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ORIGINAL PAPER

Evolution of iron ore prices

Jacques Astier[1]

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Abstract The benchmark system to establish iron ore prices was abandoned after many years in 2010. Instead, the use of spot prices has increased and new systems based on indexes have been introduced. It seems as if iron ore prices in the first year after the discontinuation of benchmark negotiations were largely determined on the one hand by the cost of production of Chinese iron ores or concentrates and the price for imported ores on the other. These two are mainly influenced by (1) the increasing production costs of Chinese iron ore mines and (2) the general economic situation in both China and the rest of the world. The prices of iron ore, like many other raw materials and commodities, have been fluctuating widely since a few years. They have, in particular in recent times, been increasing. To understand the various mechanisms behind this development, four aspects will be discussed: Firstly, the evolution of the mechanisms to establish iron ore prices worldwide; secondly, the costs of producing saleable iron ore or concentrates as they are delivered to the iron and steel industry; thirdly, the important and growing role of China and finally, the present situation and future trends.

Keywords China · Iron ore · Price · Benchmark · Production cost

Iron ore price mechanisms worldwide

It is clear that in the end of the first decade of the twenty-first century, there was an interesting change in the way of fixing iron ore prices: during a long period prices were agreed by annual negotiations between the main steel companies and the major iron ore miners, what was known as the "benchmark system". Although some mining companies are trying to stick to an annual fixed price FOB, this system is disappearing. It seems to be replaced by a negotiation of prices based on various, more or less established indexes based on spot prices. It is hence important to remember that part of the iron ore trade is made based on spot prices.

The evolution of iron ore prices between 2005 and 2011 is shown in principle in Fig. 1. This figure has been constructed by using the prices during the last years of the benchmark system (i.e. FOB) and adding an estimate of the average freight cost for fines at about 65 % Fe from Brazil to the Far East. After the discontinuation of the benchmark system, estimates of spot prices for Indian 62 % Fe delivered to China have been used. The benchmark price is also indicated in Fig. 1.

This estimate can be compared to studies by World Steel Dynamics (World Steel Dynamics 2011) and reproduced in Figs. 2 and 3. Figure 2 confirms our estimates in Fig. 1. Figure 3 is more interesting in that it explains how iron ore prices are moving. There are two major facts to keep in mind when studying this figure. Firstly, China is by far the largest iron ore importer. In 2009, according to UNCTAD (UNCTAD 2010 iron ore statistics), it imported 628 Mt out of a world total of 937 Mt. Secondly, China is also relying on domestic production. It is, as we know from our visits and meetings in China,[1] costly because it is based on many relatively small and, often, difficult deposits of low-grade ores which necessitates costly preparation and beneficiation, depending on the nature of the deposits and the structure of the crude ores. As a

✉ Jacques Astier
magnus.1.ericsson@ltu.se

[1] Brassy, France

[1] The author has travelled widely in all Asia, including India and China, since the 1950s.

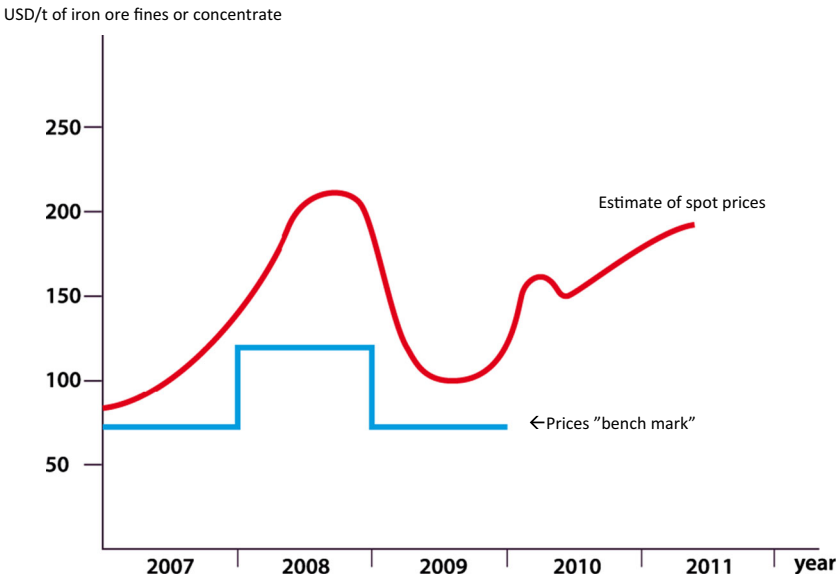

Fig. 1 Schematic evolution of iron ore prices delivered to the Far East (USD/t)

consequence, iron ore export prices to China varied between 150 and 200 USD/t of fines with a grade between 62 and 65 % Fe in the beginning of 2011. In this region, the market seemed to be in a kind of equilibrium between the imported ores and the ores from domestic producers.

Production costs of iron ore

At this point, it is important to have some general ideas about the production costs of iron ore. In a study published in Les Techniques de l'Ingénieur (Astier 2011), an up-to-date simplified model was developed. The results are shown in Table 1. The range of production costs for high-grade fines or concentrates as delivered to the iron and steel industry vary widely mainly depending on two parameters:

Type of mine, from the easy and relatively cheap extraction in large-scale open pits with limited over burden via mines with higher strip ratios to smaller operations and underground mines with highest costs.

Type of ores, similarly a wide range from natural, high-grade direct shipping ores (DSO) to lower grades but easy to concentrate to complex ores difficult to process.

It is clear that the large-scale, efficient operations in Australia and Brazil are on the left part of this table. This is in good agreement with Fig. 4. At the other end of the cost curve are Chinese mining and processing operations at the right end part of Table 1. This table emphasises the wide range of costs of

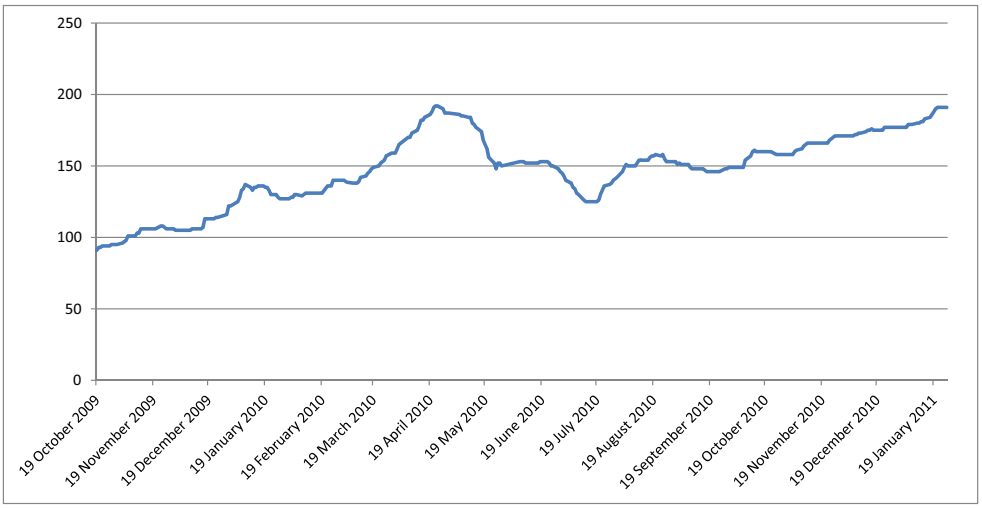

Fig. 2 Evolution of iron ore prices delivered to the Far East (daily average price, USD/dry tonne). Published with permission from World Steel Dynamics. Source: World Steel Dynamics (2011)

Source: Metal Bulletin

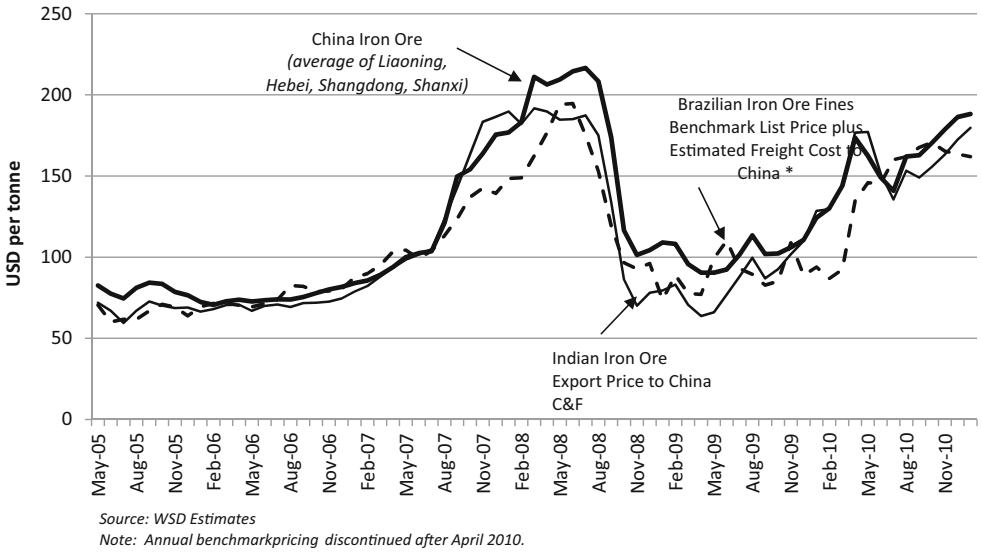

Fig. 3 Iron ore prices in China, domestic and imported ores. Published with permission from World Steel Dynamics. Source: World Steel Dynamics (2011).

production of iron ores worldwide, especially between the large open-pit operations based on naturally high-grade ores and the more difficult, smaller mining and processing facilities. From Table 1 and Fig. 4, it can be estimated that the major exporting mines of Brazil and Australia have operating costs of around 10 USD/t of fines FOB or 15 US cents (USc)/dmtu[2] also FOB. If general administrative expenses and transport costs are added, we estimate that the production cost is between 20 and 30 USD/t[3] of fines CIF China or 30–45 USc/dmtu again CIF China.

The Chinese mines and processing plants are probably among the smaller mining and processing facilities with highest operating costs. Assuming low or negligible transport costs, it can be estimated that the Chinese production costs are between 100 and 150 USD/t of fines at steel works or 150–225 USc/dmtu or even higher than indicated in Table 1.

The complete curve for the capacity of Chinese mines and processing plants as a function, at a given time, of the costs is not known but can be estimated from available information as shown in Fig. 5. This figure is based on the following assumptions:

> The various curves are not steep but flat as we assume that most Chinese mines are faced with similarly difficult conditions; as for example, small- or medium-sized operations, difficult and low-grade iron ores which need costly processing facilities.
>
> The production data are from UNCTAD, see Table 2. In this table, it also included our estimates of annual price levels for Chinese fines or concentrates.

[2] Dry metric ton unit=10 kg of iron content in dry ore.

[3] 10–20 USD/t transport might be a bit low but adding another 10 USD in freight cost does not alter the continued discussion.

It must be underlined that Fig. 5 is indicative and does not give precise figures. It does however give two clear trends.

Firstly, during the years 2000–2010, costs increased considerably partly due to increasing technical difficulties and partly to inflation driven by, among other factors, Chinese wages not being fully matched by productivity increases. Further, the prices and costs are expressed in US dollars, but the Chinese yuan has appreciated significantly vis-à-vis the dollar during the period shown. Secondly, this cost increase continues also in the future.

Development of the Chinese iron and steel industry

To understand the evolution of iron ore prices, it is necessary to review the impressive development of the Chinese iron and steel industry on the one hand and the mining and processing of ores on the other. The period after the revolution in 1949 can be divided into three: first developments from 1950 to 1973, evolution from 1974 to 2000 and recent achievements from 2000 to 2010.

First developments from 1950 to 1973

It must be remembered that the Chinese iron and steel industry started to develop from zero based on its own resources and relying entirely on the available domestic iron ores. Table 3 summarises the main data for this period. Steel production reached 25 Mt in 1973 and pig iron 25 Mt. Not only was the production based on domestic ores but also all other raw materials and resources needed were of Chinese origin. If we compare the official Chinese data (two last columns in Table. 3) with a Fe balance based on the need of Fe units to

Table 1 Estimated production costs of high-grade fines or concentrates (USD/t fob mid-2011)

Type of mining operations	Easy efficient open pit	More difficult mining operations	Easy efficient open pit	More difficult mining operations
Costs	5 to 12	10 to 20	5 to 12	10 to 20
Type of nature of the iron ore	Natural high-grade iron ores	Natural high-grade iron ores	More and more difficult ore to be concentrated[a]	More and more difficult ore to be concentrated[b]
Costs	5 to 12	5 to 12	15 to 20	20 to 25
Total range of cost FOB mine	10 to 24	15 to 32	30 to 56[a]	60 to 105[b]

[a] Assuming 3 t of crude iron ore/t of concentrates

[b] Assuming 4 t of crude iron ore/t of concentrates

produce the pig iron reported, the figures fairly well with each other. There is a small excess of Fe units produced over what is needed, but this could be explained by the loss of Fe units during the processing of crude ores.

Evolution from 1974 to 2000

In the 1970s, during study trips to China, it was clear that the Chinese authorities were well aware of the high costs of mining and processing of their domestic ores with low grades and complex composition. The authorities were also aware of the large quantities of easily available, cheap, high-grade iron ores on the world market. Thus, as illustrated in Table 4, the Chinese steel industry started to import larger and larger amounts of high-grade ores mainly from Australia and Brazil. Production of steel increased up to 131 Mt in 2000, and China became the most important steel and pig iron-producing country in the world. It should be noted that during this period, the expansion was more and more based on imported ores. China also became one of the leading importing countries. This is shown by the ratio of imported ore to total Fe needs: 15 % in 1990, 26 % in 1995 and 35 % in 2000.

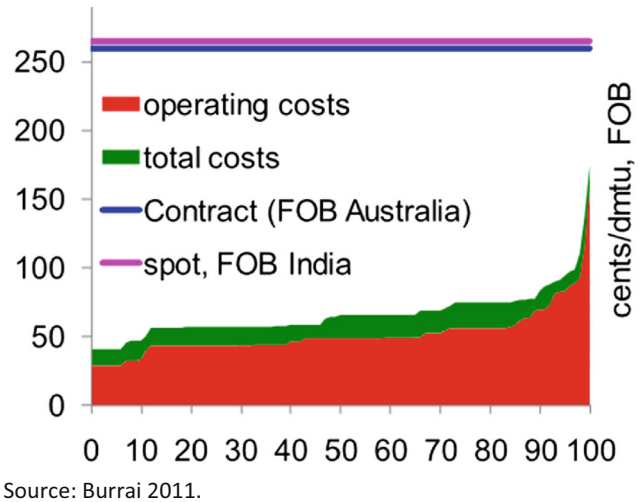

Fig. 4 Estimated cost curve sinter fines, Q2 2011. Source: Burrai (2011)

Recent achievements from 2000 to 2010

Since the year 2000, the growth of the Chinese steel industry has been impressive as shown in Tables 5 and 6. The import dependence has however increased further and reached 70 % in 2010. It means that Chinese production of concentrates is more and more difficult and costly (UNCTAD).

Possible evolution of iron ore prices

It is clear from the the preceeding tables and figures and supported by various statistical data and comments, especially from the Trust Fund on Iron Ore Information (UNCTAD, the iron ore market 2009–2011, 2010), that the world iron ore market is now dominated by China (see Table 5) and Chinese iron ore imports are and will continue to play a paramount role in this trade and particularly in determining iron ore prices.

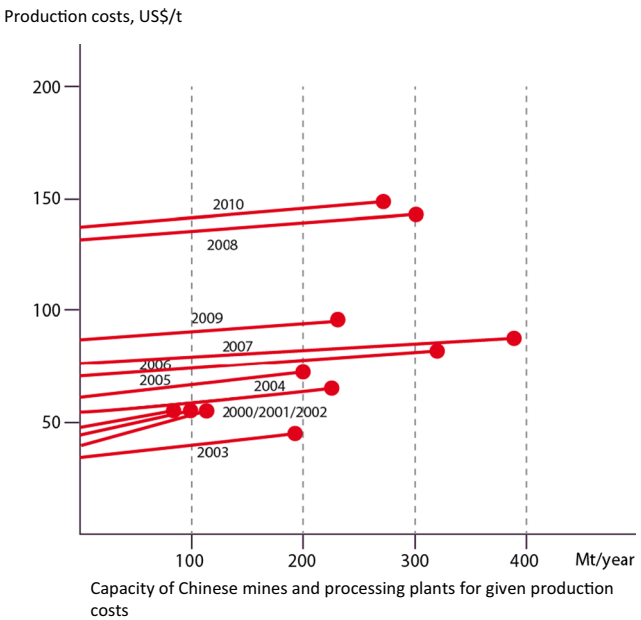

Fig. 5 Estimated cost curves of Chinese mines and processing plants

Table 2 Main characteristics of Chinese iron ore production

Year	Estimated fines or concentrates production (Mt)	Estimated prices of imported ores (USD/t)
2000	105	50
2001	102	50
2002	109	50
2003	208	50
2004	214	70
2005	284	70
2006	356	80
2007	400	90
2008	323	150
2009	234	100
2010	315	150

Table 3 Chinese iron ore, the first developments 1950–1973

Year	Pig iron		Iron ore production Chinese data	
	Mt	Mt Fe	Mt	Mt Fe
1950	1.0	0.95	2	0.6
1951	1.3	1.2	3	0.9
1952	1.9	1.8	9	2.7
1953	2.1	2.0	12	3.6
1954	2.9	2.7	12	3.6
1955	3.7	3.5	16	4.6
1956	4.7	4.5	17	5.0
1957	5.4	5.1	18	5.6
1958	13.5	12.2	30	10
1959	20.2	19	44	13.5
1960	25	24	55	16.5
1961	14	13	45	13.5
1962	11	10.5	50	15.0
1963	11	10.5	26	13.0
1964	12	11.4	29	14.5
1965	14	13.3	43	21.5
1966	14	13.3	31	15.5
1967	15	14.2	31	15.4
1968	16	15.2	42	21
1969	16	15.2	42	21
1970	17	16	64	24
1971	19	18	72	24
1972	21	20	85	25
1973	21	20	63	28

Sources: Pig iron data from World Steel Association (2011) (formerly IISI)

Iron ore data in the fourth column are from World Steel Association until 1959 and from 1960, it is from UNCTAD; the data in the fifth column are from official Chinese sources

Table 4 Chinese iron ore, evolution from 1973 to 2000

Year	Pig iron		Imported ores		Chinese iron ore production			
	Mt	Mt Fe	Mt 63 % Fe	Mt Fe	Our calculation		Chinese data	
					Mt Fe	Mt 63 % Fe	Mt crude ore	Mt Fe
1	2	3	4	5	6		7	8
1974	21	20	1.6	1.0	19	30	84	29
1975	25	24	1.4	0.9	23	36	94	29
1976	22	21	1.4	0.9	20	32	87	53
1977	25	24	1.4	0.9	23	36	94	53
1978	35	33	6.2	3.9	29	46	118	66
1979	37	35	7.2	4.5	31	49	119	42
1980	38	36	7.3	4.6	31	49	113	40
1981	34	32	3.3	2.1	30	48	105	49
1982	36	34	3.5	2.2	32	51	107	37
1983	37	35	4.4	2.8	32	51	114	30
1984	40	38	6	3.8	34	54	122	43
1985	44	42	10	6.3	36	57	138	46
1986	51	48	12	7.6	40	63	147	49
1987	55	52	12	7.6	44	70	144	50
1988	57	54	13	8.2	46	73	155	54
1989	58	55	13	8.2	47	75	160	54
1990	62	59	14	9	50	79	179	56
1991	68	65	19	12	53	84	175	
1992	76	72	25	16	56	89	196	
1993	87	83	33	21	52	83	235	
1994	97	92	37	23	69	110	239	
1995	105	100	41	26	74	117	262	
1996	107	102	44	28	74	117	252	
1997	116	110	56	35	75	119	267	
1998	118	112	52	33	79	125	247	
1999	125	120	55	35	85	135	237	
2000	131	124	70	44	80	126	224	

Columns 2 and 4 are official published information (UNCTAD)

Columns 3 and 5 are calculated with 95 % Fe in pig iron and 63 % Fe in imported iron ores

Column 6 is the difference between 3 and 5: the need of Mt Fe in Chinese iron ores with the calculation assuming the Chinese iron ore concentrates are 63 % Fe

Column 7 is the official Chinese iron ore production (crude ore)

Column 8 is the official Chinese data on Fe content in the crude ore, not published after 1990

Considering the cost curves from Fig. 5, it can be suggested, based on Fig. 6, that from the present situation (curve in black), there are two possibilities:

If price increases, the trend upwards and to the right will prevail where it will be possible for a number of Chinese

Table 5 Chinese iron and steel industry in 2010

Total world steel production	1414 Mt	
Chinese steel production	627 Mt	i.e. 44 %
Total world pig iron production	1030 Mt	
Chinese pig iron production	549 Mt	i.e. 50 %
Total world iron ore production	1830 Mt	
Total world iron ore trade	1068 Mt	
Total world iron ore maritime trade	1053 Mt	
of which Chinese imports	619 Mt[a]	i.e. 59 %

[a] The managing director of Sinosteel indicated at the Metal Bulletin Seminar in Geneva in 2011 that the expected Chinese imports could be 700 Mt in the year 2011 (Feng 2011)

mines to continue operating profitably or even some to re-open and a decrease of Chinese iron ore imports would follow. Such a development would be welcomed by Chinese miners, but steel producers in China, and elsewhere, would complain.

If price decreases, the arrow downwards and to the left indicates that an additional number of Chinese mines would get into a difficult situation and would probably have to close their operations and an increase of iron ore imports would take place. This development would be welcomed by steel producers in China and elsewhere but Chinese miners and other high-cost producers would complain.

Table 6 Chinese iron ore —the impressive latest developments

Year	Pig iron		Imported ores		Chinese iron ore production			
	Mt	Mt Fe	Mt 63 % Fe	Mt Fe	Our calculation		Chinese data	
					Mt Fe	Mt 63% Fe	Mt	Mt Fe
1	2	3	4	5	6		7	8
2000	131	124	70	44	80	126	224	
2001	156	148	92	58	90	142	217	
2002	171	162	111	70	92	146	231	
2003	214	203	148	93	110	175	261	
2004	268	255	208	131	113	179	310	
2005	344	327	275	173	154	244	420	
2006	412	391	326	205	183	290	588	
2007	477	453	383	241	206	327	707	
2008	470	447	444	280	167	265	824	
2009	549	521	628	396	125	198	880	
2010	590	560	619	390	170	270	1065	

Columns 2 and 4 are official published information (UNCTAD)

Columns 3 and 5 are calculated with 95 % Fe in pig iron and 63 % Fe in imported iron ores

Column 6 is the difference between 3 and 5: the need of Mt Fe in Chinese iron ores with the calculation assuming the Chinese iron ore concentrates are 63 % Fe

Column 7 is the official Chinese iron ore production (probably crude ore?)

Column 8 should be the official Chinese iron ore production in Fe content but is no more published as far as we know

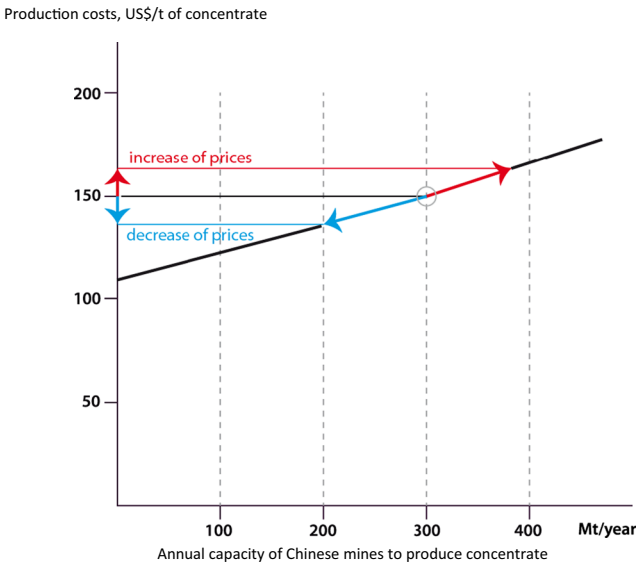

Fig. 6 Estimated variations of Chinese iron ore production as a function of price

In other words, the present situation appears to be fairly stable, unless an increase of production costs with general inflation or for other reasons moves the curve upwards and results again in a trend to increase iron ore prices. To summarise:

- A lower export iron ore price would benefit the steel industry worldwide and the major iron ore producers could manage such a situation without serious problems, but it would further decrease Chinese iron ore production.
- A higher iron ore export price would benefit Chinese mines, which would become more competitive and produce more ore and decrease Chinese imports at least in the short run. This is not an advantage for the iron ore-exporting countries. It would further not be appreciated by steel producers which have serious problems to transfer such a price increase to their customers.
- Finally, the decrease of the production rate of steel in China, the growing inflation and the present economic crisis could lead to a lowering of iron ore demand when new projects will increase supply (Östensson 2011) and thus point to a decrease in iron ore prices after 2012 rather than an increase.

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