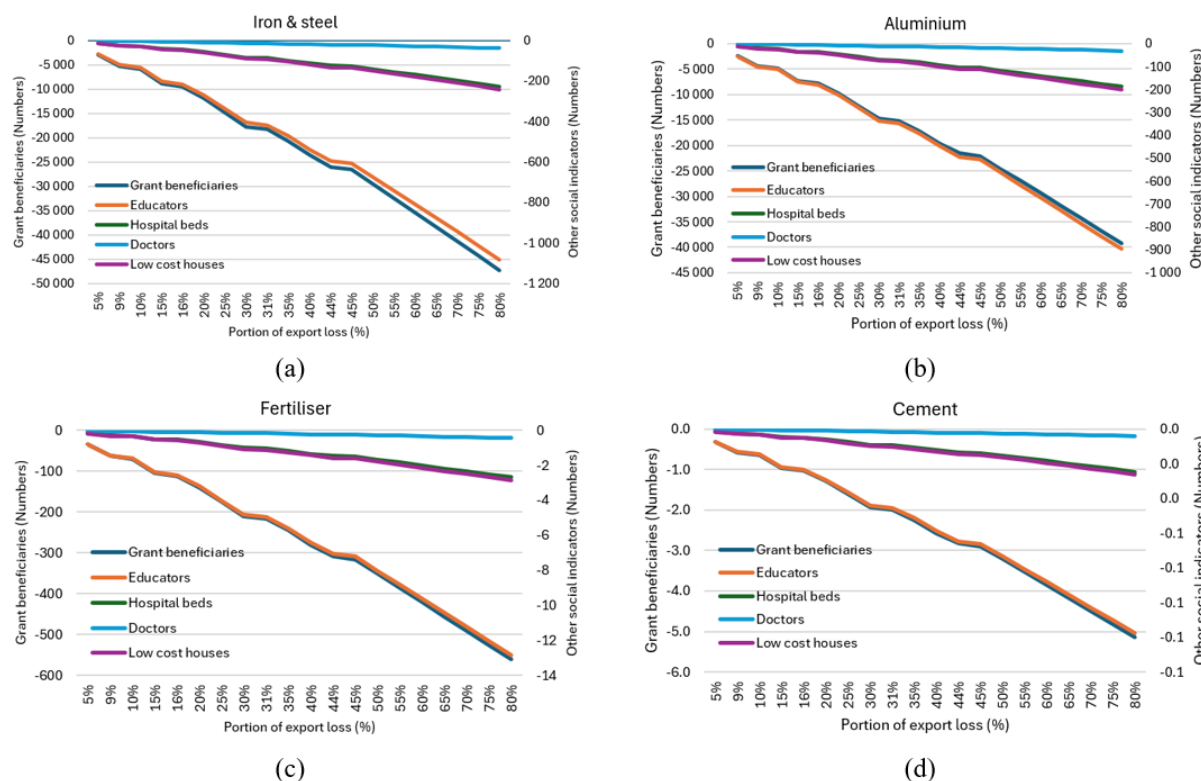


Figure 4: Sensitivity analysis of the change in the percentage proportion of export loss (%) on social indicators

Source: Compiled by the authors from MEIM

6 Discussion

The study found that the monetary value of exports estimated to be lost due to the implementation of the EU CBAM in 2030 amounts to about R3.9 billion, with (R2.2 billion for iron & steel, R1.7 billion for aluminium, R11.1 million for fertiliser and R0.01 million for cement) under the low case scenario. The monetary values are estimated to increase to about R7.8 billion (R5.4 billion for iron & steel, R2.4 billion for aluminium, R23.5 million for fertiliser and R0.9 million for cement) under the mid-case scenario. They are estimated to increase further to R11.7 billion (R8.6 billion for iron & steel, R3.1 billion for aluminium, R36.0 million for fertiliser and R11.0 million for cement) under the high-case scenario. Across all scenarios, the iron & steel industry is estimated to remain the most impacted, followed by the aluminium industry, given its large export base to the EU. Comparatively, the fertiliser and cement industries are estimated to be insignificantly impacted.

The results show a substantial socio-economic impact of these reduced exports, including a decline in GDP, household income, government revenue, net exports and employment. In addition, the study results show that government social expenditure programmes in education, public healthcare, the social security system and housing assistance are estimated to be significantly impacted. These results may be underestimated, as the remaining markets for these industries are also expected to decrease further due to other countries introducing their own measures that impose a carbon price on imported goods, as well as increased

competition from industries with low-carbon production processes (NBI, 2023). This will harm the South African economy since the failure to decarbonise the production processes of these industries will likely exacerbate the triple threat of unemployment, poverty, and inequality.

The study findings align with those of Li et al. (2026) indicating that CBAM imposes substantial macroeconomic effects on export-oriented developing countries and reduces their trade competitiveness. Metal industries, particularly iron & steel and aluminium, which are the backbone of industrial development in these countries, are disproportionately affected by CBAM due to substantial trade volumes and elevated emissions intensities (Hermawan et al., 2026; Li et al., 2026). In line with the literature, the results of the study revealed that the carbon-intensive industries expected to be significantly impacted are the iron & steel and aluminium industries due to their large trade volumes. According to the National Business Initiative (NBI) (NBI, 2023), iron & steel is responsible for about 46.4 million tons (Mt) of CO₂eq, with aluminium and cement accounting for 12.1 and 10.5 Mt of CO₂eq, respectively. This includes scope 1 and 2 emissions coming from the production capacity of 9.5 Mt p.a. for iron & steel, 1.0 Mt p.a. for aluminium, and 19–22 Mt p.a. for cement (NBI, 2023; SAISI, 2023). To maintain South Africa's position in the global market for these industries, their production processes should be decarbonised. In addition, it is necessary to protect the country's export market, as a limited export market could lead to severe socio-economic consequences. As shown in the results section, the implementation of the CBAM will affect employment and government funding for social services due to reduced export earnings. Social services are essential to reducing poverty, inequality, and vulnerability in South Africa (GCIS, 2012). According to Zhang & Sovacool (2025), the inflexibility of the country's labour market increases vulnerability to employment shocks and income inequality. Therefore, the study results further emphasise South Africa's trade exposure and vulnerability under the CBAM (Eicke et al., 2021).

To reduce exposure and vulnerability, carbon-intensive industries that are highly dependent on trade with the EU should consider adapting production processes to use less carbon-intensive methods and/or reducing reliance on EU markets by exploring alternative trading markets (Alexander et al., 2024). The main decarbonisation pathways that can be considered include material substitution, material efficiency, process integration, technology innovation, and investment in clean energy technologies (Lytton et al., 2018). South Africa has comparative advantages in terms of abundant renewable energy resources and technological capabilities to support the adoption of clean energy technologies (Zhang & Sovacool, 2025).

However, there are challenges to decarbonising industrial processes using clean energy technologies, such as inadequate infrastructure, high capital costs, and lack of policy support. Currently, the JET-IP prioritises green electricity and hydrogen as decarbonising pathways. The concessional funding mobilised under the JET-IP can be leveraged to de-risk the costs of these technologies and their associated infrastructure, which can be adopted in these four industries (South African Government, 2024; The Presidency, 2022). Studies suggest that regional integration is vital to overcome these challenges, as it allows harmonisation of policies, resource sharing and cost reduction. Consequently, promoting economic growth and energy security (Charamba et al., 2025). Additionally, to encourage carbon-intensive industries to invest in clean energy technologies and energy efficiency, there is a need to explore different pathways to reduce carbon pricing exposure or consider using existing fiscal

policy tools such as a domestic carbon tax. This can be done by ensuring that the current carbon tax aligns with global carbon pricing trends (TIPS, 2026). Leveraging existing resources and policy tools will enable domestic industries to become more resilient, cushion adverse socio-economic impacts and maintain trade competitiveness.

7 Conclusion

The implementation of the CBAM will impact various EU trading partners, such as South Africa, that export high-carbon-intensive commodities. The carbon tariff on exported commodities will increase costs and reduce the country's export competitiveness. This potential export risk will negatively affect the South African economy. This study used the macro-economic impact model (MEIM) to quantify the socio-economic impact of export reduction on the economy for four carbon-intensive industries: iron & steel, aluminium, fertiliser and cement. Beyond macro-economic indicators, the model can also translate government revenue into expenditure related to social services, such as the availability of educators, hospital beds, doctors, affordable housing, and beneficiaries of grants.

The study found that the iron & steel and aluminium industries are at a higher risk of losing their competitiveness than the fertiliser and cement industries. The results also revealed that a reduction in exports will lead to a decline in GDP, government revenue, net exports, and employment opportunities. The decline in government revenue will lead to a decrease in government expenditure on social services such as education, healthcare, social security, and housing.

The study measures the impacts associated with the failure of targeted carbon-intensive industries to decarbonise their production processes, without consideration for decarbonisation solutions. Considering the above, it is necessary for carbon-intensive industries to decarbonise in order to maintain South Africa's trade competitiveness in the global export market and mitigate the adverse socio-economic impacts. This will require industries to explore alternative pathways for reducing carbon intensity in production processes such as energy efficiency, material efficiency and substitution, as well as investment in clean energy technologies. The adoption of clean energy technologies offers an opportunity to take advantage of existing abundant renewable energy sources and capabilities to transition and contribute to global climate goals. Thus, new industries and employment opportunities can be created, resulting in new revenue streams and improved net exports. However, this will require the consideration of policies that incentivise domestic producers and encourage innovation, investment, and localisation. These recommendations will ensure that South Africa maintains economic growth and remains competitive in international markets while aligning with global environmental standards.

This study has some limitations, including the fact that the model simulates the upper-bound results due to its inability to capture the behavioural, technological and market adjustments such as changes in prices, input substitution, trade diversion and factor and goods market equilibrium; and the model is also based on the 2019 SAM database, which does not allow for the examination of the socio-economic impacts of CBAM on current economic development. Future studies can be conducted using Input-Output based models with an updated SAM database.

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Declaration of conflict of interest

The authors declare that the research was conducted without any commercial or financial relationships that could be perceived as a potential conflict of interest.

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