COMPETITION 🛡 COMMISSION

AGGREGATES, CEMENT AND READY-MIX CONCRETE MARKET INVESTIGATION

Estimating the competitive price of cement from cost and demand data

Summary

1. The purpose of this working paper is to quantify some aspects of the detriment due to the AECs in cement. In paragraphs 8.271 to 8.273 of the provisional findings, we provided one estimate of this detriment by reference to our analysis of profitability of GB cement producers. In this working paper, we seek to estimate the detriment using another method, namely by comparing the average cement prices and the cement price that we would expect to observe under effective competition. We refer to this difference as the overcharge in cement. To do this, we aimed to establish a benchmark price that would prevail in a well-functioning market and compared that benchmark price to the actual price of cement. The difference between the benchmark price and the actual price allowed us to quantify some aspects of the detriment in cement.

2. To establish our benchmark price, we have derived a competitive supply curve of cement. The competitive supply curve is derived from producers' costs of supplying cement. In a well-functioning market, the interaction of competitive supply and demand would be expected to establish a market clearing, competitive, price of cement.

3. We find a benchmark price for 2011 of about £69.50 per tonne, around £10.50 less than the average price of a tonne of cement in 2011. Based on 8.78 million tonnes of cement sold in GB in 2011, an overcharge of £10.50 per tonne translates to a detriment of £92 million in 2011. We will consider the implications of these results for

our assessment of proportionality, in the light of any comments we receive, alongside other estimates of detriment as part of our provisional decision on remedies.

The approach

4. In this working paper our aim is to estimate the *overcharge* in cement, ie the difference between the average price of cement in GB cement markets and the price of cement under effective competition. We aimed to establish a benchmark price that would prevail in a well-functioning market, and compared that benchmark price to the actual price. The difference between the benchmark price and the actual price allowed us to quantify some aspects of the detriment in cement.

5. Coordination may have an impact on any dimension of competition, including price and output levels, the scope of firms' geographic operations, investment or innovation.[1] The overcharge measures only the impact on price due to coordination and thus may not capture the full detriment due to coordination. It does not take into account losses from any output reduction associated with higher prices.[2] Neither does it measure any longer-term or dynamic aspects of detriment, for example due to reduced investments in efficient production technology or reduced investments in research and development.

6. In our approach to estimating a benchmark price for cement we took existing cement works' capacities and costs as given. We used data on capacities and costs to derive a competitive short-run supply curve of cement. Between them, the supply curve and the demand for cement will pin down a market clearing price of cement. Since the supply curve was derived based on the assumption of cement suppliers acting

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[1] The CC's Guidelines for market investigations (CC3), paragraph 241.
[2] When the price is higher than in a well-functioning market, the most price-sensitive customers refrain from buying cement. Some of these customers may have bought more cement at the competitive price. These forgone sales represent a detriment which is not captured by estimates of the overcharge. The detriment due to forgone sales could in principle be estimated if the elasticity of demand for cement in GB were known. Due to the absence of reliable estimates of the elasticity of demand for cement in GB we have chosen not to estimate detriment due to forgone sales. However, the demand for cement is likely to be relatively inelastic, which means the detriment due to forgone sales will be limited.

competitively, the market clearing price gives a reasonable indication of what would constitute a competitive price of cement. The cement overcharge was the difference between the benchmark price and the actual price.

7. We used data on 2011 costs, capacities and demand to estimate a benchmark price and compared this with the 2011 weighted average price. Our reasons for using 2011 data were the following:

   (a) it is the most recent year for which detailed data on prices, costs and capacities are available to us; and

   (b) after several years of large changes in demand and supply conditions (2008 and 2009), demand and supply conditions stabilized in 2010 and 2011. Indeed, the demand for cement declined sharply between 2007 and 2009.[3] This resulted in GB cement producers closing or mothballing cement production capacity in 2008 to 2010.[4] In 2011, supply conditions appeared to be stable, and we also note that demand for cement stabilized in 2010 and 2011.

8. We therefore believe that estimating the detriment based on data on 2011 prices, costs and capacities is appropriate, though we will take into account more recent data on total volumes of cement sold in 2012 when this data is available.

9. We begin by describing the assumptions we made to derive a competitive supply curve and the data upon which we based our estimate of the supply curve. We then describe how we constructed a demand curve and an equilibrium to arrive at a competitive price.

Deriving a competitive supply curve

10. In order to derive a competitive supply curve we made the following assumptions:

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[3] See Figure 2.3 in Section 2 of the provisional findings.
[4] See Table 11 in Appendix 7.2 of the provisional findings.

(a) one-shot outcome, ie no scope for repeated interaction to influence behaviour;

(b) firms are price takers;

(c) one plant's production decision does not take into consideration its effect on other plants (ie plants act as if they were all operated by distinct firms, each firm caring only about its own profit); and

(d) firms do not engage in price discrimination.

11. Assumptions *(a)* to *(c)* capture the competitive nature of the market we use to establish our benchmark competitive price. Assumption *(d)* simplifies our analysis. However, we would expect the scope for price discrimination to be limited in a competitive market, as prices for all customers would tend towards the market clearing level.

12. The first assumption was made to rule out repeated interaction. If repeated interaction were considered, there may be scope for coordination. Such outcomes would not be informative about the competitive price.

13. Assuming firms to be price takers allowed us to identify a competitive outcome.[5] Given plants' fixed and variable costs, we determined whether or not a given plant would be active at a given price. Since we assumed that firms would not engage in price discrimination, there was only one price that had to be taken into consideration. This simplifying assumption enabled us to derive the amount of cement that would be supplied at a given price.

14. In addition to assumptions *(a)* to *(d)* above, we assumed for the purpose of exposition that there was no geographic differentiation between cement works. We

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[5] We do this using a *tâtonnement* process. A tâtonnement process is a process for finding a competitive price. A hypothetical auctioneer announces a price. Each producer states the quantity she would be willing to supply at that price, and each buyer announces the quantity she would be willing to buy at that price. If there is an imbalance between supply and demand, the price is not market clearing and the auctioneer announces a revised price. The process stops when supply and demand balance.

maintain that assumption for the purpose of explaining the basics of this approach. We then relaxed this assumption to allow for a specific type of geographic differentiation. We describe the approach we took to dealing with geographic differentiation in the subsection titled 'Dealing with geographic differentiation' in paragraphs 33 to 38.

15. In this analysis, we assume that, absent coordination, cement producers would behave as price takers and would thus not be able to act strategically or exercise unilateral market power. In reality, GB cement producers may have a degree of unilateral market power even in the absence of coordinated behaviour. If this were the case, the price that would prevail absent coordination may be higher than the price we estimate here.[6]

Individual plants' supply decisions

16. The assumptions *(a)* to *(d)* above are in themselves not sufficient to derive a supply curve for cement. In addition, it was necessary to assess whether or not each individual plant would be active at a given price, and the volume that active plants would supply at that price. According to assumption *(c)* above, each plant decides independently on whether or not to supply. We note that cement plants are capacity constrained, and took the view that they will supply when the price of cement exceeds an appropriate measure of the plant's costs. This subsection describes how we reasoned about individual plants' supply decisions. In particular, it sets out which costs we considered relevant in these decisions.

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[6] The assumptions that plants operate independently and that there is no geographic differentiation could also diminish the degree of unilateral market power exhibited by market participants in the model. Since the assumption that firms are price takers already rules unilateral market power out, the assumptions of independence and lack of differentiation are unlikely to make a difference. Only if the assumption of price-taking behaviour were relaxed would the assumptions of independence and lack of differentiation matter in terms of the degree of market power displayed in the model.

17.   For this analysis, we relied to a large extent on the same data as the analysis in Appendix 6.5 in the provisional findings. We therefore adopted the same terminology with respect to costs as in Appendix 6.4:

(a) Distribution costs are the distribution and haulage charges paid by customers for delivery of the goods from the seller's sites to the customers' job sites.[7] Distribution costs do not include the costs of transporting goods or raw materials between a seller's sites. The costs of transporting goods or raw material between a seller's sites are included in the variable cost, as described below.

(b) Variable costs are those costs that necessarily vary in line with small changes in production volumes (and to a lesser extent, sales volumes) during a normal production run at an active production site. A key assumption underpinning our definition of variable costs is that changes in production take place within existing production capacity limits, such that production could be increased without necessitating any further investment into plant or equipment. Our definition of variable costs thus excludes large step-changes in cost associated with increasing capacity or bringing mothballed capacity back on stream.

(c) Fixed costs are the converse of our definition of variable costs, ie costs that do not necessarily change in line with production or sales volumes. We subdivided fixed costs into the following subcategories:

(i) site fixed costs;

(ii) divisional fixed costs;

(iii) central costs; and

(iv) depreciation and amortization.

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[7] As far as possible, we have used charges paid by customers to cement producers as a proxy for the distribution cost. In the case of Hanson and Tarmac we used actual distribution costs, since these producers did not explicitly charge customers for haulage. We believe delivery charges are a reasonable measure of distribution costs since we do not believe haulage to be a profit centre. If cement producers are in fact making a positive margin on haulage, we would be over-estimating the distribution cost. This, in turn, would lead to an over-estimate of the competitive price and an under-estimate of the overcharge in cement.

18.   A price-taking firm's decision about whether to produce at a plant or not depends on the plant's costs and the prevailing cement price. In deciding whether to produce or not, an operator of an existing plant will not take sunk costs into consideration since these costs have by definition already been incurred or will be incurred regardless of whether the plant is used for production or not. We considered any central or divisional fixed costs as being sunk for the purpose of this analysis. If variable costs and site fixed costs are covered at the prevailing price, there will be a positive contribution to central or divisional costs. Foregoing this contribution would not be rational. We also considered depreciation and cost of capital as being sunk for the purpose of this analysis, since these costs would be incurred regardless of whether the plant were used for production or not.

19.   We defined a plant's operating costs to include the plant's site fixed cost, the plant's variable cost and the cost of distributing the plant's output (ie distribution cost). The operating cost thus excludes divisional and central fixed costs, depreciation and cost of capital. The operating cost excludes costs which are avoidable only in the long term and are therefore considered sunk. The operating costs are thus the relevant costs in deciding whether to use a plant or not in the short term.

20.   A plant's unit operating cost is operating cost divided by output. Unit operating cost obviously depends on a plant's output. Unless otherwise stated, our convention has been to calculate unit operating cost based on a plant's maximum output, ie when operating at full capacity. We employ this convention because the unit operating cost calculated based on a plant's maximum output is the lowest price at which it could at all be rational to have the plant in operation.

21.   If the market price of cement is too low to even cover a plant's operating costs (ie total site cost less depreciation and cost of capital, which are sunk), it will be rational

to close or mothball the plant. If the market price is sufficiently high for a plant to cover its operating costs, it will be rational to operate the plant. This will be the case even if the price is not high enough to cover the plant's sunk costs, since those costs would not decrease even if the plant were to be mothballed.

22. For the purpose of deriving a supply curve, we thus assumed that each plant would be prepared to supply up to its capacity as long as the price was sufficiently high to cover the plant's operating cost.[8,9]

Demand

23. For the purposes of this analysis, we took the demand for cement as given and equal to realized GB demand in 2011. This simplified the analysis somewhat and also reflected the fact that cement demand is likely to be relatively inelastic.[10] However, we recognized that this assumption could have implications for our conclusions: a more elastic demand curve will, in general, contribute to establishing a higher benchmark price. A higher benchmark price will in turn result in a lower estimate of detriment due to prices. On the other hand, a more elastic demand curve will mean that there is a larger detriment arising from higher prices due to lower volumes being sold as a result of these higher prices (see paragraph 5 above). Therefore, the effect of a more elastic demand on the overall estimate of detriment is not clear-cut: the direct price effect is likely to be less, but the effect due to lower volumes being sold will be higher.

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[8] Note that this is not equivalent to a plant always being active when the price is above the plant's unit operating cost (as calculated based on the plant's maximum output). It could be that the plant is not in a position to sell more than a fraction of the quantity the plant could produce, in which case the plant would be able to cover its operating cost only if the price were above unit operating cost as calculated based on the plant's maximum output.

[9] For a plant to be able to commit to not selling at any price which covers operating cost, it would need some degree of unilateral market power. This assumption is thus not independent, but rather a consequence of the assumption that firms are price takers.

[10] Cement is an intermediate good; it serves as an input to various construction projects, has very few substitutes and the cost of cement represents only a relatively small proportion of the final price of such projects. Therefore, the demand for cement is unlikely to respond much to changes in prices of cement.

24.   We maintained the assumption of given demand in our analysis, and chose to discuss the implications of this assumption when assessing our results. Our analysis of how the conclusions change when demand is more responsive to changes in price is in Appendix 4.

25.   Once we had constructed a demand curve, we calculated the market clearing prices. This is illustrated in Figure 1. The demand curve is shown as a vertical line in the figure, and the supply curve is pictured as a sequence of blocks denoted A–D. Each block corresponds to a production plant. The width of a block represents the corresponding plant's capacity and the height of a block represents the corresponding plant's unit operating cost. In the figure, it can be seen that the price would have to be above the unit operating cost of plant C in order for the market to clear. At any lower price, there would be too little cement to meet demand. It can also be seen that if the price were to exceed the unit operating cost of plant D, then plant D would have an incentive to produce and there would be excess supply.

FIGURE 1

A supply curve, a demand curve and the marginal plant

Price and costs (£)
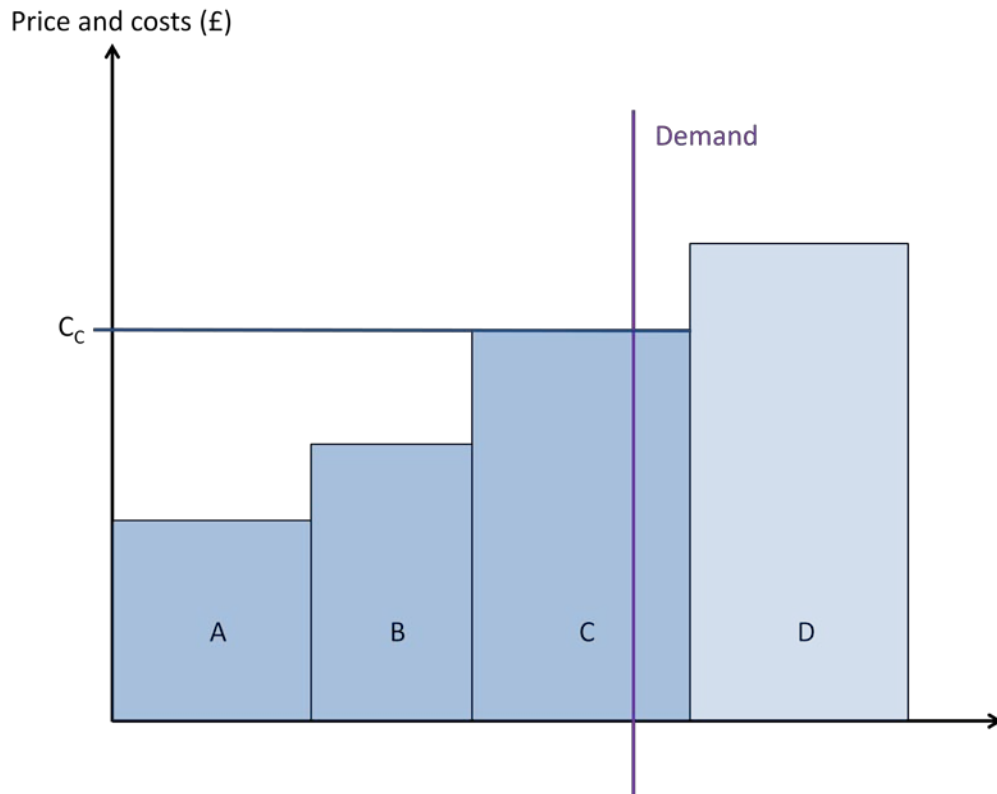
Source: CC.

26.　We refer to the least efficient plant that has to operate in order to fill demand as the marginal plant. In the figure, plant C is the marginal plant.

27.　Since cement producers' production capacities are limited, prices can rise above the marginal plant's unit operating cost due to customers competing for limited quantities. On the face of it, such situations appear to be non-competitive in the sense that firms are selling at prices above marginal or average incremental cost. This would seem at odds with price competition—usually one would expect there to be an incentive to gain additional business by under-cutting rivals' prices. However, this assumes that firms can expand output without incurring high incremental costs. If all plants are operating at full capacity, this is clearly not the case. Thus, no plant would have an incentive to expand its output and thereby depress the market price.

28.   This shows that the marginal plant's unit operating cost is only a lower bound on the market clearing price. If we identify the marginal plant for the GB cement market, we can use cost data for this plant to estimate a lower bound for the competitive price of cement.

29.   The set of prices that can be supported by a competitive outcome in a given market configuration is bounded from above by the cost of bringing additional capacity online.[11] In the figure, plant D represents idle capacity which would be brought online if the price were to rise sufficiently.

30.   Additional capacity can be brought online in many ways: de-mothballing of a mothballed plant, expanding the capacity of an existing plant (eg *debottlenecking*), or building a new plant. In addition to this, imported cement or imported clinker ground in GB could also act as a form of entry. Imported cement is different from other types of entry as an importers' capacity does not come in discrete increments to the same extent as domestic producer's capacity. Whether the upper bound is given by imports, de-mothballed capacity or new capacity depends on which the marginal plant is and which mothballed capacity exists.

31.   Since capacity comes in 'lumps' and we assumed that demand is given, it will in general not be possible to have an exact match between demand and supply. If demand is such that the marginal plant can only sell a small fraction of its potential output, it would not be economically rational to keep the plant operational unless the cement price is far above the plants unit operating cost.[12] If the marginal plant has to supply a volume close to its capacity in order to satisfy demand, we will use the

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[11] This is subject to the caveat in paragraph 22.
[12] There is also a more theoretical point related to existence of equilibrium. Unless we assume that plants get to serve customers according to efficiency, ie most efficient plant gets to sell all its output before the second most efficient plant gets to sell etc, it would be the case that all plants that can economically supply at a given price will want to produce at capacity. This would lead to supply and demand not balancing. An assumption that plants get to serve customers in order of efficiency might be unrealistic outside a very structured, auction-like setting. In a structured setting such behaviour might arise in equilibrium.

marginal plant's unit operating cost as an indicator of the lower bound on the competitive price.

32.   Cement imports may be used to fill any gaps between supply and demand if domestic supply is not well matched to domestic demand. Another alternative would be for GB suppliers to operate the marginal plant at or close to full capacity and export any excess cement. Given that GB producers' exports are very limited, the latter option seems less plausible. A third possibility is that all plants operate at slightly lower capacity and the price is slightly above the unit operating cost of the marginal plant.
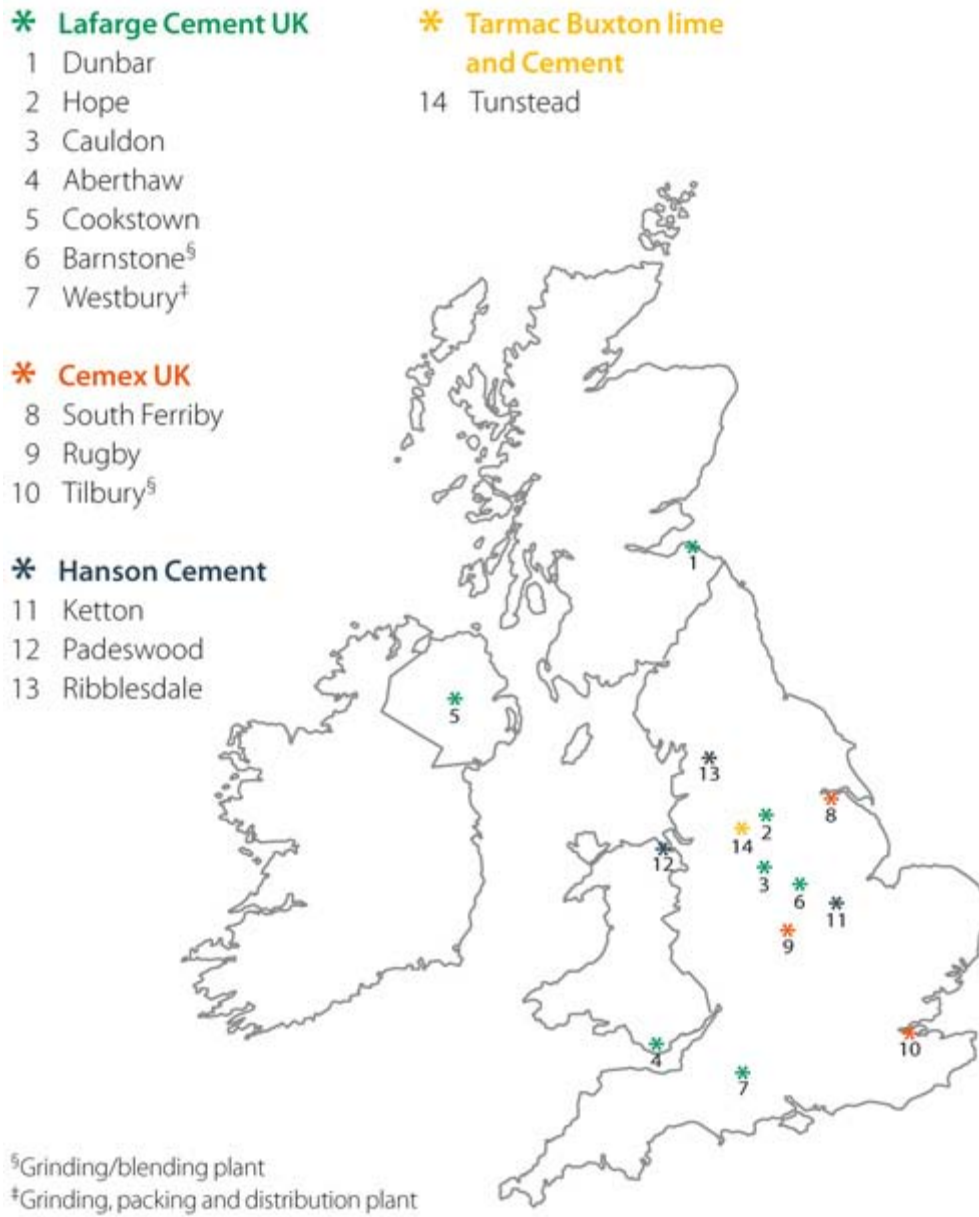
Dealing with geographic differentiation

33.   The cost of transporting cement represents a meaningful fraction of the price a customer pays for the product. We therefore considered how best to reflect differentiation between cement works in terms of geographic location and other aspects of logistical efficiency in identifying a benchmark price.

34.   Figure 2 shows that most cement plants are located in a fairly small geographic area, with Lafarge's Dunbar and Aberthaw being exceptions. The latter are located in southern Scotland and southern Wales, respectively. We have captured this geographic differentiation by assuming that these plants will sell in their local areas (Scotland and Wales),[13] and that any residual capacity at these plants can then be used to supply England. We have also estimated the cost of supplying cement into England from these plants.

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[13] Dunbar sold [✄] per cent of its output in Scotland in 2011. Aberthaw sold [✄] per cent of its output to Wales in 2011.

FIGURE 2

Map of the Majors' cement plants in the UK, 2012

＊ **Lafarge Cement UK**
1 Dunbar
2 Hope
3 Cauldon
4 Aberthaw
5 Cookstown
6 Barnstone§
7 Westbury‡

＊ **Cemex UK**
8 South Ferriby
9 Rugby
10 Tilbury§

＊ **Hanson Cement**
11 Ketton
12 Padeswood
13 Ribblesdale

＊ **Tarmac Buxton lime and Cement**
14 Tunstead

§Grinding/blending plant
‡Grinding, packing and distribution plant

Source: MPA website:
http://cement.mineralproducts.org/cement/manufacture/location_of_mpa_members_cement_plants.php.

35.   The reason for focusing on the price of supplying cement to England is that England

accounts for about 88 per cent of GB cement consumption. To assess detriment, we

compare our estimated benchmark price to a volume weighted average of the GB cement price.[14]

36.   Effectively, we allocated some capacity at each cement works to Scotland and Wales. This mainly affected the Aberthaw, Ribblesdale, South Ferriby and Dunbar cement works. Capacity which had not been allocated to Scotland and Wales could be used to supply England. We called the capacity which has not been allocated *effective capacity*. GB cement works capacities and effective capacities are found in Appendix 1 of this paper.

37.   We were concerned that the distribution cost would not properly reflect the costs faced by the Dunbar and Aberthaw works when serving customers in areas outside Scotland and Wales, respectively. For this reason we imputed revised distribution costs to these plants. Costs and imputed distribution costs are found in Appendix 2 of this paper.

38.   Figures relating to demand for cement and the residual demand (ie demand once certain quantities have been allocated to Scotland and Wales) are in Appendix 3 of this paper.

Results

39.   Table 1 shows unit operating cost and effective capacity to supply England of all GB cement works. The cement works have been ranked in ascending order according to unit operating cost, which means that the most efficient plant appears at the top of

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[14] Estimating the overcharge by subtracting the benchmark price for England from the GB-wide weighted average is an approximation. A more comprehensive approach would have been to estimate benchmark prices for England, Wales and Scotland, calculate the weighted average of these benchmark prices and then subtract the result from the actual GB-wide average. We have only estimated the price that would prevail in England in a well-functioning market. If the benchmark prices for Scotland and Wales were equal to the benchmark price for England, subtracting the benchmark price for England from the actual GB-wide weighted average does not introduce an error into the overcharge estimate. We note that the gain in precision from following the more comprehensive approach is limited. By way of example, if the benchmark price for England were £70 per tonne and the benchmark prices for Scotland and Wales were £77 per tonne, the error introduced by our approximation is less than £1 per tonne. This is due to the large weight given to England in the weighted average.

the table and least efficient plant appears at the bottom of the table. The table also shows cumulative capacity. For a given cement works, the cumulative capacity is calculated by summing the effective capacities of all plants which are at least as efficient as the cement works in question. Comparing the table to Figure 1, the cumulative capacity on the row of a given plant corresponds to the total capacity of the plant and of all plants to the left of the plant. Appendix 2 of this paper sets out how we arrived at unit operating costs and Appendix 1 sets out how we arrived at effective capacities.

TABLE 1 **Unit operating costs and effective capacities to supply England of GB cement works**

tonnes/year

Plant	Unit operating cost	Effective capacity	Cumulative effective capacity
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]

Source: GB cement producers' profit and loss data, GB cement producers' replies to market questionnaire, CC calculations.

40.   We have defined the marginal plant as the least efficient plant that has to be active to fill demand. The marginal plant is thus found by comparing residual demand to cumulative effective capacity. We have used a residual demand of 7.7 million tonnes, see Appendix 3 of this paper. It follows from Table 1 that [Plant 1] is the marginal plant. [Plant 2] and all plants more efficient than [Plant 2] have an effective capacity of less than 7.7 million tonnes per year. This means these plants do not have sufficient effective capacity to fill residual demand and that the market clearing price must be above £63 per tonne. [Plant 1] and all plants more efficient than [Plant 1] have a cumulative effective capacity of just over 7.7 million tonnes per year, which is just sufficient to fill the residual demand of 7.7 million tonnes per year. This implies that the market clearing price must be at least £66.60 per tonne. If the price were to

rise above £69.50 per tonne, [Plant 3] would have an incentive to produce cement. This would create a situation where there is more supply than there is demand. A price above £69.50 per tonne would thus not be market clearing. It follows that the market clearing price is in the range of £66.60 per tonne to £69.50 per tonne, since the plants that will be supplying cement when the price is in this range have sufficient capacity to fill demand.

41.   The conclusions of our analysis could potentially change if the [✂] kiln at [Plant 4], [✂]. We therefore considered it likely that cement prices would have to increase significantly to make it rational for [✂] to [✂] kiln [✂].

42.   We noted in Appendix 1 that [Plant 5's] variable cost of serving areas outside [✂] may in fact be higher than indicated by Table 6. As [Plant 5's] unit operating cost is considerably below those of [Plant 1] and [Plant 3], [Plant 5's] variable cost could rise considerably before the outcome of our model is affected.

43.   We noted above that our assumption of given demand could affect our conclusions. Appendix 4 of this paper deals with this issue. The analysis in Appendix 4 shows that a scenario where [Plant 3] is active and the benchmark price is close to £69.50 per tonne is consistent with a reasonable degree of elasticity of demand. In a scenario where [Plant 1] is the marginal plant, demand for cement would have to be very inelastic for supply and demand to balance. We therefore considered this scenario less plausible.

44.   GB producers' average price of cement in GB was approximately £80 per tonne in 2011.[15] A benchmark price of £69.50 per tonne suggests that the overcharge was

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[15] Volume weighted average of GB cement producers' price of bulk cement sold to independent buyers in 2011, as found in Table 1 in Appendix 7.8.

around £10.50 per tonne in 2011. Based on 8.78 million tonnes of cement sold in GB in 2011, this translates to a detriment due to elevated prices of £92 million in 2011.[16]

45.   We also note that price of £69.50 per tonne represents the lowest price at which [Plant 3] would be operating. The plant would be prepared to supply at any price above £69.50 per tonne. If demand is sufficiently elastic, the competitive price would be above £69.50 per tonne. As we believe the demand for cement to be inelastic, we do not believe that the competitive price is materially above £69.50 per tonne.

The role of EU ETS

46.   Trading of CO_2 allowances could change producers' incentives to supply cement. If the ability to trade CO_2 allowances gives some plants an incentive to reduce output in order to sell excess CO_2 allowances on the open market, this could affect the price that would prevail in a well-functioning market.

47.   Since we are comparing the 2011 outcome to a 2011 benchmark, we consider EU ETS Phase II as the relevant framework for assessing the incentives introduced by emissions trading.[17] There was no partial cessation rule in EU ETS Phase II, and therefore we do not consider it likely that any plant could have an incentive to expand production due to emissions trading incentives. For this reason, we have restricted our attention to incentives to reduce output arising from emissions trading.

48.   Under EU ETS Phase II, the closing of a plant would mean that the plant's allocation of allowances would usually be forfeited.[18] For this reason, we rule out the option of closing a plant (and thereby avoiding the entire operating cost) and selling all the

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[16] We assume here that the £69.50 benchmark price would also apply to Scotland and Wales.
[17] Please refer to Appendix 2.2 of the provisional findings for a description of the EU ETS emissions trading framework.
[18] Cases where the operator of a plant closed an inefficient plant were an exception. In such cases, the operator could transfer the closed plant's allowances to a more efficient plant.

plant's allowances. In order to be able to sell allowances, a plant would thus have to incur site fixed cost.

49.   A cement works is thus faced with a trade off between producing cement and selling allowances, and considers site fixed cost as unavoidable when making this choice. Using the variable and distribution costs in Table 6 and the revised distribution costs for Aberthaw and Dunbar, the margin between the cement price and variable and distribution costs is above £14.50 per tonne for all cement works at a cement price of £69.50 per tonne. The 2011 average price of allowances was about €14 per tonne of CO_2,[19] or about £13.50 at the 2011 exchange rate. This suggests that, given the competitive price of cement of £69.50 per tonne, it would always be more profitable for GB cement producers to produce cement than to sell allowances. The competitive price of cement would need to fall to about £68.50 per tonne in order for this not to be the case, and even if the price were to fall below this point the resulting output reduction would be very limited.[20] This bound is conservative, since one tonne of cement corresponds to less than one tonne of CO_2. The market price of cement could therefore drop further before incentives to sell allowances rather than cement arise. We therefore do not believe that EU ETS affects our estimate of the competitive price of cement.

Preliminary conclusions

50.   Based on the above, our preliminary conclusion is that [Plant 3] is likely to be the marginal plant and that the benchmark price derived from our model is about £69.50 per tonne. This corresponds to a 2011 overcharge of around £10.50 per tonne. Based on 8.78 million tonnes of cement sold in GB in 2011, an overcharge of £10.50 per tonne translates to a detriment of £92 million in 2011.

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[19] Provisional findings, Appendix 2.2, Figure 4.
[20] [✂]

Capacities and effective capacities

1.   In this appendix we describe the measures of capacity we have relied on in

        estimating the competitive price of cement. We also describe the effective capacities

        we calculated to capture geographic differentiation between cement works. The

        effective capacity measures a cement works' capacity to supply England.

Capacity of GB cement works

2.   Cement is ground clinker. This means there are two capacity constraints that matter

        in the production of cement: kiln capacity and grinding capacity. When ground, one

        tonne of clinker will produce approximately 1.1 tonnes of CEM I. We have used the

        lesser of 1.1 times a cement works' clinker capacity and its grinding capacity in our

        analysis.

3.   We use figures from Appendix 7.2 of the provisional findings for GB cement works'

        clinker capacity. These figures take kilns' planned and unplanned downtime into

        account and are thus below kilns' nameplate capacities.

4.   As set out in Appendix 7.2, Lafarge submitted clinker capacities for their cement

        works, as well as a measure called 'expected cement capacity'. They describe this as

        'a synthetic view of what cement is capable of being produced in the 'context' of the

        constraints for that year'.[21] To assess whether Lafarge's cement works' capacities

        were constrained by clinker capacity or grinding capacity, we divided expected

        cement capacity by clinker capacity. If the binding constraint on a cement works is its

        clinker capacity, the ratio between expected cement capacity and clinker capacity

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[21] Lafarge Tarmac told us that expected cement capacity was affected by factors outside of its control, including market demand, customer specifications, employment and weather, and that these might impact on the ability to produce at 'expected cement capacity'.

should be close to 1.1. If the cement works' output is constrained by some other factor, the ratio should be significantly below 1.1.

5.   The clinker capacity and expected cement capacity of Lafarge's cement works can be found in Table 2. This table also contains the ratio between expected cement capacity and clinker capacity for each cement works. The ratios suggest that Cauldon and Hope are constrained by their clinker capacities, while Aberthaw and Dunbar are constrained by other factors. This is consistent with Lafarge's statement that Aberthaw is 'grinding constrained'.

TABLE 2   **Lafarge's cement works clinker capacities and expected capacities**

Plant	Clinker capacity tonnes/year	Expected cement capacity tonnes/year	Expected/ clinker
Aberthaw	[✂]	[✂]	[✂]
Cauldon	[✂]	[✂]	[✂]
Dunbar	[✂]	[✂]	[✂]
Hope	[✂]	[✂]	[✂]

Source: Lafarge's response to the market questionnaire, CC calculations.

6.   For our analysis, we thus used expected cement capacity for Aberthaw and Dunbar as the measure of cement capacity. For Cauldon and Hope, we used 1.1 times clinker capacity as the measure of cement capacity. Data submitted by Cemex and Hanson suggest that their cement works are constrained by clinker capacity rather than grinding capacity.[22] For these cement works, we used 1.1 times clinker capacity as a measure of cement capacity. The capacities of GB cement works we used in our analysis can be found in Table 3. Note that with our definition of capacity, these capacities pertain to CEM I. We have not included mothballed capacity in cement works' capacities. The potential for mothballed capacity to alter our conclusions will, however, be considered in our analysis.

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[22] Cemex told us that its cement capacity far exceeded its clinker capacity because of Tilbury, a grinding and blending plant.

TABLE 3 **Capacities of GB cement plants**

Plant	Capacity tonnes/year
Rugby	[✂]
S Ferriby	[✂]
Ketton	[✂]
Padeswood	[✂]
Ribblesdale	[✂]
Aberthaw	[✂]
Cauldon	[✂]
Dunbar	[✂]
Hope	[✂]
Tunstead	[✂]

Source: GB cement producers' response to the market questionnaire, CC calculations.

Cement works' effective capacities to supply England

7.   In order to take into account the geographic differentiation between cement works, we calculated the effective capacity of each GB cement work to supply England. The effective capacity of a cement works is its remaining capacity once volumes supplied to Scotland and Wales have been subtracted and measures the cement works' capacity to supply England.

8.   To calculate a cement works' effective capacity, we subtracted from actual capacity the volume supplied to Scotland and Wales in 2011 by the works in question. Since we measured a cement works' capacity in terms of potential output of CEM I, we converted any non-CEM-I volumes to CEM I. We assumed that any non-CEM-I volume was 70 per cent CEM I, for example one tonne of CEM II was converted to 0.7 tonnes of CEM I. The resulting CEM-I-equivalent volumes supplied to Scotland and Wales by GB cement works are found in Table 4.

TABLE 4 **Volumes supplied to Scotland and Wales in 2011**

tonnes

Plant	Scotland	Wales
[%]	[%]	[%]
[%]	[%]	[%]
[%]		[%]
[%]	[%]	[%]
[%]	[%]	[%]
[%]	[%]	[%]
[%]	[%]	[%]
[%]	[%]	
[%]		[%]
[%]	[%]	

Source: GB cement producers' transaction data, CC calculations.

Note: Volumes have been converted to CEM I equivalent.

9.   Cemex's transaction data did not distinguish between works of manufacture. For this reason we assumed that any volumes sold by Cemex to customers in Scotland were manufactured at South Ferriby and any volumes sold by Cemex to customers in Wales were manufactured at Rugby. This assumption is motivated by the cement works' locations and the fact that neither cement works is rail linked.[23]

10.   Table 5 contains GB cement works' effective capacities. These effective capacities were obtained by subtracting volumes in Table 4 from the capacities in Table 3.

TABLE 5 **GB cement works' effective capacities**

Plant	Effective capacity tonnes/year
[%]	[%]
[%]	[%]
[%]	[%]
[%]	[%]
[%]	[%]
[%]	[%]
[%]	[%]
[%]	[%]
[%]	[%]
[%]	[%]

Source: GB cement producers' responses to market questionnaire, GB cement producers' transaction data, CC calculations.

[23] While Cemex's transaction data does not distinguish between works of manufacture, it does distinguish between shipping facilities. The data shows that volumes shipped from the Rugby works to Scotland in 2011 were very limited, which is broadly consistent with our assumption.

Costs and revised distribution costs

GB cement works' operating costs

1.   As stated in paragraph 19 above, plant's operating costs are the relevant costs in assessing whether or not the plant will be active at a given price. Operating costs include site fixed cost, plants' variable costs and plants' distribution costs, but excludes depreciation and cost of capital as well as divisional and central costs. Table 6 shows GB cement works' operating costs. These figures are based on the GB cement producers' profit and loss data.

TABLE 6   **Cement works' 2011 operating costs**

Plant	Site fixed cost £	Variable cost £/tonne	Distribution cost £/tonne
Rugby	[✂]	[✂]	[✂]
S Ferriby	[✂]	[✂]	[✂]
Ketton	[✂]	[✂]	[✂]
Padeswood	[✂]	[✂]	[✂]
Ribblesdale	[✂]	[✂]	[✂]
Aberthaw	[✂]	[✂]	[✂]
Cauldon	[✂]	[✂]	[✂]
Dunbar	[✂]	[✂]	[✂]
Hope	[✂]	[✂]	[✂]
Tunstead	[✂]	[✂]	[✂]

Source: GB cement producers' profit and loss data, CC calculations.

2.   The Cauldon, Rugby, Padeswood and South Ferriby plants are not rail linked. This potentially affects their distribution costs.

3.   Note that the operating costs in Table 6 pertain to a cement works' entire output. The costs also include the costs of those depots and blending depots that are part of the delivery networks of the cement plants. To the extent that a cement works produces CEM II or other blended products, the cost of producing that output is included in the operating costs. This introduces some imprecision in our analysis as we use the overall variable cost as one of the components of unit operating cost based on CEM I

capacity. We do not think that this approximation introduces any material difference as most output is CEM I.

Distribution costs

4.   Distribution costs are significant in relation to a cement work's variable costs. The distribution costs in Table 6 were not well adapted to capturing geographic differentiation and differentiation terms of logistic efficiency. We only observed cement works' distribution costs in aggregate. By dividing a given cement works' total distribution cost by its output we got a distribution cost per tonne. Since we did not control for the typical distance over which a cement works' output is transported, we could not arrive at a measure of distribution cost per tonne per mile. It appears plausible that a cement works primarily serves the customers it is best placed to serve, and that cement works with less efficient distribution supply over smaller distances than cement works with more efficient distribution. The observed distribution cost per tonne would reflect this, and thus not be particularly informative about a cement works' location and how efficient a cement works' distribution is.

5.   In particular, the observed distribution cost would not represent a good measure of the cost faced by a cement works when supplying customers farther afield. The cost of supplying distant customers is likely important when assessing how the Dunbar and Aberthaw works affect the competitive price in England. For this reason, we estimate in the next subsection the costs faced by these plants when supplying customers in England.

Revised distribution costs for Dunbar and Aberthaw

6.   Lafarge's transaction data contained an estimated haulage cost of shipments. Since the transaction data distinguishes between regions and identifies a shipments works of manufacture, the data can be used to estimate the cost of hauling cement from

works of manufacture to a given region. We have used 2011 transactions for our estimates.

7. Lafarge estimated haulage costs in its transaction data. To evaluate the reliability of these estimates, we compared the volume weighted 2011 average haulage cost per tonne to the average 2011 distribution cost per tonne as estimated from Lafarge's profit and loss data.

8. Table 7 contains Lafarge's cement works' haulage costs as estimated from transaction data and distribution costs as estimated from profit and loss data. Note that we excluded collected sales when we calculated haulage costs based on transactions data. We did so on account of collected sales not being informative of haulage cost.

FIGURE 3

Lafarge's cement works haulage and distribution costs

[✂]

Source: Lafarge transaction data, Lafarge profit and loss data, CC calculations.

TABLE 7 **Estimated haulage cost and distribution cost per cement works**

£/tonne

	Estimated cost based on	
Works	*Transaction data*	*Profit and loss data*
Aberthaw	[✂]	[✂]
Cauldon	[✂]	[✂]
Dunbar	[✂]	[✂]
Hope	[✂]	[✂]

Source: Lafarge transaction data, Lafarge profit and loss data, CC calculations.

Note: We excluded collected sales when calculating the haulage costs from transaction data.

9. Figure 3 shows that the average estimated haulage cost based on the transaction data is generally below the average distribution cost based on the profit and loss

data. For Aberthaw, there is a discrepancy of approximately £[✄] per tonne. In the case of Dunbar, there is a discrepancy of around £[✄] per tonne.

10.   Because of the discrepancy between haulage costs (as estimated from transaction data) and distribution cost (as estimated from profit and loss data), we have decided not to base our estimates of Aberthaw's and Dunbar's costs of supplying England on the transaction data haulage cost alone. We believe the profit and loss data to be more reliable as a measure of average distribution cost per tonne. The transaction data haulage costs appear to be approximated based on radial distances. Since cement will in practice not be transported in straight lines, this approximation will underestimate the cost of haulage. However, we believe that the transaction data can be informative about the relative costs of hauling cement to various regions. To reconcile these views we rescale the costs of hauling to England in an a manner that makes the average haulage cost equal to the average distribution cost, as estimated from the profit and loss data.

Dunbar

11.   Table 8 shows estimated haulage costs for the Dunbar works.

TABLE 8 **Volume weighted average 2011 haulage costs for destinations inside and outside Scotland**

Destination	Haulage cost £/tonne
Scotland	[✄]
Other	[✄]

Source: Lafarge transaction data.

Note: We excluded collected sales when calculating the haulage costs from transaction data.

12.   Since there is an economically significant difference in the cost of haulage depending on whether the destination is in Scotland or not, we believe there is a need to revise the distribution cost to reflect this.

13.   The distribution cost, as estimated from profit and loss data, is a weighted average of the cost of distributing cement to customers in Scotland and the cost of distributing cement to customers outside Scotland.[24] We assume that sales collected by customers do not incur delivery costs. Based on the figures in Table 8, we assume that the cost of distributing cement to customers outside Scotland is approximately 1.2 times the cost of distributing cement to customers in Scotland. These two restrictions identify the cost of distributing cement to customers in Scotland and the cost of distributing cement to customers outside Scotland.[25]

14.   Based on the Lafarge transaction data, we have calculated the volume delivered from Dunbar to destinations in Scotland in 2011, the volume delivered from Dunbar to destinations outside Scotland in 2011 and the volume collected at Dunbar by customers in 2011. The results are in Table 9. Based on these volumes, we calculated the weights we used in the first restriction described in the previous paragraph. The 2011 average distribution cost is £[✂] per tonne (see Table 1). Our estimate of the distribution cost for destinations outside Scotland is thus £[✂] per tonne.

TABLE 9 **Dunbar 2011 volumes according to destination**

	Volume tonnes
Collect	[✂]
Scotland	[✂]
Outside Scotland	[✂]
Total	[✂]

Source: Lafarge transaction data.

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[24] Let *c* be the distribution cost as estimated from profit and loss data. Then $c=(q^C c^C + q^S c^S + q^O c^O)/Q$, where c^C is the cost incurred when customer collects and c^S and c^O are the costs of distributing to Scotland and outside Scotland, respectively, q^C is the volume collected by customers, q^S is volume distributed to Scotland, q^O is volume distributed outside Scotland and $Q = q^C + q^S + q^O$. The costs c^S and c^O are unobserved, while q^S and q^O are observable in e.g. transaction data.
[25] We have assumed that $c^S = \gamma c^O$, with $\gamma = 1.25$ and that $q^C = 0$. From these restrictions and the restriction set out in the previous footnote, it follows that $c^S = c/(q^S/Q + \gamma q^O/Q)$.

Aberthaw

15. Table 10 shows estimated haulage costs for the Aberthaw works. These are higher for destinations outside Wales than for destinations in Wales. We believe that the differences could potentially be economically significant.[26]

TABLE 10 **Volume weighted average 2011 haulage costs for destinations inside and outside Wales**

Destintaion	Haulage cost £/tonne
Wales	[✂]
Other	[✂]

Source: Lafarge transaction data.

Note: We excluded collected sales when calculating the haulage costs from transaction data.

16. Since there is an economically significant difference in the cost of haulage depending on whether the destination is in Wales or not, we believe that there is a need to revise the distribution cost to reflect this fact. We adjusted the cost in the same way as we adjusted Dunbar's distribution cost. Based on the figures in Table 10, we assume that the cost of distributing cement to customers outside Wales is approximately 2.2 times the cost of distributing cement to customers in Wales.

17. Based on the Lafarge transaction data, we have calculated the volume delivered from Aberthaw to destinations in Wales in 2011, the volume delivered from Aberthaw to destinations outside Wales in 2011 and the volume collected at Aberthaw by customers in 2011. The results are in Table 11.

Table 11 **Aberthaw 2011 volumes according to destination**

	Volume tonnes
Collect	[✂]
Wales	[✂]
Outside Wales	[✂]
Total	[✂]

Source: Lafarge transaction data.

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[26] Lafarge Tarmac told us that transporting from Aberthaw involved payment of a toll when supplies were transported into England over the Severn Bridge.

18. Aberthaw's 2011 average distribution cost is £[✂] per tonne (see Table 6). Our estimate of the distribution cost for destinations outside Wales is thus £[✂] per tonne.

Demand and residual demand

1.   In this appendix, we set out our model of GB demand for cement. In order to capture the effect of cement works' locations, we calculate a residual demand. This is the demand that remains once GB cement works have filled the demand they face in Scotland and Wales. The appendix has two sections. In the first section, we describe GB demand. In the second section, we derive the residual demand.

GB cement demand

2.   CEM I is the appropriate product to consider in this case, since capacities as set out in Appendix 1 measure cement works' capacity to produce CEM I. CEM I is blended to produce other types of cement. Sales of cement other than CEM I thus indirectly contribute to demand for CEM I. We assumed that blended cement and bagged cement contained on average 70 per cent CEM I.[27]

3.   Table 12 contains demand for various types of cement in GB in 2011. Based on the figures in Table 12 and our assumption that blended cement and bagged cement contain on average 70 per cent CEM I, we estimated demand for CEM I in GB in 2011 at 8.78 million tonnes. We assumed that unclassified sales are CEM I, on the grounds that these are sales made by minor importers and our understanding that most imported cement is CEM I.

TABLE 12 **GB 2011 demand for cement**

tonnes

Bulk		Bagged	Unclassified
CEM I	Non-CEM-I		
6,187,410	1,412,413	1,712,545	409,039

Source: GB cement producers' and importers' transaction data, CC calculations.

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[27] This figure is consistent with MPA data on members' clinker production and GB cement producers' transaction data.

4.   Our estimate of demand for CEM I was not particularly sensitive to changes in the assumption about the proportion of CEM I in blended cement and bagged cement. Changing the proportion of CEM I by ten percentage points changed the estimated demand for CEM I by less than 4 per cent. This was a consequence of most GB cement sales being sales of CEM I.

5.   GB cement works' total active capacity in 2011 was just over 9.5 million tonnes of CEM I per year. The available capacity was thus sufficient to meet demand in 2011. GB cement works meeting GB demand would have required cement works operating at approximately 92 per cent of full capacity.

Residual cement demand

6.   We defined the residual demand as the demand that remains once GB cement works have filled the demand they face in Scotland and Wales. We calculated the demand faced in Scotland and Wales in 2011 from Table 4 in Appendix 1 by summing up the volumes supplied by each cement works in these regions. This gave us an estimated demand of 1.07 million tonnes, which we subtracted from the GB demand of 8.78 million tonnes to arrive at an estimated residual demand of 7.7 million tonnes.

Dealing with elastic demand

1.   In our analysis, we assumed that demand for cement was given, ie that customers would buy the same quantity of cement irrespective of price. While we believe demand for cement is likely to change only moderately in response to price changes,[28] we recognize that assuming that demand is given can affect the conclusions of our analysis. In this appendix, we evaluate the consequences of this assumption.

2.   In our analysis, we assumed that the GB demand for cement was equal to the quantity of cement sold in GB in 2011 and that customers would demand this quantity irrespective of price. Realized GB demand in 2011 is a point on the demand curve for cement. We believe the price in 2011 was elevated due to coordination between GB cement producers and the GGBS arrangements. If demand for cement is, in fact, somewhat elastic, then demand would be higher at any price below the 2011 price. In particular, demand would be higher at a market clearing price calculated based on a competitive supply curve and a given demand.

3.   If the demand curve is elastic, a competitive price estimated based on an assumption of given demand might thus fail to be a market clearing price. This failure results from demand potentially exceeding supply at such a price. Available capacity might simply not be sufficient to accommodate expanded demand due to the lower price. This is illustrated in Figure 4, where there would be excess demand at any price between the unit operating cost of the marginal plant if demand is given (Plant C) and the most efficient inactive plant (Plant D).

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[28] Cement is an intermediate good. It serves as an input and typically accounts for a limited fraction of the total cost of the final product. Cement price increases are thus likely to be passed on to customers of the final product.

FIGURE 4

Demand at decreased price depending on elasticity of demand
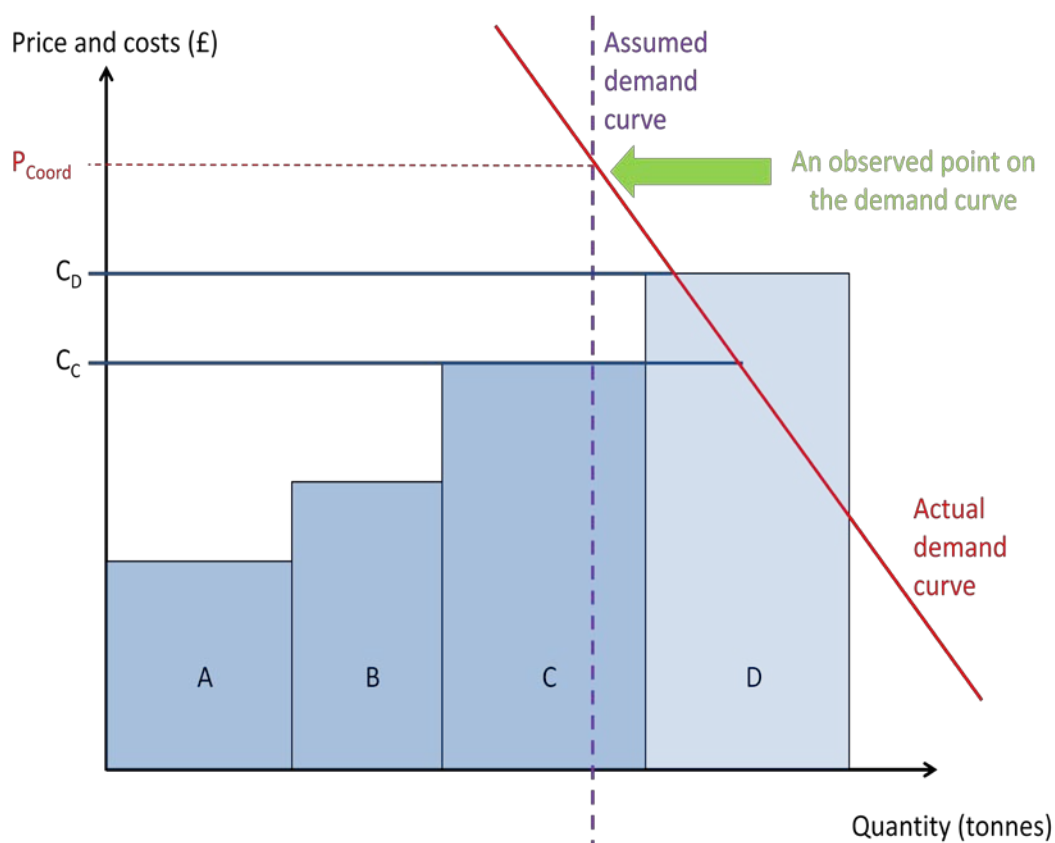
Source: CC.

4. We note that while elastic demand means that the benchmark price will increase, it
    does not follow that total detriment will necessarily decrease as a consequence. This
    is apparent from inspection of Figure 4. When demand is responsive to price, any
    price below the coordinated price implies increased demand. Sales forgone due to
    the elevated price represent a source of detriment. If demand were actually elastic,
    plant D would be the marginal plant. The detriment due to forgone sales is
    represented by triangle between the vertical, assumed demand curve, the actual
    demand curve and the line representing the unit operating cost of plant D. If demand
    were responsive to price, this detriment would be non-zero. There are thus two
    opposing effects at work and the effect on total detriment is therefore not clear-cut. In
    particular, it is not obvious that the assumption of given demand would result in an
    overestimate of total detriment.

5.   While we did not have access to an estimate of how elastic the GB demand for cement is, we could derive an upper bound on how elastic demand can be and still accommodate an expansion in demand due to a lower price. If the demand for cement would have to be unreasonably inelastic for the market to balance at our estimated competitive price, we would have less confidence in the validity of our estimate.

6.   We calculated bounds on the elasticity for demand in two scenarios:

        (a) a scenario where [Plant 1] is active but [Plant 3] is not; and

        (b) a scenario where [Plant 3] is active.

7.   Throughout the analysis, we assumed that the coordinated price was £80 per tonne. Our analysis relied on the observation that in any scenario, demand could expand by at most a quantity equal to available spare capacity (measured relative to 2011 demand) before balance of supply and demand is violated.

8.   In the first scenario, the competitive price is between £66.60 per tonne and £69.50 per tonne. These prices correspond to reductions of 16 and 13 per cent relative to the coordinated price, respectively. There would be virtually no available spare capacity at any price below £69.50 per tonne. Demand would need to be very inelastic for supply and demand to balance.[29]

9.   In the second scenario, the competitive price is £69.50 per tonne or above. A price of £69.50 per tonne represents a reduction of 13 per cent relative to the average price of cement in 2011. With both [Plant 1] and [Plant 3] active spare capacity would be around [✂]kT per year. In this scenario, demand could thus expand by just under

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[29] Our estimated of the elasticity of demand was the negative of the relative change in demand divided by the relative change in price. This is equivalent to assuming that the demand curve is linear. Compared with the elasticites implied by a constant elasticity of demand system, the approximation results in slightly more elastic demand.

4 per cent relative to realized 2011 GB demand before demand exceeds supply. To a first approximation, demand price elasticity would, in absolute terms, have to be 0.3 or less for supply and demand to balance at the competitive price.