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ILLEGAL CARTEL OVERCHARGES IN MARKETS WITH A LEGAL CARTEL HISTORY: THE SOUTH AFRICAN BITUMEN MARKET

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Abstract

A number of South African price-fixing cases have been brought in markets previously characterised by legal cartels or monopolies. Furthermore, many South African markets have been liberalised since 1994, reflected in structural change in many market relationships and rendering many of the markets subject to international price developments. These features create special difficulties for the calculation of overcharges. Conventional approaches often rely on a temporal approach, where prices during the cartel period are compared to prices in another – supposedly competitive – period. In the presence of legal cartels, such a historic period is not available, which limits the temporal approach. A spatial approach, where South African prices are compared to those in other countries, offers a better alternative. We apply these methods to estimate overcharge by the bitumen price-fixing cartel in South Africa. We find that while South African bitumen prices may have similar responses to demand and supply shocks, a spatial approach unmasks the persistent effect of high price levels. This sheds further light on the transition of legal to illegal collusion, a topic of both local and international interest.

JEL classification

L41, L43, K21

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Collusion cases often involve markets historically characterised by legal cartels. For example, a number of South African price-fixing cases concern collusion among members of formerly legal cartels. These legal cartels were outlawed in the 1990s, but long-standing market relationships appear to have prolonged coordinated conduct in many of these markets. Economists know little about the differences in market outcomes in periods of legal compared to illegal collusion. This creates particular challenges in determining damages in competition cases.

This paper compares two econometric approaches to estimate overcharge in a market with a legal cartel history. The paper first considers a temporal approach, which involves comparing market outcomes during the period of alleged collusion with those in a period without such collusion. While this is the dominant approach to overcharge calculation, the paper points to its limitations in a legal cartel context. Consequently, the paper considers a spatial approach, comparing prices in the market under investigation with those in other locations, while controlling for differing demand and supply factors. The paper argues that this approach is preferable in markets with a legal cartel history.

The empirical application involves a South African price-fixing case in the market for bitumen. The case is particularly important, given that this market is a prime example of one originally characterised by a legal cartel exempted from competition policy until 2000. Subsequently, information exchange continued among market participants, allegedly for the purpose of continuing to calculate a reference price requested by government and industry.

The paper is structured as follows. We first consider a taxonomy of econometric approaches to estimating overcharge. Thereafter, we discuss the bitumen case and then proceed to the econometric results, followed by the conclusions.

1. Methodologies for calculating overcharges

This paper focuses on methodologies for determining cartel overcharges, which, in turn, determines the size of fines and damages. We focus on direct price overcharge due to the cartel and do not consider non-price effects or the effects of pass-through that may increase or reduce the impact on buyers (Rubinfeld, 2012).

Price overcharge refers to the difference between the actual price and the so-called ‘but for’ price, i.e. the price that would have prevailed in the absence of the cartel. The determination of a ‘but for’ price faces an identification problem: prices, even under cartels, are affected by demand and cost conditions and the modeller must isolate the effect of the cartel from these other effects. The typical solution to this identification problem is to adopt comparative approaches, where prices during the cartel period are compared with prices for a comparable market not characterised by cartel activity. The two dominant approaches[2] to the identification of the comparator market can be termed the temporal and the spatial approaches and we consider the uses and limits of each in the following paragraphs.

[2] There are also methods based on a comparison of costs and margins across industries (see Rubinfeld (1985)).

One comparative approach is the ‘temporal’ approach, which relies on the market under investigation as the comparable market, but in a period not characterised by the allegedly collusive conduct. That is, the approach involves studying price formation in a period either prior to the formation of the cartel or following the cessation of the cartel and using this information to predict ‘but for’ prices during the cartel period.

This approach houses a number of possible methods. The simplest temporal approach is the so-called ‘before-and-after’ method, where prices in the cartel and non-cartel period are compared. It is difficult to identify the coordinated conduct under this approach, because of the lack of control for demand and supply shocks (White et al., 2006). Therefore, a better approach is the so-called ‘multivariate’ method, where price is modelled as a function of demand and supply drivers. The parameters in the fitted model are then applied to data during the period of alleged collusion to predict ‘but for’ prices. The temporal approach, in whatever guise, is the most commonly employed method, but – as we discuss in the application – it is vulnerable to structural change over time. An econometric comparison of two consecutive periods requires sufficient data points in both, but this requires data over a fairly long time period during which relationships may well have changed.

Another comparative approach is the ‘spatial’ approach, which uses a market in a different region (or for a similar product) as the comparable market to provide information on price formation and help to predict ‘but for’ prices in the market under investigation. One such a spatial method is the yardstick method, which involves a direct comparison of prices in different regions. A more appropriate method, analogous to the temporal approach, would involve a multivariate analysis where prices are compared after controlling for demand and supply shocks. This approach is not often employed and it is worth considering in this case: if one collects data for a sufficiently large number of comparator markets, one can model relationships over a much shorter and more recent sample period – reducing the impact of any structural change. However, the challenge in employing a spatial approach lies with identifying a set of comparator markets that exhibit similar degrees of competition and that are not characterised by collusion (Rubinfeld, 2012).

This approach has been used less often, as it may often be difficult to collect information on demand and cost drivers in every market. But in the case of homogeneous products especially commodities or commodity-derived products, including the bitumen market investigated in this paper, obtaining such data may be much easier: for example, most market prices may be affected by the same international commodity price. Nevertheless, identification in spatial approaches is more difficult due to the possibility of region- or product-specific price effects.

Where the multivariate method has been used in a spatial approach (see Davis and Garcés (2010: 360) for an application to steel price overcharge in the EU), the focus has been on using a dummy variable to measure overcharge. That is, the market under investigation is included with the comparator markets and a dummy variable is used to measure the extent to which prices in the market under investigation diverges from those for the comparator markets. The dummy variable involves the fairly crude assumption that prices undergo a step shift in the period of collusion. In the context of markets with a legal cartel history, such an assumption is not tenable. As we show in the empirical application, the temporal approach is likely not to indicate any significant deviation in price between the alleged

collusion period and the legal cartel period. We therefore employ the forecasting method as discussed above: i.e. we use the model fitted on the comparator markets to predict the price in the market under investigation.

In the South African literature, Khumalo, Mashiane and Roberts (2012) employ a spatial approach to calculate overcharges by a precast concrete products cartel uncovered in 2007. They compare prices for the cartelised product (pipes) with prices of comparator products (kerbs and channels/drains). In particular, they calculate the ratio of prices for the cartelised and comparator products during a competitive period. This ratio is then applied to the prices of the comparator product during the cartel period to infer 'but for' prices for the cartelised product. As discussed above, this is effectively a yardstick approach, where the implicit assumption is that the comparator and cartelised products share the same cost and demand shocks. The assumption is reasonable when comparator products, closely related to the cartelised product, are available. Under alternative conditions, such as in the case discussed in this paper, this assumption may be more difficult and alternative econometric approaches, which allow for demand and cost controls, may be required.

Mncube (2013) adopts a temporal approach to estimate overcharges by a wheat flour cartel uncovered in 2007. In particular, he employs a multivariate econometric method controlling for demand and cost drivers of flour prices, and includes a dummy variable to capture the effect of the cartel. An analysis of the wheat flour cartel faces many of the challenges considered in this paper, due to the flour and baking industry's long history of regulation. In particular, it is difficult to identify a competitive period preceding the cartel period that can provide a benchmark for cartel prices – an issue that we consider in more detail later in the paper. Mncube also notes that prices in the post-cartel period (even if available) may also bias conclusions: cartel behaviour may well persist following competition policy proceedings (see Harrington (2004)). Mncube's rich analysis, including an alternative evaluation based on industry profits, serves to support his econometric overcharge estimates. Nevertheless, it is important to consider to what extent a spatial approach can assist in overcoming the problem of finding a suitable benchmark period in markets with a history of regulation and legal cartel behaviour.

This paper employs both the temporal and spatial approach in determining 'but for' prices for bitumen in South Africa, following a cartel investigation. The following section introduces the case.

2. Bitumen case

In 2010/2011 the South African Competition Commission (CC) initiated a price-fixing complaint in respect of bitumen against the six oil companies operating in South Africa[3]. Bitumen is a residual product of the distillation process at these refineries. The largest proportion of bitumen produced by the refineries is 'penetration grade' bitumen. Value-added bitumen producers purchase this penetration grade bitumen from refineries and manufacture

[3] The CC alleged that Total, BP, Shell, Chevron, Engen and Sasol engaged in price fixing in contravention of Section 4(1)(b)(i) of the South African Competition Act, which prohibits an agreement between or concerted practice by firms if it involves fixing a purchase or selling price or any other trading condition.

three types of value-added bitumen products: (i) emulsions, (ii) modified bitumen, and (iii) primes. These value-added products are used in road construction and rehabilitation in two ways, either as part of asphalt[4] surfacing (the dominant surfacing methods for roads) or in "chip and spray" applications (for roads that do not justify the high capital outlay associated with asphalt surfacing).

The oil companies produce bitumen at four crude oil refineries in South Africa: Natref (operated by Sasol and Total), Sapref (operated by BP and Shell), Enref (operated by Engen) and Calref (operated by Chevron). Therefore, oil companies compete with each other in the production and sale of bitumen and bituminous products. All the oil companies are members of the South African Bitumen and Tar Association (SABITA). The CC submitted that SABITA was a platform to share price sensitive information among horizontal competitors, and to jointly determine a wholesale list price (and a price index) for bitumen. In other words, the complaint concerned the operation of a cartel in the pricing of bitumen within South Africa, which operated through SABITA and through other forms of communication between the respondents. The CC argued that this cartel substantially prevented or lessened competition in the bitumen market.

2.1 *History of bitumen pricing in South Africa*

Until August 2000, oil companies enjoyed exemption from competition law in respect of bitumen price-setting. South African oil companies based their own prices for bitumen on a jointly agreed Wholesale List Selling Price (WLSP) for bitumen and bituminous products. The WLSP for bitumen was an import parity price: transport costs were added to a free-on-board price for heavy fuel oil (HFO) at selected international refineries to arrive at a base price[5]. In the 1990s, this base price was replaced by another import parity price, the price of bunker fuel oil[6] at Durban harbour. To arrive at the final WLSP, taxes and levies as well as a legislated margin were added to the base price.

The new competition policy regime, introduced in 1998, was part of a larger policy effort to transform South African markets, some of which were previously characterised by legal cartels (Roberts, 2004). The bitumen price-setting exemption lapsed in August 2000 and the expectation from competition authorities was that this would foster more aggressive price competition among the oil companies. The greater variability foreseen in bitumen prices were not necessarily welcomed by road constructors and other large buyers of bitumen. The road construction industry argued that bitumen price fluctuations created challenges for construction tenders: road construction projects typically involve long-term tenders with government, in which contractors are required to specify how the prices quoted in a tender will be adjusted to account for variation in underlying cost drivers. This was considered particularly important in the case of bitumen, given its salience as a cost component in road

[4] Asphalt is produced by mixing penetration grade bitumen and value-added bitumen with various other products, primarily stone aggregate.

[5] HFO prices are often used to approximate prices for bitumen: while bitumen is not directly substitutable with HFO from the demand side, further chemical processes can convert bitumen to heavy fuel oil.

[6] Bunker fuel oil (BFO) refers to fuel oil used to power ships. It is also often referred to as marine fuel oil (MFO). BFO/MFO consists is a collective term referring to various types of fuel oil, including heavy fuel oil (HFO). The terms BFO, MFO and HFO are often used interchangeably.

construction and the possibilities of large losses given the long time periods associated with road construction projects (Ross and Field, 2007). Bitumen users, including the government roads agency, therefore petitioned SABITA to develop a standard price formula that could be used in road construction contracts.

In response, SABITA apparently investigated the drivers of bitumen prices and then suggested that a reference wholesale bitumen price should be a function of an underlying fuel oil price and some general price level variable (such as the consumer price index (CPI) or the producer price index (PPI)). SABITA therefore developed a Bitumen Price Adjustment Factor (BPAF) that could be used to calculate monthly price escalations in contracts, as follows:

$$BPI_t = BPI_{t-1} * BPAF = BPI_{t-1} * \left[f * \frac{HFO_t}{HFO_{t-1}} + (1-f) * \frac{PPI_t}{PPI_{t-1}} \right]$$

where IP_t is the bitumen price index in month t.

SABITA assigned values of 0.6 to f. The price suggested by the formula was then called the Bitumen Price Index (BPI), effectively a replacement of the WLSP. The first BPI was apparently calculated on 1 February 2002, by multiplying the WLSP of the time (R1 665 per tonne) with the BPAF.

The CC alleged that the oil companies, being parties in a horizontal relationship, engaged in price fixing by agreeing to develop and implement the BPAF. The Commission argued that it was unlawful to employ the WLSP after 2000 and that the use of the BPAF effectively perpetuated the WLSP. In particular, the CC argued that the oil companies based their individual list prices on this formula. Therefore, the CC alleged price-fixing behaviour from 2000 until December 2009[7].

The CC argued that the result of the conduct was that final customers of bitumen were forced to pay prices not determined by the market and that the oil companies engaged in this conduct in order to unfairly enrich themselves at the expense of final bitumen consumers, 90% of which are government departments, agencies (e.g. SANRAL) and municipalities.

2.2 *Bitumen price indices internationally*

Official reference prices for bitumen, in index form, are published in a number of countries, including the US[8], Canada, New Zealand and India. Similar to the South African formula, official bitumen price calculations in these countries also track international fuel oil prices. For example, the New Zealand Transport Agency calculates a Bitumen Price Index monthly based on the average monthly spot price of Singapore HFO and the exchange rate (Olsen, 2010). The import parity principle is motivated on the basis that the input required to produce bitumen, namely crude oil, is often imported.

The aim with the publication of bitumen price indices also appear to be similar: most countries aim to assist contractors and government in calculating adjustments to bitumen

[7] The oil companies disagreed with the period of alleged collusion, arguing that SABITA discontinued BPAF calculations from middle 2008.
[8] In the case of the US and Canada, ‘paving asphalt’ or ‘asphalt cement’ refers to bitumen.

prices in construction contracts. In fact, the Canadian index specifies thresholds for the difference between the index and actual prices, below which no contractual adjustments are allowed. However, in countries publishing bitumen price indices, public institutions assume responsibility for calculating and disseminating the price information. In the South African case, a private industry association assumed the responsibility of official statistician. Therefore, SABITA could argue that it was merely filling an institutional void: insufficient capacity at the official statistics bureau and at government departments led the industry organisation to collect and disseminate critical price information. Even if this benign explanation is plausible, the cooperation of competitors in regard to pricing may well have faciliated collusion: the use of a reference price can create a focal point for collusion and the cooperation within the association could have facilitated information exchange to sustain a collusive outcome (Motta, 2004). This is plausible, given price-fixing convictions in Spanish and Dutch bitumen markets, as discussed later. It is therefore necessary to measure the extent to which South African bitumen prices reflected underlying demand and supply drivers.

2.3 *Importance of the case*

The above suggests that the bitumen case may be of interest to those interested in the tensions between information collection and dissemination on the one hand and collusion on the other. But the bitumen case is particularly relevant to the literature on cartel overcharges, as it elucidates the empirical challenges of estimating overcharges in markets with a legal collusion history.

Many of South Africa's commodity markets, including steel, energy, and agricultural products, were historically regulated oligopolies (sometimes, monopolies). In keeping with market liberalisation efforts in other emerging markets, the South African government implemented wide-ranging market reforms in the 1990s, including opening up these markets to international trade and finance flows. However, many of these markets remain oligopolistic in nature, with strategic behaviour that reflects the structure of these markets and is often quite similar to that during the period of legal collusion. The estimation of counterfactual prices for the illegal collusion period is therefore challenging – and not only in the South African regime.

Furthermore, the focus on import parity pricing in this case is also insightful, as the practice of setting price at international levels is the basis of a number of competition investigations in recent years. For example, IPP has been the basis for an excessive pricing case against South African steel-maker that has been the subject of debate (Calcagno and Walker, 2010; Roberts, 2008). IPP can be particularly problematic in cartel cases brought in markets with a legal collusion history. Where import parity prices were used during the legal collusion period, and was also used in the illegal collusion period, these prices may well be viewed as remnants of the legal collusion period. It is therefore important to obtain 'but for' prices based on international experience, as this would establish the extent to which commodity markets elsewhere adopt similar IPP practices.

3. Analysis: temporal approach

3.1 Data

The data sources and variables employed in the temporal analysis are summarised in Table 1. The sample period is 1980 quarter 1 to 2012 quarter 3. The sample period therefore includes period of alleged collusion, namely 2000-2009[9].

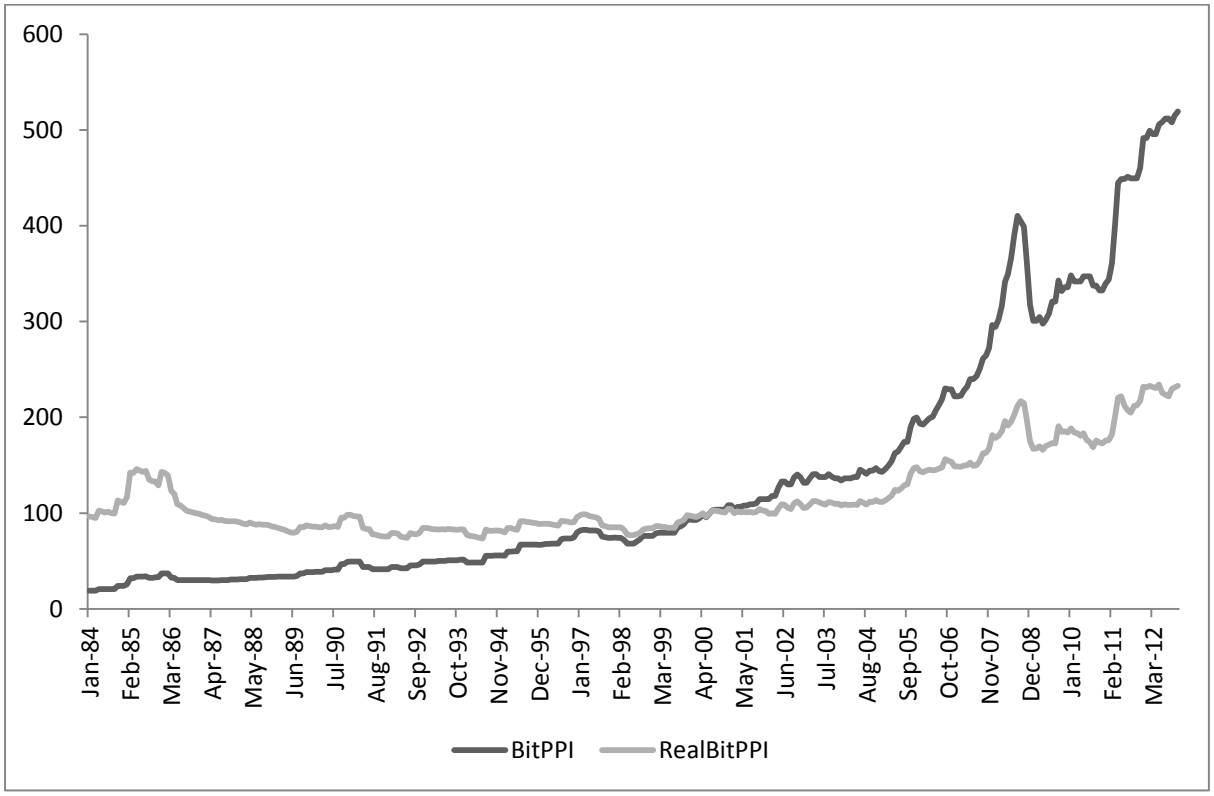
Table 1. Data and variables

Variable	Source	Description
Bitumen prices		
Bitumen PPI	Statistics South Africa	PI92001 'Producer price index for selected materials: bitumen', base year 2000
Other variables		
Crude oil	South African Reserve Bank	Brent crude oil price per barrel in US$
Construction GDP	South African Reserve Bank	KBP6636D 'Gross value added at basic prices of construction (contractors) (GDP)', constant 2005 prices
Bitumen volumes	Industry sources	-
Singapore HFO (Platts)	Platts	Singapore HS Fuel Oil 180 cst price per barrel in US$, cargoes
Rand/US dollar	South African Reserve Bank	KBP5339M 'Foreign exchange rate: SA Rand per USA dollar middle rates'

The first data series relates to bitumen prices. The temporal analysis requires an appropriate representative price series for bitumen, i.e. a price that accurately captures general price trends in the South African bitumen market. This study relies on the bitumen producer price index, published as part of the producer price index (PPI) reported by Statistics South Africa. Figure 1 shows the evolution of this bitumen price series in real and nominal terms. Note how real bitumen prices remain quite stable until around 2000, which reflects the period of stable prices due to legal price-fixing. After 2000, real prices rise, especially during 2008-2009. All commodity prices rose sharply during 2008-2009 and it is interesting to note how many price-fixing cases were initiated, or pursued with greater vigour, because of this general price trend (these include the prosecution of a bread cartel). It reflects the competition authority's dissatisfaction with, as we shall see, the large impact of international commodity prices on local prices.

[9] The starting point for sample periods of South African data is often in 1994. This year, which marks the year of democratic transition, is also the start of a liberalisation period, which saw the removal of sanctions and government control affecting a range of product markets in the country.

Figure 1. Comparison of monthly bitumen price index at current and constant prices, 1984-2012 (base year 2000)



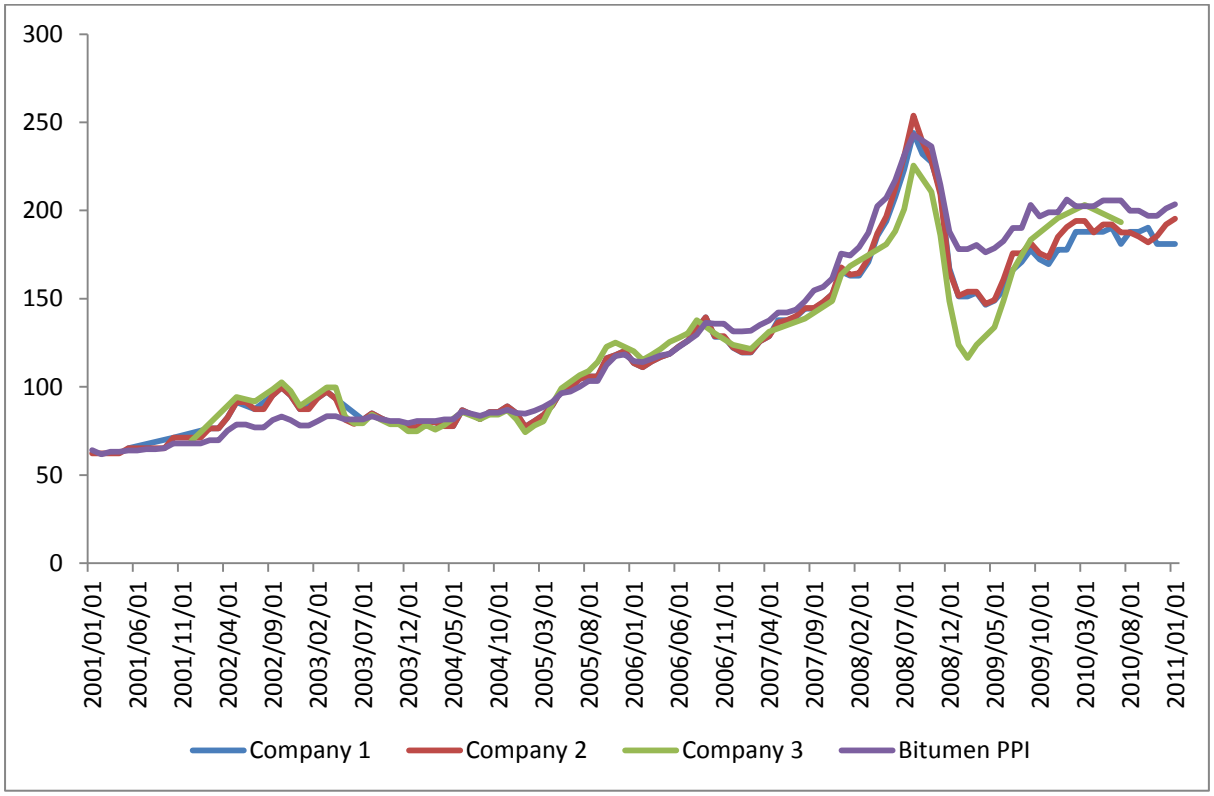
Source: Statistics South Africa

The bitumen PPI is a fairly representative price series, even if bitumen is supplied in various grades, some of which may attract higher prices[10]. This can be seen by comparing bitumen PPI with a selection of company-specific list prices for 80/100 penetration grade bitumen, as shown in Figure 2. The behaviour of the bitumen PPI is consistent with those of the list prices for bitumen at the various individual firms[11]. Correlation statistics between the three company list prices and the bitumen PPI suggests statistically significant correlation of 0.95 and higher for the variables in levels and 0.83 and higher for the variables in first-differences. This suggests that the bitumen PPI may accurately reflect market trends.

[10] While there is some price differentiation due to grade differences, companies often charge similar prices for three of the five most common types of penetration grade bitumen.

[11] Ideally one would want realised prices from individual companies, as the bitumen PPI is a realised price.

Figure 2. Comparison of monthly bitumen PPI with list price indices at three oil companies, 2000 to 2010 (base year 2005) (penetration grade bitumen 80/100)



Source: Various industry contacts (anonymous and converted to indices to protect confidentiality)

Apart from prices, the temporal approach requires data on demand and supply drivers. We use two proxies for bitumen demand: the construction component of real GDP and the volume of bitumen sold in South Africa. For supply drivers, we rely on the rand/dollar exchange rate and the Brent crude oil price.

3.2 Econometric model

The temporal approach involves fitting a reduced-form model of price and then using the fitted parameters to predict 'but for' prices. It is popular to view the reduced-form model as a single-equation model[12]. This paper follows an autoregressive distributed lag (ARDL) model of lag order p:

$$\Delta bitP_t = \beta_0 + \sum_{i=1}^{p} \beta_{1,i} \Delta bitP_{t-i} + \sum_{i=0}^{p} \beta_{2,i} \Delta brent_{t-i} + \sum_{i=0}^{p} \beta_{3,i} \Delta demand_{t-i} + \alpha_1 bitP_{t-1} + \alpha_2 Brent_{t-1} + \alpha_3 demand_{t-1} + \boldsymbol{\gamma}' \boldsymbol{Z}_t + \varepsilon_t$$

where, in period t, $bitP_t$ is log domestic bitumen price, $brent_t$ is log Brent crude oil price, $demand_t$ is a demand proxy, either log of construction GDP or log of bitumen volumes sold locally, $\boldsymbol{Z}_t$ is a vector of dummy variables dealing with data outliers, and $\{\varepsilon_t\}$ are assumed a serially uncorrelated series.

[12] This draft focuses on single-equation approaches, but multiple-equation models can also be considered. A key constraint here is the number of available data points.

The model can then be used to predict the "but for" prices, and hence the overcharge, during the cartel period. Alternatively, the models can be estimated on data from the cartel period and then used to predict prices prior to or following the cartel[13]. We focus mostly on the latter, given the limited data points before the cartel – even though bitumen price data is available for a considerable period (back to the early 1980s), the structural change in the South African economy is such that it is only useful to look at data from 1994 onwards.

3.3 ***Results***

We start by fitting a model on data from the period preceding the illegal collusion period, i.e. from the period prior to 2000. Appendix A contains the regression results for the period 1986Q4-1999Q4. While we do have access to data from 1980, we commence the analysis in 1986 following adoption of a market-based monetary policy in South Africa, a move that significantly affected the exchange rate. While the model results are fairly stable, there is significant evidence of parameter non-constancy, reflecting the structural change during the 1990s. It seems that most of this change occurs during the first part of the nineties, suggesting that a model over the latter period may be more stable. However, this reduces the available data points to a meagre 20. Therefore, fitting a stable model on the period prior to the illegal collusion period is not feasible.

Instead, we consider the alternative approach, namely to fit a model on data from the period of illegal collusion and to use that model to predict prices for the preceding period, i.e. the period when a legal cartel was in operation. Effectively, the fitted model will reveal the effect that the pricing formula and information exchange had on realised prices and their response to Brent crude oil and demand shocks. Predicting prices in the preceding period based on this model will then show how prices during the legal cartel period differed in their response to crude oil and demand shocks from prices during the period of illegal collusion.

We consider three variants of the model: (i) Model 1 is fitted on the entire period for which the CC claimed collusion (ii) Model 2 is fitted only up to 2007 and (iii) Model 3 is Model 2 but where the demand proxy is bitumen volumes instead of construction GDP. The motivation for considering a shorter sample period comes from parameter non-constancy tests, which indicate structural change towards the end of the sample period.

After the initial models are fitted, we assess the congruency of the models with the data using misspecification and diagnostic tests of the residuals. If a model passes these tests, it is considered a general unrestricted model (GUM). The GUM may contain irrelevant variables that could bias coefficient estimates. We use a general-to-specific (GETS) algorithm to reduce the GUM to a so-called specific model. This algorithm involves a multiple-path, stepwise process to remove irrelevant variables with minimal information loss (Campos et al., 2005). The regression results for the GUM and specific versions of all three models are reported in Appendix B. We report the estimates for the long-run coefficients for both the GUM and the specific models in Table 2. Firstly, long-run coefficients remain significant in all three cases. Secondly, results change for Model 2 and 3 due to a shorter

[13] A rudimentary alternative to predicting prices out-of-sample is to use a dummy variable for the cartel period and to fit the model over both the cartel and non-cartel period. This approach assumes that collusive behaviour manifests in a step shift in the intercept, which ignores parameter changes due to the collusion.

sample period and different demand proxy, while the speed of adjustment coefficients (the time it takes to restore long-run equilibrium following a demand or supply shock) are lower for Model 2 and especially Model 3. All in all, while the legal allegations deal with a specific period 2000-2009, the behaviour of bitumen pricing within that sample period is far from stable. Therefore, the legal period of collusion is not necessarily corroborated by empirical reality.

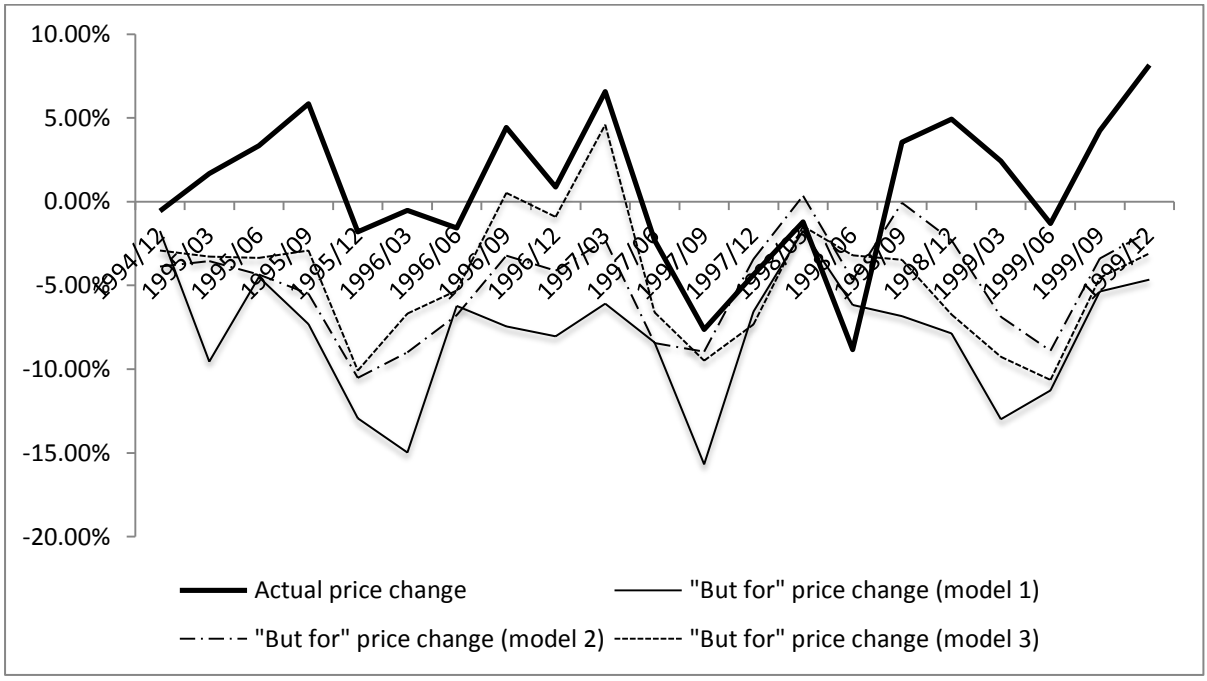
Table 2. Long-run parameters.

Parameter	**Model 1 (2000Q4-2009Q4)**		**Model 2 (2000Q4-2007Q4)**		**Model 3 (2000Q4-2007Q4)**	
	GUM	**Specific**	**GUM**	**Specific**	**GUM**	**Specific**
Brent crude	0.30	0.17	0.17	0.27	0.25	0.44
Construction GDP	0.58	0.61	0.61	0.64	-	-
Bitumen volumes	-	-	-	-	0.90	0.76
Speed of adjustment	-0.76	-1.77	-1.77	-0.60	-0.43	-0.42

Despite these uncertainties, the specific models can be used to ‘backcast’ prices in the period before the alleged collusion. The underlying theory is that overcharge has occurred if backcasted prices are higher than actual prices: if behaviour is assumed stable and the period preceding collusion is assumed to be competitive, then higher predicted prices suggest lower competition. Figure 3 shows the predicted prices based on the specific models. In this case, the predicted prices are quite similar and sometimes lower (ignoring statistical uncertainty): if price-setting behaviour in the 2000s were followed in the 1990s, bitumen prices in the 1990s would have been broadly similar to those of the 2000s or even slightly lower. In other words, there is no evidence from the temporal approach that prices were higher.

But the assumptions, of competition and stability, are heroic. Firstly, the choice of “competitive” or non-coordination period is crucial to the exercise. Strictly speaking, this need not be a “competitive” period, i.e. one characterised by intense competition. A period very similar to the period under investigation, “but for” the coordination, will do. The nineties was a period during which the South African bitumen market was characterised by a ‘legal’ cartel. Therefore, comparing prices during the period of alleged collusion with prices in this legal cartel period can only tell us if market outcomes changed for the worse. Presumably, under a legal cartel, prices would have been set at the monopoly level. So if, using post-2000 data, prices are predicted to have been more or less the same, one could argue that behaviour has not really changed. If predicted prices are lower (in a statistically significant way), then one could argue that there has been a change for the better. The evidence does not suggest that behaviour has worsened.

Figure 3. Predicted (backcasted) quarter-on-quarter price changes for the legal cartel period.



3.4 Conclusions

The results suggest that the temporal approach faces a number of limitations in the current context. First, the identification of a “but for” period is challenging as the “but for” period itself is a period of sanctioned coordination, which was supposed to be followed by a period of oligopolistic competition without concerted action or explicit coordination. This need not be a problem if it is possible to identify the effect of sanctioned coordination in the “but for” period. This identification is not possible and represents a fundamental limit to the temporal approach when dealing with post-sanctioned coordination. This limit forces us to consider the spatial approach which would allow us to compare prices to those in other markets potentially characterised by oligopolistic competition rather than coordinated behaviour of an illegal nature.

At best, then, if the temporal approach suggests higher “but for” prices than actual prices, one could argue that there must have been some deviation from the original coordinated behaviour in the sanctioned period. The main criticism, however, is that because of the identification problem it is impossible to know the extent to which such deviation is sufficient. But it defines a maximum for the harm: it may well be that the coordination in the post-sanctioned era inhibited the price in moving to more competitive levels but it can be said that this coordinated price was still lower than the original sanctioned cartel level.

Second, the selection of the collusion and extra-collusion periods requires identifying periods during which stable econometric models can be estimated and used for prediction purposes. Econometrically, the process of identifying collusion can be interpreted as the process of identifying structural breaks. The interesting question facing economists therefore is how to match periods identified by courts or antitrust bodies with those suggested by econometric procedures focused on structural breaks. Often, econometric models may suggest

alternative structural breaks due to the industry itself experiences particular structural shifts. These structural changes again create difficulties for the identification of the cartel conduct. This is not a problem *per se* for the temporal approach. Under the spatial approach, which relies on comparisons of market outcomes across regions, structural changes that are not uniform across countries can bias the analysis. However, in this particular case, structural change over time is significant, occurring in both the legal cartel period and the period of alleged collusion. Econometric modelling can either take the collusion or extra-collusion period as basis. The selection of the appropriate benchmark is dictated mostly by practical considerations, including the length of the two periods. However, even for the shorter period in this case, the assumption is that market behaviour is sufficiently stable in relation to the modelled parameters to allow prediction using the other period's model. Therefore it is important to check for structural breaks, as this raises the probability of correctly identifying the cartel conduct.

If one could address these concerns upfront, the temporal analysis may yet yield important information for overcharge calculations. Nevertheless, the fundamental problem is that the temporal approach does not rely on external yardsticks. This deficiency prevents testing one of the CC's arguments in the bitumen case, namely that prices were set, anti-competitively, on an import parity principle.

3. Analysis: spatial approach

Given the limits of the temporal approach, we proceed to a spatial approach to estimating 'but for' bitumen prices. One strategy for implementing a spatial approach involves considering the behaviour of domestic bitumen prices in other countries. As discussed, the price data in this regard is quite limited. We had access to New Zealand and US (Californian) bitumen prices for a sample period that roughly accords with that of the price-fixing case in South Africa[14]. The series appear to co-move, though the South African series does not decline nearly as strongly as the other two series in 2008/2009. Similar to our strategy under the temporal approach, we estimate a reduced-form ARDL model to isolate the relationship between bitumen prices in New Zealand and California and international crude oil prices. As before, we first fit a general specification and then derive specific models. Misspecification tests indicate that all models have robust error properties and are congruent with the data; the source data and full econometric results (including the misspecification test results) are available from the author and have been omitted to save space.

The results suggest that the long-run elasticity of domestic bitumen prices with respect to crude oil prices is close to unity, in both California and New Zealand. This estimate is much higher than the equivalent coefficient values for South Africa reported earlier. The relevance of these conclusions may be limited, given the differences between South Africa and the developed economies of the US and New Zealand. The following section therefore interrogates data from a larger selection of countries – including countries similar to South Africa – in order to predict 'but for' prices.

[14] We also have some limited data for India, but this is for a different sample period.

3.1 International import prices

Absent domestic bitumen prices for a large number of countries, one can rely on import price data to predict 'but for' prices. Using import prices to predict domestic 'but for' prices implies an assumption that import prices and domestic prices share the same demand and supply drivers. This appears to be a feasible assumption from the demand side: the demand for bitumen in South Africa includes the demand for imported bitumen, so that these share the same drivers (namely, construction activity). The supply of domestically-produced bitumen is determined by internationally-determined input costs (Brent crude and the exchange rate), while the supply of imported bitumen is also directly determined by international conditions.

The data consists of an unbalanced panel on annual bitumen import values (in US dollars) and import weights (in kilogram) for 226 countries from 1990-2011. From this dataset, we calculate a realised bitumen import price. Some data on weights and especially prices are suspect. We therefore construct a balanced panel of 64 countries for the period 2001-2010 and remove all countries for which the weight of petroleum bitumen imports are generally lower than 100 kilogram or for which the implied price is above $10. It turns that the data points removed are generally data pertaining to very small economies, where information collection capacity is probably limited and the potential for measurement error is high.

We first estimate a homogeneous-slope fixed-effects model in levels:

$$p_{it} = \alpha + \beta_{1i} + \beta_2 p_{i,t-1} + \beta_3 p_{i,t-2} + \beta_4 brent_{it} + \beta_5 brent_{i,t-1} + \beta_6 brent_{i,t-2} + \beta_7 quantity_{i,t} + \beta_8 quantity_{i,t-1} + \beta_9 quantity_{i,t-2} + \boldsymbol{\gamma}' \boldsymbol{Z}_{it} + e_{it},\ e_{it} \sim i.i.d.(0, \sigma_i^2),\ i = 1, \dots, N,\ t = 1, \dots, T$$

where, in period t, p_{it} is log bitumen import price for country i, $brent_{it}$ is log Brent crude oil price, $quantity_{it}$ is log volume bitumen imports for country i, $\boldsymbol{Z}_t$ is a vector of dummy variables for country i, dealing with data outliers.

We then study how the parameters for the full panel model (termed model (1)) differ from those for a model first controlling for OECD[15]-specific slopes (model (2)). The underlying assumption is therefore that markets in advanced economies behave differently from those in developing economies. Controlling for OECD-specific effects reduces biased inference with regard to non-OECD (developing) market behaviour, which is used to infer the expected market behaviour in South Africa. Thereafter, we fit a model for a panel of upper-middle income (UMI[16]) countries as defined by the World Bank (South Africa is an UMI country) (model (3)). Coefficients are estimated using both panel efficient GLS estimation and GMM estimation.

We are particularly interested in the impact of Brent crude oil prices, given its salience as cost driver in bitumen production. Table 3 reports the regression results for models (1) and (2) and Table 4 for model (3).

[15] http://www.oecd.org/general/listofoecdmembercountries-ratificationoftheconventionontheoecd.htm
[16] http://data.worldbank.org/about/country-classifications/country-and-lending-groups

Table 3. Coefficient estimates for panel price models (1) and (2).

	(1)		(2)	
	GLS	**GMM**	**GLS**	**GMM**
$\boldsymbol{\beta_2}$	0.30***	0.26***	0.34***	0.37***
	(0.05)	(0.01)	(0.06)	(0.03)
$\boldsymbol{\beta_3}$	-0.02	0.07***	0.01	-0.03
	(0.05)	(0.01)	(0.07)	(0.04)
$\boldsymbol{\beta_4}$	0.52***	0.53***	0.50***	0.51***
	(0.03)	(0.02)	(0.04)	(0.08)
$\boldsymbol{\beta_5}$	-0.13***	-0.06***	-0.14***	-0.24***
	(0.04)	(0.02)	(0.04)	(0.04)
$\boldsymbol{\beta_6}$	0.29***	0.23***	0.25***	0.34***
	(0.04)	(0.01)	(0.06)	(0.09)
$\boldsymbol{\beta_7}$	-0.03**	-0.07***	-0.01	-0.14***
	(0.01)	(0.01)	(0.01)	(0.03)
$\boldsymbol{\beta_8}$	0.01	-0.05***	-0.00	-0.08***
	(0.01)	(0.01)	(0.02)	(0.03)
$\boldsymbol{\beta_9}$	-0.01	0.01	0.00	0.12***
	(0.01)	(0.01)	(0.01)	(0.03)
Fixed effects redundancy	3.88***	-	3.52***	-

Table 4. Coefficient estimates for panel price model (3).

	(3)	
	GLS	**GMM**
$\boldsymbol{\beta_2}$	0.24***	0.03
	(0.06)	(0.07)
$\boldsymbol{\beta_3}$	0.05	0.13***
	(0.07)	(0.04)
$\boldsymbol{\beta_4}$	0.48***	0.53***
	(0.04)	(0.05)
$\boldsymbol{\beta_5}$	-0.10*	0.04
	(0.06)	(0.06)
$\boldsymbol{\beta_6}$	0.29***	0.30***
	(0.06)	(0.06)
$\boldsymbol{\beta_7}$	-0.06***	-0.03
	(0.02)	(0.03)
$\boldsymbol{\beta_8}$	0.02	-0.05
	(0.02)	(0.05)
$\boldsymbol{\beta_9}$	0.01	0.01
	(0.02)	(0.02)
$\boldsymbol{\beta_{2,UMI}}$	0.14**	0.52***
	(0.06)	(0.09)
$\boldsymbol{\beta_{3,UMI}}$	-0.11	-0.34***
	(0.08)	(0..09)
$\boldsymbol{\beta_{4,UMI}}$	0.12*	-0.27
	(0.07)	(0.18)
$\boldsymbol{\beta_{5,UMI}}$	-0.06	-0.29
	(0.07)	(0.13)
$\boldsymbol{\beta_{6,UMI}}$	-0.06	0.08
	(0.08)	(0.17)
$\boldsymbol{\beta_{7,UMI}}$	0.04	-0.09*
	(0.03)	(0.05)

$\boldsymbol{\beta_{8,UMI}}$	-0.02 (0.03)	0.15 (0.07)**
$\boldsymbol{\beta_{9,UMI}}$	-0.02 (0.03)	-0.04 (0.05)
Fixed effects redundancy	3.40***	-

The GLS and GMM estimates are comparable for all models, apart from the lagged price effects in model (3). The long-run impacts of Brent crude oil and bitumen volume on bitumen import prices can be summarised as follows:

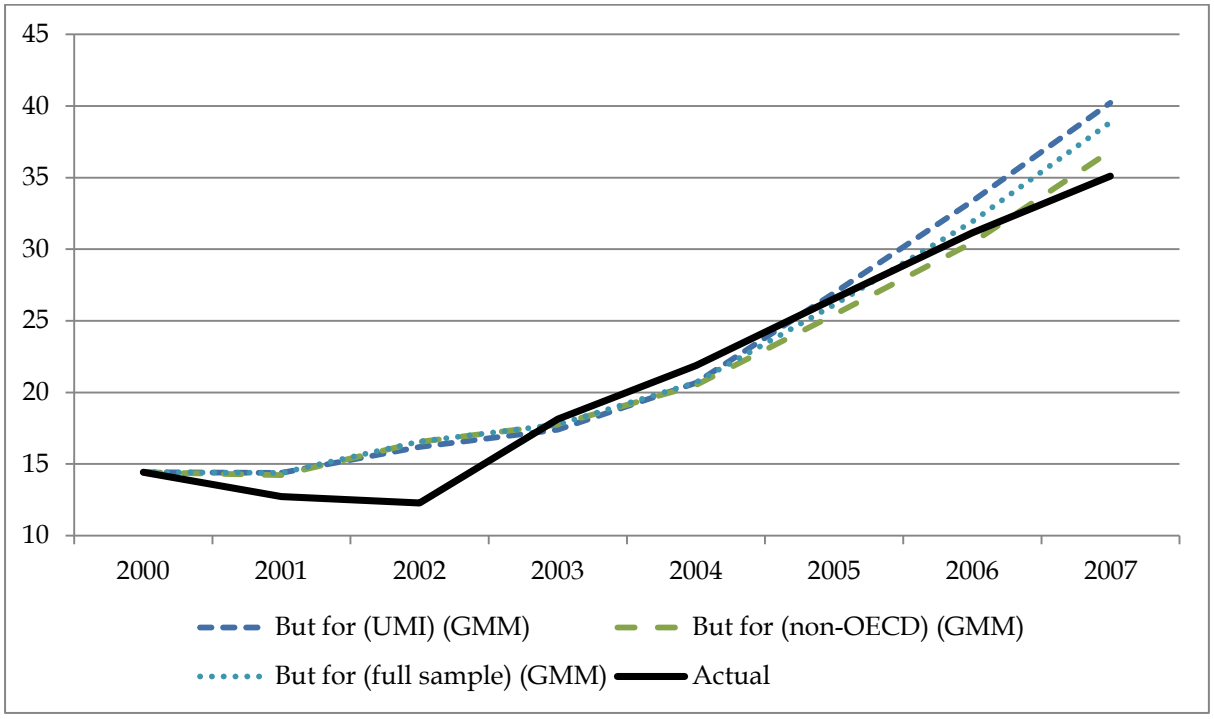
Table 5. Long-run coefficients estimate for panel price models.

	(1)		**(2)**		**(3)**	
	GLS	**GMM**	**GLS**	**GMM**	**GLS**	**GMM**
Brent	0.94	1.04	0.94	0.92	0.94	1.04
Bitumen volume	-0.04	-0.16	-0.02	-0.15	-0.04	-0.08

The results suggest a one-to-one relationship between crude oil prices and bitumen import prices. The ‘general’ impact of crude oil prices is around 0.9, and the impact again rises to 1 for UMI countries. This would suggests that the South African results, which suggest that the response of domestic bitumen price is estimated between 0.17 and 0.44 (see previous Table 2), is not excessive. The price response to bitumen volumes is around -0.04 for GLS estimates and up to -0.16 for GMM estimates.

One can generate formal ‘but for’ predictions from the fitted models, as shown in Figure 4. Figure 5 starts the bitumen price index at 100 in 2001 and then uses the estimated coefficients from panel model to calculate predicted the ‘but for’ price index. We calculate two potential ‘but for’ prices, one based on the panel results as a whole (not controlling for group-specific effects) and another based on the panel results for upper-middle income countries in particular.

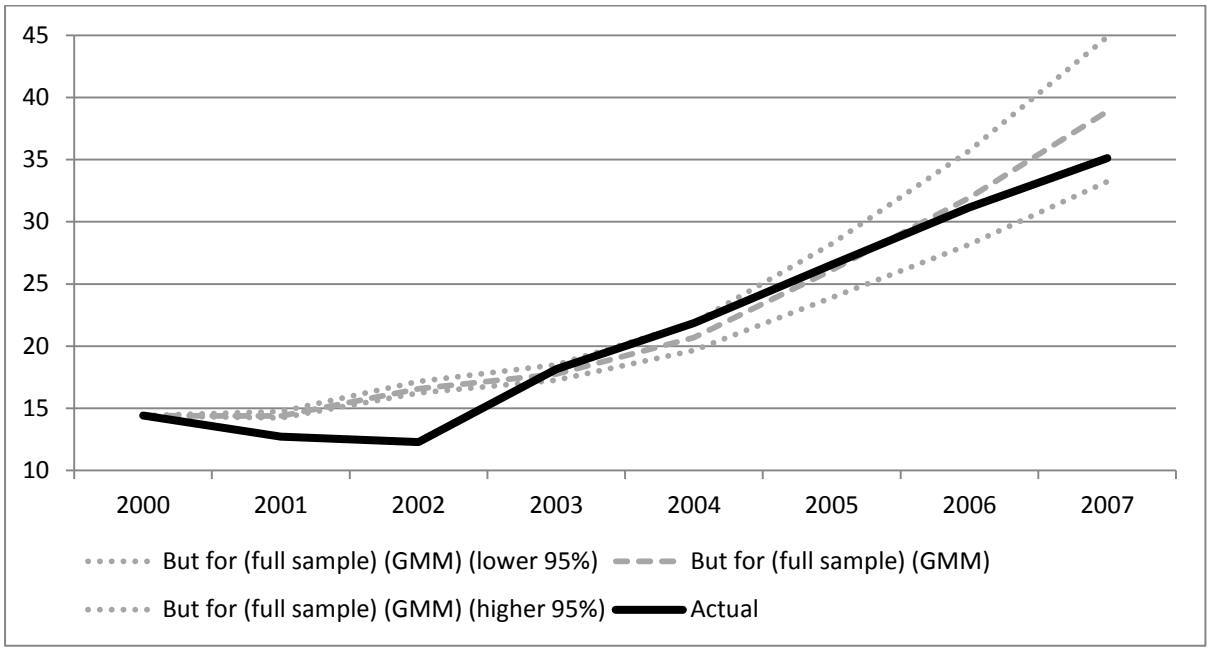
Figure 4. Predicted bitumen price (in rand) for the period of alleged collusion using import price panel models (GMM estimation)



The figure suggests that the predicted price index is lower in 2003-2005 (which would indicate an overcharge), but higher before and subsequently. This pattern holds regardless of which panel sample is used: the 'full sample', which bases the prediction on the behaviour of all countries (developed and developing alike) produce results similar to the samples where the OECD countries are removed or where only UMI countries are considered.

Once one accounts for confidence intervals, to account for uncertainty in parameter estimates, one finds that the differences between the actual and predicted prices are not statistically significant in any period except during 2000-2002: as shown in Figure 5, the 95% confidence intervals, generated by considering the 95% confidence bands for the underlying parameter estimates, include the actual price series from 2003, but are higher before that. We find similar results for the non-OECD and UMI-only samples, as shown in Appendix C. We also note that the results for the panel models estimated using GLS are similar, if more uncertain, as shown in Appendix C.

Figure 5. Predicted bitumen price (in rand), including 95% confidence interval, for the period of alleged collusion using an import price panel model (full sample, GMM estimation)

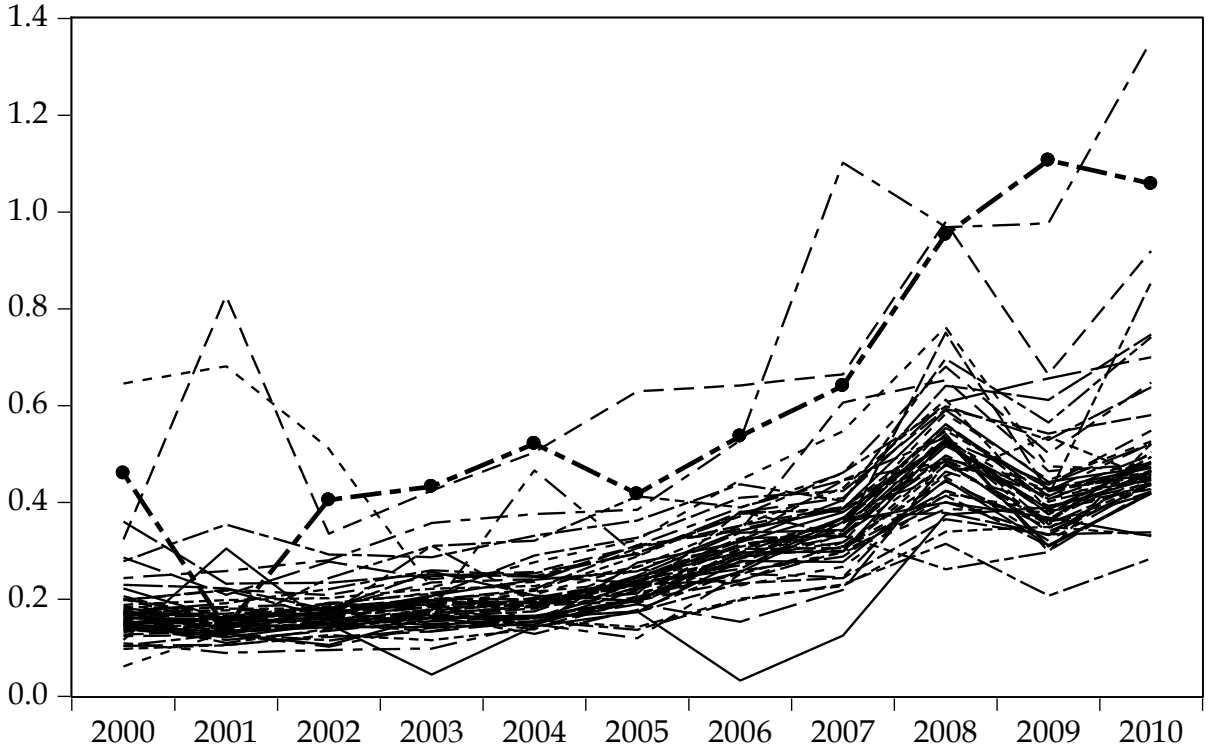


The deviation prior to 2003 is noteworthy, as all models predict a sharp increase in the South African price following the sharp depreciation of the South African currency in 2001, even though actual prices were far more stable. This may reflect cost absorption and smoothing of the price by the bitumen producers, but it also reflects the fact that the specific formula in use at the start of the cartel period was not yet agreed upon, as noted earlier. In other words, it does confirm that there was a period of instability following the cartel's loss of legal status.

The approach employed so far relies on fitting a panel model on data from countries other than South Africa and using that model to predict South African prices in the alleged cartel period. As an alternative, one may *include* South African data in the panel and employ a difference-in-difference approach to measure the average deviation of South African prices from international prices. This is an approach suggested by the EC in a guidance document on overcharge calculations (Directorate-General for Competition of the European Commission, 2009). Under this approach, the South African market is identified as the treatment group (where the 'treatment' is the presence of a cartel), while all other countries are identified as the control group (which do not experience the presence of a cartel). The aim is to isolate the effect of the 'treatment' econometrically.

Figure 6 shows the evolution of import prices for the entire panel, with the South African price highlighted. It is quite clear from the graph that the South African prices exceed average prices over most of the sample period.

Figure 6. Bitumen import prices (in dollar per kilogram) for full sample of countries, 2000-2010 (South Africa highlighted)



Source: United Nations Energy Statistics (2013)

Similar to the preceding analyses, one can therefore re-run the three models discussed earlier, but now include dummies for South Africa, the OECD and UMI countries. This effectively implies three alternative control groups: all countries in the sample beyond South Africa, only non-OECD countries, and only UMI countries. The model results confirm the graphical intuition. Model (1) contains only a dummy variable for South Africa, and shows South African prices to be about 18% higher. The result is robust across model specification: for Model (2) and (3), where we control for OECD and UMI membership, the effect remains around 19-20%. Table 6 reports the estimates for models (1) to (3) using GLS estimation:

Table 6. South African effects for panel price models (1) to (2).

Effect	(1)	(2)	(3)
ZA	0.18***	0.19***	0.20***
	(0.03)	(0.01)	(0.03)
OECD		-0.01	-0.02
		(0.01)	(0.02)
UMI			-0.02
			(0.01)

Therefore, the difference-in-difference models show that, even though the responsiveness of South African prices to cost and demand drivers is not as different from those of other countries, the overall *level* of South African prices were much higher – a feature that reflects the long history of legal collusion in this industry. In fact, it confirms one of the central claims of the CC in the cartel case. It was not just that cartel members agreed on how prices would evolve in response to cost and demand drivers, but it was the level at which the calculation started. The cartel members agreed to start the BPAF on R1165 per ton, which is a value

based on prices in the previous legal cartel period. In other words, they agreed on maintaining the level of bitumen prices, even though subsequent price changes would follow cost and demand movements.

The panel models so far assume that the countries in the sample represent competitive markets[17] and therefore do not account for potential collusion in these countries. Two European bitumen price-fixing cases were settled during the sample period. In 2006, the EC fined 14 companies a total of €266.717 million for price fixing of road bitumen in the Netherlands.[18] The companies colluded to fix the gross price of road pavement bitumen and to set a uniform (minimum) rebate on the gross price for a group of participant road builders as well as a smaller (maximum) rebate on the gross price for other road builders.

In Spain, the EC in 2007 fined bitumen suppliers €183 million for market sharing and price coordination[19]. The companies established market quotas and allocated volumes and customers to each participant. They also monitored the implementation of the market sharing arrangements and established a compensation mechanism to correct deviations from the market sharing arrangements. They also agreed on the variation of bitumen prices and the moment at which the new prices would apply.

Given that both Spain and the Netherlands are included in the dataset, one can also use a difference-in-difference approach to identify the size of overcharge by the European cartels. Both cartel cases involved conduct that ceased in 2002. Given that we have an annual dataset starting in 2001, this cartel period implies only two data points (2001 and 2002) over which the model is required to estimate the cartel effect in addition to the other parameters. Not surprising, the results, reported in Appendix D (Table D1), do not suggest a significant cartel effect on Spanish or Dutch prices. The limited data points are likely to have played a significant role here. But the limited data is in itself also an indication of the difference between the South African cartel on the one hand and the Dutch and Spanish cartels on the other. The illegal European cartels emerge for a specific period in otherwise more competitive conditions, while the South African cartel develops from a long period of legal cooperation. Nevertheless, the inclusion of controls for Dutch and Spanish collusion in our panel models does not alter our overcharge estimates for the South African cartel.

3.2 Discussion of spatial approach results

The response of South African domestic bitumen prices to cost and demand drivers do not differ significantly from the response of bitumen prices in other countries to the same drivers. This finding is robust to choice of comparator group (whether including all non-OECD countries or only UMI countries) – it would appear that the responsiveness does not differ significantly between developing and developed economies. Defendants often use the absence of such an effect to argue that a cartel did not result in significant damages. This is misleading. Long-standing cartels may well respond to cost and demand drivers in a similar fashion to players in more competitive markets, but would *already* have priced in a monopoly

[17] As also noted later, ‘competitive’ refers to oligopolistic competition, rather than textbook perfect competition. This is based on the fact that only large oil companies are capable of producing bitumen, which would imply that most bitumen markets would be characterised by a few large players.
[18] Netherlands (2006) – Case COMP/38.456 – Bitumen - NL
[19] Spain (2007) - Case COMP/38.710 – Bitumen Spain

premium – that is, the long-run level of prices are higher than in comparable competitive markets.

In their settlements with the competition authorities, Engen Petroleum, Shell South Africa and Masana Petroleum Solutions agreed to pay administrative penalties of R28.8 million, R26.3 million and R13 million respectively (Competition Tribunal, 2010, 2012a, b). SABITA, the industry organisation, also agreed to an administrative penalty of R0.5 million. The relevant court orders do not set out the basis for the calculation of these penalties, but Shell reports that its penalty was calculated as 9% of its 2009 bitumen sales (Shell, 2012). This is a modest amount, given our estimate of 18-20% overcharge. It partly reflects the lower fines imposed due to parties settling with the competition authorities prior to litigation. But it is still necessary to consider the economic basis for these calculations, especially in light of the large number of South African price-fixing cases in markets with a history of regulation that permitted collusion.

Other evidence can offer external validity tests for the overcharge estimates. In a comment on our paper, it was suggested that the margin (or 'administrative premium') built into the WLSP offer direct quantitative evidence of the size of cartel overcharge. This information is confidential and we did not have access to this, but if available may well be useful in supporting the econometric estimates. The problem with relying on the margin built into the cartel's price calculations is that it does not show us which portion of the margin is due to oligopoly profit and which portion due to the collusion. The benefit of the econometric models is that we rely on data from bitumen markets that probably have quite similar competitive features to the South African market and therefore already account for potential oligopoly profits[20]. Any deviation between these prices and those in South Africa may therefore be identified as the collusion overcharge (controlling, of course, for demand and cost drivers). Nevertheless, the econometric models themselves do face limitations, and it is necessary to merge various pieces of evidence when assessing overcharge. In particular, depending on the behaviour of the particular cartel, there may well be a period of transition that could yield interesting evidence. One option could be a comparison of profit margins over the collusive and transition period, following the approach by Mncube (2013). This would require confidential information in this case, which is not in the public domain.

3.3 Implications for the broader literature

This study has general implications for competition policy. The results suggest that detecting whether members of a formerly legal cartel continue to collude under a new regime may be more difficult than detecting the emergence of a 'typical' cartel for a specific period. These cartels do not necessarily exhibit behaviour substantially different from those of more competitive players. Employing the traditional temporal analysis may not yield any indication of behavioural changes – compare this finding to similar conclusions for the Dutch construction cartel uncovered in the 2000s: Van Bergeijk (2007) notes that a number of Dutch studies, using conventional techniques, failed to identify cartel conduct in an industry with a long history of legal collusion. Furthermore, even a comparison of market behaviour to those in other countries may not suggest significant deviations in behaviour in the absence

[20] Bitumen is a product of the refinery process, which restricts the number of competitors in most countries to a few large oil companies.

of readily comparable price data: it may often be that price *levels* are higher on a sustained basis, an empirical feature which would need to be uncovered using price panel data.

In general, then, the choice of econometric approach for overcharge estimation should be informed by the type of cartel being investigated. While the temporal approach is by far the most popular approach in estimating damages, South African price-fixing cases – at least those in markets with a history of regulation and legal cartels – may well require a spatial approach. Where possible, such a spatial approach should rely on a multivariate method that controls for demand and supply conditions in other countries during the period under investigation and allows for a difference-in-difference analysis to identify differences in price levels. Furthermore, the special empirical features of these types of cartels may require different tools at the detection or screening phase of competition investigations. Many of the screening tools depend on identifying changes in the statistical moments of a price distribution, but would generally fail to identify these cartels.

4. Conclusions

In recent years, a number of price-fixing cases have been brought in South African markets that were previously regulated and where active cooperation among competitors was allowed. Furthermore, many South African markets have been liberalised since 1994, reflected in structural change in many market relationships and rendering many of the markets subject to international price developments. These features create special difficulties for the calculation of overcharges. Conventional approaches often rely on a temporal approach, where prices during the cartel period are compared to prices in another – supposedly competitive – period. For historically legal cartels, a competitive period that precedes the period of illegal collusion is not available, while the post-illegal collusion period is often too short to allow stable econometric modelling. This limits the use of a temporal approach for these cartel cases. A spatial approach, where prices are compared to those in other countries, offers a better alternative. We apply these methods to estimate overcharge by the bitumen price-fixing cartel in South Africa. We find that while South African bitumen prices may have similar responses to demand and supply shocks, a spatial approach unmasks the persistent effect of high price levels. This sheds further light on the transition of legal to illegal collusion, a topic of both local and international interest.

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Appendix A

ARDL regression results for 1986Q4-1999Q4

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EQ(27) Modelling dRealBitPPI by OLS
       The dataset is: C:\Users\Willem H\Documents\Akademie\Navorsing\Navorsing
2013\New papers\Bitumen pricing\Data\Temporal data\new07.in7
       The estimation sample is: 1986(4) - 1999(4)

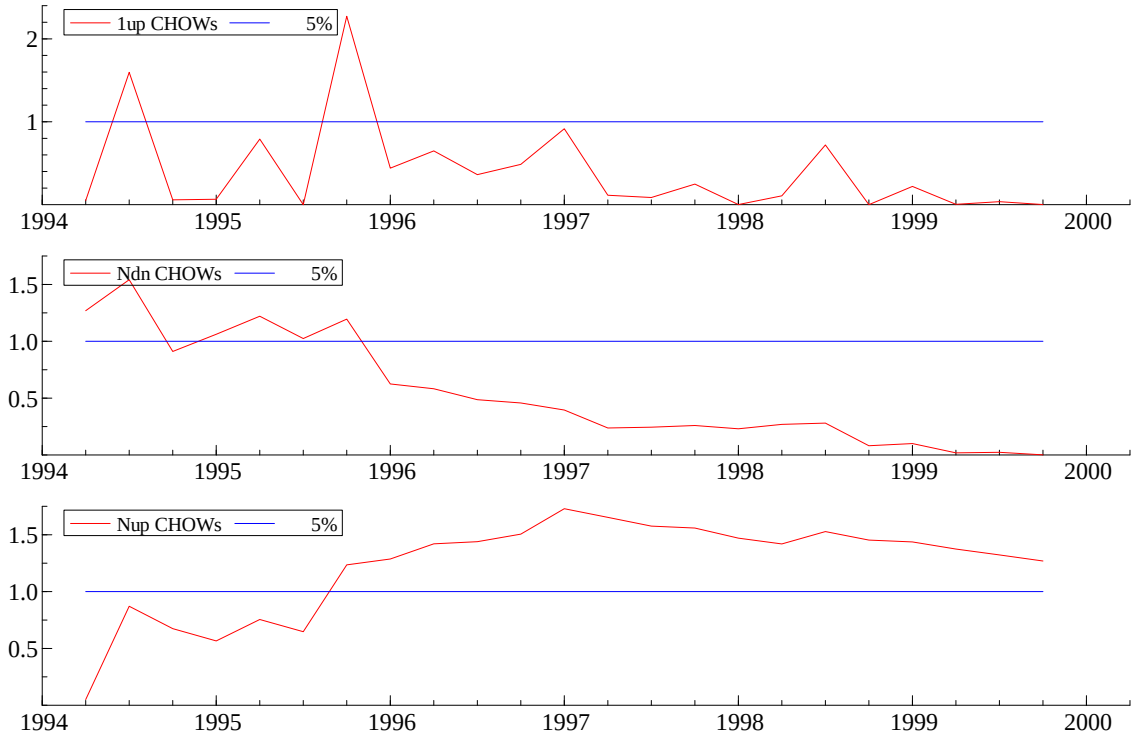
                  Coefficient  Std.Error  t-value  t-prob Part.R^2
dRealBitPPI_1        0.332010     0.1770     1.88  0.0701   0.1019
dRealBitPPI_2       -0.221232     0.1785    -1.24  0.2245   0.0472
dRealBitPPI_3        0.225096     0.1713     1.31  0.1984   0.0528
dRealBitPPI_4       -0.242066     0.1303    -1.86  0.0727   0.1002
Constant              1.00965      1.761    0.573  0.5707   0.0105
drealcrude          0.0526141    0.04637     1.13  0.2652   0.0399
drealcrude_1         0.137468    0.07763     1.77  0.0864   0.0919
drealcrude_2        0.0247630    0.07651    0.324  0.7484   0.0034
drealcrude_3        0.0444213    0.06375    0.697  0.4911   0.0154
drealcrude_4       -0.0358019    0.06186   -0.579  0.5669   0.0107
dconstrGDP          -0.221237     0.4470   -0.495  0.6242   0.0078
dconstrGDP_1         0.684389     0.4090     1.67  0.1043   0.0829
dconstrGDP_2       -0.0135912     0.4079  -0.0333  0.9736   0.0000
dconstrGDP_3        -0.565707     0.4066    -1.39  0.1741   0.0588
dconstrGDP_4        0.0474445     0.4139    0.115  0.9095   0.0004
Seasonal           0.00407222    0.01763    0.231  0.8188   0.0017
Seasonal_1         -0.0336642    0.01743    -1.93  0.0626   0.1074
Seasonal_2          0.0136164    0.01715    0.794  0.4332   0.0199
constrGDP_1        -0.0224554     0.1788   -0.126  0.9009   0.0005
RealBitPPI_1        -0.224511     0.1233    -1.82  0.0783   0.0966
realcrude_1         0.0476201    0.09326    0.511  0.6132   0.0083
dum1995q3           0.0761348    0.04166     1.83  0.0773   0.0973

sigma               0.0337511  RSS              0.0353133417
R^2                   0.69367  F(21,31) =    3.343 [0.001]**
Adj.R^2              0.486155  log-likelihood        118.612
no. of observations        53  no. of parameters          22
mean(Y)           -0.00131085  se(Y)               0.0470839
When the log-likelihood constant is NOT included:
AIC                  -6.48360  SC                   -5.66574
HQ                   -6.16909  FPE                0.00161199
When the log-likelihood constant is included:
AIC                  -3.64572  SC                   -2.82786
HQ                   -3.33121  FPE                 0.0275319

AR 1-4 test:      F(4,27)   =   1.0865 [0.3829]
ARCH 1-4 test:    F(4,45)   =  0.41530 [0.7967]
Normality test:   Chi^2(2)  =  0.83574 [0.6584]
Hetero test:      F(37,14)  =  0.97128 [0.5526]
RESET23 test:     F(2,29)   =  0.73613 [0.4877]
```

Parameter non-constancy test results

The graph below reports one-step, forecast and breakpoint Chow tests. The blue line represents the normalised 5% critical value and the red line the Chow test statistics. In all cases the graphs suggest a structural break in 1995/1996:



Appendix B

Unrestricted model (2000Q4-2009Q4)

```
EQ(83) Modelling dRealBitPPI by OLS
       The dataset is: C:\Users\Willem H\Documents\Akademie\Navorsing\Navorsing
2013\New papers\Bitumen pricing\Data\Temporal data\new07.in7
       The estimation sample is: 2000(4) - 2009(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
dRealBitPPI_1        0.400302     0.2838     1.41  0.1775   0.1106
dRealBitPPI_2       0.0854162     0.2343    0.365  0.7202   0.0082
dRealBitPPI_3        0.199077     0.1983     1.00  0.3304   0.0593
dRealBitPPI_4      0.00334981     0.2226   0.0150  0.9882   0.0000
Constant             -2.19211      1.096    -2.00  0.0628   0.1999
drealcrude          0.0225236    0.06635    0.339  0.7387   0.0072
drealcrude_1       -0.0183150    0.09555   -0.192  0.8504   0.0023
drealcrude_2       -0.0371116    0.08398   -0.442  0.6645   0.0121
drealcrude_3        -0.183447    0.08319    -2.21  0.0424   0.2331
drealcrude_4       -0.0171660    0.07827   -0.219  0.8292   0.0030
dconstrGDP          0.0246093     0.5819   0.0423  0.9668   0.0001
dconstrGDP_1        -0.375517     0.5945   -0.632  0.5365   0.0243
dconstrGDP_2        -0.651256     0.5809    -1.12  0.2788   0.0728
dconstrGDP_3         0.909970     0.6276     1.45  0.1664   0.1161
dconstrGDP_4        0.0589556     0.6888   0.0856  0.9329   0.0005
Seasonal           -0.0168629    0.02178   -0.774  0.4501   0.0361
Seasonal_1          0.0163580    0.02190    0.747  0.4659   0.0337
Seasonal_2         -0.0320731    0.02448    -1.31  0.2087   0.0969
constrGDP_1          0.441498     0.2111     2.09  0.0528   0.2147
RealBitPPI_1        -0.758732     0.2901    -2.62  0.0187   0.2995
realcrude_1          0.225966    0.08140     2.78  0.0135   0.3251

sigma               0.0297349  RSS               0.014146612
R^2                  0.830379  F(20,16) =    3.916 [0.004]**
Adj.R^2              0.618352  log-likelihood        93.0794
no. of observations        37  no. of parameters          21
mean(Y)             0.0159606  se(Y)               0.0481321
When the log-likelihood constant is NOT included:
AIC                  -6.73406  SC                   -5.81976
HQ                   -6.41173  FPE                0.00138599
When the log-likelihood constant is included:
AIC                  -3.89619  SC                   -2.98188
HQ                   -3.57385  FPE                 0.0236719

AR 1-3 test:      F(3,13)   =   1.7621 [0.2039]
ARCH 1-3 test:    F(3,31)   =  0.59373 [0.6238]
Normality test:   Chi^2(2)  =   2.2478 [0.3250]
Hetero test: not enough observations
RESET23 test:     F(2,14)   =  0.53334 [0.5981]
```

Restricted final model

The addition of a dummy variable for 2007q1 in the unrestricted model (to deal with structural break suggested by Chow tests) does not alter the final model.

```
EQ(85) Modelling dRealBitPPI by OLS
       The dataset is: C:\Users\Willem H\Documents\Akademie\Navorsing\Navorsing
2013\New papers\Bitumen pricing\Data\Temporal data\new07.in7
       The estimation sample is: 2000(4) - 2009(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
dRealBitPPI_1        0.247312     0.1122     2.20  0.0357   0.1434
Constant             -1.74280     0.4543    -3.84  0.0006   0.3367
drealcrude_3        -0.127013    0.04019    -3.16  0.0037   0.2562
dconstrGDP_3         0.947084     0.4296     2.20  0.0356   0.1435
Seasonal_1          0.0314721    0.01170     2.69  0.0117   0.1997
constrGDP_1          0.348278    0.08145     4.28  0.0002   0.3867
RealBitPPI_1        -0.627702     0.1023    -6.14  0.0000   0.5649
realcrude_1          0.201371    0.03460     5.82  0.0000   0.5388

sigma               0.0255606  RSS              0.0189470316
R^2                  0.772821  F(7,29) =     14.09 [0.000]**
Adj.R^2              0.717984  log-likelihood        87.6743
no. of observations        37  no. of parameters           8
mean(Y)             0.0159606  se(Y)               0.0481321
When the log-likelihood constant is NOT included:
AIC                  -7.14459  SC                   -6.79629
HQ                   -7.02180  FPE               0.000794610
When the log-likelihood constant is included:
AIC                  -4.30672  SC                   -3.95841
HQ                   -4.18392  FPE                 0.0135715

AR 1-3 test:      F(3,26)   =  0.27662 [0.8417]
ARCH 1-3 test:    F(3,31)   =  0.58051 [0.6322]
Normality test:   Chi^2(2)  =   2.9171 [0.2326]
Hetero test:      F(13,23)  =  0.32267 [0.9808]
Hetero-X test: not enough observations
RESET23 test:     F(2,27)   =   1.2124 [0.3132]


Test for excluding:
[0] = constrGDP_1
[1] = RealBitPPI_1
[2] = realcrude_1
Subset F(3,29)   =   16.069 [0.0000]**
```

Unrestricted model (2000Q4-2007Q4)

```
GUM(99) Modelling dRealBitPPI by OLS
        The dataset is: C:\Users\Willem H\Documents\Akademie\Navorsing\Navorsing
2013\New papers\Bitumen pricing\Data\Temporal data\new07.in7
        The estimation sample is: 2000(4) - 2007(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
dRealBitPPI_1         1.05455     0.2717     3.88  0.0082   0.7152
dRealBitPPI_2        0.995203     0.2161     4.60  0.0037   0.7794
dRealBitPPI_3         1.01534     0.2843     3.57  0.0118   0.6800
dRealBitPPI_4        0.814350     0.2871     2.84  0.0297   0.5728
Constant             -4.38651      1.592    -2.76  0.0331   0.5586
drealcrude           0.105552    0.08491     1.24  0.2602   0.2048
drealcrude_1        -0.242552    0.09556    -2.54  0.0442   0.5178
drealcrude_2       -0.0905694    0.06970    -1.30  0.2415   0.2196
drealcrude_3        -0.339479     0.1140    -2.98  0.0247   0.5965
drealcrude_4        -0.202225    0.08697    -2.33  0.0590   0.4740
dconstrGDP           -3.66723      1.502    -2.44  0.0504   0.4982
dconstrGDP_1          2.45430     0.9366     2.62  0.0396   0.5337
dconstrGDP_2         -1.85337     0.8252    -2.25  0.0658   0.4567
dconstrGDP_3         0.638510      1.376    0.464  0.6590   0.0347
dconstrGDP_4         -1.50956      1.505    -1.00  0.3546   0.1436
Seasonal           -0.0765549    0.03046    -2.51  0.0457   0.5129
Seasonal_1         0.00104568    0.02226   0.0470  0.9641   0.0004
Seasonal_2         -0.0503334    0.03305    -1.52  0.1787   0.2787
constrGDP_1           1.08205     0.2954     3.66  0.0105   0.6910
RealBitPPI_1         -1.76616     0.3757    -4.70  0.0033   0.7864
realcrude_1          0.293364    0.07285     4.03  0.0069   0.7299
dum2007q1            0.251811    0.07484     3.36  0.0151   0.6536
dum2007q4            0.131098    0.05664     2.31  0.0599   0.4717

sigma               0.0166561  RSS             0.00166455902
R^2                   0.95401  F(22,6) =      5.657 [0.020]*
Adj.R^2              0.785379  log-likelihood         100.45
no. of observations        29  no. of parameters          23
mean(Y)             0.0176211  se(Y)               0.0359533
When the log-likelihood constant is NOT included:
AIC                  -8.17928  SC                   -7.09488
HQ                   -7.83966  FPE               0.000497454
When the log-likelihood constant is included:
AIC                  -5.34141  SC                   -4.25700
HQ                   -5.00178  FPE                0.00849626

AR 1-1 test:      F(1,5)    =0.00010323 [0.9923]
ARCH 1-1 test:    F(1,27)   =   1.2455 [0.2743]
Normality test:   Chi^2(2)  =  0.87491 [0.6457]
Hetero test: not enough observations
Chow test: not enough observations
```

Restricted final model (2000Q4-2007Q4)

```
EQ(100) Modelling dRealBitPPI by OLS
        The dataset is: C:\Users\Willem H\Documents\Akademie\Navorsing\Navorsing
2013\New papers\Bitumen pricing\Data\Temporal data\new07.in7
        The estimation sample is: 2000(4) - 2007(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
Constant             -1.99631     0.4258    -4.69  0.0001   0.4679
constrGDP_1          0.384911    0.08385     4.59  0.0001   0.4574
RealBitPPI_1        -0.604686     0.1236    -4.89  0.0000   0.4891
realcrude_1          0.162297    0.03806     4.26  0.0003   0.4211

sigma               0.0247343  RSS              0.0152946527
R^2                  0.577424  F(3,25) =     11.39 [0.000]**
Adj.R^2              0.526715  log-likelihood        68.2902
no. of observations        29  no. of parameters           4
mean(Y)             0.0176211  se(Y)               0.0359533
When the log-likelihood constant is NOT included:
AIC                  -7.27169  SC                   -7.08309
HQ                   -7.21262  FPE               0.000696170
When the log-likelihood constant is included:
AIC                  -4.43381  SC                   -4.24522
HQ                   -4.37474  FPE                 0.0118902

AR 1-3 test:      F(3,22)   =  0.70320 [0.5602]
ARCH 1-3 test:    F(3,23)   =  0.57264 [0.6387]
Normality test:   Chi^2(2)  =   4.4251 [0.1094]
Hetero test:      F(6,22)   =  0.86030 [0.5388]
Hetero-X test:    F(9,19)   =   1.3740 [0.2666]
RESET23 test:     F(2,23)   =   2.5394 [0.1008]
```

Unrestricted model (2000Q4-2007Q4) (using bitumen volumes)

```
EQ(17) Modelling dRealBitPPI by OLS
       The dataset is: C:\Users\Willem H\Documents\Akademie\Navorsing\Navorsing
2013\New papers\Bitumen pricing\Data\Temporal data\new07.in7
       The estimation sample is: 2000(4) - 2007(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
dRealBitPPI_1       0.0334929     0.2483    0.135  0.8960   0.0023
dRealBitPPI_2        0.400593     0.2467     1.62  0.1431   0.2478
dRealBitPPI_3        0.272222     0.2037     1.34  0.2181   0.1825
dRealBitPPI_4        0.194790     0.3185    0.612  0.5578   0.0447
Constant            -0.166059     0.1843   -0.901  0.3939   0.0921
drealcrude           0.127286    0.07674     1.66  0.1358   0.2559
drealcrude_1        0.0323759    0.07838    0.413  0.6904   0.0209
drealcrude_2        0.0574818    0.06780    0.848  0.4212   0.0824
drealcrude_3       -0.0425036    0.08629   -0.493  0.6356   0.0294
drealcrude_4       -0.0688275    0.08312   -0.828  0.4317   0.0789
Seasonal           -0.0463165    0.02230    -2.08  0.0714   0.3504
Seasonal_1         -0.0303877    0.02582    -1.18  0.2730   0.1476
Seasonal_2         -0.0318337    0.02261    -1.41  0.1969   0.1985
RealBitPPI_1        -0.429490     0.1828    -2.35  0.0467   0.4082
realcrude_1          0.108449    0.06816     1.59  0.1503   0.2404
bitvolSAPIA_1        0.388354     0.1499     2.59  0.0321   0.4563
dbitvolSAPIA        0.0871580    0.07118     1.22  0.2556   0.1578
dbitvolSAPIA_1      -0.160763     0.1258    -1.28  0.2372   0.1695
dbitvolSAPIA_2     -0.0315180     0.1194   -0.264  0.7985   0.0086
dbitvolSAPIA_3       0.209189     0.1270     1.65  0.1382   0.2532
dbitvolSAPIA_4       0.148946    0.09367     1.59  0.1505   0.2402

sigma               0.0226723  RSS             0.00411228361
R^2                  0.886382  F(20,8) =       3.121 [0.051]
Adj.R^2              0.602336  log-likelihood        87.3363
no. of observations        29  no. of parameters          21
mean(Y)             0.0176211  se(Y)               0.0359533
When the log-likelihood constant is NOT included:
AIC                  -7.41280  SC                   -6.42269
HQ                   -7.10271  FPE               0.000886268
When the log-likelihood constant is included:
AIC                  -4.57492  SC                   -3.58481
HQ                   -4.26483  FPE                 0.0151370

AR 1-1 test:      F(1,7)    = 0.037027 [0.8529]
ARCH 1-1 test:    F(1,27)   = 0.041809 [0.8395]
Normality test:   Chi^2(2)  =   2.0996 [0.3500]
Hetero test: not enough observations
RESET23 test:     F(2,6)    =   4.9853 [0.0530]
```

Restricted final model (2000Q4-2007Q4) (using bitumen volumes)

```
EQ(16) Modelling dRealBitPPI by OLS
       The dataset is: C:\Users\Willem H\Documents\Akademie\Navorsing\Navorsing
2013\New papers\Bitumen pricing\Data\Temporal data\new07.in7
       The estimation sample is: 2000(4) - 2007(4)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
Constant            -0.349405     0.1575    -2.22  0.0367   0.1763
RealBitPPI_1        -0.422228    0.09519    -4.44  0.0002   0.4610
realcrude_1          0.188503    0.04022     4.69  0.0001   0.4885
bitvolSAPIA_1        0.321913    0.08060     3.99  0.0006   0.4095
dbitvolSAPIA_1      -0.272338    0.06603    -4.12  0.0004   0.4251
dbitvolSAPIA_2      -0.182980    0.04738    -3.86  0.0008   0.3934

sigma               0.0249289  RSS              0.0142933272
R^2                  0.605089  F(5,23) =     7.048 [0.000]**
Adj.R^2              0.519239  log-likelihood         69.272
no. of observations        29  no. of parameters           6
mean(Y)             0.0176211  se(Y)               0.0359533
When the log-likelihood constant is NOT included:
AIC                  -7.20147  SC                   -6.91858
HQ                   -7.11287  FPE               0.000750025
When the log-likelihood constant is included:
AIC                  -4.36359  SC                   -4.08070
HQ                   -4.27499  FPE                 0.0128100

AR 1-3 test:      F(3,20)   =   1.7892 [0.1817]
ARCH 1-3 test:    F(3,23)   =  0.76125 [0.5273]
Normality test:   Chi^2(2)  =   4.0237 [0.1337]
Hetero test:      F(10,18)  =  0.57668 [0.8121]
Hetero-X test: not enough observations
RESET23 test:     F(2,21)   =   5.8826 [0.0094]**
```

Appendix C

Figure C1. Predicted bitumen price, with 95% confidence interval, for the period of alleged collusion using import price panel models (non-OECD sample, GMM estimation)

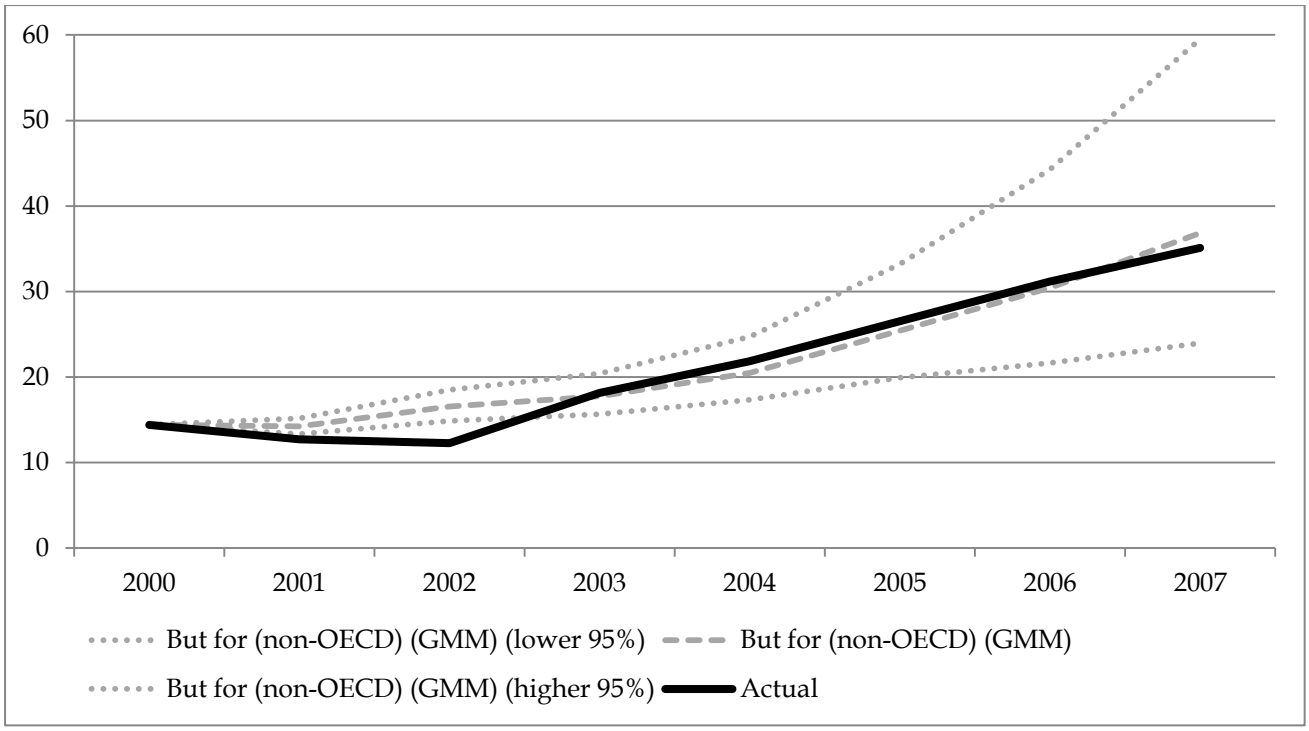
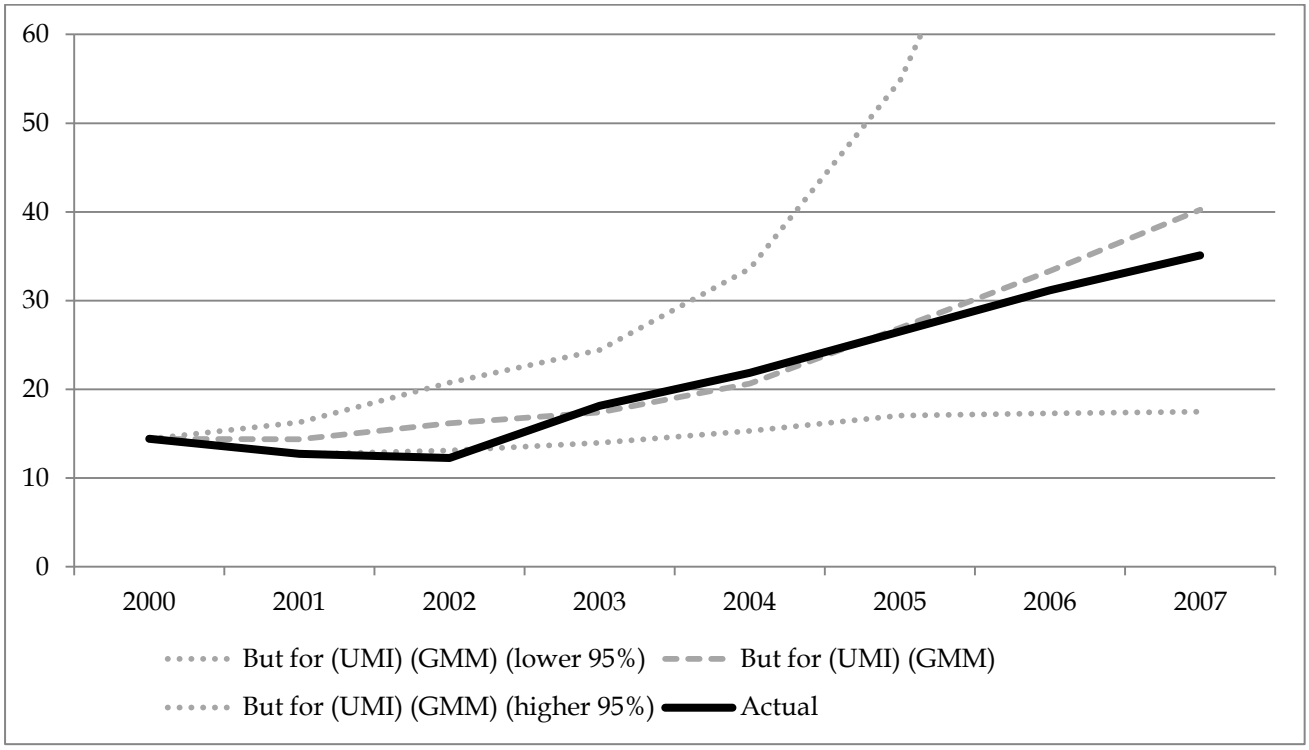


Figure C2. Predicted bitumen price, with 95% confidence interval, for the period of alleged collusion using import price panel models (UMI sample, GMM estimation)



Appendix D

Table D1. Difference-in-difference estimates of the impact of Spanish and Dutch collusion on import prices.

Variables	Full panel
$\boldsymbol{\beta_{2,Spain,2000-2002}}$	-5.76
	(7.83)
$\boldsymbol{\beta_{4,Spain,2000-2002}}$	0.95
	(1.29)
$\boldsymbol{\beta_{2,Netherlands,2000-2002}}$	12.79
	(10.82)
$\boldsymbol{\beta_{4,Netherlands,2000-2002}}$	-2.19
	(1.85)