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Market Integration in the International Coal Industry: A Cointegration Approach

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Abstract

The purpose of this paper is to test the hypothesis of the existence of a single economic market for the international coal industry, separated for coking coal and steam coal, and to investigate market integration over time. This has been conducted by applying cointegration and error correction models on quarterly price series data in Europe and Japan between 1980 and 2000. Both the coking coal and the steam coal market show evidence of global market integration, as demonstrated by the stable long run cointegrating relationship between the respective price series in different world regions. This supports the hypothesis of a globally integrated market. However, when analyzing market integration over time regarding steam coal, it is not possible to confirm increasing integration in the 1990s for steam coal. A policy implication of the finding that the steam coal market cannot be considered cointegrated in the 1990s, is that the market are more regional in scope, and thus mergers and acquisitions during this period might have added more to the merged companies' market power, as the same activity during the 1980s.

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1. Introduction

The international coal industry has been characterized by fundamental changes during the last decades. In the 1960s the coal market was far from international, given that production almost exclusively was aimed at national usage. Trade between different world regions was not well established. The oil crises in 1973 and 1979 forced a revision of this setting, and initiated the rapid development of the international coal market to its appearance today. In addition, transportation costs for shipments have decreased considerably since the 1950s (Lundgren, 1996). This has contributed to the large increase in coal trade. Since 1970 world coal *demand* has increased by more than 60 percent, which is even faster than the increase of world demand for oil, but the most significant increase has though been on the world market of *traded* coal, which increased by over 230 percent during the same time period (Keay, 2003). This development has during recent years led many analysts to consider the international coal market as an essentially unified global market (e.g., Ellerman, 1995; Humphreys and Welham, 2000).

Lately the coal industry has as well experienced a number of mergers and acquisitions, which have consequently led to a more consolidated market (Regibeau, 2000). This development has raised the concern for whether the new and larger companies can exert market power, and thus raise consumer prices. In order to determine this it is important to define the relevant market boundaries for coal. Defining market boundaries is a vital part when determining whether a market is anti-competitive. This procedure starts with an evaluation of market shares of leading firms, compared to critical threshold values.[1] It is in this initial phase that market boundaries are defined and assessed. In order to conclude that a market is anti-competitive further investigations regarding barriers to entry, price discrimination, collusion, and possible mark-ups on the defined market is necessary. However, the results of these tests will be strongly affected by the defined market boundary. For instance, mergers within a particular country or region ought to be less problematic if the relevant coal market is worldwide instead of local.

[1] Markets are in antitrust analysis defined both over product space and geographic space. Given the aim of this research, only the relevant geographic market boundary will be analyzed. A further reason for this is given by the relatively homogeneity of the two main coal products, as compared to differentiated product markets, such as the market for automobiles.

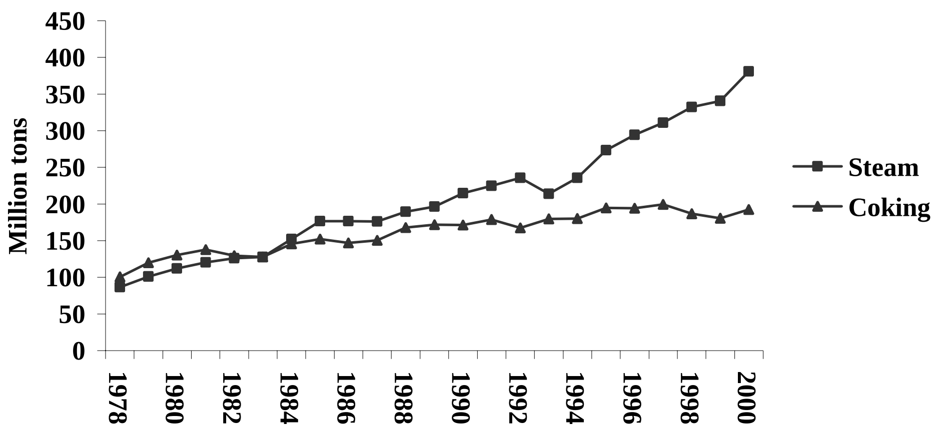
The purpose of this paper is to test the hypothesis of a world market for coal, and to investigate whether the industry has experienced increased market integration over time. International trade and price relationships in spatially separated markets are the focus of this analysis where the general concept of the 'law of one price' is used for defining the presence of a single market. The logic behind this is that when there is trade between two regions, the price differential, in equilibrium, should not exceed the transport cost between them. For example, consider a large coal exporter, e.g., Australia, shipping to, say, Japan and Europe. Then, the equilibrium price differential between Europe and Japan should be the difference in shipping costs between Australia-Europe and Australia-Japan. Spatial equilibrium analysis has a long history dating back to Samuelson (1952). In the late 1980s and early 1990s many authors began to use time series techniques to correlated prices in spatially separated markets (DeVany and Walls, 1993; Sauer, 1994; Asche et al., 2001). Cointegration testing has become a common way of investigating the law of one price, and will be used here together with an analysis of short run price adjustments. The present paper's contribution is to apply these techniques to two kinds of internationally traded coal, steam coal and coking coal.

The paper proceeds as follows. Section two examines the historical development of internationally traded steam and coking coal. Section three provides a theoretical background to cointegration and error correction models. In section four the empirical results are presented, and the last part of this section divides the price series data into different time periods in order to study market integration over time. Finally, in section five, some concluding remarks are made.

2. The Development of the International Coal Industry

Before the 1960s the coal market was mainly national in scope, and most trade was land-based between neighboring countries. A natural obstacle for the development of a world market for traded coal, compared with e.g., oil, has been the high transportation costs involved in shipping and handling coal (IEA, 1997). According to Lundgren (1996) freight rates for bulk products, such as coal, have however decreased about 65-70 percent since the 1950s. This has created an opportunity for the development of a global market for seaborne trade. Figure 1 illustrates the development for the world trade of steam coal and coking coal, from 1978 to 2000.[2] Regarding coking coal we can see that world trade almost doubled during this time period. World trade in steam coal has though grown considerably faster during the same period, an increase of more than 438 percent in traded steam coal during the last two decades. One reason for this can be ascribed to the high oil prices caused by the OPEC cartel in the 1970s, which substantially increased the demand for coal as input into electricity generation. This market has continued to grow, something which is mainly explained by the high energy consumption levels in the world today. Due to the different uses and developments of coking coal and steam coal, these products will be treated separately in the remainder of the article.[3]

Figure 1
World Trade for Steam and Coking Coal



Source: IEA (2001).

2.1 Coking Coal

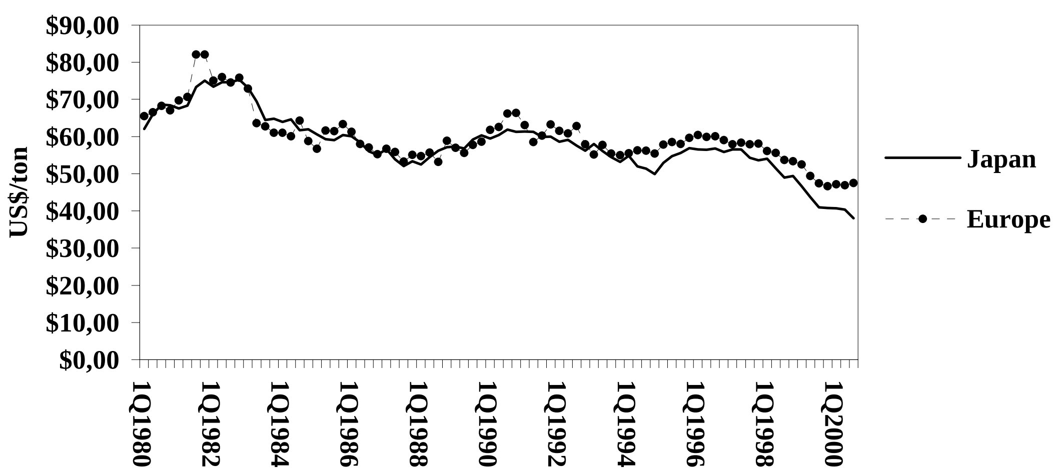
Coking coal is primarily used as a chemical reductant in iron and steel production. Growth in the coking coal market was most evident during the 1960s, something which can be explained by higher demand for coking coal primarily in Europe where production could not sustain the newly created demand. The higher demand for coking coal in the

[2] Data separating steam coal and coking coal date back to 1978 at International Energy Agency (IEA).
[3] Substitution between coking coal and steam coal possible, but it requires preparation of the products, in order to go with either the steel making process or the energy process (IEA, 1998).

steel and iron making process in many European countries produced significant trade of seaborne coal. During the 1970s the demand for coking coal increased substantially in the newly industrializing countries, mainly in Asia and Latin America, something which reinforced the development in the 1960s. During the 1980s growth in the coking coal market slowed down due to the modest growth in industry use for coking coal (mainly in Europe), and a new technical process that decreased the use of coke in the steel making process (IEA, 1997).

In 2000 the total volume of export in coking coal was 192 million tons and the largest exporter, Australia, represent 51 percent of the market. The quarterly price levels for import of coking coal in the two dominant regions, Europe and Japan, were in 2000 US$ 47.9/ton and US$ 39.5/ton in average customs unit values, respectively (IEA, 2001). Figure 2 presents coking coal price levels for Europe and Japan from 1980 until 2000. It is evident from this figure that the prices in these geographical markets tend to be closely correlated.

Figure 2
Import Prices for Coking Coal



Source: IEA (quarterly).

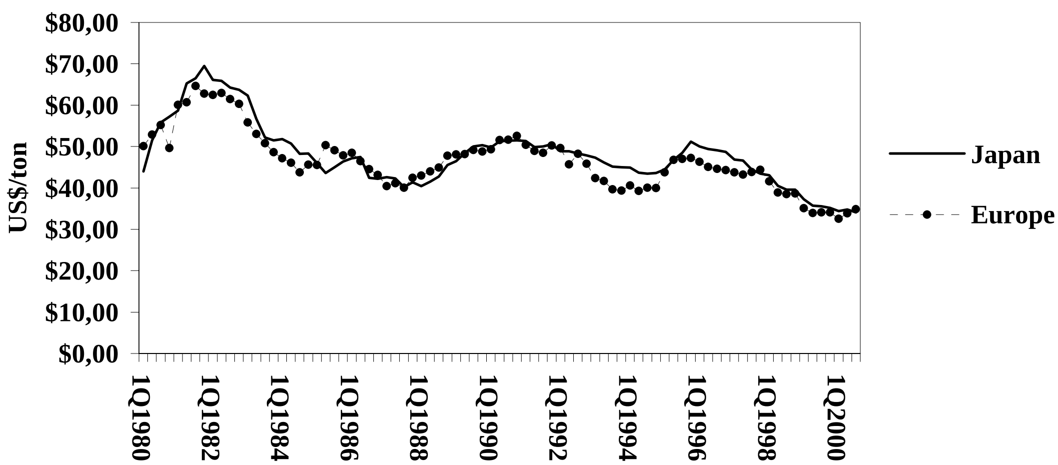
The prices for coking coal are generally settled in long term contracts (more than five years) through bilateral negotiations between suppliers and consumers. During the last 5-6 years spot markets for coal have developed, but these are still limited in scope since the demand for coking coal is to a large extent fixed in the short run. There is though evidence that the prices paid in spot markets have an effect on the contract prices settlements, especially in the European market (IEA, 1997). Despite the existence of long-term contracts, the prices for coking coal are considered to be relatively flexible. Annual renegotiations, allowing the prices to change, are the norm. The timing of the negotiations has a great impact on the prices, and for the coking coal market the price settlements with the Japanese Steel Mills are the most influential. These settlements are made before the negotiations involving European and South African steel makers. In Japan it has also been common to conclude negotiations for coking coal before steam coal, mainly due to the fact that the Japanese Steel Mills have a longer tradition of coal import than have the Japanese Power utilities (IEA, 1997).

2.2 Steam Coal

Steam coal is primarily used for electricity generation, and in recent years it has represented more than 60 percent of all traded coal. Compared to the coking coal market the steam coal market has grown considerably faster during the last 20 years, something which is mainly explained by the substantial increase in electricity demand during this period (IEA, 2000). The oil crises in 1973 and 1979 were the two individual events that have had the most impact on the creation of a world market for seaborne steam coal trade. The high oil prices enforced by the OPEC cartel increased the demand for internationally traded steam coal. Transportation costs and storing costs for steam coal seemed no longer to be an overwhelming obstacle, especially since 'security of supply' became a political issue that appeared as important as a cost driven perspective (Söderholm, 1998).

In 2000 the total volume of export in steam coal was 381 million tons, and Australia was the largest exporter with a 23 percent share of the market. South Africa represented the second largest exporter, with 18 percent of the total export in steam coal. The price levels for imported steam coal in the two dominating regions, Europe and Japan, were in 2000 US$ 34.9/ton and US$ 34.6/ton, respectively, measured in average customs unit values (IEA, 2001). Figure 3 presents the quarterly steam coal prices for Europe and Japan from 1980 until 2000. The contractual arrangements for steam coal are by and large the same as those for coking coal. So far long term contracts are dominating the market, but spot markets are becoming increasingly common in the price formation process. The spot purchasing practice is more developed for steam coal than that for coking coal, which is mainly due to the greater number of supply alternatives in the steam coal market. Spot markets are most frequent and developed in the Asian market, where spot sales are functioning as indicators for the long-term contract negotiations. The prices in the Asian market are also influenced by the prices set in the European market, since prices in the European market are mostly set one quarter ahead of the contract prices in Asia (IEA, 1997).

Figure 3
Import Prices for Steam Coal



Source: IEA (quarterly).

Figures 2 and 3 illustrate that the prices for coking coal and steam coal have roughly followed the same path. Imports prices around the world, for steam coal and coking coal, were at their 'all time high' in 1982, and have thereafter been declining both in nominal and real terms. This is mainly due to increases in productivity, a more open and unregulated market and the oil price collapse in 1986. The high coal prices in the early 1980s created an excess supply capacity for coal, something which coincided with cheaper nuclear power plants, higher ocean freight rates, and environmental concerns for coal use. As a result, the demand growth for coal declined and the coal price was thereafter mostly determined by coal-to-coal competition. Other factors that have contributed to a downward pressure on the world coal prices are the widely distributed coal reserves, the possibility for US producers to enter the market when prices rise, and the entry of new low cost producers from new exporting countries (IEA, 1997).

2.3 Is there a Single Economic Market for Internationally Traded Coal?

One aspect of the international coal market, which contradicts the notion of a unified global *economic* market, is the domination of two *geographical* markets, the European and the Asian-Pacific market. The existence of two geographically separated markets is sustained primarily by relatively high transportation costs. Table 1 presents some indicative costs insured to produce and ship steam coal and coking coal to Europe and Japan, from major exporting countries.

Table 1

Indicative Production and Transportation costs for Coking and Steam Coal (2000 US$/ton)

Coking coal exporters	**Mine mouth price**	**Inland transport**	**Loading**	**Ocean freight to Japan**	**CIF Japan**	**Ocean freight to Europe**	**CIF Europe**
Australia							
Queensland							
- underground	30.7-37.1	3.9-6.5	1.7-2.6	5.6-9.0	48.8-55.2	10.1-17.0	55.0-61.4
- surface	27.2-37.6	3.9-6.5	1.7-2.6	5.6-9.0	45.3-55.7	10.1-17.0	51.5-61.9
Canada							
Western Canada							
- surface	34.3-42.5	9.3-13.4	2.1-4.1	5.8-8.8	41.7-49.9	10.8-17.4	34.3-42.5
South Africa							
Transvaal							
- underground	30.7-33.4	5.9-6.4	1.2-1.5	7.2-11.3	37.3-40.0	7.5-13.4	47.1-49.8
United States							
Appalachia							
-underground	23.9-32.2	15.3-18.6	0.5-1.1	13.1-18.3	56.6-64.8	5.8-9.5	48.3-56.6
-surface	34.7-37.8	8.0-9.3	1.3-2.9	14.4-20.1	62.1-65.3	6.5-9.4	53.4-56.5
Steam coal exporters	**Mine mouth price**	**Inland transport**	**Loading**	**Ocean freight to Japan**	**CIF Japan**	**Ocean freight to Europe**	**CIF Europe**
Australia							
Queensland							
- surface	13.2-17.6	3.9-6.5	1.7-2.6	5.6-9.0	31.3-35.7	10.1-17.0	37.5-41.9
Canada							
Western Canada							
- surface	27.0-35.3	9.3-13.4	2.1-4.1	5.8-8.8	34.4-42.7	10.8-17.4	27.0-35.3
South Africa							
Transvaal							
- surface	14.2-25.6	5.9-6.4	1.2-1.5	7.2-11.3	22.1-32.2	7.5-13.4	25.0-27.0
United States							
Appalachia							
-surface	16.4-25.4	15.3-18.6	0.5-1.1	13.1-18.3	49.1-58.1	5.8-9.5	40.8-49.8

Source: IEA (2001).

Interesting to note is that regarding exports from Canada, the CIF prices in Japan and Europe are opposite of what one would expect given the ocean freight rates. The freight rate to Japan from Canada is less than the equivalent to Europe, but still the CIF price is higher in Japan than it is in Europe. However, this does not seem to oppose the presence of two geographical regions which is also illustrated in Table 2. Here we can see that countries that are geographically closer to each other are the primary exporters/importers. The Asian-Pacific market, with Japan as the biggest importer, is mainly supplied by Australia and Canada in the case of coking coal and for steam coal by Australia, China, and Indonesia. The other regional market, Europe, is mainly supplied by South Africa, Colombia, and Poland concerning steam coal, and for coking coal by the US and Australia.

Table 2

World Trade in Coking and Steam Coal in 2000 (Mt)

	Coking Coal			Steam Coal		
Exporters	**Japan**	**Other Asia**	**OECD Europe**	**Japan**	**Other Asia**	**OECD Europe**
Australia	40.7	28.4	21.6	46.8	28.7	9.9
Canada	12.1	5.4	6.7	1.3	1.7	0.3
Poland	-	-	4.0	-	-	18.1
United States	1.0	0.9	15.7	3.1	1.1	5.8
Other OECD	0.9	0.5	4.3	-	-	6.7
Total OECD	**54.8**	**35.3**	**52.3**	**51.1**	**31.5**	**40.9**
China	3.3	3.2	-	13.2	35.6	2.9
Colombia	0.1	-	0.1	-	-	21.8
Indonesia	3.9	4.3	0.4	10.5	30.0	8.0
Former SU	2.4	1.0	1.2	3.1	2.3	17.2
South Africa	0.3	-	0.4	1.6	11.5	41.8
Oth Non-OECD	-	-	0.3	1.0	0.7	3.7
Tot. Imp/Exp	**64.7**	**43.8**	**54.8**	**80.6**	**110.9**	**136.3**

Source: IEA (2001).

Two important links between these geographically separated markets are, concerning steam coal, Australia and in particular South Africa, whose geographic locations create potential for exports to both the European and Asian-Pacific markets. In the case of coking coal we can see that Australia exports both to the Asian-Pacific market and to the European market. This is primarily explained by the excess supply from the Australian producers. Australia can therefore be seen as a marginal supplier. Another link between the markets is the possibility for the US producers to enter the international coal market when price levels are favorable, something which makes the US a swing supplier with the excess capacity to move in and out of the market depending on the current market situation (IEA, 1997).[4] The above facts, and the relatively strong relationship between coal prices as illustrated in Figures 2 and 3, tend to support the notion of a unified market for internationally traded coal (see also Ellerman, 1995).

Still, even if the prices tend to follow the same path in the long run, the responses to price deviations in the short run can provide useful information on the degree of market integration. In addition, the recent development of more consolidated coal suppliers may be an issue of concern, since the prospect of these companies exercising market power increases substantially when there are fewer, more dominant, players operating in the market (IEA, 2000). An additional reason supporting the chosen topic is that previous research has to a large extent focused on the steam coal market, but the assumption about a single economic market is often made for the international coal market as a whole (e.g., IEA, 1997).

3. Cointegration and Error Correction Models

The method for determining market integration in this paper is an error correction model introduced by Engle and Granger (1987). The error correction model incorporates a long run cointegrating relationship, which implies that two cointegrated price series will not drift apart without limit. Error correction models have gained increased support for empirical estimations of market integration in energy industries during the last ten years (e.g., DeVany and Walls, 1993; Sauer, 1994; Asche et al., 2001). The technique examines movements in prices for goods located in different regions in order to test the hypothesis

[4] Market integration between the US and Europe is because of the US role as swing supplier considered to be strong (Ellerman, 1995). It is therefore reasonable to believe that any regional tendencies (i.e., lack of market integration) are more likely to be detected between Europe and Japan. Worth noting is also that the US is not a big importer of coal, given their large production at home.

of a long run cointegrating relationship. The examination of market integration in the international coal market follows two steps. First, the cointegration relationship is investigated in order to determine whether the price series show evidence of stable long run relationships. The finding of cointegration is however not sufficient to verify that two regions belong to the same market (Gjolberg, et al., 1996). An investigation of the price adjustment process, where significant responses to different price shocks can be recognized, provides further evidence for market integration. The price adjustment is considered a short run process and represents the second step in the examination of market integration. The analysis of the speed and strength of the adjustment back towards the long run equilibrium level will help to determine market integration.

Consider two price series, p_i and p_j, that by themselves are non-stationary and must be differenced once to generate stationarity. A linear transformation of the two original series can though result in a series ε_t that is stationary, $I(1)$:[5]

$$p_{j,t} - \alpha - \beta p_{i,t} = \varepsilon_t \tag{1}$$

If this linear transformation exists between p_i and p_j, the time series are considered cointegrated since the regression indicates that the difference between the time series, $p_{j,t} - \beta p_{i,t}$, is varying at random around a fixed level (Engle and Granger, 1987). When this is the case, it is possible to distinguish between a long run and a short run relationship between p_i and p_j. The long run relationship captures the cointegration relationship, in which the series move together around a fixed level. The short run relationship describes deviations of p_i and p_j from their long run trends. The vector [1, $-\beta$] in equation (1) captures the cointegration relationship between the two price series. When cointegration between time series is evident there is an indication of a single market.

The model that differentiates between a long run and a short run relationship for time series analysis has been widely known as the error correction mechanism (ECM) model (Engle and Granger, 1987). When non-stationary variables in a model are verified as cointegrated, the following ECM model can be derived:

[5] This is only true if p_i and p_j are integrated of the same order, in this case integrated of order one (Greene, 1993).

$$\Delta p_{j,t} = \beta_j \Delta p_{j,t-k} + \beta_i \Delta p_{i,t-k} + \delta EC_{t-1} + \varepsilon_t, \qquad (2)$$

where *k* represents the lag length and the error-correction term is represented by EC_{t-1}, which adopts the following form:

$$EC_{t-1} = p_{j,t-1} - \alpha - \beta p_{i,t-1} \qquad (3)$$

and this term captures the deviation from long-run equilibrium, and the coefficient δ in equation (2) measures the speed of adjustment, which indicates how long it takes for the time series to move back to the equilibrium level in case of a price shock in one region. The coefficients β_i and β_j represent the short run counterparts to the long run solution in equation (2).

Werden and Froeb (1993) criticize the use of price series data to define the relevant market. There are primarily two reasons for this conclusion. *First*, it is often difficult to identify the correct price, as well as transportation cost, when the geographically separated markets include a variety of products with different prices, and conclusions based on poor data may be misleading. *Second*, even if it is possible that when prices for products sold in geographically separated markets tend to unity or follow the same trend they belong to the same economic market area, it does not necessary have to be the case. For example, the prices in two distinct markets could exhibit the same movements even if it is coincidental, or caused by the price change of a common input factor, i.e., so-called spurious correlation. Given this situation, an assessment of price data would induce the wrong assumption of an integrated geographic market area, when in fact this is not the case.

4. Results for the International Coal Industry 1980-2000

The data used for this study represent quarterly import prices for coking coal and steam coal from the first quarter in 1980 to the third quarter in 2000, for the two dominating geographical markets for internationally traded coal Europe and Japan. These have been collected from the International Energy Agency’s (IEA’s) quarterly publication *Energy Prices and Taxes*, and represent import CIF prices in US Dollars/ton, including the sum of cost, insurances and freight.[6] Monthly or weekly data would have been preferred given that short run responses provide finer results due to closer observations, but since coal prices are in many cases set in long term contracts (adjusted every year) quarterly data should be sufficient for recognizing the short run adjustment process. The econometric model outlined in section 3 will be employed in logarithmic form.[7]

The main critique directed towards the use of prices in defining relevant markets concerns mainly the accuracy of the underlying data (the prices) and spurious correlation. When using prices in order to define a relevant geographic the analyst relies on the underlying assumption that the prices are determined by the balance of supply and demand in the market. According to Chang (1995) there are many reasons to believe that, at least, the coking coal industry is not a competitive market. The main reasons for this are that coking coal is not a homogenous product, and the market primarily uses long term contractual arrangements which are renegotiated once a year. Chang also stresses that steel mills are risk averse in that they tend to secure supply of a certain coal quality. Coking coal prices may therefore be formed based on quality differences, as well as the need of different suppliers, which would imply that prices for this market is not formed competitively.

Chang further discusses the difference in using FOB (free on board) coal prices and CIF (cost, insurance, and freight) prices in evaluating price differences for coking coal. CIF prices are often derived by adding an estimated transport cost component to the FOB contract prices, and thus the quality of the CIF price thus depends on the accuracy of the estimated transport costs. However, for the analysis conducted in this paper it is important to include the transport prices, and given that specified prices of origin with respective transportation costs data is not available CIF prices are considered to be the best proxy available for a spatial analysis. Another caveat regards that the CIF prices are blended prices, where for example they blend multiyear contract prices with spot prices, blend delivered prices for coal shipped from scattered sources to a common destination,

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[6] The prices used are so called blended prices (BTU).

[7] Logarithmic form prevents that growth rates depend on the levels of the price series (Hendry and Juselius, 2001). The coefficients also become easier to interpret, since they are scale-invariant. One problem with the log-form is, though, that the prices are not quoted as they are in arithmetic form. However, the results will not differ depending of which of these is used, and log form is therefore applied.

and blend prices for coal with slightly different qualities. Thus, the coal prices used here are collected averages and do therefore to some extent not reflect the actual price paid in all instances. However, given the range of different prices this would generate, some averaging in order to ease the handling of the prices are necessary.

There are though potential complications that arise when using blended or averaged prices. For example, systematic variations in the unobserved characteristics may be present. This would be the case if there were evidence that changes in the length of contracts were different in Japan than in Europe, or if there were transport cost changes during the period that affected Japanese or European buyers differently. However, there is no evidence that any systematic variations in the unobserved characteristics are so substantial that the results of this paper should be overthrown. Further complications with using prices are if the similar price movements are coincidental, perhaps caused by a common input factor. Also regarding this issue there are no direct evidence that the movements in prices of steam coal and coking coal are not caused by competition and thus this does not seem to influence the forthcoming results.

The results for the two separate markets, coking coal and steam coal, are presented after testing for the general condition of unit root. This test identifies non-stationarity among price series in levels, and stationary series after first differencing, which is a necessary condition for cointegration. This has been performed using a Dickey-Fuller (DF) test, and the results show that tests for cointegration can be conducted both for coking coal and steam coal. The Engle and Granger test uses a standard OLS estimation for the long run relationship between the two price series. In order to conclude that the price series are cointegrated, the residuals from the OLS estimation have to obey stationarity. When this is the case, the residuals from the cointegrating relationship are incorporated in the ECM model and the equation then only consists of stationary variables, so standard estimation procedures can be applied (Dolado et al., 1990).

Results for Coking Coal

The cointegrating regression of prices in Japan (P_J) on prices in Europe (P_E) and a constant was run. The result, normalized on Europe, has the following representation:

$$P_E = 1.04 + 0.75P_J \quad (4)$$
$$(-7.66) \quad (-22.5)$$

Equation (4) indicates that when the price in Japan rises by one percent, the corresponding long run increase in the European price level is 0.75 percent. The values in the parentheses represent the *t*-statistics. An economic interpretation of the intercept term is that it represents the price differences between the time series in the long run, which in the case of coal incorporates transportation costs and quality differences. The sign indicates that the price level in Japan is lower than the price level in Europe, as is also evident when looking at Figure 2. To test for cointegration the residuals from Equation (4) have to obey stationarity. This implies that the residuals have to reject the null hypothesis of "no-cointegration" according to the test statistics given by the DF test. The test statistics is -4.52, which is statistically significant at the 1 percent level and implies that the price series in Japan and Europe are cointegrated.

The choice of dependent variable when using prices is not clear. If you know that variable Europe cause's variable Japan then the choice of dependent variable in the Engel-Granger method is clear. Since this is not the case using prices, the same procedure was repeated for the reverse regression. The result, normalized on Japan, is presented in Equation (5):

$$P_J = -0.63 + 1.15P_E \quad (5)$$
$$(-3.03) \quad (-22.5)$$

Equation (5) shows the reverse relationship; thus when the price in Europe rises by one percent, the corresponding long run increase in the Japanese price level is 1.15 percent. The result form this regression confirms the conclusion of a higher price level in Europe than in Japan. The DF test is run and the test statistic is -3.9, which is statistically significant at the 1 percent level. The reverse regression thus also shows that the price series in Europe and Japan are cointegrated, and thus the error correcting dynamics can be tested for. However, given that coking coal prices in Japan are set before the prices in Europe (see section 2), it is reasonable to believe that the results from normalizing on European prices provide more information.

The error correction model used is given in equation (2). Regressions with up to four lags have been performed, but presented in the tables are only models where the lag length is one since these were the models that were statistically significant. Note that the model already includes one lag given the regression of changes in prices. The dependent variable is Europe in equation (2), but an estimation using Japan as the dependent variable has also been performed. We have thus:

$$\Delta p_{E,t} = b_E \Delta p_{E,t-1} + b_J \Delta p_{J,t-1} + \delta EC_{t-1}, \qquad (6)$$

where b_J and b_E is the estimated short run counterparts to the long run solution, and δ represents the speed of adjustment parameter, which indicates how fast the prices moves back towards long run equilibrium in case of a deviation in the previous time period. Table 4 presents the estimated values of these parameters, using both prices in Europe and Japan as the dependent variable.

Table 4

Error Correction Estimates (Coking Coal)

	EUROPE			**JAPAN**		
Coefficients	$\boldsymbol{b_E}$	$\boldsymbol{b_J}$	$\boldsymbol{\delta_E}$	$\boldsymbol{b_J}$	$\boldsymbol{b_E}$	$\boldsymbol{\delta_J}$
Estimate	0.03	**0.41***	**-0.38***	**0.20******	0.09	-0.03
t-values	(0.28)	(2.58)	(-3.20)	(1.69)	(0.97)	(-0.47)

*Bold numbers indicate statistical significance at * 1 % level, ** 5 % level, and *** 10 % level.

The results using prices in Europe as the dependent variable indicate that a one percent increase of prices in Japan the preceding period yields a 0.41 percent increase of the price level in Europe the present time period. This suggests that the prices in Europe are reacting to price changes in Japan the previous time period. The speed of adjustment parameter implies that a deviation from the long run equilibrium in Japan the preceding time period, is adjusted for by 38 percent in Europe the following quarter. Turning the attention to the results when using Japanese prices as the dependent variable we can see that none of the short term response parameters are statistically significant.

When summarizing the results for coking coal, it is evident that the prices in Europe and Japan are cointegrated, and therefore follow a long run relationship. This result supports the hypothesis of an integrated world market for coking coal. When examining the short run response to the long run equilibrium we can see that a change in the Japanese prices in the previous period will be adjusted for by 40 percent in Europe the following period. However, there is no evidence of Japanese prices adjusting to price changes in Europe. This result may be explained by the timing of price negotiations, since coking coal prices in Japan normally are settled before the prices in Europe (see section 2).

Cointegration Results for Steam Coal

The tests for cointegration and error correction for the steam coal market follow the same general procedure as for coking coal. The cointegrating regression of prices in Japan (P_J) on prices in Europe (P_E) and a constant was run. The results, normalized on Europe and Japan, are as follows:

$$P_E = 0.30 + 0.91P_J \qquad\qquad P_J = 0.21 + 0.95P_E \tag{10}$$
$$\qquad (2.00)\ \ (23.39) \qquad\qquad\qquad (1.35)\ \ (23.39)$$

Equation (10) indicates that when the price in Japan (Europe) increases by one percent, the corresponding long run increase in the European (Japanese) price level is 91 (95) percent. Compared to the coking coal market, it is evident that the price changes are closer to one. To test for cointegration the residuals from Equation (10) have to obey stationarity. The DF test statistics are -4.82 and -4.65 respectively, which is statistically significant at all significance levels. This implies that the price series in Japan and Europe are cointegrated. As well, given the price formation, that prices in Europe are set before prices in Japan concerning steam coal, the equation normalizing on Japanese prices provides more information.

The error correction model is once again performed as outlined in equation (6). Table 5 presents the estimated values of these parameters, using both Europe and Japan as the dependent variable. The results when using Europe as the dependent variable show that none of the short run response parameters are statistically significant at an acceptable significance level. When using Japan as the dependent variable a one percent increase of prices in Europe the preceding period yields a 0.25 percent increase of the price level in Japan the present time period. The result of a price change in the own region the preceding time period is adjusted for by 25 percent the following. The speed of adjustment parameter is 0.17 when using Japan as the dependent variable.

Table 5

Error Correction Estimates (Steam Coal)

	EUROPE			JAPAN		
Coefficients	b_E	b_J	δ_E	b_J	b_E	δ_J
Estimate	0.003	**0.25*** **	-0.16	**0.25***	**0.21***	**-0.17***
t-values	(0.20)	(1.78)	(-1.38)	(2.76)	(2.33)	(-2.41)

* Bold numbers indicate statistical significance at * 1 % level, ** 5 % level, and *** 10 % level.

Compared to the results for the coking coal market, these findings are indicating that it is the European prices that seem to influence the Japanese and not vice versa. The results considering steam coal thus indicate that the European and the Japanese markets are integrated into one market, given the presence of cointegration. When examining the short run response, given by the adjustment towards the long run equilibrium, the results show that European prices influence Japanese prices. This may once again be explained by the timing of price negotiations, since steam coal prices in Europe normally are settled before the prices in Japan (see section 2). Notable is though that the short run responses to price changes are lower for steam coal than for coking. This might be explained by the fact that coking coal prices are higher than those for steam coal, and transportation costs constitute a lower proportion of total costs.

Market Integration over Time

In order to investigate whether the coal markets have experienced increased market integration over time, the price series have been separated into two time periods. The first period represents price data from quarter one in 1980 to quarter four in 1989, and the second time period represents prices from quarter one in 1990 until quarter three in 2000. The selection of 1990 as the breakpoint, besides it being the midpoint in the series, is motivated also by two empirical observations.

First, large structural changes occurred in Europe after 1990, and these have had a great impact on the coal industry. Before the 1990s the European coal market was highly subsidized, mainly due to security of supply concerns and the fact that European coal producers could not compete with low cost producers in other parts of the world. A policy change, towards a more cost efficient market approach that involves decreasing subsidies for coal, was implemented both in Eastern Europe and in Western Europe during the 1990s. In Eastern Europe, where the Socialist economic regimes were replaced by more market-oriented regimes, the change was a natural cause in adapting to the West-European standards, and affected the coal industries for the large producers in Poland and Czechoslovakia substantially (e.g., Radetzki, 1995). This policy change has not been as clear-cut in Western Europe, but there has been a strong tendency towards privatization of state-managed economic activities and liberalization of trade (especially within the European Union) that initiated rationalization programs to coal production in many Western European countries (Radetzki, 1994).

Second, the changes in the contractual arrangements for the coal industry were mainly introduced during the 1990s. In 1991 the MCIS (McCloskey Coal Information Services), functioning as a marker-price to spot prices in North-West Europe, was first published, and in 1992 the TaiPower, the Asian equivalent of MCIS, was introduced. Since then there has been a movement away from five-year contracts towards contracts that are characterized by a shorter perspective, such as spot prices and contracts that are renegotiated annually. It is worth noting that this development has been most significant regarding steam coal, mainly due to the increased demand of steam coal and because industries using coking coal is more dependent upon a specific coal quality (IEA, 2000).

The general procedure of the error correction analysis, separated into two time periods, is the same as outlined in sections 4.1-4.3. The first step in finding evidence of cointegration relationships among price series is to test for unit roots. The results from the DF-tests indicate that the price series are non-stationary in levels, and becomes stationary after first differencing. Tests for cointegration can therefore be conducted both for coking coal and steam coal in the two time periods.

Before estimating the long run and short run relationships it is however of interest to determine whether it is at all statistically motivated to divide the price series into two time periods. In order to determine this, a Chow test of the validity of combining two sub-samples to fit regression model was conducted. This test verifies if the improvement in the fit due to the break up of the sample is statistically significant or not (Dougherty, 1992). The chow test has been conducted on the cointegration equations. The F-statistic is 6.03 for steam coal and –1.87 for coking coal. Given a critical value of 3.15, these results imply that separating the price series into two time periods is motivated concerning steam coal but not for coking coal. Thus, only for steam coal the Chow test rejected the null hypothesis that the two sub-samples could be combined into one single error correction model. As a consequence, the following estimations of the error correction model can only be motivated for the steam coal market.

The results from the long run cointegration relationships for steam coal, separated in the two time periods, are presented in Table 6. The results indicate that the long run price change in one region, due to a one percent increase in the other region, is stronger in the 1990s compared to the 1980s. This is evident especially when regressing prices in Japan on prices in Europe, given that a one percent increase in the price level in Japan yields a 0.99 percent increase in the European price level in the long run in the 1990s compared to 0.76 percent in the 1980s.

Table 6

The Long Run Cointegration Results for Selected Time Periods (Steam Coal)

STEAM COAL	**1980Q1-1989Q4**		**1990Q1-2000Q3**	
	Japan	**Intercept**	**Japan**	**Intercept**
Estimate	0.76	0.93	0.99	-0.01
t-values	*(15.01)*	*(4.66)*	*(18.58)*	*(-0.07)*
	Europe	**Intercept**	**Europe**	**Intercept**
Estimate	1.13	-0.48	0.90	0.42
t-values	*(15.01)*	*(-1.62)*	*(18.58)*	*(2.28)*

To test for cointegration the residuals from the regressions presented in Table 6 have to obey stationarity. When regressing the change in the residuals on past levels and no lagged changes, the results show that in the 1980s the residuals obey stationarity. This implies that the price series in Japan and Europe are cointegrated in the 1980s, and thus that Error Correction estimates can be employed. However, when turning the attention to the 1990s, where the price series are more correlated, we cannot find evidence of cointegration based on the Dickey-Fuller test.

The error correction model is performed as outlined in equation (6). Table 7 presents the estimated values of these parameters, using both Europe and Japan as the dependent variable. The results for the 1980s, when using Europe as the dependent variable, show that none of the short run response parameters are statistically significant at an acceptable significance level. When using Japan as the dependent variable the results show that the effect of a one percent increase of the price level in the own region the preceding period will lead to an increase in the price level by 0.27 percent the present quarter. The speed of adjustment parameter indicates that the prices move back to the equilibrium level by 29 percent after the first quarter. The results from the 1990s should not be interpreted given that the residuals do not obey stationarity.

Table 7

Error Correction Estimates for Selected Time Periods (Steam Coal)

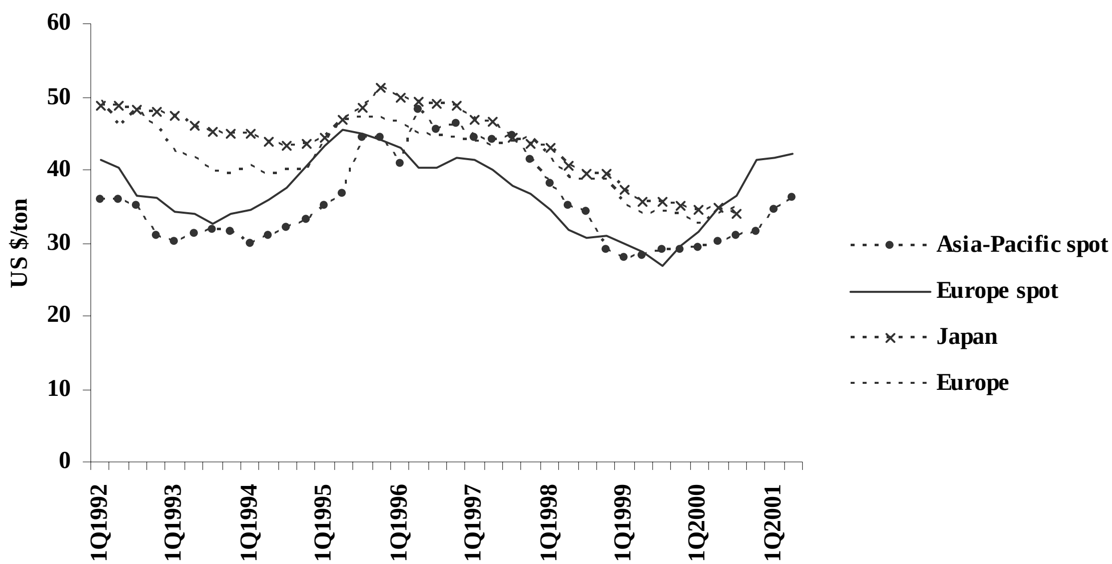
STEAM COAL	**EUROPE**			**JAPAN**		
1980Q1-1989Q4	b_E	b_J	δ_E	b_J	b_E	δ_J
Estimate	0.03	0.22	-0.31	**0.27****	0.16	**-0.29****
t-values	*(0.16)*	*(1.25)*	*(-1.38)*	*(2.25)*	*(1.10)*	*(-2.29)*
1990Q1-2000Q3	b_E	b_J	δ_E	b_J	b_E	δ_J
Estimate	0.20	0.28	**-0.28*****	0.20	0.21	-0.01
t-values	*(0.97)*	*(0.98)*	*(-1.78)*	*(1.11)*	*(1.67)*	*(-0.14)*

* Bold numbers indicate statistical significance at * 1 % level, ** 5 % level, and *** 10 % level.

The results from the long run relationship between prices in Europe and Japan indicate that the long run price adjustment to changes in the other region is larger in the 1990s than in the 1980s. However, when analyzing the cointegration relationship the results show that steam coal prices for the 1990s are not cointegrated. One likely explanation might be that the prices used in the regression are based on customs unit values. Customs unit values are average values derived from customs' administrations total volume and total value data. These data indicate broad price movements given that they reflect the contract terms and conditions under which the trade occurs. Preferable is therefore to use spot and tender prices that is reported in the trade press, given that these pertain to one time transactions, and thus reflect more short term market conditions. This provides a more accurate estimation of the price formation process.

A regression using spot and tender prices for steam coal during the 1990s has therefore been conducted. Spot and tender prices before this time period are not available, which is why the previous regression has not used spot prices. Figure 4 shows quarterly averages of spot and tender prices collected by Taipower in the Asia Pacific market, and by MCIS in the European market, as well as the reported customs unit values of steam coal during the same time period. The figure indicates that the spot prices are mostly lower than the customs unit values, and also there seem to be larger differences between the two dominating regions.

Figure 4
Spot and Tender CIF Prices for Steam Coal



Source: IEA (2001).

The same procedure as earlier is applied. The DF tests do not reject unit roots in levels, but do when variables are first differenced, which implies that tests for cointegration can be applied. The results when regressing spot prices in Asia-Pacific on spot prices in Europe, and vice versa, are presented in Table 8. The results indicate that that the long run price change in one region, due to a one percent increase in the other region, is not as large as when regressing customs unit values. The results show that when the price in Asia-Pacific increases by one percent, the corresponding long run increase in the European price level is 0.57 percent, compared to 0.99 percent in Table 9. The results when regressing prices in Europe on prices in Asia-Pacific show a similar result.

Table 8

The Long Run Cointegration Results for Steam Coal Using Spot Prices

STEAM COAL	**1992Q1-2001Q2**			
	Japan	**Intercept**	**Europe**	**Intercept**
Estimate	0.57	1.56	0.61	0.82
t-values	*(5.64)*	*(4.30)*	*(5.64)*	*(1.18)*

To test for cointegration the residuals from the regressions presented in Table 11 have to obey stationarity. However, when regressing the change in the residuals on past levels, with or without lagged changes, the results show that the residuals do not obey stationarity. This result is in line with the finding from regressing average steam coal prices in the 1990s. Thus, the spot markets in Europe and Asia-Pacific cannot, according to the cointegration results, be considered as integrated in the 1990s. To conclude, the results for steam coal when analyzing market integration over time indicate that the long run price change in one region, due to a one percent increase in the other region, is stronger in the 1990s, but the price series do not indicate cointegration, either when using custom unit values or spot and tender prices. However, one should be cautious when analyzing the results of market integration over time, given that the data set is reduced in half. A data set with fewer observations will be more sensitive than a data set with more observations.

5. Concluding Remarks and Policy Implications

The purpose of this paper has been to test the hypothesis of the existence of a single economic market for the international coal industry, and to investigate whether the industry has experienced increased market integration over time. This has been conducted by analyzing whether the price series in Europe and Japan, using quarterly data between 1980 and 2000, are cointegrated. If a long run cointegrating relationship is present, it is also of interest for market integration purposes to analyze the short run responses to price deviations in the other region. In order to analyze market integration over time the same analysis has been conducted when dividing the data set into two separate time periods, the 1980s and the 1990s.

The results, when examining the entire time period, show that both the coking coal and steam coal markets indicate the existence of a world market, as demonstrated by the long run cointegrating relationship between the price series in the different world regions. A policy implication from this result is that mergers within a particular country or region ought to be less problematic, since the relevant coal market is worldwide instead of local or regional. For antitrust analysts the result should be of interest given that since there is a single steam coal and coking coal market in the world, national and regional market-share measures are not the proper indicators when examining the market power for the firms in the industry. However, this is the long run results, and we also found it of interest to see if these results are confirmed in the short run estimates, and also when dividing the price series into two periods.

When analyzing the short run estimates the results seem to indicate a faster adjustment towards the long run equilibrium level for coking coal than for steam coal. Noteworthy is that the short run price adjustments are only significant from one direction, both for coking coal and steam coal. In the coking coal market, the results are consistent with Japanese prices influencing European prices, and vice versa in the steam coal market. This result may be explained by the timing of price negotiations, where the Japanese prices are normally settled before the European prices concerning coking coal, and vice versa for steam coal. In order to test for market integration over time, the price series data are separated into two time periods. The structural break in 1990 is confirmed for steam coal when using a Chow test, but not for coking coal. The results regarding steam coal show that the long run price change is stronger in the 1990s than in the 1980s. However, since cointegration cannot be confirmed in the latter time period the conclusion of a world market cannot be maintained. Furthermore, when conducting the same regression using spot prices, the price series do not indicate cointegration. It is though important to be aware of that the regressions of the shorter time periods do not contain as many data points, and it would be interesting to conduct the same regressions when using monthly or weekly data.

A policy implication of the finding that the steam coal market cannot be considered cointegrated in the 1990s, is that the market are more regional in scope, and thus mergers and acquisitions during this period might have added more to the merged companies' market power, as the same activity during the 1980s. In the coking coal market the situation is somewhat different. There are tendencies towards greater integration, given that the short run adjustment for the prices is stronger, and thus the evidence points towards an integrated world market, and thus the possibility that a given merger would result in non-competitive pricing is smaller. However the finding of no cointegration for the steam coal market in the 1990s does not have to imply that competition on the market is constrained. Defining market boundaries is a first step in competition analysis, and the presence of monopoly power and mark-ups depends on the price elasticity of demand which is not directly estimated in this study. Thus, the method applied is limited when analyzing antitrust issues, but it still provides useful information and guidance for the antitrust practitioner.

An important caveat concerning the error correction model is that it is sensitive to the different econometric specifications that are necessary for estimating the relevant coefficients, i.e. how many lags to include, should an intercept and trend be included in the model and so on. Because of this all results should be treated cautiously, and reliant upon the specified levels and orders. We therefore conclude that the results produced in this paper needs to be reinforced by the use of other methods in order to provide a more comprehensive analysis of market integration in the international coal market. The error correction model produces necessary conditions for market integration, but these are not sufficient for concluding that the market is fully integrated. It is therefore important to undertake further research concerning market integration, preferably using alternative research methods.

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