QSMII Assignment 3 Teammates: Adnan Arif, Bendeguz Istvan Biksi
Prof. Frank Verboven Due Date: 19/02/16

Question 1

A cartel means that firms in a homogeneous product market collude and act monopolistically to maximise joint profits. Specifically, it will be assumed that firms agree on a collusive price with their competitors. Collusion ceases as soon as one firm's price appears to fall below the collusive price, causing fierce competitive behaviour by all firms as a punishment mechanism. Firms will either continue fierce competitive conduct for the infinite future or resume collusive conduct after an indefinite period of competition. Using this model of cartel behaviour, econometric techniques can be used to investigate whether patterns of behaviour are consistent with collusive conduct, and if so, the price overcharge caused by the cartel.

We consider the **start** of the cartel the year **1991** and the **end** as **November 2001**, when Readymix (the cartelbreaker cement producer) announced to start replacing deliveries of cement of other cartel members to its subsidiary concrete producers downstream with its own cement. In terms of econometric estimation, this will be notated by the use of dummy variable(s) that takes value 1 if the time period is a cartel period and 0 during competitive conduct.

Question 2

Figure 1: Cement price index evolution from 1991-2010 in Germany (2005=100)

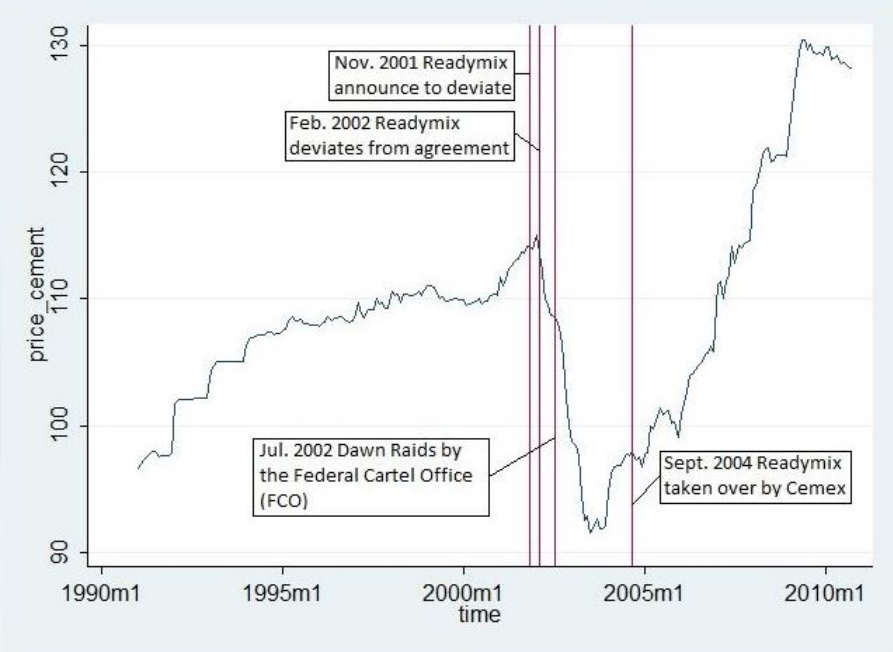

Figure 1 depicts fluctuations in the price index for the German cement industry from 1991 to 2010. The price index of cement is computed as $\frac{p_t}{p_b}$, where p_t is the current period nominal cement price and p_b is the nominal cement price in the base year (2005). The use of a price index takes into account the effect of inflation, and therefore enables the graph in figure 1 to represent changes in the real price of cement.

In figure 1 we identify the most relevant dates of the cartel as follows. In November 2001, the cartel broke down with the announcement of Readymix to replace third-party inputs with its own. In February

2002, the announcement made by Readymix came into effect. In July 2002, the national competition authority carried out dawn raids, to which firms reacted with sharp price decreases to reestablish market segmentation. Intense price competition continued until the acquisition of Readymix by Cemex in September 2004. We hypothesise that the change in the price index from 110 at the announcement of deviation by readymix in 2001, and the price index of 100 during price-war in 2004, indicates a 10% price overcharge by the cartel members. Fluctuations in the price-index can occur in the event of changes to the cost of inputs, demand shocks, or due to collusive agreements between competing firms. To identify the role a cartel in real price fluctuations and the subsequent overcharge entailed if detected, it is important to consider relevant input costs and demand factors.

Question 3

Figure 2: Input price indices and cement price index: 1990-2010 in Germany (2005=100)

Portland cement clinker, the most comment type of cement production around the world, is made from a raw material mix mainly consisting of limestone, chalk and clay (Kema, 2005). The raw material mix is heated up to a temperature of approximately 1450 C° in a rotary kiln until it starts sintering. This results in the raw materials forming new compounds and is known as the clinker phases (VDZ, 2008). Clinker manufacturing is an energy intensive activity, requiring substantial fuel inputs that can represent 65-75% of the variable costs for production (Endress Hauser). To determine the most relevant input costs of cement production, we compute correlations between the price index of cement and all available input price indices in Table 1. Based on the correlations, we select the three most correlated inputs—limestone, electricity and browncoal—as the most relevant input costs to consider in our analysis. Limestone represents the bulk of the raw materials used, while energy costs consist mainly of electricity and browncoal.

Table 1: Pairwise Correlations	Cement Price
Price-Limestone	0.559
Price-Heatingoil	0.3724
Price-Electricity	0.5914
Price-Browncoal	0.64
Price-Blackcoal	0.5109

Figure 2 illustrates the price evolution of the cement price index alongside the most relevant input price indices selected above. It is clear that from 1995 until 2002, the price of the key inputs dropped, although the cement price continued to rise. This fact is consistent with both a boom in demand in addition to collusive behaviour of cement producers.

Question 4

Similarly to Question 3, to determine the most relevant demand variables that may affect the cement price, we observe the correlations between Industry wide cement demand and all available measures of economic activity in Table 2. Based on the observed correlations, we select demand of concretparts and the value of construction demand as the most relevant variables. We cannot include all available demand variables in an analysis due to the potential for multicollinearity bias from specific variables. Multicollinearity may arise due to a high correlation between Demand-Readymix and Demand-Concreteparts of 0.9651, and an obvious strong correlation between Construction Demand-Quantity and Construction Demand-Value of 0.9864. Thus, we have selected only one variable from each of the potentially problematic pairs of demand variables.

Table 2: Pairwise Correlations	Cement Industry Demand
Demand-Readymix	0.9325
Demand-Concreteparts	0.9654
Construction Demand-Quantity	0.7523
Construction Demand-Value	0.7648
Cement Plants	0.3332

Question 5

X_t is a vector of demand shifters, W_t is a vector of supply/cost shifters, $Q_{D,t}$ is the demanded quantity, $D_{1,t}$ is a cartel dummy, that takes value 1, if there was a cartel from 1991 to 1997 and 0 otherwise, $D_{2,t}$ is a cartel dummy that takes value 1, if there was a cartel from 1998 to 2001 and 0 otherwise. $P_{i,t}$ for $i = C, N$ and $t = 1991, ..., 2010$ is the actual nominal cement price, while P_B is the base year's nominal cement price. Our log-log specification of the cement price index is the following[1]

$$logCPI_{i,t} = \alpha + \beta * logX_t + \gamma * logW_t + \eta * logQ_{D,t} + \delta_1 * D_{1,t} + \delta_2 * D_{2,t} + \epsilon_t \tag{5.1}$$

for $i = C, N$ and $t = 1991, ..., 2010$ (for the rest, let us drop the t subscript).

Due to endogeneity, namely $cov(Q_{D,t}, \epsilon_t) \neq 0$, we use instrumental variable approach i.e. 2sls. Endogeneity is an issue since the demanded cement quantity is correlated with omitted variables, that are captured by the error term such as consumers' willingness to pay or technological progress of the producers of cement. We select instrumental variables that affect the demanded quantity of cement but not the omitted variables captured by ϵ_t. Our instruments are various measures of economic activity such as, the value of construction and production of concrete building parts. These variables affect the demanded cement quantity, but it is unlikely that they affect the omitted variables. The cost shifters are the following variables: price index of the key inputs, such as limestone, Electricity and browncoal. As a cost shifter we also include the wage per employee in the cement industry. We also include a time trend in the above equation.

[1]The lin-lin model contains precisely the same variables (except taking the logarithm of the variables it, uses levels).

Question 6

$CPI_C = \frac{P_C}{P_B}$ is the cement price index for cartel periods (C) (i.e. either $D_1 = 1$ or $D_2 = 1$), while $CPI_N = \frac{P_N}{P_B}$ is the cement price index in non-cartel periods (N) (i.e. when $D_1 = D_2 = 0$).

The coefficient of the cartel dummy (δ_j) in the lin-lin scenario refers to the percentage change in the nominal cement price in terms of the base year. In the log-log case $e^{\delta_j} - 1$ refers to the percentage change from a non-cartelized to a cartelized nominal cement price.

With the lin-lin specification:

$$CPI_i = \alpha + \beta * X + \gamma * W + \eta * Q_D + \delta_1 * D_1 + \delta_2 * D_2 + \epsilon \qquad \text{for } i = C, N$$

$$CPI_C - CPI_N = A = \delta_j = \frac{P_C - P_N}{P_B} \qquad \text{for } j = 1, 2$$

With the log-log specification:

$$logCPI_C = \alpha + \beta * logX + \gamma * logW + \eta * logQ_D + \delta_j + \epsilon \qquad \text{for } j = 1, 2$$

$$logCPI_N = \alpha + \beta * logX + \gamma * logW + \eta * logQ_D + \epsilon$$

$$CPI_C = e^{\alpha} * e^{\epsilon} * e^{\delta_j} * X^{\beta} * W^{\gamma} * Q_D^{\eta} \quad \text{for } j = 1, 2 \qquad CPI_N = e^{\alpha} * e^{\epsilon} * X^{\beta} * W^{\gamma} * Q_D^{\eta}$$

$$\frac{CPI_C}{CPI_N} = e^{\delta_j} \quad \text{for } j = 1, 2 \qquad CPI_C - CPI_N = A \qquad \frac{CPI_C}{CPI_N} - 1 = \frac{A}{CPI_N}$$

$$\frac{CPI_C - CPI_N}{CPI_N} = e^{\delta_j} - 1 \qquad \frac{\frac{P_C}{P_B} - \frac{P_N}{P_B}}{\frac{P_N}{P_B}} = e^{\delta_j} - 1 \qquad \frac{P_C - P_N}{P_N} = e^{\delta_j} - 1 \quad \text{for } j = 1, 2 \text{ respectively.}$$

Question 7

Table 3: Estimated coefficients	Lin-Lin	Log-Log
Limestone	1.50 (0.17)	1.34 (0.16)
Electricity	0.11 (0.06)	0.09 (0.06)
Browncoal	0.76 (0.16)	0.76 (0.16)
Wage/employee	0.03 (0.77)	-0.004 (0.03)

In Table 3 we report (the regression tables are in the appendix) the estimated coefficients (and the standard errors of the coefficients) of the 2sls approach for both specifications. The estimated coefficients have reasonable signs in terms of economic common sense. The meaning of a positive input price coefficient is that, if the price of the input increases, cement (the output) price rises as well. From the control input price variables, limestone has the most highest and significant impact on cement prices, while the wage/employee variable has an insignificant coefficint. Although electricity is a key input of cement production it has a significant positive sign in the linear scenario. The most important parameters are the coefficients of the cartel dummies.

Table 4: Estimated price overcharge (%)	Lin-Lin (δ_j)	Log-Log ($e^{\delta_j} - 1$)
Cartel: 1991-1997	11.94	12.40
Cartel: 1998-2001	17.69	18.38

Table 4 reports the estimated price overcharge between 11.95% and 18.38% over the entire duration of the cartel. Notice from the regression output, that all the cartel dummy variables are significant in 99% confidence interval.

Question 8

We account for the merger by adding a dummy variable M_t to our full model in equation 5.1, where M_t takes the value 0 prior to the Merger in September 2004 and 1 after the merger.

Table 5: Estimated price overcharge post-merger (%)	Lin-Lin (δ_j)	Log-Log ($e^{\delta_j} - 1$)
Cartel: 1991-1997	11,59	11,65
Cartel: 1998-2001	17,62	18,21

Table 5 reports the estimated price overcharge to be between $11,59\%$ and $18,21\%$, while both cartel dummy variables are still significant at a 99% confidence interval. We find that all price overcharge estimates are smaller when the merger is accounted for than when it is not accounted for. The intuition is that since the overcharge is calculated using the difference between "before and after cartel prices", the after cartel price will differ depending on whether the merger is accounted for. When the merger is (not) accounted for, the post-cartel price is higher (lower) and the estimated price overcharge is smaller (larger).

Question 9

We used the first lag (beside the current period) of the independent variables, namely the input price indices. We note that the coefficients of the cartel dummies change only slightly after adding the lag and that all lagged variables had insignificant coefficients at a 5% significance level regardless of the specification. We also attempted to use three lags of brown coal (because the third lag was significant), but the cartel dummy coefficients remained nearly the same.

Question 10

We calculate the mean of cement price during and after the cartel, with the aim of deriving the overcharge from the difference in the two mean values of cement price. We find that the mean of cement price during the cartel is 107.28 and after the cartel is 110.20. This is a nonsensical result caused by the rapid rise in prices as Cemex merged with Readymix. It implies that the price is lower during the well acknowledged cartel period than after this period. Due to the high variance of prices in the post-cartel period, it is not plausible to make statistically founded conclusions using a basic non-econometric model. A carefully considered "before and after" econometric model is warranted for an overcharge estimation of this particular nature.

Appendix

Here we report the output of the 2sls approach with the two specifications for question 7.

VARIABLES	Lin-Lin	Log-Log
prod_cement	0.0123	
	(0.0112)	
inpprice_limestone	1.502***	
	(0.166)	
inpprice_electricity	0.114*	
	(0.0631)	
inpprice_browncoal	0.761***	
	(0.163)	
wagecostperem	0.0279	
	(0.770)	
cartel91to97	11.94***	0.117***
	(2.668)	(0.0256)
cartel98to01	17.69***	0.169***
	(1.455)	(0.0137)
time	0.0122	0.000148
	(0.0273)	(0.000267)
logprod_cement		0.0112
		(0.00975)
loginpprice_limestone		1.341***
		(0.161)
loginpprice_electricity		0.0870
		(0.0592)
loginpprice_browncoal		0.757***
		(0.162)
logwagecostperem		-0.00358
		(0.0276)
Constant	-143.4***	-5.562***
	(12.71)	(0.827)
Observations	187	187
R-squared	0.782	0.754

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	Lin-Lin first lag	Log-Log first lag
prod_cement	0.0112	
	(0.0119)	
inpprice_limestone	1.289**	
	(0.524)	
inpprice_electricity	-0.0107	
	(0.255)	
inpprice_browncoal	0.286	
	(0.316)	
wagecostperem	-0.249	
	(0.773)	
L.inpprice_limestone	0.246	
	(0.526)	
L.inpprice_electricity	0.105	
	(0.253)	
L.inpprice_browncoal	0.561*	
	(0.309)	
L.wagecostperem	0.739	
	(0.770)	
cartel91to97	11.55***	0.114***
	(2.659)	(0.0255)
cartel98to01	17.61***	0.168***
	(1.463)	(0.0138)
time	0.00303	6.87e-05
	(0.0281)	(0.000276)
logprod_cement		0.00879
		(0.0104)
loginpprice_limestone		1.180**
		(0.516)
loginpprice_electricity		-0.0284
		(0.242)
loginpprice_browncoal		0.290
		(0.311)
logwagecostperem		-0.0125
		(0.0277)
L.loginpprice_limestone		0.184
		(0.519)
L.loginpprice_electricity		0.0994
		(0.240)
L.loginpprice_browncoal		0.546*
		(0.302)
L.logwagecostperem		0.0234
		(0.0273)
Constant	-149.9***	-5.922***
	(12.92)	(0.837)
Observations	186	186
R-squared	0.789	0.761

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1