Assessing follow-on cartel damages in the SA construction sector

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This note theoretically considers alternative methods for the quantification of follow-on damages in competition cases, with specific application to the construction sector. Construction is one of the high-impact sectors prioritised by the Competition Commission. As a result, and in response to the Construction Fast Track Settlement offer, various construction companies recently disclosed their part in bid-rigging activities. The settlements concluded the legal process for the competition authorities. Affected parties now have the right to claim civil damages in terms of the Competition Act, as communicated by the Commission’s Construction Fast Track Process. The quantification of such follow-on damages is a relatively new undertaking in the South African context, as no case for damages in the South African construction sector has been brought to court. Furthermore, quantification of damages in the construction sector are particularly challenging: construction projects are often unique, once-off projects for which long price and other comparator series are not available. Building on the literature and past EU policy experience, this paper evaluates a range of economic methods applied in the quantification of follow-on damages, with specific reference to their value within the construction sector. The evaluation also includes a consideration of recent international examples of follow-on damages in the construction sector from other jurisdictions.

1 Introduction

Construction is one of the high-impact sectors prioritised by the Competition Commission (‘the Commission’): the efficient functioning of this sector is of utmost importance both to the Commission, as well as the South African economy in general. However, this sector has been subject to widespread collusive actions in contravention of the Competition Act (Number 89 of 1998). As a result of the Construction Fast Track Settlement Process (CSP) which the Commission launched in 2011, various instances of bid-rigging were uncovered. At the conclusion of the Commission’s settlement process, there were settlements by 15 out of the 18 construction firms that participated in the CSP, resulting in aggregate administrative penalties of approximately R1.46 billion. The conclusion of the competition processes has now paved the way for follow-on civil damages claims.

The quantification of such follow-on damages is relatively new in South Africa, and to date no successful case for damages in the South African construction sector has been
brought to court. Furthermore, quantification of damages in the construction sector is particularly challenging: construction projects are often unique, once-off projects for which long price and other comparator series are not readily available, complicating the calculation of the “but for” price. Building on the literature and recent EU experience, this note evaluates a range of economic methods applied in the quantification of follow-on damages, with specific reference to their applicability within the South African construction sector.

2 Evidence of collusion in the SA construction sector

Evidence of widespread contraventions of the Competition Act has been uncovered by the Commission through their very successful Corporate Leniency Policy (CLP). A key tool in an investigation into cartel conduct internationally is the use of a corporate leniency provision. In the South African context, the Commission’s CLP provides leniency to the first firm to provide information on a cartel to the authority in exchange for its full co-operation. Co-operation outside the scope of the CLP can also be encouraged through programs that incentivise firms to disclose information regarding cartels, by offering them a reduction in the fine to be paid in a settlement agreement through targeted programmes. The CSP, which the Commission launched in February 2011, is an example of such a programme.

As a result of the CSP, more than 300 instances of bid-rigging were uncovered between roughly 2000 and 2009. These collusive practices were instigated by the top-tier of South Africa’s construction firms graded for large projects in the Construction Industry Development Board’s General Building and Civil Engineering categories for grade 9 firms. Ultimately, 160 (53%) of the uncovered projects were prescribed and 140 (47%) were non-prescribed, which were subsequently considered for settlement. The value of the non-prescribed projects amounted to R37.1 billion (79% of total projects). In terms of value, the affected projects for private and public sector constitute 40% and 60% respectively. Thus, in value terms, the Commission’s investigation and settlements covered a substantial portion of the projects affected by the bid-rigging conspiracy, with relatively more projects covered in the public sector.

The settlements resulted in aggregate penalties amounting to approximately R1.46 billion. While the Competition Commission and various parties involved have declared themselves satisfied with this outcome, there are various organisations (such as SANRAL and certain municipalities) that are intent on pursuing civil damage claims. While follow-on damages have been pursued by various international jurisdictions (for instance the US, UK and EU), it is a recent undertaking in South Africa. As such, it is crucial that in the event that follow-

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1. We note the public reports which state that the City of Cape Town has brought a damages claim against inter alia WBHO for colluding on a tender for the construction of the 2010 World Cup Stadium. The case is ongoing.
2. As explained further in the paper, the “but for” price is the price that would have prevailed but for the collusion.
3. See the Competition Commission’s 2013/2014 Annual Report for more information regarding this policy.
6. Ibid.
7. These are firms which do not have a limit as to the maximum contract amount they are allowed to tender on. See CIDB Guidelines for Contractor Registration for more information.
8. They were prescribed in the sense that they fell outside the prescription period within which a complaint can be brought against parties involved in prohibited anti-competitive practices. See Section 67 of the South African Competition Act for more details.
on damages are pursued, the international experience is taken into account and applied to the South African case.

3 Methodological overview

The primary purpose of an award for damages in South Africa, much like in the EU, is to compensate the individual or firm which suffered harm, and not to punish the offender. Quantification requires the estimation of a counterfactual world in which the infringement is deemed not to have taken place, which reflects the actual world “but for” the existence of the cartel. The spread between the realised and the “but-for” prices or profits provide an estimate of the financial damages incurred.

There are various methods available to construct such a “but-for” estimate, each with various underlying assumptions. Each of these methods and techniques have particular features, strengths and weaknesses that make them relatively more or less suitable for the situation at hand. The most important methods are discussed below.

3.1.1 Comparator Based Methods

Comparator based methods use data (e.g. prices, sales volumes or profit margins) external to the infringement in order to calculate the counterfactual. Specifically, these methods estimate what would have happened absent the infringement by looking at other unaffected markets and/or unaffected time periods before and/or after the infringement. These methods broadly fall into three categories: cross-sectional methods (comparing different geographic or product markets), time series methods (analysing prices before, during and/or after the infringement) or a combination of both, called difference-in-differences methods. Cross-sectional methods aim to estimate the effect of the infringement by comparing data in the relevant market with data observed in different and unaffected geographic or product markets. These methods assume that a comparator market has been chosen in such a manner that any observed differences are the result of the infringement. While comparisons could be made between geographic markets or even distinct but comparable product markets, comparisons could also be made between individual firms, depending on the extent of the infringement.

Figure 1: Cross-sectional Data

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infringement and data availability. Pure cross-sectional models do not take into account the effects over time, and are based on data in the same time period (refer to Figure 1).

Such a cross-sectional analysis could be applied in the construction sector using, for instance, data from unrigged contracts from comparator markets or contracts. However, while this method is applicable in general, it is often the case that the specifics of any one case complicate the analysis. One of the main difficulties with using cross-sectional (as well as time series) methods in the construction sector is the availability and quality of data. Very often the projects in the construction industry are once-off projects with very little, if any viable geographic or product comparators. For instance, in a bid-rigging case, absent a sufficient number of unrigged contracts, standard statistical techniques would not yield reliable estimates. This complication does not apply to the rigged bids where a single observation is appropriate, but rather to the control group of unrigged bids used to construct the counterfactual.

In addition, even if contracts awarded in a separate geographic market were available, there is generally a problem in verifying whether these were indeed unaffected by the bid-rigging schemes. Identifying an adequate control group is particularly difficult in the construction sector, and could take a considerable amount of time. This brings into question the cost and time involved in establishing an estimate of damages suffered, and how this relates to the potential size of the damage claim.

An alternative method is the time series method. This method typically involves using the

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14. European Commission, Quantifying Harm in Actions for Damages Based on Breaches of Article 101 or 102 of The Treaty on The Functioning of The European Union; Ashton, Competition Damages Actions in the EU.
15. Oxera, Quantifying Antitrust Damages Towards Non-Binding Guidance for Courts; Scallan, Mbikwa, and Blignaut, “Compensating for Harm Arising from Anti-Competitive Conduct.”
17. Ibid.
18. Scallan, Mbikwa, and Blignaut, “Compensating for Harm Arising from Anti-Competitive Conduct.”
same market before, during and/or after the cartel period to estimate damages. This method is especially useful when the whole market is affected by the infringement and other markets are not deemed to be robust comparators. A time series model typically compares data on companies or markets during the period in which the infringement takes place with the same companies or markets in a period without the violation (refer to Figure 2).

As noted, very often the projects in the construction sector have little or no historical information available to construct a time series. This is especially true in a bidding market, where there is often very limited or no price history. Contracts that were awarded prior to the formation of the cartel, after the collapse of the cartel, or both, could potentially be used to construct a time series. However, such historical data are seldom available prior to the conspiracy, and if the damage case is brought promptly, there may be few observable data points available post the infringement.

A theoretically superior alternative to the abovementioned methods is the panel data (difference-in-differences) analysis which combines the cross-sectional and time series comparator based methods for estimating the counterfactual price. This method is based on a simultaneous observation of price developments through time on the infringement market and on one or more comparable but geographically separated markets. In essence, difference-in-differences estimators control for what would have happened absent the infringement through an examination of what changed over time in the infringement and non-infringement markets, followed by a comparison of those differences (Figure 3).

Figure 3: Panel Data

The difference-in-differences methods are an improvement on pure cross section and time series methods as it exploits both time- and firm-specific variations. This aids in the estimation of the effect of the infringement and can also account for key factors which affect prices in the two markets. Nevertheless, this approach does have some drawbacks. For instance, it cannot distinguish between the infringement and that of a separate factor affecting the treatment group (but not the control group) in the same way and at the same time as the infringement. Also, the data requirements for the difference-in-differences methods are much greater than for either the time

19. Peter J. Davis and Eliana Garces, Quantitative Techniques for Competition and Antitrust Analysis (Princeton, N.J.: Princeton University Press, 2010); Ashton, Competition Damages Actions in the EU; European Commission, Quantifying Harm in Actions for Damages Based on Breaches of Article 101 or 102 of The Treaty on The Functioning of The European Union.
22. Ashton, Competition Damages Actions in the EU.
series or cross-sectional, limiting their applicability in the construction sector.

3.1.2 Financial Analysis Based Methods

A further set of approaches to quantify damages is the financial analysis based approaches. This set of approaches relies on corporate finance theory and practical techniques used in financial analysis in order to assess the value of damages in anti-trust cases. In practice, it is often difficult to differentiate between finance and non-finance based methods. For instance, in some cases, the financial analysis forms the basis of the analytical approach, whereas in other cases it is used to address specific issues, such as discounting, to arrive at a final value for damages.

One advantage of the financial analysis based methods relative to comparator based methods, is that the data are more readily available. The importance of financial data to companies, investors and governments necessitates the generation of data at a high frequency. Data such as statutory accounts, periodic financial reports, public accounts as well as share prices are often readily available for companies listed on the stock exchange. A disadvantage of the use of financial data, as was the case with cross-sectional and time-series comparator based methods, is that it is often difficult to distinguish between the impact of external factors and that of the infringement on financial performance.

Financial analysis based methods might be more applicable in the construction sector than the abovementioned comparator based methods. These methods use a combination of theory, assumptions and market specific information to arrive at a counterfactual. As noted, the data required for using these methods are often more readily available than the data required to use comparator based methods, due to the strategic nature thereof. Such data are also available from public sources and for a longer period of time than would be the case with, for instance, bids or engineering estimates data.

3.1.3 Market Structure Based Methods

In some instances, the methods discussed above will be unable to yield useful results. These cases may warrant the use of an artificially constructed counterfactual through market structure based methods. To this end, Industrial Organisation (IO) theory has developed a range of models of competitive interaction and firm behaviour that predict a variety of outcomes.
ranging from a monopoly market to a perfectly competitive market. These models can be employed to estimate or simulate market outcomes such as prices or volumes in the factual or counterfactual scenario (or both), and in doing so provide information used to quantify the damage.

These models can range from purely theoretical (providing information to understand market outcomes conceptually) to the empirical (calibrated models which can estimate the counterfactual value). Taking into account factors such as the nature of cartelised goods, the central competition parameters and the allocation mechanism, one can resort to some of the standard oligopoly models.

Within the construction sector, this type of method could be especially useful. The structure of auction and bidding markets are well known, rendering them more conducive to modelling than other markets. Specifically, the outcome of bidding and auction markets can be modelled by probabilistic models, augmented with game theoretic principles (a more sophisticated application of the above models, which allows for repeated interaction). In the context of damages actions, these models can be used to either simulate the effect on price and output of removing a competitor (e.g. exclusionary conduct) or of changing the bidding behaviour of different players (e.g. bid-rigging). For instance, for a given type of auction and market structure, competitive bids could be modelled and then compared with outcomes in the presence of bid-rigging in order to quantify damages suffered as a result of an anti-trust violation.

In considering the above methods, we argue that comparator based methods are the least likely to be useful in the construction sector, while financial analysis based and market structure based methods are more useful. However it should be noted that it is not prudent to draw a general conclusion on the appropriate method to use; rather their applicability should be considered in the context of the case at hand. Next, we consider how one might apply these methods in a practical manner.

4 Practical applications

While the above discussion serves to illustrate how cartel damages can be quantified, it is relevant to also consider what the outcomes are when these methods are applied in practice. To this end, we consider the outcome of a meta-study conducted by Connor (2014) as well as a practical example focusing on the construction of the 2010 World Cup Stadia.

4.1 Connor (2014) Meta-study

In order to understand the magnitude of damages that arise from anti-competitive conduct in the construction sector, we first consider data from a meta-study conducted by Connor (2014). The data contained in the study provide detailed information on about 1,100 hard-core international cartels. Of these, about 55 are in the

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28. Oxera, Quantifying Antitrust Damages Towards Non-Binding Guidance for Courts; Ashton, Competition Damages Actions in the EU; European Commission, Quantifying Harm in Actions for Damages Based on Breaches of Article 101 or 102 of the Treaty on The Functioning of The European Union.
29. Oxera, Quantifying Antitrust Damages Towards Non-Binding Guidance for Courts; European Commission, Quantifying Harm in Actions for Damages Based on Breaches of Article 101 or 102 of The Treaty on The Functioning of The European Union.
30. Ashton, Competition Damages Actions in the EU; European Commission, Quantifying Harm in Actions for Damages Based on Breaches of Article 101 or 102 of The Treaty on The Functioning of The European Union.
31. Note that there is a distinction between auction and bidding markets. While bidding markets tend to be more narrowly defined, the definition of an auction is somewhat wider.
32. Oxera, Quantifying Antitrust Damages Towards Non-Binding Guidance for Courts.
construction industry, almost all of which are bid-rigging cartels\textsuperscript{34}. Using the most up-to-date version of this database (February 2014\textsuperscript{35}), Connor estimates a mean overcharge in the construction industry of 23.4%. Connor goes on to note that “Construction industry cartels achieve lower overcharges than many other industries because competitive industry profits are low. Collusion typically doubles or triples competitive profits.”\textsuperscript{36}

Using data from Connor (2014)\textsuperscript{37}, which is understood to have information on cartels up until October 2013, an average overcharge in the construction sector of 21.9% is obtained\textsuperscript{38}.

Figure 4 shows the distribution of the overcharge estimates.

The estimated overcharge varies quite considerably between different cases, with the bulk of overcharges falling below 20%. Note that, while a useful indication, such a meta-study is a poor substitute for a case-by-case estimation of damages, due to the diverse nature of projects in the construction sector. We present a practical example of quantifying overcharges in the South African construction sector below.

4.2 Construction of 2010 World Cup Stadia

To illustrate how one might quantify damages in the South African context, we look at bid-rigging in construction of the 2010 World Cup Stadia, which was one of the largest public sector projects affected by the bid-rigging conspiracies. Using evidence from the consent agreement of Aveng\textsuperscript{39}, it is possible to provide an estimate of the damages caused by the construction companies who rigged bids in the construction of the stadia.

Note that what follows is only a high level exercise to illustrate what is possible with publicly available data. A more robust analysis would need to be augmented with case and firm specific documentation and data pertaining to the details of the contract between the construction firm(s) and the city in which a stadium was built.

In order to calculate the damages resulting from collusion in this sector, publicly available financial data is analysed. We employ a financial analysis based approach, best described as a ‘top-down’ method of damages calculation based on an analysis of profit margins. In

![Figure 4: Distribution of Overcharge Estimates from Connor (2014)](source: Connor (2014), Author’s calculations)
general, one would prefer to use a combination of methods to calculate the damages. However, in the current case the only publicly available information and industry profit margins are published by Statistics South Africa (StatsSA). While this limits the analysis, it is nevertheless a valuable first step in calculating damages.

Note that according to the consent agreement of Aveng, the firms implicated in the bid-rigging of the 2010 World Cup Stadia agreed to each aim to obtain a 17.5% profit margin. In order to draw a reasonable comparison between this collusive profit margin and the profit margins which prevailed in the market at that time, one needs to study to what extent the margins observed in the industry during the time of the contravention was reflective of true economic conditions rather than anti-competitive conduct.

To this end, we construct a “but-for” price of aggregate industry tender prices, using an econometric model of the economy, taking into account demand and supply conditions. We employ both a forecasting, as well as a dummy variable approach. While the former uses calibrated parameters from the model fitted on data before the collusive period to forecast the evolution of prices during the collusive period, the latter uses a binary indicator variable to statistically test for the significance of a deviation in unexplained tender price increases during the collusive period.

Data from 1994Q1 to 2013Q4 are employed and the “collusive period” is defined as the period starting in 2007Q1 and ending in 2009Q4. It is in this period which most of the World Cup Stadia contracts were awarded, and in which the stadium was built. As a proxy for tender bid prices, the Building Cost Index (BCI) which is jointly constructed by the Bureau for Economic Research (BER) and Medium-Term Forecasting Associates (MFA), is used. We use as a proxy for input costs into construction an index calculated and published by StatSA on behalf of the Joint Building Contractors Committee (JBCC) for use in conjunction with the Haylett formula. As a proxy for demand in the construction industry, the RMB/BER Business Confidence Index for Building Contractors - which shows the gross percentage of building contractors rating prevailing business conditions satisfactory - is utilised.

Using this data, the model is estimated from 1994Q1 to 2006Q4, and then used to forecast “but-for” prices over the collusive period. The estimation starts with unrestricted models (i.e. with all variables included) and are then reduced to specific models (i.e. only statistically significant variables are included) through the GETS algorithm (a well-known econometric procedure). This ultimately provides the most robust and parsimonious specification of the model. While not reported, we note that the chosen model satisfies all the necessary diagnostic tests. Figure 5 shows the results for the unrestricted and specific

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41. The information from which the index is calculated is supplied on a quarterly basis by registered quantity surveyors throughout South Africa. Once a tender has been accepted, the quantity surveyors take the rates of a selected 22 items in the bills of quantities and supply these to the BER on Building Cost Index forms. See for instance “Medium-Term Forecasting Associates in association with the BER, Report on Building Costs, First Quarter 2014” or “Ursela Segalla, The BER Building Cost Index - An Overview, Studies in Economics and Econometrics 15, no. 1 (1991): 43–58” for further information.
42. These indices are derived from changes in the cost structures prevailing in 37 different sectors of the building industry. The indices represent components of various cost inputs of building contracts, i.e. labour, materials, plant and fuel. For present purposes, only the index derived from Workgroup 181 which represents Commercial/Industrial buildings is employed. See CPAP Committee, CPAP Indices Application Manual for Use with P0151 Indices Published by Statistics South Africa, January 2013 for further information.
43. The index ranges between 0 and 100. A value of 50 is indicative of neutrality, a value of 100 indicates extreme confidence and a value of 0 indicates extreme lack of confidence. As such, this index would capture both present and expected future market sentiment in the construction industry.
44. Specifically, we use the GETS algorithm native in the OxMetrics statistical package.
models respectively. The forecasted period is shaded in the figure. The dashed lines represent 95% confidence intervals around the forecasted values.

From the figures it is clear that the actual tender prices fall, for the most part, inside the confidence intervals. As such, based on market relationships between tender prices, input costs and demand drivers, the forecasts do not suggest that prices were any higher during the collusive period than a naïve econometric model would suggest. It can be concluded that tender prices were, on aggregate over the entire construction industry, not significantly higher than would have been expected during the collusive period. This result is also confirmed when using the dummy variable approach. Note that this is not to say that the bid prices in the projects affected by bid-rigging were not higher than they should have been. Instead, it implies that the projects on aggregate were not pervasive enough to influence the industry tender prices.

One possible explanation as to why the prices do not seem to be any higher than would have been otherwise expected during a period in which there was collusive conduct in the construction industry, is that the value of the affected projects are not pervasive enough in the construction industry, on aggregate. As noted, the value of total affected projects amounted to approximately R47 billion worth of projects for roughly the period between 2000 and 2009. When considering these amounts in relative terms, one finds that the R47 billion only represents about 11.01% (using current prices) of the total Gross Domestic Product (GDP) for construction between 2000 and 2009. Even when only considering the period between 2007 and 2009, one still finds that the R47 billion only represents 21.79% of GDP created during that period.

Based on the above analysis, it is found that the aggregate tender prices, as proxied by the BER BCI, were not any higher during the collusive period than a naive econometric model would suggest. By implication, the profit margins which were prevalent in the industry during this period are in line with what could be expected in a competitive market and could therefore serve as “but-for” estimates to which the profit margin added by the construction companies can be compared.

The 17.5% profit margin agreed to by the construction companies can be compared to overall profit margins for the construction-

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46. GDP represents the total value of all goods and services produced within a specific territory during a certain year.
tion sector. In order to do this, annual financial data compiled by StatsSA is used to calculate various profit margins in the construction industry. The data are collected through the annual financial statistics survey (AFS), previously published as the economic activity survey (EAS), and contains estimates of financial data for several industries. While the magnitude of the profit margin is dependent on the specific type of profit margin one specifies, we do not address the issue of what the correct margin would be in this note. Rather, we provide a menu of various different profit margins. This is shown in Table 5.

Based on the specific measure of profit, it seems that an average profit margin of between 5.83 – 9.70% is applicable as a “but-for” estimate to determine damages resulting from the bid-rigging by the implicated firms.

Having shown with the above econometric model that overall construction profit margins (based on tender prices) were not significantly different during the collusion period than during the competitive period, these aggregate industry profit margins can be used to compare with the 17.5% added by the construction firms. This equates to an overcharge estimate of between 7.8 and 11.67%. Note that this overcharge estimate applies to each of the construction projects individually. In order to arrive at a financial value of the cartel damage, these overcharge margins must be compared to each of the final contract amounts paid by interested parties, taking into account the time having elapsed since then.

3 Concluding remarks

This note set out to investigate the different methods of quantifying cartel follow-on damages, both in general and applied to the construction sector in South Africa. It was noted that, due to the nature of the various underlying assumptions of the methods, their applicability is case dependent. The comparator based methods, while applicable in some international jurisdictions, is somewhat limited by the dearth of comparable and reliable data available from the South African construction sector. Specifically, the projects involved are often large, once-off projects, with little or no comparator prices or products. Furthermore, it was noted that the financial analysis based methods have data that is more readily available (due to its strategic function) as well as simpler to obtain from public sources. Finally, it was noted that the structure of auction and bidding markets are conducive to the use of market structure

Table 5: Relevant Average profit margins, 2007 - 2010

<table>
<thead>
<tr>
<th>Date</th>
<th>Net Profit Margin (before tax)</th>
<th>Profit before interest, tax, amortization and depreciation margin</th>
<th>Profit before interest and tax margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total: Entire Construction Industry</td>
<td>7.16%</td>
<td>9.70%</td>
<td>7.54%</td>
</tr>
<tr>
<td>Firm Size according to revenue: Large</td>
<td>5.83%</td>
<td>7.57%</td>
<td>5.85%</td>
</tr>
<tr>
<td>Construction Activity: Building of complete constructions or parts thereof and civil engineering</td>
<td>6.37%</td>
<td>8.17%</td>
<td>6.54%</td>
</tr>
</tbody>
</table>

Source: Econex Calculations

47. For more information, refer to Statistical Publication P0021 published by Statistics South Africa.
based methods and can thus be very useful in the construction sector.

In addition to the above, it has been shown, both through the investigation of a meta-study as well as a practical example in the South African construction sector, what range of damage estimates one might expect in this sector. The meta-study showed that, when taking into account various different damage estimates internationally, an average overcharge of 23.4% is to be expected. However, the bulk of these estimates lie in the 0 – 20% range. This fits in with our estimate of damages suffered as a result of bid-rigging in construction of the 2010 World Cup Stadia amounting to between 7.8 and 11.67% when using a financial analysis based approach. This also accords with the finding that construction industry cartels achieve lower overcharges than many other industries.

When considering the estimation of damages, economists always face a trade-off between accuracy and practicability. Such a trade-off, however, should not deter damage claims when harm was caused. Once an anti-trust infringement has occurred, the evidentiary burden for the quantification of the damages should not be so high that it would impede the victims’ right of effective compensation.

Ultimately, what is deemed acceptable depends on the specifics of the judiciary system and data availability. None of the methods described above claim to provide anything more than an estimation of the damage suffered, and as such the South African courts should take a pragmatic approach to the calculation of damages and be aware of the fact that there is a trade-off between accuracy and practicability.