A South African price fixing story: Estimating overcharges in the long steel cartel

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Abstract:

This study investigates the economic impact of the long steel cartel in South Africa by estimating price overcharges and evaluating whether the administrative penalties imposed reflected the harm caused. Using a reduced-form error correction model, overcharges are estimated through both a dummy variable and a forecasting approach. The results show an average overcharge of 1.05% for billets using the dummy method, and 7.29% and 10.82% for billets and angles, respectively, under the forecasting method, indicating significant variation across methods. The analysis reveals that fines imposed, particularly on ArcelorMittal and Cape Gate, were substantially lower than the estimated economic damage, falling short of international enforcement benchmarks. The study argues that while structural factors in the industry may explain stable overcharges over time, enforcement mechanisms remain misaligned with harm-based deterrence principles. These findings support the integration of empirical overcharge estimates into competition penalty frameworks to improve fairness, accountability, and deterrence in cartel enforcement.

Keywords: Cartel overcharges, long steel cartel, competition policy, reduced-form regression, dummy variable, forecasting approach, South Africa, AMSA, penalty assessment, deterrence, collusion.

1. Background

Historically, the South African steel industry has been marked by high concentration levels with a few large firms dominating the market (Chabane et al., 2003). This has provided fertile ground for cartel behaviour, as evidenced by the long steel cartel that emerged in the early 2000s, reported by the Competition Commission of South Africa (Commission)[1] (2017). In its investigation, the Commission discovered that from 2001, firms involved in the steel cartel participated in direct price-fixing, bid-rigging, and output restrictions, which significantly distorted the market. These activities likely resulted in increased prices for steel products, significantly implicating downstream industries reliant on steel as an input (Competition Tribunal, 2020).

[1] The Competition Commission ("Commission") which acts as the "prosecutor" in the competition system of South Africa as part of the Competition Act 89 of 1998's three divisions. It investigates and prosecutes firms that engage in collusive conduct.

In a settlement agreement between the Commission and Acerlomittal South Africa Limited (AMSA),[2] the events regarding the long steel cartel were as follows:

- On 22 April 2008, the Commission initiated a complaint regarding collusion among the producers of long steel products, known as the steel mills, in South Africa. On 27 June 2008, in its application for a marker, Scaw South Africa (Pty) Ltd. (Scaw) acknowledged the existence of a longstanding culture of collaboration among the steel mills. The collaboration included agreements on pricing strategies, such as the determination of prices and discounts for various steel products, as well as arrangements to divide the market to limit competition in the market.

- On 21 July 2008, Scaw was granted leniency under the Commission's Corporate Leniency Policy (CLP) for admitting being involved in price-fixing and market allocation practices concerning steel products. The product also included rebar, wire rod, and sections such as rounds, squares, angles, and profiles. In return for the leniency, Scaw cooperated with the Commission in its investigation. Towards the end of 2009, the Commission referred its collusion case to the Competition Tribunal (Tribunal)[3] for adjudication. The Commission alleged that the leading suppliers of long steel products had colluded by fixing prices, among other collusive practices. The firms involved in the cartel were AMSA, Scaw, Cape Gate (Pty) Ltd (Cape Gate), and Cape Town Iron and Steel Works (Pty) Ltd (CISCO).

On 16 November 2016, the Tribunal confirmed the settlement agreement between AMSA and the Commission. The other members of the cartel are still being prosecuted. The Commission alleged that the cartel started in about 2001. If a firm is found guilty of cartel conduct, it may be subject to a fine.

1.1. Problem statement

The Commission has uncovered cartel conduct in numerous markets such as poultry, construction, cement, glass, milk, banking and fertiliser. Despite these discoveries and the imposition of administrative penalties, there remains a national scarcity of empirical studies that

[2] Competition Commission Case No: 2008Apr3696.
[3] The Competition Tribunal adjudicates competition cases referred to it by the Commission.

quantifies the economic harm caused by these cartels. The few studies that have estimated cartel overcharges, often differ in methodology, scope, and assumptions, leading to fragmented insights (Connor, 2007; Van Dijk and Verboven, 2015).

Estimating cartel overcharges is essential for several reasons. First, it provides a monetary estimate of consumer and market harm, which is crucial for private damage claims and class action lawsuits. Second, it informs policy on the adequacy and deterrent effect of penalties imposed by enforcement authorities (OECD, 2012). Third, understanding the extent of overcharges reveals the distortions that cartels create in competitive markets, thereby guiding effective competition policy.

Moreover, existing literature on cartel overcharges tends to abstract from real-world institutional dynamics by focusing instead on theoretical or static models of collusion. In practice, cartel operates under complex conditions which involve asymmetries between firms, secret communication, and strategic coordination while evading legal detection (Harrington, 2006). There is a growing recognition that current econometric models are underutilised in institutions for capturing these dynamics and their economic consequences (Rubinfeld, 2009; Motta, 2004).

This research, therefore, aims to address these gaps by empirically estimating the overcharges in the long steel cartel in South Africa, which started from 2001 until it was reported in 2008. Theoretically, the study also aims to evaluate whether the fines imposed correspond with the economic damage inflicted, thereby contributing to the broader debates on the effectiveness of cartel deterrence.

The objectives of the study are as follows: (i) to estimate the overcharges that resulted from the long steel cartel by observing the period 1993 to 2016. This objective aim to provide an empirical analysis on how overcharges can be calculating using econometric methods available in cartel literature. It further aims to illustrate how empirical results in real-world data-driven cartel cases can be interpreted. (ii) To evaluate whether the administrative penalties imposed on cartel firms align with the economic harm caused, as measured by the overcharge. This objective aims to address a critical policy concern which is, *are enforcement penalties calibrated in a way that deters future collusion and reflects the magnitude of harm to consumers and the economy*? (iii) The objective is also to suggest a methodological framework for estimating cartel overcharges that is grounded in real-world institutional detail. Many empirical models fail to incorporate the strategic realities, such as asymmetric firm behaviour and risks of detection and prosecution with can provide a holistic (both theory and empirical) insight of cartel conduct.

The study's analysis is grounded in the hypothesis that the long steel cartel's conduct led to price increases which were beyond the competitive conditions (accepted market prices). Furthermore, in theory, the penalties charged may not have accurately reflected the actual damages caused. Given these hypotheses, the research questions are as follows:

(i) *What was the cartel overcharge in the long steel cartel case*? This question seeks to empirically estimate the economic harm caused by cartels, using pricing data before, during and after the collusive period.

(ii) *Do fines imposed on firms engaged in cartel conduct correspond to the damages caused by cartels as quantified by the overcharge estimates*? This question examines the alignment (or misalignment) between the theoretical intent of cartel deterrence and its practical implications, particularly in terms of financial penalties.

In addition, the study may assist in future directions in academia and research institutions for identifying cartel theories and empirical regulations. This information can also be used as guidance for empirical modelling for estimating complex cartel overcharges, provided that there is data availability. By empirically estimating the overcharge in the long steel cartel and comparing it to the actual fines levied, the study aims to contribute to the literature on cartel enforcement by:

- Providing a quantitative benchmark for assessing deterrence effectiveness,
- Providing insights into how enforcement lags behind economic harm in real-world cases, and
- Illustrating the importance of contextualising economic models within legal and institutional realities of cartel enforcement.

More broadly, this study aims to advance the field of competition economics by illustrating the value of integrated approaches that combine theory, case evidence and empirical estimation. Following the background (1) above, the study extends to six more sections: (2) where I provide an overview of the South African steel industry, its history, and cartel formation; (3) I present the cartel framework demonstrating the effects of price overcharges by cartels. (4) I outline the literature review on methods and models employed and the gaps in using these mechanisms. (5) I describe the model, method and data sources from wherein I extracted time series for this research. (6) I present the results and interpret the findings from the estimations, answering the research questions for my study, and further discussing the Competition policies as well as providing recommendations in section (7).

2. Overview of the South African steel industry

2.1 *The history of South African iron and steel*

The development and growth of the South African iron and steel industry began between 1910 and 1925 in the Transvaal, currently partitioned into Gauteng, Limpopo, Mpumalanga, and North West provinces (Scott, 1951). Four plants were established of which three were located on the Witwatersrand goldfield and one, which received government sponsorship, in the Vaal River at Vereeniging. World War I stimulated the industry by curtailing imports of the two commodities, however, the post-war depression and a collapse in steel prices hampered further expansion due to difficulties in raising capital overseas (Scott, 1951).

By 1934, the South African Iron and Steel Corporation (Iscor) was established in Pretoria, becoming a significant player by 1937 and producing 92 percent (%) of the steel consumed nationwide. In the same year, Isco formed African Metals Corporation (Amcor) as its subsidiary. The industry saw exponential growth in production during the 1940s, driven by wartime demands and post-war recovery that led to doubling the output. Vanderbijl Park emerged as a major steel district due to its strategic location and industrial facilities as the geographic distribution of the industry evolved (Scott, 1951).

The availability of raw materials, particularly iron ore and steel from Thabazimbi and coking coal from the Witbank coalfield, were crucial players in the development of the industry. Despite the challenges posed by limited coking coal reserves, the industry has continued to expand, with projections indicating that establishing new steelworks would significantly lower costs and support the growth of secondary industries in South Africa (Scott, 1951).

According to its company profile, AMSA was established in 1928 and has since been Africa's largest steel producer. The company is headquartered in Vanderbijlpark, Gauteng. It has an annual production capacity of approximately 5.5 million tonnes of steel and accounts for over 60% of the steel used in South Africa and surrounding regions. AMSA's operations include a fully integrated steel-making process that transforms raw materials into a wide range of steel products. The company operates through key facilities, including:

2.1.1 Vanderbijlpark Works: A flat steel producer.
2.1.2 Newcastle Works: Specializing in long steel products.
2.1.3 Saldanha Works: A small, high-technology flat steel producer.

The company also focuses on sustainable production practices to reduce its environmental footprint, aiming to align with global sustainability standards (ArcelorMittal South Africa, n.d.). Of relevance to this research is the companies' (AMSA, Scaw, and Cisco) long steel products including but not limited to wire rods, rebar, and sections (heavy, medium and light).

2.2 *Global economic impact*

On the economic aspect, Scott further discusses that the iron and steel industry played a crucial role in shaping the global economy and trade patterns during the Industrial Revolution. The emergence of this industry in South Africa, particularly from 1910 to 1925, was significantly influenced by the demands of gold mining, which created a substantial market for steel. The establishment of Isco in 1934 marked a pivotal moment, as it began producing a large portion of the steel consumed domestically, contributing to a tripling of steel consumption within five years of establishment.

As the industry expanded during the wartime and post-war periods, South Africa's production capabilities increased dramatically, allowing it to meet both domestic and international demands. The shift in geographies not only impacted local economies but also altered trade patterns, as South Africa began to export steel products to neighbouring regions like Southern Rhodesia, albeit in small quantities (Scott, 1951).

Moreover, South Africa's reliance on local raw materials, such as iron ore from Thabazimbi and coking coal from Witbank, further integrated the economy and reduced transportation costs. The industry's growth was also supported by favourable railway policies that facilitated the movement of finished goods, thereby enhancing trade efficiency. Overall, the iron and steel industry not only transformed South Africa's economic landscape but also contributed to broader global trade dynamics during the Industrial Revolution (Scott, 1951).

2.3 *Activities of the steel and long steel industry*

Steel is created when carbon, recycled steel, and small amounts of other elements are mixed with iron. The most important engineering and construction material in the world is steel. Almost every part of our lives uses steel, from cars and construction products to refrigerators and washing machines (World Steel Association, 2024).

Long steel products play a critical role in various industries due to their structural strength and versatility. According to AMSA's online profile, these products encompass a wide range of applications. Wire rods are used in the construction of security and boundary fences and electricity wiring, while forgings, shaped through heating and hammering, are essential in machinery and structural applications. Furthermore, heavy structural sections, such as universal beams and columns, form the backbone of building frameworks and infrastructure projects, such as the construction of buildings and bridges, providing essential support and stability.

Hexagon bars are utilized in the mining sector and for manufacturing specialised bolts and nuts, while hollow bars, with their hollow centres, are primarily used as drill rods in mining operations. Concomitantly, mining bars, featuring deformations to improve resin adhesion, are specifically designed for underground mining. Additionally, rails are crucial for mining operations and broader transportation networks, facilitating both on-site mobility and mainline applications. These products are indispensable across the construction, mining, and manufacturing sectors, providing the durability and functionality required for diverse industrial uses (ArcelorMittal South Africa, 2024).

In summary, the overview emphasises the steel industry's vital role in South Africa and how its emergence enhanced the local and global economy. This information is crucial for this study as it highlights South Africa's potential to participate competitively on a national and international scope. It further climaxes the activities which are key to creating substantial industries such as the mining and car sectors and infrastructure such as construction and railways, that may attract foreign investors and improve our economic performance in the relevant markets. In perspective, it will provide a forecast of the steel industry's performance pre- and post-cartel in relation to the study.

3. Framework on cartel overcharges

A cartel is an agreement between firms not to compete with one another. The main goal of most cartels is to increase the price of their members' products. Collusion, whether explicit (through agreements) or tacit (through concerted practices), undermines fair competitive practices in the market (Mncube and Theron, 2021). Cartels involve firms collaborating to set higher prices, cause scarcity, lead to inefficient production, restrict consumer choice, and reduce quality (Motta, 2004). This type of antitrust violation primarily harms those further down the supply chain, as they end up paying more for the product than they would in a competitive market (Motta, 2004). Furthermore, price fixing, market allocation, and collusive tendering allow firms to exploit their market power, which usually leads to artificially high prices, reduced innovation, and worsened consumer welfare (Mncube and Theron, 2021). Consequently, higher prices typically lead to existing customers buying less or not buying at all if they had purchased at a lower, competitive price.

Mncube and Theron describe cartels as "the most egregious infringements in competition law" as they strike at the heart of what competition authorities aim to protect – fair and effective competition in the market. Naturally, cartels distort competition, prevent efficiency, harm consumers, and have a damaging impact on market dynamics (Mncube and Theron, 2021). Moreover, cartel behaviour is inherently secretive, causing harmful practices to go unnoticed for extended periods and allowing firms to reap benefits that distort market conditions. The difficulty in detecting cartels is compounded by the fact that firms involved in cartels often engage in tactics to obfuscate their behaviour, further emphasising the strong need for regulatory tools and deterrents (Mncube and Theron, 2021).

Cartels tend to be persistent and resilient, even in the face of deregulation and liberalisation. In their discussion, Mncube and Grimbeek (2016) highlight how South Africa's transition from a regulated to a more liberalised economy has led to the dismantling of former cartels. But also created new incentives for firms to engage in cartel-like behaviour in previously protected markets. Adam Smith's comment in *The Wealth of Nations (1776),* that "*people of the same trade seldom meet together, even for merriment and diversion, but the conversations end in a conspiracy against the public, or in some contrivance to raise prices*", highlights the enduring nature of cartel behaviour (Whish, 2009, p. 496). Whish argues that Smith's comment was prescient, considering evidence corroborating his demonstration that the persistence of collusive practices is ancient and often incentivised by the government. Moreover, during the Eastern Roman Empire (Byzantium), the Constitution of Zeno of 483 AD explicitly prohibited price fixing on commodities such as clothes, fish, sea urchins and other goods, punishing offenders with perpetual exile, often to Britain (Whish, 2009, p. 496).

Despite the adoption of competition laws and the imposition of stringent sanctions, cartels have continued to thrive, frequently leveraging sophisticated methods to evade detection. For instance, in *the Gas Insulated Switchgear*[4] cartel case decided by the European Commission, participants used various strategies to conceal their activities (Whish, 2009, p. 497). These included using coded languages to obscure their company names, encryption software to secure e-mails and telephone communication, free email providers with anonymous mailboxes, and password-protected documents with frequently changed passwords. Additionally, cartel members systematically destroyed e-mails, downloaded attachments onto the memory sticks instead of computers and used encrypted mobile telephones provided by a member of a company (Whish, 2009, p. 497).

Similarly, in *the Industrial Bags* case, a document discovered by the European Commission instructed members to destroy all records related to VALVEPLAST, the industry's trade association, containing market allocation and price information. This underscores the lengths to which cartels go to illicit activities. As Whish states, from clandestine meetings in "smoke-filled rooms" to covert communications in "smoke-free" online chat rooms, the risk of cartel activities remains a persistent challenge (Whish, 2009, p. 497).

Harrington (2006) identifies properties of cartels such as quantity allocation, where members of cartels often allocate market shares or production quotas among themselves to control supply and prevent competition, ensuring that each member maintains a stable market presence. To sustain these agreements, the participants implement monitoring systems to track compliance and establish punishment mechanisms for any deviation. Moreover, the participants must respond to disruptions from non-cartel suppliers. To do this, they employ various methods such

[4]European Commission decision of 24 January 2007, available at www.ec.europa.eu/comm/competition/index_en.htlm, regarding the appeal in Cases T-117/07 Areva & others v Commission, which has not yet been decided.

as temporary price adjustments to retain customers and market coordination to stabilise the market. Effective communication amongst participants is also crucial for quickly addressing external threats and developing unified strategies to ensure sustained market power.

Kwoka (2001) provides a detailed empirical analysis of one of the most well-documented historical cartels, the Joint Executive Committee (JEC) in the U.S. railroad industry during the late 19th century.[5] Kwoka finds that while the cartel was able to achieve some degree of price stabilisation, it faced persistent challenges in enforcing agreements, particularly during periods of demand fluctuation and external competitive pressure. The paper highlights the inherent instability of collusion even in a structured, rule-based cartel, emphasising the role of monitoring, enforcement mechanisms, and firm asymmetries in sustaining anti-competitive outcomes. This case study underscores the importance of institutional arrangements and market conditions in determining cartel effectiveness and contributes to the empirical understanding of how collusion operates in practice.

With regards to these insights, it is evident that cartels are an ancient and ongoing concern in the market. Its conspiracy dynamics have not changed from the past but have become trickiest and highly unnoticed, negatively affecting competition in the market. It is, therefore, highly required that continuous assessments such as this study, which employs multiple and effective methods of cartel investigations, be expanded to suggest effective deterrence in future collusive practices and ensure competitive compliance in the market.

3.2. Detecting Cartel overcharges

Recent advances in cartel detection have introduced both traditional and statistical screening techniques, including modern computational tools for enhancing the identification of collusive behaviours. Harrington (2006) emphasises the importance of empirical patterns such as bid clustering and abnormal price rigidity as early indicators of coordination among cartel members. Building on this, recent studies like Chassang et al. (2012) suggest that low bid variance, isolated winning bids, and clustered losing bids can be statistically evaluated to flag potential collusion in procurement and pricing data. In parallel, deep learning approaches, especially those using

[5] Using archival pricing and output data, the study examines how the JEC coordinated pricing among competing railroads and evaluates the extent to which it successfully maintained collusion over time.

convolutional neural networks (CNNs), have demonstrated high accuracy in distinguishing collusion from competitive bidding patterns by analysing graph-based representations of inter-firm pricing behaviour.

Beyond detection, a central concern in the literature is not only how to identify collusive behaviour ex post but also how to deter it ex ante through effective penalty design and proactive detection. In this regard, the European experience offers valuable lessons in both evaluating the deterrence effect of antitrust penalties and improving screening methods using real-world enforcement data.

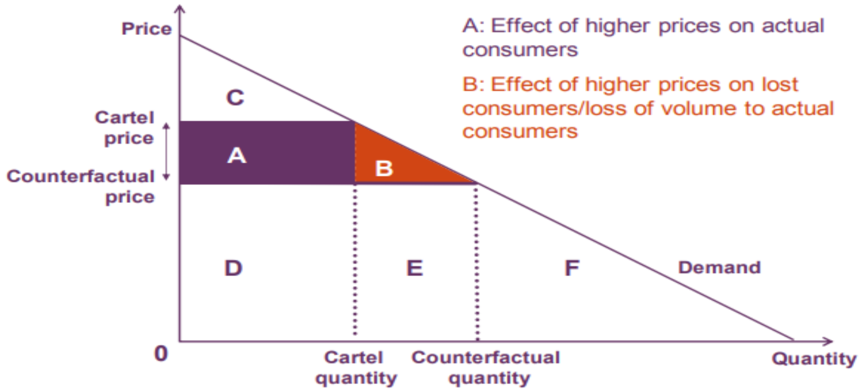
The paper by Schinkel (2007) argues that while the European Commission has significantly increased its cartel enforcement activity, the deterrent effect remains limited due to the relatively low probability of detection and prosecution. Schinkel contends that current fines often fall short of optimal deterrence levels, particularly when they fail to exceed the economic gains firms obtain from collusion. The study advocated for a more rigorous and transparent methodology in calculating fines, one that accounts for overcharges, duration of collusion, and the risk-adjusted profits of cartel activity, to enhance the credibility and impact of enforcement mechanisms.

Complementing this policy, Schinkel and Paha (2022) developed a data-driven approach to improve the early detection of cartel behaviour by analysing patterns in past enforcement decisions. Using statistical classification techniques, the study trains screening models on actual decisions made by antitrust authorities to identify features common to prosecuted cartels. The paper demonstrates that these supervised learning models can detect potential cartels more accurately than traditional structural screens (e.g., price variance or profit margins alone). Their findings suggest that integrating machine learning into cartel screening can significantly reduce the likelihood of false positives while enabling more proactive and efficient allocation of enforcement resources.

The European Commission (2009) demonstrate a cartel detection in that increased prices and decreased output often go hand in hand, as shown by the downward-sloping demand curve in Figure 1 below. Consequently, price-fixing and output-fixing cartels tend to have similar effects. This reduction in sales volume often harm potential buyers who would have been willing to purchase at a lower, non-cartel price. However, it is often difficult to identify these buyers, which makes it challenging to prove and seek remedies for the lost sales in many cases (European

Commission, 2009).

Figure 1: Cartel overcharge demonstration



Source: Based on standard textbook representation, European Commission (2009)

The figure also demonstrates how a cartel's overcharge and lost-volume effect harm direct purchasers, whether they are sellers or end-consumers. While both face the overcharge, the actual harm depends on how much the price increase is passed down the supply chain. This complication makes antitrust damage claims difficult, as it involves figuring out how costs or price changes are distributed along the supply chain. The pass-on issue does not change the overcharge amount but shows how the harm is spread.

Rectangle A represents an overcharge that is calculated by multiplying the number of units sold by the cartel with the difference between the cartel price and the counterfactual price. For example, if the price of a cartel is R125 and the counterfactual price is R100, the overcharge expressed as a percentage of the actual price will be 20% (125-100/125 * 100). The lost-volume effect, represented by triangle B, is a deadweight welfare loss, signifying an overall economic inefficiency.

In general, the cartel framework literature briefly provides insight into the evolution of cartel detection and deterrence, from theoretical models and structural markers to advanced algorithmic tools and policy-oriented strategies. While empirical patterns remain essential for initial screening, the integration of machine learning and improved penalty frameworks marks a shift toward more effective and proactive antitrust enforcement. Together, these developments underscore the importance of combining institutional insight, data analytics, and legal reform in constructing a robust framework for combating cartels.

4. Literature review on estimating cartel overcharges

Price-fixing is one of the most prominent reported cases resulting from cartel formation. The effect of cartels on pricing has been the subject of most empirical studies, which have mostly focused on developed countries. Connor (2007) presents a meta-analysis of over 400 cartel instances worldwide, concluding that a typical overcharge imposed by cartels runs between 20% and 30% over competitive rates. In a separate investigation, Bolotova et al. (2008) discovered that cartels in the US agriculture sector overcharged by as much as 50%, demonstrating the influence collusive businesses may have.

Nonetheless, research on overcharging in emerging markets remains scarce. After a similar cartel investigation, Boshoff (2015) calculated the overcharges in the cement sector in South Africa and discovered that prices were raised by around 15%. Although in smaller percentages than in the US agriculture, cartel actions have low to zero justification and may cause direct or indirect economic harm. This emphasises how further studies are required to fully comprehend the dynamics of cartels, including the long steel sector.

4.1 *Methodology for Estimating Overcharges in Case Studies*

Considering the scarcity of calculations of overcharges in emerging countries, the methods of estimating overcharges remain common to those employed in developed countries. There are several methods of estimating overcharges and Boyer and Kotchoni (2011) identify five methods of estimating overcharges namely, (1) the before-and-after method, (2) the price during a price war method, (3) the yardstick method, (4) the cost-based method, and (5) Econometric method.

According to Van Dijk and Verboven (2015), two primary methods are frequently used to assess price overcharges. The first method is the yardstick method which compares prices in the cartelised market to those in a comparable market unaffected by the cartel. This could involve comparing prices in different geographic regions or across similar products (Rubinfeld, 2009). For example, in the context of the long steel cartel, a potential yardstick could be steel prices in another African country that was not affected by the cartel. One of the advantages of this method is that it provides a clear, external reference point. However, its limitation lies in the assumption that the yardstick market is sufficiently similar to the cartelised market. Differences in demand conditions, costs, or regulatory environments can make this comparison less reliable, even after adjustments through regression analysis (Rubinfeld, 2009).

The second strategy is the benchmark method, which focuses on price movements within the cartelised market, comparing prices during the cartel period to those in a non-cartel period, either before or after the cartel's influence (Van Dijk and Verboven, 2015). This method has the advantage of using data from the same market, which might better account for eccentric factors affecting prices. For instance, in the long steel cartel, historical price data from periods outside the cartel's influence could provide a more accurate baseline for competitive pricing. However, this approach requires that the non-cartel period be sufficiently similar to the cartel period, with adjustments made for any shifts in demand, supply, or costs during the cartel period (Rubinfeld, 2009).

Regression analysis can be employed to enhance both methods. The before-and-after method, also known as the "forecasting" approach, uses data from non-cartel periods to predict prices without the cartel (Rubinfeld, 2009). While useful, this method assumes that factors influencing prices in the non-cartel period would have remained consistent during the cartel period. This is an assumption that might not hold in dynamic markets (Connor, 2010) or lead to a lack of robustness as a result of an incorrect conspiracy period that may lead to biased estimates (Boyer and Kotchoni, 2011).

Alternatively, the dummy variable method uses regression models with data from both the cartel and non-cartel periods to estimate the average effect of the cartel on prices (Rubinfeld, 2009). Rubinfeld argues that this method is more flexible as it allows for the inclusion of other variables that may have changed alongside the cartel's influence. However, it assumes that the covariates (e.g., demand and cost factors) are not directly affected by the cartel, a condition that might not always be met.

In summary, both the yardstick and benchmark methods provide robust tools for estimating overcharges, though their effectiveness depends on data availability and market conditions. The yardstick method can be powerful when a comparable market exists, while the benchmark method may be preferable when such markets are difficult to identify. In the case of my study of the long steel cartel, the benchmark approach may offer a more reliable means of estimating overcharges due to the difficulty in finding a comparable steel market that was unaffected by the collusion in the country. This could be based on South Africa's position as the major exporter of steel products to most countries, including the neighbouring countries (World Bank, 2023)[6]. However, the choice of my study methods depends on the specifics of the data and the distinctions of the South African steel market.

4.2 *Empirical analysis of overcharge estimation methods*

The use of econometric models to estimate overcharges has been extensively applied in antitrust cases, particularly in cases of price-fixing. The following are some of the models employed in various competition studies and practiced by cartel analysists.

4.2.1 Reduced-form regression and benchmark approach

Nieberding (2006) explores the application of reduced-form regression techniques, a method commonly used to estimate overcharges by modelling the relationship between prices and other relevant variables over time. In his study, Nieberding compares two approaches within this econometric framework: the dummy variable and the forecasting approach.

Nieberding found that the estimated overcharge during the cartel period was 14.73% using the dummy variable approach, compared to 12.09% when accounting for a lagged dependent variable. The forecasting approach yielded similar results, with overcharges estimated at 15.27% without the lagged dependent variable and 11.53% when it was included. The proximity of these results suggests that the estimates are robust across different methodologies. However, Nieberding emphasizes the importance of ensuring that the estimated average overcharge accurately reflects the but-for price, which represents what the market price would have been absent the cartel.

Concurrently, Brander and Ross (2017) identify reduced-form regression analysis and comparator benchmark methods as leading techniques for estimating damages from price-fixing or overcharging. Reduced-form regression models, as previously discussed by Nieberding

[6] In 2023, South Africa's exports of iron and steel rails amounted to approximately $4.56 million for Zimbabwe, Namibia, Botswana, Zambia and the DRC.

(2006), allow for the isolation of cartel effects by controlling for market variables such as cost and demand fluctuations. Brander and Ross argue that advances in data availability and computing power have significantly improved the accuracy of damage estimates. However, they caution against overreliance on statistical significance, emphasizing the risk of specification search bias in econometric models.

As stated by Rubinfeld (2009), the reduced-form regression is particularly relevant in cases where direct data on competitive prices are unavailable, or where prices are influenced by multiple factors that need to be controlled for. The model provides flexibility by allowing the inclusion of various independent variables (e.g., cost inputs and demand factors) that directly or indirectly influence price levels. Moreover, the flexibility of the reduced-form model in accommodating different regression techniques, such as the inclusion of lagged variables or dummy variables, helps ensure that the overcharge estimates are as accurate as possible.

In contrast, Nieberding's findings demonstrate that both the dummy variable and forecasting approaches produced relatively consistent results, reinforcing the model's robustness. The comparator benchmark method, which involves comparing prices during the cartel period with those in a similar, non-collusive market, could also be applied, though finding an appropriate benchmark market remains a challenge.

4.2.2 *Before-and-after Approach and Structural Analysis*

Hüschelrath, Müller, and Veith (2012) explore the estimation of overcharges in price-fixing cartels within the European Union (EU), focusing specifically on the cement cartel. The study uses the before-and-after method in conjunction with the structural break analysis to estimate overcharges. By identifying significant changes in price trends at the end of the cartel period, structural break analysis helps pinpoint when competitive pricing resumed, providing a clear demarcation for the before-and-after comparison. The authors conclude that transaction data should be regularly used in antitrust cases for a detailed assessment of the cartel's impact on consumers. This method may be directly applicable to the long steel cartel case in South Africa. By employing structural break analysis, it is possible to accurately estimate the point at which cartel influence ended, offering a foundation for before-and-after price comparisons. Additionally, the regular use of transaction data, as suggested by Hüschelrath et al. (2012), could provide more granular insights into the impact of collusion on steel prices.

In recent studies, Das Nair and Mondliwa (2019) provided one of the few empirical estimates of overcharges in the South African reinforcing bar cartel. Using a price trend analysis before, during, and after the cartel, they found substantial evidence of collusive overpricing. While their work offers crucial insights into the extent of harm caused by the cartel, it was limited by its reliance on aggregate price-cost margins and did not account for firm-specific pricing behaviour or external cost shocks. This study aims to build on their work by adopting a more granular empirical strategy that controls for market-specific shocks and heterogeneity across firms, offering a more robust counterfactual for estimating overcharges.

While significant research has been conducted on cartels and their economic impacts, there are notable gaps in the literature regarding cartel behaviour in the steel industry, particularly in emerging economies like South Africa. Few studies have quantified the specific overcharges resulting from cartels in African markets. The long steel cartel study aims to provide an opportunity to contribute to bridging this gap. Furthermore, while the methods for estimating overcharges are well-developed, there is a need for more refined analyses that consider the unique market conditions in South Africa, including the effects of regulatory frameworks.

5. Data, method and empirical analysis

As highlighted in the literature review, there are several methods for measuring price overcharges, each with its limitations. Among these, the reduced-form model using either a "forecasting" or dummy variable method has gained considerable advocacy from several authors due to their relative simplicity, transparency and robustness in capturing cartel effects. According to Nieberding (2006, p.365-379), this method can estimate a model through the dummy variable approach, which includes an indicator (or "dummy") variable that is equal to one (1) during the conspiracy period and zero (0) otherwise. The coefficient of the dummy variable provides an estimate of the average overcharge due to the price-fixing conspiracy. In parallel, the forecasting approach is also used by regressing the non-cartel period to predict competitive prices that could have prevailed absent the collusion. Cartel overcharge will then be computed by the difference between the actual and the predicted price.

However, these methods are also not exempt from drawbacks. The dummy variable may overstate or understate the effects if the period of the cartel is misidentified or if there were uncaptured structural changes that occurred during the same period (Bolton, Branstetter, and Christopher, 2012). This approach may also risk omitting relevant time-varying confounders that can produce biased results if not controlled for correctly. On the other hand, while useful in the absence of clean control groups, the accuracy of the forecasting approach depends heavily on model specification and the assumption of structural stability over time, which may not hold in volatile commodity markets like steel (Harrington, 2004; OECD, 2013). This approach can also suffer from selection bias, especially if it fails to account for shocks that are unrelated to cartel behaviour that influenced the prices during the observed period (Fischer and Hüschelrath, 2014).

5.1 *Data*

In estimating overcharges for the long steel cartel and for alignment to economic theory and robustness, my dependent variable is the monthly Producer Price Index (PPI)[7] for mild steel billets and angles[8] acquired from Statistics South Africa (Stats SA). Data on billets and angles were found to be more consistently available and traceable across our observed period, providing ease to the quantitative analysis. Billets are square or rectangular cross-sectioned steel products which are semi-finished and processed through continuous casting or rolling for finished products like bars or construction shapes (Jiyuan Steel, n.d.). In other words, billets are core intermediary inputs to the production of rebar and other long steel products such as angles and channels. Therefore, distortion in billets prices (through upstream market power, internal transfer pricing within vertically integrated firms or cost inflation) is likely to reflect the underlying effects of the long steel cartel. In this regard, analysing prices of billets may provide insight into upstream overcharge that influences downstream prices

On the other hand, angles are L-shaped steel products used for structural support in construction, manufacturing and infrastructure, varied for frameworks, bridges and machinery (Rosha Steel, n.d.). Although it is implicit whether angles were cartelised, angles are close substitutes to rebars within the long steel market and were often produced by the same firms implicated in the cartel[9]. In using these products, the study has the opportunity to detect collusive pricing patterns through

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[7] PPI serves as a measure of price movement at the producer level and reflects the cost-push and demand-pull factors that influence the prices of long steel.
[8] See https://www.statssa.gov.za/?page_id=1847 for PPI Billets and angles.
[9] Angles are also long steel structural products, widely used in construction, infrastructure, transmission towers

indirect channels[10] to provide a vertical assessment of the cartel overcharge.
According to Lubbe (October 2009), billet consumption by the South African long-steel sector increased from approximately 3.2 million tonnes in 2007 to 3.4 million tonnes in 2008, while angle consumption rose from 1.1 to 1.15 million tonnes in the same period. The average selling price of billets increased from about R 4,200 per ton in 2007 to R 4,600 per ton in 2008, with angles rising from R 5,800 per ton to R 6,200. These products together accounted for over 70% of the physical volume of long-steel products consumed by construction, infrastructure, and engineering firms, demonstrating both their economic significance and price sensitivity, making them critical proxies in estimating cartel overcharges. The upward price trends in these key products also align with periods of suspected cartel activity, underscoring that billet and angle data provide relevant markers of input and output price distortion in the absence of reliable rebar-specific data.

The independent variables include the demand factors such as the national monthly total buildings passed, non-residential buildings passed, and the value of the buildings completed, all measured at current prices. I further included the total buildings completed measured in square metres. These are proxies for construction activities, which are major consumers of long steel products, and the data is collected from Stats SA[11]. I also include the GDP at current market prices[12] from the South African Reserve Bank (SARB), which serves as a broad measure of the steel demand across various industries, such as the agriculture sector for fencing and the mining sector. For the input cost factors, I used iron ore prices per dry metric ton (US dollar) as the primary raw material and operational expenses, through its price fluctuations, with data extracted from Market Index[13], adjusted to rands through respective exchange rates from SARB[14]. Moreover, I used the monthly PPI of electricity and coal (for the domestic output of the SA industry group) because steel manufacturing is highly energy intensive. I also used the unit labour cost of manufacturing to account for cost competitiveness.[15]

[10] See OECD (2012) for literature on input market pricing and vertical abuse.
[11] See Statistics South Africa - P5041.1.
[12] See https://www.resbank.co.za/en/home/what-we-do/statistics/releases/economic-and-financial-data-for-south-africa Economics and financial statistics for SA: GDP at Market prices (current, sa) in Rmillions.
[13] See https://www.marketindex.com.au/iron-ore originally sourced from the International Monetary Fund from July 2017, MYNEX cash.
[14] See https://www.resbank.co.za/en/home/what-we-do/statistics/key-statistics
[15] See https://fred.stlouisfed.org/series/LCULMN01ZAQ661S for Labor Compensation: Unit Labor Cost: Manufacturing: Total for South Africa (LCULMN01ZAQ661S)

Despite data accessibility, the independent variables are also appropriate factors for estimating South Africa's long steel cartel overcharge for this study. These variables represent the cost-price pressures that affect price, where an increase in input cost, such as iron ore, often leads to higher prices if passed on to consumers. Consequently, if the cost of iron ore was reduced within the period studied, we would expect long-steel prices to be affordable for consumers. Any deviation from this expected cost-price relationship could indicate a potential cartel pattern.

5.2 *Method and empirical analysis*

This study is both theoretical (in evaluation of cartel conducts and policies) and empirical (in assessing overcharges). Empirically, the study aims to estimate the long steel cartel overcharges by using the reduced form regressions. Since the hypothesis in grounded in that the cartel conduct led to price increases beyond what would be expected under competitive conditions. The approaches used to assess the impact of the cartel conduct in the long steel industry SA are the dummy variable (or cartel indicator) and the forecasting. For this study, the dummy variable approach is essentially a during-and-after approach, which compares prices for billets and angles (mild steel) during and after the cartel conduct. I will apply a basic Ordinary Least Square (OLS) model to determine the relationship between the prices for billets (mild steel), controlling for demand and supply conditions that prevailed in the period 1993-2016. To avoid repetition in terms of the dependent variables, I will only interpret the forecasted result of angles in comparison to that of billets.

A binary cartel dummy variable takes on the value "1" during the cartel (2001-2008) period and "0" otherwise. It is intended to capture the magnitude of any unexplained price increases that occurred during the cartel period. This approach effectively assumes that there was a discrete upward or downward shift in the price for billets and angles (mild steel) when the dummy variable is equal to 1. The coefficient of the dummy variable captures the magnitude of this shift, i.e. by how much prices were elevated due to the cartel. The model takes the Error Correction Method (ECM)[16], which assists in correcting nonstationary and high cointegration experienced

[16] See Wooldridge (2000, pp. 591-593) for a discussion of ECMs and their general specification.

in the dataset[17] and represents situations where prices do not instantly react to changes in market conditions. The model takes the ECM of a reduced-form regression:

$$\Delta InPrice_t = \beta_0 + \beta_1 \Delta InDemand_t + \beta_2 \Delta InCost_t + \beta_3 Dummy_t + \gamma EC_{t-1} + \varepsilon_t \ (1)$$

where: Δ represents the first difference (change from the previous period)[18].

- EC_{t-1} is the lagged ECM, capturing the deviation from the long-term equilibrium.
- γ is the coefficient on the ECM, which reflects the speed of adjustment back to equilibrium. For example, suppose the prices during the cartel period were 20% higher than expected, but post-cartel prices remained elevated by 10% for the next two quarters. The lagged price term would allow this model to account for this delayed return to normal pricing, providing robust estimates of the cartel's long-term effect on price
- ε_t is the error term.

$$\Delta InPrice_t = \beta_0 + \beta_1 \Delta InDemand_t + \beta_2 \Delta InCost_t + \beta_3 Dummy_t + \gamma(InPrice_{t-1} - \beta_0 - \beta_1 InDemand_{t-1} - \beta_2 InCost_{t-1}) + \varepsilon_t \ (2)$$

where: β_0 is the intercept that is assumed to be equal for all the variables, presented as cons, $Price_t$ reflects the prices of billets and angles (mild steel) as $InPPI\_Billets_t$ and $InPPI\_Angles_t$ respective of the regressions, and t for time. The $\beta_1 InDemand_{t-1}$ is presented as $\beta_1 InIron_t$ for Iron, $\beta_2 InElec\_PPI_t$ for electricity, $\beta_3 InCoal\_PPI_t$ for coal, and $\beta_4 InULC\_Man_t$ for labour costs. The $\beta_2 InCost_{t-1}$ (input costs) is regressed as $\beta_5 InBuilding\_p_t$ for the total building passed nationally, $\beta_6 InNonres\_Pa_t$ for the total non-residential buildings passed, $\beta_7 InBuildings\_com_t$ for the total completed buildings in square meters, and $\beta_8 InBuildings\_com{\sim}e\ _t$ for the total values of completed buildings. The GDP per market price is regressed as $\beta_9 InGDPatmark_t$, and the Dummy variable as $\beta_{10} Dummy_t$.

The variables are expressed in natural logarithmic terms (In), meaning the regression coefficients will be interpreted in terms of percentage changes (i.e. elasticities). Estimating the models in logs

[17] I used the Dickey-Fuller test for stationarity and found that my time series reveals p-value > 0.05, indicating nonstationary. I then checked for cointegration using the Johansen test and found my time series test statistics to be well above the critical values, indicating high cointegration. To correct for these

[18] For data issues with pot spurious findings, I used the first differences of the variables to make the data stationary as Nieberding (2006, 375) introduced as the ECM.

narrows the range of the variables, making the analysis less sensitive to outliers.

The study is particularly interested in the dummy variable coefficient β_3. If the coefficient on the dummy variable is positive and significant, this would be an indication of an overcharge during the cartel period. The overcharge percentage is computed as:

$$Overcharge\ (\%) = \left(e^{\beta 3} - 1\right) * 10$$

6. Results

This section presents the core empirical findings, building on the econometric methodology outlined in section 5. First, I will report and interpret the estimated long-run and short-run ECM results for billets prices and then derive counterfactual ("but for") prices under the dummy variable and forecast approaches. Second, I will delineate the competition conditions that prevailed in South Africa during the observed period, also comparing the results with the administrative penalties imposed by the Tribunal, thereby evaluating whether fines reflected the economic harm caused by cartel conduct.

6.1 Table 1[19]: The long-run correlation (cointegration) billets mild steel.

Source	SS	df	MS			
				Number of obs	=	288
				F(9, 278)	=	2099.24
Model	94.1227844	9	10.4580872	Prob > F	=	0.0000
Residual	1.38495234	278	.004981843	R-squared	=	0.9855
				Adj R-squared	=	0.9850
Total	95.5077367	287	.33277957	Root MSE	=	.07058

lnPPI_Bille~2	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
lnIron	.1375299	.0251131	5.48	0.000	.0880939	.1869659
lnElec_PPI	-.1322133	.0235665	-5.61	0.000	-.1786048	-.0858218
lnCoal_PPI	.1838103	.0597264	3.08	0.002	.0662369	.3013838
lnULC_Man	.1079835	.1055559	1.02	0.307	-.0998069	.3157739
lnBuildings~d	.0728256	.0301837	2.41	0.016	.013408	.1322432
lnNonres_Pa~d	-.0480638	.0148416	-3.24	0.001	-.0772801	-.0188475
lnbuild_com~m	-.0031662	.0558669	-0.06	0.955	-.113142	.1068096
lnbuild_com~e	.1071535	.0468101	2.29	0.023	.0150062	.1993009
lnGDPatmark~e	.3072555	.0709144	4.33	0.000	.1676582	.4468528
_cons	-3.839551	.692757	-5.54	0.000	-5.203267	-2.475835

[19] See Appendix for other regressed results.

Variable	Obs	Mean	Std. dev.	Min	Max
ECM_term_2	288	-6.69e-16	.0694667	-.1578938	.2518421

Table 1 above presents the long-run[20] estimates for PPI billets (InPPI_Bille~2) with a similar R-square and Adjusted R-square (AdjR^2) of 0.985. Table 2 below shows the short-run estimates for PPI billets with a low 0.099 R-square. The R-square values of both table 1 and 2 indicate that approximately 98.6% of the variation in the long-run billets prices and 9.9% of the variation in the short-run is explained by the demand and input cost factors, as influenced by the ECM effect.

Table 2: ECM short run estimates

Source	SS	df	MS
Model	.020799896	11	.0018909
Residual	.189012086	275	.000687317
Total	.209811982	286	.000733608

Number of obs	=	287
F(11, 275)	=	2.75
Prob > F	=	0.0021
R-squared	=	0.0991
Adj R-squared	=	0.0631
Root MSE	=	.02622

D. lnPPI_Bille~2	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
lnIron D1.	.0063416	.0199833	0.32	0.751	-.0329981	.0456812
lnElec_PPI D1.	-.0046591	.0135219	-0.34	0.731	-.0312787	.0219605
lnCoal_PPI D1.	-.0579979	.0471341	-1.23	0.220	-.1507875	.0347917
lnULC_Man D1.	-.2019058	.1160341	-1.74	0.083	-.4303337	.026522
lnBuildings~d D1.	-.0042292	.0133363	-0.32	0.751	-.0304834	.0220251
lnNonres_Pa~d D1.	.0008088	.0055924	0.14	0.885	-.0102007	.0118182
lnbuild_com~m D1.	.0289144	.0219396	1.32	0.189	-.0142766	.0721053
lnbuild_com~e D1.	-.0171103	.0182573	-0.94	0.349	-.0530521	.0188314
lnGDPatmark~e D1.	-.2850299	.1247633	-2.28	0.023	-.5306424	-.0394173
ECM_term_2	.0798219	.0233136	3.42	0.001	.0339262	.1257177
Dummy	.007862	.0033184	2.37	0.019	.0013292	.0143948
_cons	.0068254	.0022888	2.98	0.003	.0023196	.0113312

[20] Unlike the short-run estimates, the long-run estimates do not include dummy variables since their relationship is derived from variables that share a common stochastic trend. Dummy variables, which introduce discrete shifts, may disrupt the estimation of these relationships and affect stationarity properties.

Residuals

variable	obs	Mean	Std. dev.	Min	Max
residual	287	-4.17e-19	0.0257076	-0.754083	0.166359

This also shows that there is a high positive correlation between the long-run variables and weak correlation between the short-run. In terms of statistical significance[21], the results show that the input cost factors of the long-run estimates, such as the prices of iron, electricity, and coal, are significant at 1% while insignificant for unit of labour costs. This means that for every one percent increase in prices of iron and coal, there was an increase of 13.75% and 18.38% in prices of billets ceteris paribus, indicating a strong pass-through effect. Interestingly, electricity PPI shows a negative and significant long-run effect (-13.22%), which may point to multicollinearity or structural dynamics within the energy market which deserve further investigation.

Other significant long-run effects associated with prices of billets include a 5% level for buildings passed at a 7.28% increase and the value of the buildings completed at a 10.72% increase ceteris paribus, reflecting the role of construction demand for billets. The non-residential buildings passed, conversely, show a 1% significantly negative effect at 4.8%, which may suggest demand substitutions or misalignment (e.g., corruption or underspending) with investment and budget patterns. GDP at market prices is captured at a strong 1% significance, leading to a 30.73% increase in billets prices ceteris paribus; this underscores the procyclical behaviour of the steel sector. The buildings completed per square metre reveal insignificance.

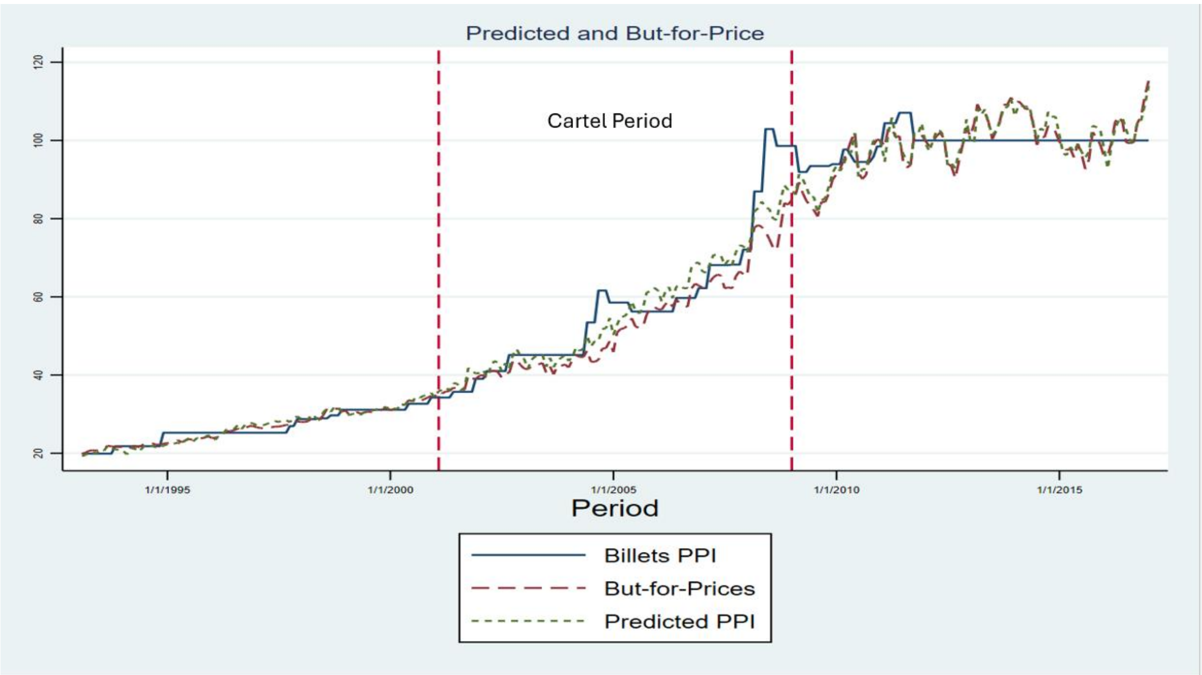
In contrast, the short-run estimates find no significance in the entire input cost factors and demand factors, except for the GDP at market price. With a 5% significance level, the GDP market prices decreased the price of billets by 28.50% ceteris paribus, potentially reflecting inflation targeting or cyclical corrections in price movements at that period. Of relevance to this study is the dummy variable coefficient representing the cartel period 2001 to 2008, which is statistically significant at 0.0079. This coefficient suggests that the prices of billets were approximately 0.79% higher during the cartel period ceteris paribus, providing quantitative evidence for short-run overcharge linked to the cartel behaviour.

[21] If the t-statistic is |>| 1.96 the variable is significant at 1%, if t-statistic is |>| 2.58 the variable is significant at 5%, etc.

Figure 1 below presents the predicted[22] and but-for prices[23] against the actual prices for the period observed in the dummy variable approach. Using the ECM short-run regressed estimates, the actual and predicted prices for PPI billets for the cartel period revealed an average of 56.99% and 56.06%, respectively, with a difference of 0.93%. In parallel, the but-for prices averaged approximately 52.66%, with a difference of 4.33% and 3.4% in respect of the actual and the predicted prices. The average overcharge for PPI billets was approximately 1.05%, suggesting that the cartel price-fixing may have had a weak impact on the market forces influenced by high input costs or demand elasticities. Because this approach conditions on cartel-period observations, it risks downward bias (Rubinfeld, 2009).

Moreover, this modest overcharge may explain the varying levels of cartel compliance by the long steel firms, leading to partial price coordination[24]. This may further suggest that the Commission may have over-penalised the long steel firms involved in the cartel.[25]

6.1.1 Figure 1: The Actual vs. Predicted Prices and But-for Price from ECM (DV approach)

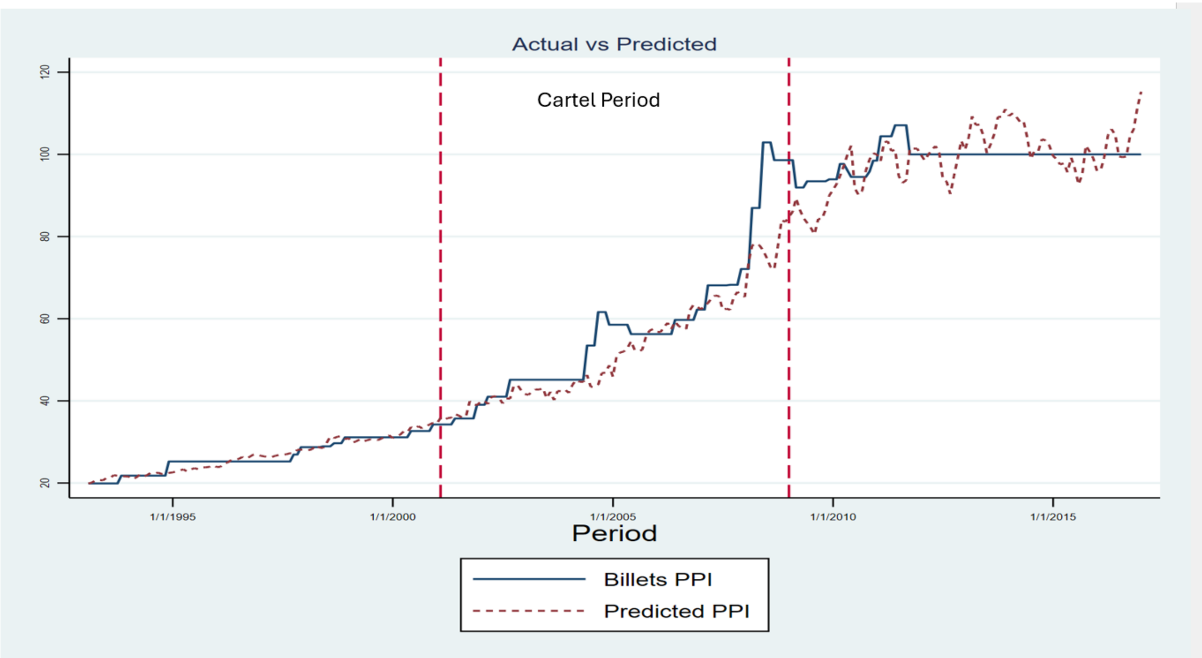


[22] Predicted prices are computed by using data from the non-cartel period, reflecting competitive price without the influence of collusion.
[23] The but-for prices are estimated by setting *Dummyt* equal to 0 for the cartel period.
[24] This interpretation aligns with economic literature suggesting that cartels often struggle to maintain strict price discipline due to incentives for individual members to undercut agreed-upon prices.
[25] Penalty amounts regarding the long steel cartel are discussed in section 7 of this study.

Source: Author (2025)

By contrast, the forecasting approach, which only forecasts the predicted price using the non-cartel period (see Figure 2), revealed a substantially higher average overcharge of 7.29%. This discrepancy in overcharge suggests that the dummy variable approach may have underestimated the true impact of the long steel cartel conduct due to the reliance on the cartel period only. In other views, this estimate may suggest that the Commission may have been incentivised to inflate the steel cartel assessment as related to penalties imposed. In light of this study, the high overcharge estimate revealed using the forecasting approach suggests that the long steel cartel successfully inflated billets prices beyond what they would have been in a competitive market.

6.1.2 Figure 2: The Actual vs. Predicted Prices from ECM-PPI_billets (Forecasting)



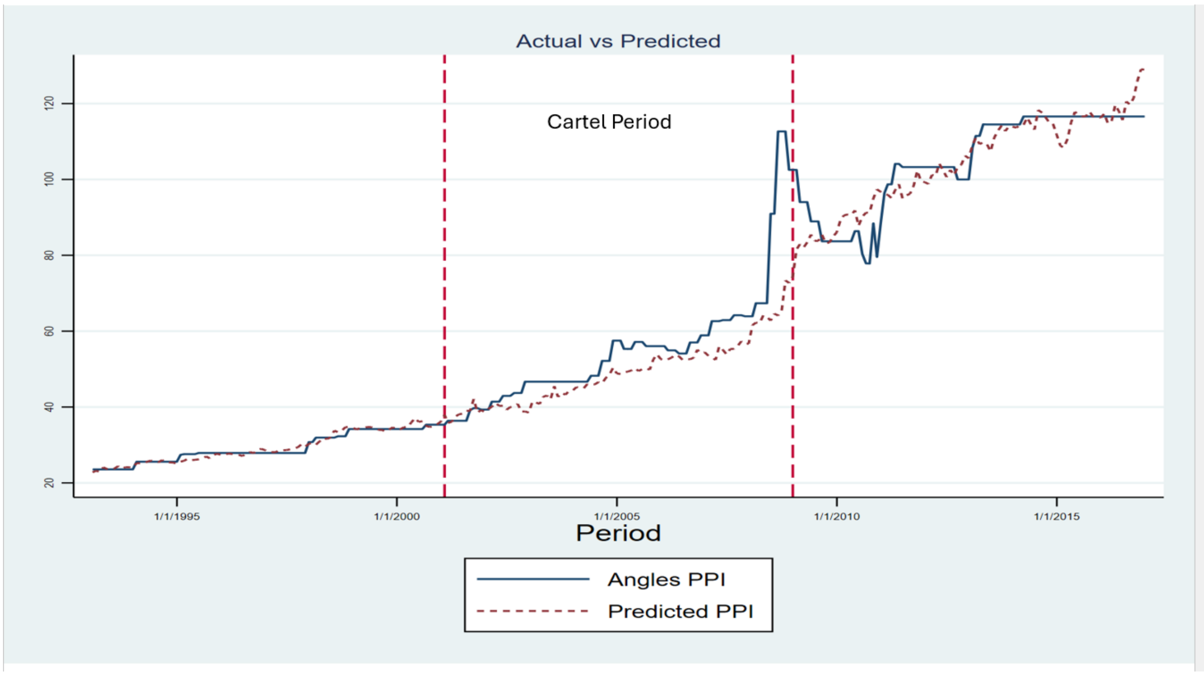
Source: Author (2025)

In terms of trends, Figure 1 and 2 shows an upward slope for PPI billets, which peaks between 2004 and around the first quarter of 2005. Another high shock for the PPI billets is revealed around 2008, prolonging to the third quarter of the same year, wherein a complaint about price-fixing by the steel firms was initiated by the Commission. Considering the peaks, Figure 1 shows that the but-for prices are slightly lower than the predicted prices, whereas the PPI billets are consistently above both the prices, reinforcing a possible overcharge in the long steel industry.

Moreover, the predicted PPI were marginally above the PPI billets and but-for prices during the years 2006, which may have indicated the continued cartel effects post-cartel.

Conversely, Figure 2 (forecasting approach) reveals that the predicted PPI was marginally above the PPI billets around the early years of its assumed formation by the Commission, 2001, and some period around 2006. This could suggest an initial overestimate of the competitive prices due to some costs and demand factors as explained previously.

6.1.3 Figure 3: The Actual vs. Predicted Prices from ECM-PPI_angles (Forecasting)



Source: Author (2025)

For completeness, I also estimated the overcharge for PPI angles mild steel to compare the effects with that of PPI billets. In this section, I only compare Figure 3[26], which presents PPI angles overcharges using the forecasting approach. Similarly, the estimated average overcharge for PPI angles revealed a high and approximate 10.82%, a 3.56% difference from PPI billets. This suggests that, although both the products may have been highly charged, angles prices were inflated by an additional 3.56% relative to PPI billets. Moreover, this means that the consumers active in the construction of bridges and the manufacturing of machines incurred more harm

[26] Figure 4 showing the dummy variable approach for PPI angles is in the appendix.

from the cartel conduct. These findings support the broader conclusion that the cartel had a heterogeneous but economically significant effect on steel pricing (Hüschelrath et al., 2013)[27]. Consequently, the price-fixing trend reveals a marginal difference as compared to the forecasted trends of PPI billets, especially in the period around 2006. During this period, predicted prices were considerably lower than PPI angles as opposed to the consistency with PPI billets (see Figure 2).

6.1.4 *Overview of the results on long steel cartel overcharge (conditions and counterfactuals)*.

During the cartel period, three structural features curtailed price competition in South Africa's long-steel market, namely:

a. *Dominant integrated producer*. ArcelorMittal South Africa (AMSA) owned the only integrated iron-and-steel works and more than 70 % of domestic billet capacity, effectively acting as a price leader (Roberts, 2004).
b. *Import-parity pricing (IPP).* Domestic transaction prices were quoted at the landed cost of comparable imports plus transport and risk premia, decoupling local prices from comparatively low domestic input costs (Competition Commission, 2007).
c. *High entry barriers and explicit collusion*. Capital intensity, energy requirements and the need for secure scrap/iron-ore supply deterred new entrants; contemporaneous Commission investigations revealed routine meetings among AMSA, Cape Gate, and Scaw Metals to set prices and allocate customers between 2001 and 2008 (Competition Tribunal, 2010).

With the competition conditions in mind, the empirical evidence presented confirms that the South African long-steel cartel exerted a statistically and economically significant upward pressure on prices, particularly during the collusive period from 2001 to 2008. Studies by Connor (2014) and Boyer and Kotchoni (2011) reveal that global meta-studies put the median cartel overcharge at 15%-23%. In comparison, the forecasting approach, which excludes contaminated cartel-period data, estimates an average overcharge of 7.29% for billets and an even higher 10.82% for angles; therefore, it falls in the lower half of the global rank. These results indicate that, while the dummy-variable approach yields a more conservative estimate (1.05%), it likely

[27] This paper empirically shows that the German cement cartel had varying overcharge effects across regions, confirming that cartel impacts are not uniform but still statistically and economically significant.

underestimates the full extent of collusive pricing due to model dependence on the tainted sample.

Even though the actual degree of collusion may have varied, the observed price elevation (adjusted for cost and demand factors) appeared relatively uniform. This uniformity of overcharge across the cartel period can be rationalised by a confluence of structural and behavioural factors that allowed the firms to sustain a stable markup on long-steel prices. First, according to Roberts (2004) AMSA's dominance (controlling more than 70% of domestic billet capacity) created a price-leadership environment in which rivals followed a focal price with little incentive to undercut. Second, the industry's import-parity-pricing convention benchmarked local quotes to the landed cost of imports plus transport premia, effectively keeping an umbrella over domestic prices and masking moderate collusive surcharges (Chabane, Roberts and Goldstein, 2003).

Third, vertical integration in iron ore mining and downstream rolling reduced firms' cost volatility, allowing them to apply a steady percentage margin to relatively predictable average costs (Harrington, 2006; Schinkel, 2007). Fourth, detection risk was low before Scaw's 2008 leniency application, so firms faced few external shocks that might otherwise have forced renegotiation of collusive terms (Connor, 2007). Fifth, the 2001-2008 construction boom generated inelastic and rising demand for reinforcing steel, enabling the cartel to maintain mark-ups without eroding sales volumes (Kwoka, 2001; Connor, 2014).

Lastly, the repeated dealings in a concentrated market may have facilitated tacit monitoring and swift punishment of defection, which was a classic strategy that supported price rigidity in repeated-game models of collusion (Green and Porter, 1984). Taken together, these conditions meant that, even if the intensity of coordination varied behind the scenes, the observable premium over competitive prices remained fairly uniform, making the constant-dummy estimate a defensible, policy-relevant average of the cartel's economic harm.

The divergence between actual and but-for price series is most pronounced during known cartel activity peaks, 2004 to early 2005 and in 2008, coinciding with intensified market coordination and construction booms. Furthermore, the greater overcharge observed in angles relative to billets supports the theoretical prediction that less substitutable or more specialised products bear higher markups under cartelisation. Compared with global overcharge studies, such as those by

Connor (2014) and Hüschelrath et al. (2012), the estimated South African effects are moderate but still substantively harmful given the volume of affected output. Thus, the constructed counterfactuals support the core hypothesis of the study that cartel behaviour inflated prices above competitive levels, imposing real economic harm on downstream consumers in the construction and manufacturing industries while escaping proportional financial sanctions.

7. Penalty analysis/ Competition Policy analysis

Following the results in section 6, section 7 aims to answer the second research question of whether cartel penalties imposed by competition authorities correspond to the damages incurred as a result of the overcharge assessed. The section is divided into three subsection including (i) outlining of historic cartel penalties, using past cartel cases and the amount they were penalised; (ii) steps for calculating penalties, demonstrating the measurements employed to calculate the amount imposed on cartel conduct; and (iii) effective policy suggestions where I discuss deterrence to cartel conduct whether these methods correspond to the damages caused by cartels and effective ways to improve cartel enforcement policies in South Africa.

7.1 *Historic cartel penalties*

From 2001 onward, the European Commission has been active in prohibiting cartels, while the South African Commission has been active since 2007. There have been numerous decisions, and the fines have, in many cases, been enormous. The European Commission estimated a striking €1.836 billion fine in 2001, and the amount has since been escalating in the following years. (Whish, 2009, Chapter 13, pp. 500-501)

In South Africa, the first major cartel fine involved the bread and bakery industry. The cartel persisted from 1999 to 2006 until it was discovered in 2007 following an investigation by the Commission. The investigation revealed collusion amongst key players in the industry, including Tiger Brands (Albany), Pioneer Foods (Sasko and Duens), and Premier Foods (Blue Ribbon). The players engaged in a price-fixing and market division practice. The first penalty was imposed on Tiger Brands in November 2007, amounting to R98.87 million. Subsequently, Foodcorp was fined R45.41 million in January 2009, while Pioneer Foods received a fine of R195.72 million in February 2010 (Competition Tribunal, 2010). This case became a landmark in the country’s competition law enforcement history, showcasing the significant financial repercussions of collusive practices. The penalties highlight the efforts of the South African competition authorities to curb anti-competitive behaviours in sectors that are vital to South African consumers.

Some notable cartel cases and fines in the country include the *Fertiliser Cartel in 2009,* where the Commission uncovered cartel conduct involving key fertilizer products, leading to a settlement with Sasol in 2009, which included a penalty of approximately R250 million. In the *Construction Cartel (2013),* the Commission found that 15 construction firms were involved in a collusive tendering scheme and settled with the Commission for R1.46 billion (Competition Commission, 2020). The *SABC Cartel (2019)* where the Commission found that the SABC paid R31.85 million for price fixing and fixing trading conditions (Competition Commission, 2019). The *Cross Fire Management Cartel (2021)* was fined R12.8 million for being involved in a long-standing practice of cover pricing and collusive arrangements (Competition Tribunal, 2021).

In August 2016, AMSA admitted to having engaged in cartels related to long steel and scrap metal. Following rigorous investigations, the Commission finalised a settlement with AMSA, resolving all ongoing investigations and prosecutions involving the company. The Commission imposed an administrative fine of R1.5 billion with AMSA agreeing to specific remedies, although not admitting that the pricing practice violated the Competition Act. The remedies included capping its EBIT (earnings before interest and tax) margin of 10% for flat steel products sold locally for five years. Additionally, AMSA committed to investing R4.6 billion in capital expenditure over the next five years (Competition Commission, 2016).

On 23 June 2023, the Tribunal confirmed a settlement agreement proposed by the Commission and Cape Gate in respect of the long steel cartel practice (Competition Tribunal, 2023).[28] Four primary allegations formed the basis of the Commission's investigation and subsequent proceedings:

i. *Price fixing*: It was alleged that Cape Gate engaged in collusion to set prices for specific long steel products. This practice aimed to distort market dynamics by artificially inflating prices which, in turn, are transferred to the wholesalers of the long steel products and then to the customers.

[28] See Competition Tribunal website case no. CR029Sep09/SA203Mar23.

ii. *Market allocation*: Cape Gate was implicated in agreements to divide the market among competing firms. Such arrangements undermined competition by restricting customer options and stabilising market shares among cartel members.

iii. *Exchange of sensitive information*: The company was accused of sharing commercially sensitive information with competitors. This included details on production costs, market conditions, and future pricing strategies, thereby facilitating coordinated behaviour in the market.

iv. *Customer coordination*: The firm allegedly participated in coordinated actions regarding customer allocations, ensuring specific clients were served by particular firms to minimise competitive pressures.

As a consequence, the Tribunal imposed an administrative penalty of R1.3 million on Cape Gate. Although the company did not admit to the contravention of the Competition Act, the settlement reflected an agreement to resolve the allegations and avoid protracted litigation. The penalty amount was determined based on (a) the severity and impact of the alleged anti-competitive conduct on market competition and consumer welfare; (b) the company's cooperation with the Commission during the investigation, which mitigated potential penalties; (c) a commitment from Cape Gate to implement a compliance program to ensure adherence to competition laws in the future.

7.2 *Steps for calculating penalty.*

The Commission has issued a standard guideline it follows when determining the administrative penalties in cases contravening the Competition Act. These guidelines aim to promote consistency, transparency, and predictability in the measurement of penalties. Furthermore, the guidelines ensure that the imposed sanctions are proportionate to the offense and are aligned with the objectives of the Act. Simply put, the framework serves as a practical tool for assessing penalties while deterring anti-competitive behaviour and fostering compliance with the competition authorities (Competition Commission, 2014). The aspects of the guidelines with examples using the AMSA's case are outlined in Table 1 below:

Step	**Description**	**AMSA Case Example**
1. Determining the base amount	A percentage of turnover from affected products is	If AMSA's affected turnover from long steel and scrap metal was R10 billion,

	calculated as the base penalty.	and the base percentage was 10%, the base penalty would be R1 billion.
2. Duration of contravention	The penalty is adjusted based on the length of the misconduct.	If AMSA participated in cartel behaviour for more than three years, the base penalty of R1 billion could be increased by 50%, raising it to R1.5 billion.
3. Aggravating and mitigating factors	Adjustments are made based on factors like market power (aggravating) or cooperation (mitigating).	AMSA's dominant market position could result in a 20% increase to R1.8 billion, but cooperation in admitting misconduct might reduce it by 15% to R1.53 billion.
4. Legal maximum penalty.	The penalty cannot exceed 10% of the firm's annual turnover in the prior financial year.	If AMSA's annual turnover was R15 billion, the penalty would be capped at R1.5 billion, even if the calculated amount exceeded this limit.
5. Deterrence factor	A multiplier is applied to ensure the penalty effectively deters future misconduct.	A deterrence multiplier of 1.2 could raise a lower penalty (e.g., R1.25 billion) to R1.5 billion to emphasize the seriousness of AMSA's actions.
6. Impact on the economy	The penalty reflects the broader harm caused by the anti-competitive conduct.	AMSA's cartel activities likely inflated steel prices, impacting infrastructure costs. The R1.5 billion penalty addresses these economic consequences.
7. Ability to pay	Financial capacity is considered to ensure the firm can pay the penalty without jeopardizing its operations.	AMSA's ability to pay was deemed sufficient to support the R1.5 billion penalty, even with a R4.6 billion capital expenditure commitment over five years.

Table 1: Presents the steps for calculating penalties with examples showing how each applies to AMSA.

7.3 *Correspondence to harm*

Although systematic, the Commission’s framework may not explicitly incorporate economic harms. The evidence above strongly suggests that the administrative fines imposed on long-steel firms did not correspond to the economic harm caused by the cartel. Based on the forecasting approach, the estimated average overcharge on PPI billets was approximately 7.29%, and even higher at 10.82% for PPI angles, implying billions of rand in excess costs to downstream users over the cartel period (2001–2008).

However, the actual fines imposed were markedly lower. For instance, AMSA paid a settlement of R1.5 billion in 2017, representing less than 0.5% of its affected turnover, while Cape Gate’s fine in 2023 was just R1.3 million, equivalent to less than 0.1% of its estimated cartel-period revenue. These figures fall well below the 10% maximum allowed under Section 59 of the Competition Act and are also inconsistent with international norms, such as the European Commission’s guideline of 15-25% of affected sales *per year* of infringement (European Commission, 2006).

The disconnect arises from several institutional constraints, including statutory caps on fines, the use of settlement discounts (often up to 50%), and the lack of systematic econometric damage estimation during penalty hearings (Rubinfeld, 2009; Das Nair et al., 2014). Compared with the global median cartel overcharge of 15-23% (Connor, 2014), the South African fines appear disproportionately low, confirming the hypothesis that penalties did not adequately reflect the true extent of consumer harm resulting from the cartel's conduct.

7.3 *Effective policy suggestion*

7.3.1. Why fines fall short of damages

Fines often fall short of fully reflecting the economic harm caused by cartels due to several structural, legal, and procedural factors. First, statutory caps, such as South Africa’s 10% limit on administrative fines based on the infringing firm's turnover in the preceding financial year (Competition Act, Section 59), prevent regulators from imposing sanctions proportionate to multi-year harm. This is particularly problematic for long-standing cartels like the long steel cartel, which spanned nearly a decade (2001–2008), yet fines were calculated on just one year of turnover.

Second, settlement policies designed to promote procedural efficiency and cooperation routinely result in discounted fines, often by 30–50%, further weakening deterrence (Das Nair and Mondliwa, 2014). Third, in many jurisdictions, including South Africa, fines are not routinely tied to formal econometric estimates of overcharge or affected turnover, which means regulators may undervalue the true scale of harm (Rubinfeld, 2009).

Moreover, measurement uncertainty in overcharge estimation, especially when different empirical methods yield different magnitudes, can be exploited by respondents to negotiate lower penalties. Finally, legal and institutional constraints, including limited capacity for civil damages follow-up or lack of victim compensation mechanisms, mean that even when fines are imposed, the full extent of consumer or downstream harm is rarely recovered.

7.3.2. Deterrence strategies

While South Africa has made considerable progress in detecting and prosecuting cartels, especially since the introduction of the CLP, its deterrence architecture remains incomplete. As noted by Das Nair and Mondliwa (2017), no court has yet awarded damages to victims of cartel conduct, despite statutory provisions. This absence severely limits the financial risk faced by cartel participants. Effective deterrence requires that the expected cost of collusion, by factoring in the likelihood of detection and the magnitude of sanctions, exceeds the expected gains (Becker, 1968; Connor, 2014). However, capped administrative fines often fall short of reclaiming full cartel rents.

In the case of the rebar cartel, estimated overcharges ranged from 35.7% to 43.2%, translating to damages between R2.8 billion and R3.2 billion (Das Nair and Mondliwa, 2017). These figures far exceed the fines typically imposed, highlighting a deterrence gap. Moreover, vertically integrated cartels across multiple levels of the steel value chain reinforce collusive behaviour and raise barriers to entry. This systemic coordination increases the urgency for a deterrence framework that includes:

- Harm-based fine structures aligned with empirical overcharge estimates. International practice increasingly recognises the value of harm-based penalty benchmarks. The European Commission (2009) and the OECD (2012) suggest that overcharges, typically ranging from 10%

to 30%, should inform fine calculations, either directly or via multiplier frameworks;

- Follow-on private damages as a standard remedy, not an exception;
- Individual accountability through director disqualification or criminal sanctions;
- Market-wide compliance programmes for vertically integrated sectors.

The International Competition Network (ICN) emphasises deterrence through its cartel working group[29] composed of two sub-groups, one of which looks at the general framework and principles for the fight against cartels and the other at enforcement techniques. The projects aimed to explore the role that settlements can play in anti-cartel enforcement, the determination of the level of corporate fines in cartel cases and the development of an anti-cartel enforcement manual. The ICN holds annual anti-cartel workshops: the 2024 event was held in October, hosted by the Mexican Federal Economic Competition Commission (Cofece) in Mexico City (International Competition Network, 2024)[30].

AMSA has recently announced the closure of its long-steel products business, which could affect approximately 3,500 jobs. The decision was attributed to unsustainable increases in logistics and energy costs, insufficient government policy support, and significant challenges within the steel industry. These challenges include deteriorating global and local steel markets and an influx of low-cost imports, particularly from China, which has eroded the competitiveness of local producers (Monteiro, 2025). The closure highlights the need for targeted policy interventions to support the sustainability of South Africa's steel industry and mitigate the socio-economic impact of such developments.

In summary, competition authorities should consider effective economic harm assessment, such as the overcharge estimates, when calculating penalties to improve efficiency and equity of cartel enforcement. The transparency in how penalties are determined, especially in disclosing how overcharges were estimated, may also improve the legitimacy and predictability of enforcement. Lastly, using economic techniques to evaluate significant cartel cases in the past could assist in informing future policy and establishing standards for more proportionate and evidence-based penalties. The penalty assessment procedure by the Commission may implicitly measure the monetary harm done to consumers. It would, therefore, be possible to reflect more accurate

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[29] The working group plan is found on the ICN website: www.internationalcompetitionetwork.org.

[30] The events of the workshop are updated at the ICN website: https://www.internationalcompetitionnetwork.org/cartel/events.

penalties using empirical overcharge estimates, such as those employed in this study.

Conclusion

The study aimed to contribute to the understanding of cartel behaviour in South Africa by empirically estimating the price overcharges associated with the long steel cartel and assessing the correspondence of damages with penalties imposed. To do so, two interrelated research questions were set out: first, what was the overcharge of the long steel cartel; and second, whether the penalties imposed by the South African competition authorities adequately reflected the economic harm caused by this collusive conduct. These questions were grounded on the hypothesis that the South African long-steel cartel led to prices that exceeded those expected under competitive market conditions. Drawing on a reduced-form ECM applied to quarterly data from 1993 to 2016, the study constructed counterfactual price series using both a dummy-variable approach and an out-of-sample forecasting specification to estimate cartel overcharges. In addition, a comparative analysis of the fines imposed, and the likely economic damages was undertaken to assess deterrence effectiveness.

The findings provided robust empirical support for the hypothesis that the cartel behaviour significantly raised prices in the domestic long-steel market. Using the forecasting approach, which eliminates cartel-period data from the estimation sample, the average overcharge on billet prices was estimated at 7.29%, while the overcharge for angles mild steel reached 10.82%. These estimates aligned with theoretical expectations and global benchmarks, particularly given the differentiated nature of long-steel products and the structural features of the South African market, namely, the dominance of AMSA, the use of import-parity pricing, and the documented coordination among major producers. The timing of the price spikes, concentrated in 2004 to 2005 and 2008, coincides with known cartel activity and broader economic booms in construction.

Importantly, these overcharge estimates pointed to substantial harm for downstream consumers in construction, manufacturing, and infrastructure sectors. Even conservative estimates suggest that billions of rand were transferred from purchasers to cartel firms during the infringement period. However, the administrative fines imposed fall far short of compensating for this harm or acting as an effective deterrent. For example, the R1.5 billion fine paid by AMSA in 2017 represented less than 0.5% of its affected turnover, while Cape Gate's 2023 fine amounted to less than 0.1%. These outcomes reflect a combination of statutory constraints, such as the 10% turnover cap in the Competition Act, procedural incentives favouring settlements, and the absence of formal integration of econometric damage estimates into penalty determinations.

Comparative policy analysis reinforces the need for reform. The European Commission, for instance, routinely applies fines of 10–30% of affected turnover *per year of infringement* and uses duration multipliers to reflect prolonged harm. In contrast, South Africa's lenient penalties risk normalising cartel conduct as a low-risk, high-return business strategy. As such, this study supports consideration for stronger penalty guidelines, the institutionalisation of quantitative harm assessments, and enhanced support for follow-on civil claims as a mechanism for restitution.

In general, the evidence confirms that the South African long-steel cartel imposed measurable and economically meaningful harm on the economy, while escaping proportionate financial sanction. This mismatch between harm and penalty threatens the credibility of cartel enforcement and undermines the objectives of competition policy in promoting allocative efficiency, dynamic competition, and consumer welfare. Therefore, strengthening institutional mechanisms for cartel detection, sanctioning, and redress is essential to ensure that future enforcement actions may not only punish anti-competitive behaviour but also restore the conditions of fair and open markets.

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Appendix

Table 3: Original ECM short-run regression results (PPI_Angles)

Source	SS	df	MS			
				Number of obs	=	287
				F(11, 275)	=	3.21
Model	.032970092	11	.002997281	Prob > F	=	0.0004
Residual	.256749182	275	.000933633	R-squared	=	0.1138
				Adj R-squared	=	0.0784
Total	.289719274	286	.001013004	Root MSE	=	.03056

D. lnPPI_Angles	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
lnIron D1.	.0014026	.0233129	0.06	0.952	-.0444919	.047297
lnElec_PPI D1.	.0253197	.0155404	1.63	0.104	-.0052736	.055913
lnCoal_PPI D1.	-.0630319	.0555309	-1.14	0.257	-.1723516	.0462878
lnULC_Man D1.	-.1174705	.1360692	-0.86	0.389	-.3853401	.1503991
lnBuildings~d D1.	-.0044877	.015516	-0.29	0.773	-.035033	.0260576
lnNonres_Pa~d D1.	-.0050334	.0064757	-0.78	0.438	-.0177817	.007715
lnbuild_com~m D1.	-.0188205	.02557	-0.74	0.462	-.0691582	.0315173
lnbuild_com~e D1.	.0224626	.0212873	1.06	0.292	-.0194442	.0643695
lnGDPatmark~e D1.	-.122815	.1453872	-0.84	0.399	-.4090283	.1633983
ECM_term3	.1239201	.0270305	4.58	0.000	.0707071	.1771331
Dummy	.0070474	.0038784	1.82	0.070	-.0005876	.0146825
_cons	.0049868	.002672	1.87	0.063	-.0002733	.010247

Variable	Obs	Mean	Std. dev.	Min	Max
resid3	287	5.98e-19	.029962	-.135582	.2514279

Table 4: But-for prices (PPI_Billets)

Source	SS	df	MS			
				Number of obs	=	192
				F(9, 182)	=	3045.27
Model	86.6340584	9	9.62600648	Prob > F	=	0.0000
Residual	.575297079	182	.003160973	R-squared	=	0.9934
				Adj R-squared	=	0.9931
Total	87.2093554	191	.456593484	Root MSE	=	.05622

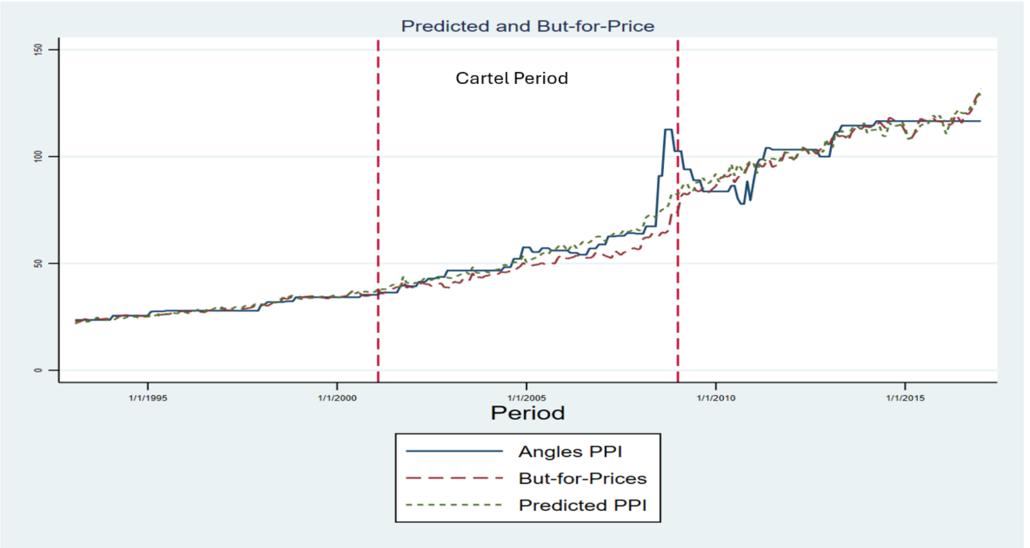
lnPPI_Bille~2	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
lnIron	.2199294	.0287946	7.64	0.000	.1631153	.2767435
lnElec_PPI	-.1502577	.0265565	-5.66	0.000	-.2026559	-.0978595
lnCoal_PPI	.020077	.067574	0.30	0.767	-.1132523	.1534062
lnULC_Man	.3213174	.156116	2.06	0.041	.0132873	.6293474
lnBuildings~d	.0566971	.037156	1.53	0.129	-.0166148	.130009
lnNonres_Pa~d	-.0238643	.0179272	-1.33	0.185	-.0592362	.0115076
lnbuild_com~m	-.0631082	.0631609	-1.00	0.319	-.18773	.0615136
lnbuild_com~e	.1006868	.0562846	1.79	0.075	-.0103674	.211741
lnGDPatmark~e	.2166926	.0991078	2.19	0.030	.0211446	.4122406
_cons	-2.102589	.9022598	-2.33	0.021	-3.882823	-.3223541

Table 5: But-for prices (PPI_Angles)

Source	SS	df	MS			
				Number of obs	=	192
				F(9, 182)	=	3605.14
Model	81.1061477	9	9.01179419	Prob > F	=	0.0000
Residual	.45494722	182	.00249971	R-squared	=	0.9944
				Adj R-squared	=	0.9941
Total	81.5610949	191	.42702144	Root MSE	=	.05

lnPPI_Angles	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
lnIron	.0551451	.0256062	2.15	0.033	.0046219	.1056684
lnElec_PPI	-.0395318	.0236159	-1.67	0.096	-.0861281	.0070644
lnCoal_PPI	.1337643	.0600917	2.23	0.027	.0151984	.2523301
lnULC_Man	1.17139	.1388296	8.44	0.000	.8974671	1.445312
lnBuildings~d	-.0109084	.0330418	-0.33	0.742	-.0761026	.0542858
lnNonres_Pa~d	.016695	.0159422	1.05	0.296	-.0147603	.0481502
lnbuild_com~m	-.1476107	.0561672	-2.63	0.009	-.2584333	-.0367881
lnbuild_com~e	.1534801	.0500523	3.07	0.002	.0547227	.2522374
lnGDPatmark~e	-.2398268	.0881337	-2.72	0.007	-.4137221	-.0659316
_cons	1.688636	.802354	2.10	0.037	.1055245	3.271748

Figure 4: The Predicted and But-for prices from ECM-PPI_Angles (Dummy Variable)



Source: Author (2025)

Figure 5: The PPI for steel industry