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The Global Iron Ore Market: From Cyclical Developments to potential Structural Changes

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Abstract: This article reviews how financialization has affected the iron ore market since the turn of the century. We account for the existence of a Chinese iron ore futures market, the emergence of which can be explained by the progressive inability of long-term commercial contracts to meet the needs of players in the value chain, in a context marked by abundant supply, price competition between the main producers and high price volatility. We also focus our analysis on what this financialization reveals about the future of iron ore markets and, more generally, the future of the mining industry. Three elements appear essential. They are as follows: 1) the possible inclusion of environmental criteria in the purchasing policy of steelmakers, which could result, all other things being equal, in greater demand for high grades and the affirmation of the 65% iron (Fe) grade as the new international price reference; 2) a progressive financialization of the upstream economic sectors, particularly minerals, in a context where base metals are all subject to future contracts; and 3) a growing assertion of Chinese commodity exchanges internationally in order to offer both price references in line with the economic weight of this country and hedging instruments designed for domestic industries.

Keywords: Commodity prices, iron ore, financialization, steel industry, environment.

1. Introduction

The iron ore market has probably received less recent media attention than base metals (copper, nickel in particular) and strategic metals such as lithium or cobalt, the extraction of which is associated with more visible and widely-documented environmental impacts. Overall, to the best of our knowledge, very little scholarship has been produced in the field of economics on the iron ore market. Yet, iron ore is, in many ways, emblematic of what commodity markets are all about. It is a “homogeneous” product: characterized by a given amount of marketable metal content (52%, 58%, 62%, 63.5%, 65% Fe content according to most available price indices). The quality of iron ore, however, is, much like any extractive or renewable resource, a determining factor of its price but differentiation strategies are, for now, ineffective in the long run. In other words, and because iron ore is a commodity like any other, when there is a demand shock, whether positive or negative, there is little or no differentiated effect on its price, regardless of quality or geographical origin. Moreover, the physical and financial volumes involved in international trade are considerable: worldwide, 2.162 billion tons of iron ore were produced in 2017, with an export volume of 1.639 billion tons over the same period (Worldsteel, 2018). As indicated in Table 1, the iron ore market is dominated on the supply side by four mining giants (Vale, BHP Billiton, Rio Tinto and Fortescue Metal Group or FMG) and by two countries, Australia and Brazil, which exported 872.75 and 383.53 million tons, respectively, in 2017. Not surprisingly, on the demand side, Chinese steelmakers are the world’s largest importers. Although China is a major producer of iron ore (albeit of low grade), it imported nearly 1.07 billion tons in 2017, with the dynamism of demand from the Chinese steel sector being one of the key variables influencing the level of prices. The market structure

is characterized by imperfect competition, most probably of a bilateral oligopoly type, just like many commodity markets.

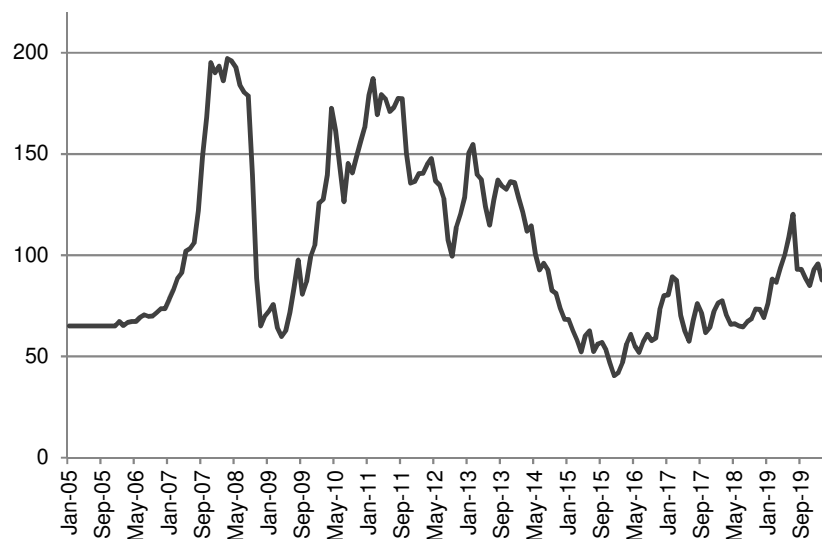
Table 1: Main iron ore producers (million tons)

Company	2014	2015	2016	2017
Vale	332.00	342.99	348.85	366.51
BHP Billiton	204.00	237.34	226.32	230.86
Rio Tinto	295.00	327.57	347.62	348.81
FMG	159.90	167.50	190.80	191.40
Total	990.90	1075.40	1113.59	1137.58

Source: companies' websites

Although the iron ore market has all the characteristics of a large commodity market, it is nevertheless unique in many respects – particularities which warrant in-depth analysis. First, unlike other mineral markets (particularly the bauxite market), it is a market where spot transactions are more prevalent than long-term fixed-price or even transfer-price contracts (Astier, 2015). As a result, short-term price volatility is, on average, historically high, which is another distinctive feature when compared to other base metal ores. Thus, while the price of bauxite varies only slightly, the price of iron ore has followed the dynamics of metals (and other major commodities) in the super-cycle of raw materials with a historical high reached, as a monthly average, in January 2008 at more than \$190/dmtu, then a significant drop over the years 2014 and 2015 due to a drop in Chinese demand and a form of price war between major producers that brought them to nearly \$40/t in January 2016. They then returned to an upward trend. Over the first few months of 2020, they proved resilient in the face of the covid-19 pandemic, but this was mainly due to the consequences of a temporary constraint on supply linked to the Brumandinho tailings dam disaster and a succession of climatic hazards in Brazil (flooding) and the Pilbara mining region (cyclone) in Australia.

Figure 1: Long term dynamics of 62%Fe iron ore spot price (US\$/dmtu)



Source: World Bank Commodity Price Data (The Pink Sheet)

The price risk resulting from this instability has created the conditions for a financialization of the market, which, albeit partially, is unique in mining industries. This is all the more particular since, at the downstream end of the value chain, steel is not fundamentally financialized

despite numerous attempts to do so¹, whereas all base metals are traded on commodity exchanges (London Metal Exchange – LME; New-York Commodity Exchange – Comex, a subdivision of the Chicago Mercantile Exchange – CME- group). As indicated in Table 2, an iron ore futures contract with physical delivery has indeed been available on the Chinese Dalian Commodity Exchange (DCE) since October 18, 2013. Denominated in yuan, this derivative product has been approved for trading to foreign investors by the China Securities Regulatory Commission (CSRC) since May 4 2018 (Friday). This is the most liquid iron ore contract but it is not the only one available. Indeed, cash-settled contracts can also be traded on the Intercontinental Exchange (ICE Europe), on the CME and, in Asia, on the Hong Kong Exchanges and Clearing Limited (HKEX) and the Singapore Commodity Exchange (SGX). As mentioned above, the market has historically been structured around a single price index: the 62% iron content index.

Table 2: Main iron ore futures contracts

Exchange	settlement	underlying asset	Reference price/ delivery venues	Contract Size	Currency
CME (Nymex)	cash	Iron ore price index	TSI Iron ore fines 62% Fe - CFR China Port	500 DMT	USD
			Iron ore fines 58% Fe, low alumina – CFR China		
DCE	physical	Iron ore	DCE warehouses and delivery locations appointed by DCE	100 MT	RMB
HKEX	cash	Iron ore price index	TSI Iron ore fines 62% Fe - CFR China Port	100 T	USD
ICE (Europe)	cash	Iron ore price index	Platts IODEX 62% Fe daily index, CFR North China	1,000 DMT ²	USD
			The Steel Index (TSI) Iron Ore 62% Fe, CFR Tianjin	500 or 1,000 DMT	
			Difference between the Platts daily assessment price for IODEX 62% Fe and TSI daily assessment price for Iron Ore	1,000 DMT	
SGX	cash	Iron ore price index	TSI iron ore (58% Fe or 62% indexes)	100 T	USD
			Metal Bulletin iron ore (58% Fe) index		
		Iron ore lump premium	Platts IO Spot Lump Premium 62.5% CFR China Index		

Source: Commodity exchanges' websites

It is important to clarify that the multiplicity of these futures contracts cannot however be interpreted as a sign of a complete financialization of the iron ore market. To our knowledge, the DCE contract is not widely used outside of China, while cash-settlement contracts are an intermediate step towards physical delivery contracts that can, when traded on very liquid markets, become an underlying asset for call and put options as in the case of the most mature financial markets. The existence of these derivatives means that the various players in the value chain can hedge against the risk of an unfavourable change in the price of iron ore, but also that physical speculation – which is always possible in the world of commodities through stockpiling strategies – may be coupled with bullish or bearish financial speculation through long or short positions.

In light of these various factors and considering the economic and strategic stakes involved, two fundamental questions need to be asked, one retrospective, the other prospective: The first is what are the reasons for the atypical configuration of the value chain linking iron ore to steel in which the former is partially financialized while the latter is not? Second, what are the

¹ We are not ignoring the fact that future contracts using different steel products (scraps, rebar, wire rod, hot-rolled coil, etc.) as underlying assets do exist on the LME, CME or SGX, but they are not physically settled. They are cash-settled which means that they cannot be considered as price references *per se* – which is one of the primary role of a future contract (Black, 1976) – but use a pre-existing price index offered by PRAs. As a result, they cannot be considered as the most advanced form of futures contract. The SHFE does offer a rebar future contract allowing for physical delivery but, albeit it is widely observed by operators, it is only traded by Chinese players and cannot be representative of global dynamics as is, for example, the LME aluminium future contract.

² Dry metric tons.

structural changes that this market could undergo over the next decade? In particular, will new futures contracts with physical delivery develop and establish themselves internationally as a price references and risk management tools, or will the DCE contract become international and become the new marker of China's assertiveness in global commodity derivatives markets? In this respect, will the 62%Fe price remain an unavoidable basis for defining the price of other grades (using positive and negative differentials) or will the 65%Fe price become the new international reference in the light of greater demand for ore with a higher environmental value? Finally, should we consider the emergence of iron ore futures contracts as the harbinger of a more general movement of financialization upstream of the metallurgical sector?

2. Financialization: a mirror image of past structural changes in the iron ore market

Financialization is a phenomenon in particular which cannot be assimilated to speculation alone, even if it is one of its direct consequences. Iron ore is the only mineral with a market that has been financialized. It is therefore important to understand what explains this atypical evolution.

2.1 The reasons behind the partial financialization of iron ore markets

The phenomenon of financialization is probably one of the developments in commodity markets that has been most studied by economists over the last decade. The question then was whether the 2002-2012 commodity super-cycle, which saw the prices of most commodities soar, was primarily due to fundamental factors, in particular the explosion in demand from emerging countries and China, or to the development of speculative strategies by “non-commercial” traders, as defined by the Commodity Futures Trading Commission – CFTC (Irwin and Sanders, 2012; De Meo, 2013; Büyüksahin and Robe, 2014; Etienne *et al.*, 2014). Obviously, these two explanations are not mutually exclusive and the objective of many research papers produced on this subject is to measure the influence of commodity index traders (CIT) and managed money traders (MMT) on price dynamics. Irrespective of the results of these scientific articles, it must be noted that financialization is systematically understood in a narrow sense (i.e., having an increased presence of investment funds on commodity derivatives markets, whether index funds or hedge funds). However, it should be noted that some commodity sectors do not have futures contracts, while others are totally dependent on these derivatives markets, particularly in terms of price formation mechanisms. It is therefore fundamental to understand the reasons behind this financialization, in the broad sense of the term – namely, the development of a futures market. In line with the abundance of research articles on the optimality of organisational structures within a value chain, this requires an analysis of the type of commercial contracts that are most commonly used in the industry and an understanding of whether or not these contracts give rise to price risk and consequent demand for hedging.

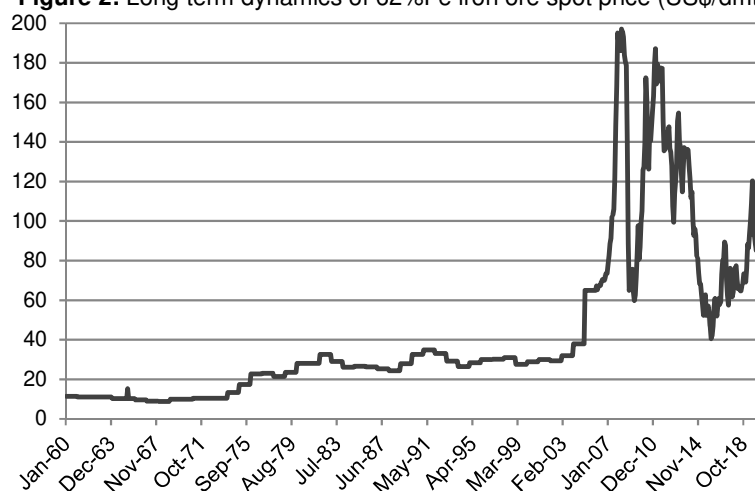
There are basically four main types of commercial contracts between producers, end-users and commodity traders: (i) spot and (ii) forward contracts providing for a single delivery of the raw material, as well as long term contracts (LTC, infra-annual, annual, multi-annual) with periodic deliveries and in which prices are fixed (iii) – although these may be indexed with periodic review clauses – or not (iv). In the latter case, a price reference and price formulas are defined but the actual price paid is only known at the time of each delivery (these reference prices may be based either on indices offered by price reporting agencies – PRA – such as Platts or CRU or directly on the prices of nearby futures contracts, which we believe is a building block of a financialized commodities industry). These different types of contracts must be analysed in terms of the risks they carry, in particular price risk and counterparty risk. Forward contracts and long-term fixed-price contracts protect buyers and sellers from price risk but are fully exposed to the counterparty risk, whereas it is the opposite for spot contracts

and price-reference contracts. Considering the high level of price volatility, one might wonder why commodity industries, historically structured around these LTC, are tending to move towards commercial contracts more exposed to this price risk. This was the case for the primary aluminium market as early as the 1970s with the launch of the first future aluminium contract by the LME in 1978 and it is today one of the major developments that characterize the LNG market (Chiappini *et al.*, 2019). Spot or price reference contracts are indeed exposed to price risk and one could imagine that they were not favoured by industrial operators. In reality, it must be understood that the switch from one type of contract to another is the result of an arbitrage between this price risk and the counterparty risk. In LTC, any significant and lasting discrepancy between the contract price and the market price can indeed create a strong incentive for the buyer or seller not to respect his commitments in order to take advantage of more favourable market conditions. This counterparty risk is *a priori* low when the variability of commodity prices is low and/or when the industrial and commercial proximity between the co-contractors is significant with, as a consequence, low information asymmetries. In the case of LNG, the considerable cost of liquefaction and regasification infrastructure has created the conditions for strong interdependence between producers and importers and thus for the use of LTC. According to Williamson's transaction cost theory (Williamson, 1975), the prevalence of long-term contracts can hence be understood as an optimal solution to the problem of *ex-post* "hold up" risk existing when business relationships require the presence of a specific asset (*i.e.*, an asset whose value is greater within bilateral trade relations than outside them, such as onshore liquefaction and regasification units) by avoiding the significant renegotiation costs associated with spot contracts and the very high rigidity, among other problems, of vertical integration. As shown by the statistics of the International Group of LNG Importers (IGLNGI), the share of spot and short-term contracts in total trade has increased structurally in recent years (from 12% in 2004 to 34% in 2019). This is the result of not only buyers' demand for flexibility linked in particular to the considerable increase in production capacity, but also increasing bilateral trading experience between the contracting parties which *de facto* decrease contracting costs

As documented by Wårell (2014) and Astier (2015), the iron ore market was too functioning under a LTC regime for several decades and it was not until 2008/2010 that a major change in the pricing structure emerged. From that date, the "benchmark system" or "producer pricing regime" progressively disappeared in favour of a trading system based on the use of price indices that are themselves constructed on the basis of spot prices. While it is difficult to know who was the first mining group to sign a quarterly trade agreement, it must be acknowledged that BHP was one of the strongest advocates of a change in favour of an index-based method for quarterly pricing, which would be gradually transformed to the monthly pricing. Few explanatory elements by these authors are nevertheless provided to explain such a structural change. Several hypotheses which are not mutually exclusive can, however, be made to understand this increasing flexibility of the iron ore market. The first is that the policy of maintaining relatively stable prices has proved to be increasingly costly for the main producers and that, since the costs of remaining in such a system have become higher than the profits, they have chosen to abandon it. As can be seen in Figure 2, iron ore prices, after a very long period of stability, experienced a very high degree of variability from the end of 2004 onwards. It reached a historic high of US\$197/dmtu³, as a monthly average, in March 2008, then fell to US\$64/dmtu a year later, following the onset of the global financial crisis. This pattern will be repeated a few years later when iron ore prices dropped from US\$135/dmtu in December 2013 to nearly US\$40/dmtu in December 2015. More recently, the failure of the Brumadinho dam (Brazil) on 27 January 2019 led Vale to shut down nearly 90 million tons of production capacity, raising prices by more than 15% in early February of that year.

³ Dry metric ton unit.

Figure 2: Long term dynamics of 62%Fe iron ore spot price (US\$/dmtu)



Source: World Bank Commodity Price Data (The Pink Sheet)

Mitigating such price variability would require producers to adjust the market by quantities and to do so in a coordinated manner, by continuously adjusting production quantities and inventory levels to changes in demand, in particular Chinese demand. The example of aluminium clearly shows that, in the 1970's, the increase both in the nature and the number of producers led to a decrease in the industry concentration ratio (Nappi, 1985 & 1989) and, consequently, to a much complex coordination issue which has favoured the launch of the LME aluminium future contract. It is clear that the iron ore market is evolving in the same paradigm in which price competition is the master word. The financialization of the iron ore market is undoubtedly possible because of the intensity of competition between the various producers. By way of illustration, during the fall in prices observed between the beginning of 2014 and the end of 2015, the "Big Four" committed themselves not to a reduction in supply but to a strategy of compensating for the negative price effect by a positive volume effect which resulted in a price war with a very strong rationalization of production costs as a backdrop. By favouring market adjustment through prices and consequently accepting high price variability, producers create *de facto* conditions for high counterparty risk within long-term contracts and thus foster the use of spot or fixed price contracts instead. This paves the way for the phenomenon of financialization, which is fuelled by this increase in price risk. It should also be noted that accepting this price risk is easier since there exists, on a commodity exchange, a futures contract allowing to manage it efficiently and especially more easily than in the framework of a forward or LTC. From this perspective, it should be remembered that an organized market (*i.e.* an exchange), whether it involves derivatives or not, relies on the use of a clearing house as an obligatory intermediary between buyers and sellers. Moreover, the use of futures contracts simplifies the division in time and space of this risk which, by nature, facilitates its transfer. For example, a Chinese steelmaker wishing to hedge 100% of its price risk on short physical position of 1,500 metric tons of iron ore will be able to buy 15 futures contracts on the DCE and, as a result, have up to 15 indirect counterparties which can, at any time, offset their short position without this having an impact on its own strategy.

While it is easy to understand why a future market has emerged in the iron ore industry, an unanswered question is why other markets, such as that for bauxite, have not experienced such a development. Each commodity chain is unique and one could make idiosyncratic arguments to explain this reality, but it is important to stress that any commodity market must, in absolute terms, be analysed in terms of its relationship to all the other markets in the value chain. In particular, it is difficult if not impossible to understand the financialization of the iron

ore market without looking at the organizational structure of the downstream sector (*i.e.*, the various steel markets). These markets are minimally financialized or not at all: numerous attempts to launch futures contracts have been made over the last two decades, but these have generally failed and only the rebar contract listed on the Shanghai Futures Exchange (SHFE) has gained significant liquidity and international recognition as a legitimate price reference.

The crude steel market is, in physical and financial terms, considerable: 1,869.9 million tons (Mt) for the year 2019 according to the statistics of the World Steel Association. It is, in this respect, more important than that of aluminium and, given the importance of the financial stakes it represents, it might seem surprising that it does not have reference futures markets whereas primary aluminium has been traded on the LME since 1978. There is probably a simple reason for this: the steel market is segmented both geographically and in terms of the finished and semi-finished products traded (hot-rolled and cold-rolled coils, sections, plates, wires, etc.). This means that a single futures contract cannot meet all the price risk management needs of the industry, especially since trade barriers limit the ability of markets to be integrated globally. Moreover, some steels, particularly those known as “specialty steels”, are hardly a commodity. They are more tailor-made products than standard products that are globally traded. For these reasons, the constraints associated with the development of financial derivatives on steel are much greater than those associated with base metals, which remain relatively homogeneous and globally traded products. The absence of multiple futures contracts on steel prevents the implementation of a cross-hedging strategy on iron ore, if one makes the reasonable assumption that the price of iron ore is fairly broadly correlated with that of steel as long as time lags are taken into account (due in particular to the inventories strategies of steelmakers). In other words, the low and complex financialization of steel markets has left the problem of the price risk on iron ore intact and this may also have been one of the reasons for the development of a future market.

2.2 The consequences of financialization

The first intrinsic consequence of the development of a futures market is to set a price reference, observable by all, without cost and without delay, which, when market liquidity is sufficiently high, is incorporated into commercial contracts as a basis for negotiation to determine the effective price to be paid/received. In a reference price contract with monthly delivery, the commercial price payable can thus be determined by a price formula such as the monthly average of the daily closing prices of a reference market such as the LME. While the development of a futures market responds to needs expressed by a value chain, it is not nevertheless without constraints and negative consequences. In particular, such a market cannot function sustainably if it does not attract the interest of speculators whose economic role, independently of any normative issues, is to assume part of the price risk that the commercial/industrial players cannot (or do not want) to bear. More precisely, and as it has been extensively documented, their role is to correct the asymmetry of hedging. For Gray (1966):

“The sales and purchases that hedging firms have to make cannot be expected to sustain a balanced futures market, even when the contract is fair and there is reasonable competition on both sides. One reason for this is that a futures market needs liquidity, which hedging firms do not provide, but a more important reason is that hedging is nearly always unbalanced in favors of the short side”. [p. 161]

Given the scale of Chinese imports, it is reasonable to assume that such an imbalance would exist in the case of the DCE future contract with more long positions (by steel producers) than short positions (by domestic mining producers) among commercial operators.

Futures trading by these speculators means that iron ore prices do not only respond solely to changes in fundamental variables (steel demand, inventories, exchange rates, price of steel

scraps), but also to bets on future price levels that these traders make. This undeniably reinforces the weight of expectations in iron ore prices formation and results in increased instability, whether it materializes by an increase in price volatility and/or by the recurrent development of speculative bubbles. Besides, the risks associated with the excessive development of speculative activities led the China Securities and Regulatory Commission (CSRC) to intervene at the beginning of 2016 to signal its desire to avoid such a risk on the DCE. However, there are, to the best of our knowledge, no studies on the effect of the introduction of an iron ore futures contract on the volatility of spot or commercial prices. Nevertheless, the analysis conducted by Wårell (2014) over the January 2003-August 2012 period (divided into two sub-periods: January 2003-November 2008, and December 2008-August 2012) addresses an important issue: namely, the impact of spot market pricing on both price level and volatility, in line with the long tradition of research papers on the determinants of volatility in commodity markets, particularly base metals' markets (Mayer *et al.*, 2017). While the abandonment of LTC in favor of spot pricing is sometimes perceived by producers as a solution to capture surplus revenues in periods of price fly-ups, the author shows that, in the case of iron ore, this change had no impact on the price level on monthly real prices of Chinese imported iron ore fines (62%Fe spot CFR Tianjin port). During the second sub-period, price volatility, on the other hand, has seemingly been exacerbated by the adoption of this spot pricing practice. However, the author suggests that these results could be biased due to differences in the construction of price series between the two periods, the first not including freight costs which can be particularly volatile. Thus, by creating a new price series taking into account the cost of transport over the whole period, Wårell (2014) shows that, on the contrary, price volatility was reduced after the adoption of the spot price system due to a strong increase in the variability of freight prices at the end of the first period.

Price instability is characterized not only by short-term volatility but also by the appearance of speculative bubbles. This aspect is studied by Etienne (2017) over the February 2014-June 2016 period using a series of daily prices constructed on the basis of the prices of nearby contracts on the DCE.⁴ The author shows that episodes of irrational exuberance are present but these are most of the time short-lived bubbles (less than one week with the longest episode occurring in mid-July 2014 and lasting nearly a month) which to prove that the market reacted promptly to any mispricing due to speculative trading. Su *et al.* (2017) raise a similar question but for a much longer period (January 1980-December 2016) and on necessarily different price series: this is a monthly frequency and is extracted from the IMF Commodity Database. The study finds that four bubbles of significant size (compared to the previous analysis) developed over the period: January-March 2005, February-August 2006, February-December 2007 and a particularly long bubble between February 2008 and October 2011, despite the 2008 financial crisis. From this perspective, the idea that the iron ore market tends to correct speculative drifts quickly by refocusing on fundamentals must be qualified.

3. The financialization of the iron ore market: A forerunner of likely changes in the markets for industrial minerals?

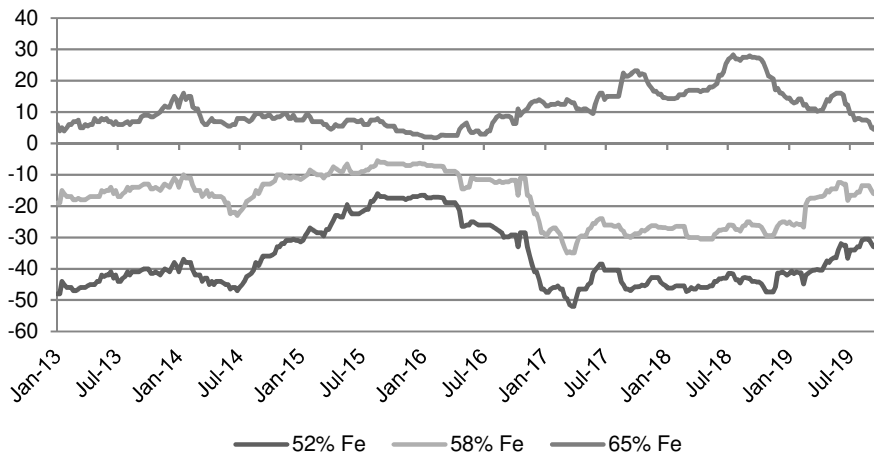
The financialization of the iron ore market is a phenomenon that must not only be explained, but also understood as the premise of the developments that could occur in the commodity markets upstream of base metals, particularly those for ores. Two questions seem particularly important from this point of view. The first is: will the environmental changes in the world economy have an impact on the markets for ores and base metals beyond the effects already observable with certain metals linked to the energy transition (*i.e.*, copper and nickel)? Second, will there be a “backward shift” in the base metals sectors, which would be reflected in increased flexibility and financialization of mineral markets?

⁴ By rolling prices into the next-to-expire contract on the first business day of the delivery month.

3.1 Towards a “greener” iron ore market?

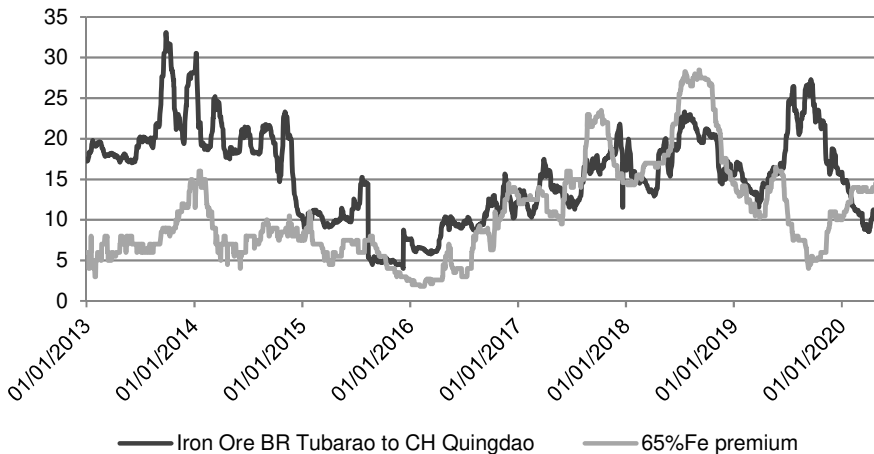
As mentioned above, the very characteristic of a global commodity market is that it is based on the prevalence of one or more price references (such as Brent or WTI for crude oil or LME references for base metals) on the basis of which all prices will be defined by a system of positive or negative differentials which should prove to be relatively stable over time. However, this does not mean that this price reference is immutable. Thus, while the 62%Fe grade has long structured the iron ore market, it is possible that different price references, particularly the 65% grade, may overtake it over the next decade. If we also look at the differential between the 62%Fe grade and the 65%Fe grade, a strong variation can be observed since 2013: while the price differential between these two ores was hovering around US\$2-3/dmtu at the beginning of 2016, it rose to nearly US\$30/dmtu in the summer of 2018 before returning to levels below \$10/dmtu from the middle of 2019 (Figure 3). Understanding the reasons for this significant variability in the differential between 62%Fe and other grades of iron ore requires in-depth econometric analysis. Based on the use of markov-switching models or VECMs with multiple structural breaks, this analysis must be able to highlight whether this evolution is primarily cyclical or whether it corresponds to one or more structural changes that are likely to persist (Chiappini *et al.*, 2020). Nevertheless, some initial explanations can be provided.

Figure 3: Evolution of price differentials for different grades of iron ore compared to the 62%Fe grade (US\$/dmtu)



Source: Thomson Reuters

Figure 4: 65%Fe premium and freight costs (Brazil Tubarao to China Quingdao, USD/DMT)



Source: Thomson Reuters

High-grade iron ore enables steelmakers to achieve better environmental performance by reducing coking coal consumption and therefore carbon emissions. Following “the blue sky” plan launched by Beijing in 2018, the environmental performance constraints now weighing on the Chinese industry can thus lead, all other things being equal, to steelmakers buying this type of ore and not the lower-grade ores, *i.e.* to a higher differential. Other variables must nevertheless be taken into account, among which maritime freight costs (graph 4): shipping ore from Brazilian (Tubarão) to Chinese ports (Qingdao) is more expensive than transporting it from Australian ports (Port Hedland in particular) and this may partly explain this positive differential. It should be noted, however, that if high freight costs may be added to the price of Brazilian ore and explain a significant differential or, symmetrically, constitute a “comparative disadvantage” which could reduce demand for 65%Fe iron ore and thus weigh on its price. To add to the complexity of this question, account must also be taken of a possible dual causal relationship: a high freight cost which could certainly “cause” an increase in the price of ore as mentioned above and a high ore price which could be the sign of a significant import demand and therefore encourage higher freight costs. Furthermore, steelmakers must preserve their profit margins and thus control the cost of their inputs, which works against the 65%Fe grade when the level of ore prices is already high. As shown by Chiappini *et al* (2020), there is indeed a negative dependence between the level of iron ore prices and the relative demand for high-grade ores. Conversely, higher coking coal prices may encourage the use of high-quality ore. The analysis of the differential between the different qualities of iron ore is therefore particularly complex because of the multiplicity of variables to be taken into account and the mechanisms at work. It would therefore be particularly important to observe, over the coming years, the degree of correlation between the various iron ore price indices. The extent of iron content depends not only on the concentration process but also on the mineralogical and metallogenic properties of the deposit from which it is extracted. A structural change in the type of iron ore most consumed worldwide would therefore have major macroeconomic and political consequences, particularly for countries such as Guinea. Located in the Nzérékoré and Kankan regions of southeastern Guinea, the Simandou deposit is the world’s richest untapped iron ore deposit. According to the Guinean Ministry of Mines and Geology, Blocks 3 and 4 (Simandou South) are believed to contain ore with a particularly high grade of 65.5%, and the magnitude of the demand for such ore is naturally critical to the country.

3.2 A slow but on-going upstream financialization process

The development of iron ore contracts should not only be analysed in an isolated logic but also, in a forward-looking logic, of what it means for other mineral industries. In other words, the question that arises is whether the development of iron ore financial derivatives will remain an atypical phenomenon or whether, conversely, it prefigures a slow “backward movement” that will see ores, such as bauxite, become a new underlying asset for futures contracts. Indeed, it should be noted that in the universe of commodities traded on large world markets, the phenomenon of financialization is particularly advanced: all base and precious metals use, to varying degrees, futures contracts, while strategic metals, cobalt and lithium are now traded on the LME, even though they do not have the same influence on commercial prices as other metals. In this respect, it is clear that commodity exchanges, which are companies like any other, are in strong competition with maintaining or gaining market share as their objective. Commodities that remain “financializable” are the focus of all their attention. This is the case for the fertilizer industries (phosphate, potash, urea) which have already experienced in the past the experience of future contracts (Bollman *et al.*, 2003) but also for certain minerals such as bauxite.

This backward movement is in fact already under way in certain industries, in particular the aluminium industry, with the launch of several contracts on alumina, an intermediate product between bauxite and aluminium, over the last five years. Historically, alumina was priced as a percentage of the outright price of aluminium on the LME, but these LTC have progressively been replaced by price-reference contracts using indices calculated by PRAs. Two cash-

settlement contracts on alumina (FOB Australia) were then introduced in the summer of 2016 on the CME, while on March 11, 2019, the LME launched a similar contract. Further upstream, the bauxite case is different with low liquidity on the spot market and producers' LTC pricing remaining the norm. The probability for financialization remains low but not nil. There is a simple reason for this. Beyond the existence of a need for price transparency, a need for tools to hedge against price risk and speculation, the launch of a future contract and its success depend on a number of technical characteristics (Shahidur *et al.*, 2010). The propensity of the mineral resource to be standardized and therefore its fungibility are, from this point of view, two absolutely essential properties. For the commodity exchange, the launch of a future must be profitable in the long term, which requires its market to become liquid and this in turn requires that the contract specifications meet the needs of the greatest number of players. Because of the multiplicity of chemical properties defining an ore, the verification of this criterion is a priori much more difficult than for a metal (with the exception, as mentioned above, of steel).

The low level of basis risk associated with the future contract is also one of the *sine qua non* conditions for its success. While it is common to say that derivatives (options, swaps and futures) offer protection against different types of risk (price, credit, exchange and interest rates, etc.), this is not entirely true in the case of futures. In reality, they simply allow an arbitrage between a flat price risk (that linked to the rise or fall in the price of the commodity) which is supposedly high against a basic risk (that linked to the decorrelation between physical prices and futures prices) which is, by construction, lower. The specifications of the contract (quality, place of delivery, type of Incoterms in particular) are therefore essential for the basic risk to be minimized and any design error in this area may lead to the failure of the contract. In view of these various criteria, it appears unlikely that the bauxite will be the subject of a future contract in the coming years. The devil is in the detail though and market developments that might seem minor are, in reality, often indicative of a gradual change in pricing mechanisms. In this respect, the frequency at which PRAs assess benchmark prices is a relevant indicator of the dynamism on the spot market and it is worth noting that in 2017 PRA Fastmarkets Metal Bulletin launched two bauxite spot price assessments: Fob Guinea and Fob Brazil.⁵ Other mineral markets may also be experiencing a change in pricing practices (e.g. chromium or manganese ores), but no comprehensive study seems to have been conducted on this subject in recent years. The economic and political stakes are considerable, however, and there is a subject for study that urgently needs to be addressed.

The development of the futures iron ore contract on the DCE is, in our opinion, also representative of the ambitions of Chinese players in the financial sphere of derivatives. As mentioned earlier, the effectiveness of hedging strategies depends on the level and stability of the correlation between the prices of futures contracts and those of commercial contracts. This correlation in turn depends on the specifications of the futures contract: the quality of the underlying asset, the size of the contract, the different maturities, and the delivery locations. However, it should be noted that while the LME has licensed warehouses around the world, this is not necessarily the case for most other commodity exchanges, particularly those in the United States and Europe. Moreover, although this observation calls for much more in-depth analysis, the mere fact that the vast majority of these contracts are listed in US dollars is a major handicap for non-US participants. At a time when China's position on commodity markets is overwhelming, particularly in the production of steel and hence iron ore imports, this can only be seen as a form of paradox which Beijing cannot accept indefinitely. Beyond the essential question of the internationalization of the renminbi, the first step to achieve this is to allow foreign players to trade on commodity exchanges, whether the SHFE or the DCE, while defining futures contracts that meet the requirements of Chinese traders. This is precisely why the Shanghai International Energy Exchange (INE) launched in March 2018 a futures contract with physical delivery on medium-density oil from the Persian Gulf with the

⁵ Market spotification is not a linear or even irreversible trend: whereas these indices were published every two weeks, since mid-2019 the frequency has been monthly due to the low liquidity of the spot market.

particularity of being the first future contract listed on the Chinese mainland open to overseas investors. The iron ore contract is part of this trend since it can be processed by foreign investors since May 2018 and this is only the beginning of a major shift. As stated by Fang Xinghai, vice-chairman of the CSRC, "China will step up the pace of opening the futures market and promote internationalization of all qualified futures varieties when the conditions are mature"⁶.

4. Conclusion

Apprehended in the broad sense as the progressive affirmation of a market for derivative futures contracts in commodity pricing mechanisms, the financialization of the iron ore market is a slow phenomenon, with implications that are much more structural than "only" the rise of index funds. With the only futures contract with physical delivery being that of the Chinese Dalian Commodity Exchange, which is still not very accessible to non-residents, and hybrid pricing methods between long-term contracts and the use of spot prices, this financialization is still an ongoing process. Moreover, it will probably take several years before the iron ore market resembles the base metals markets, which were financialized decades ago.

This phenomenon nevertheless heralds two major structural changes: the future growth of Chinese derivatives markets and the on-going financialization of mineral markets. Today, constrained by the weight of the nineteenth and the twentieth centuries' history, which has seen the North American and British derivatives markets become global, but also by the weakness of the yuan as a transaction currency, Chinese commodity exchanges are important only to Chinese operators. But this could not continue if attention is paid to the latest regulatory developments affecting them. These contracts are becoming increasingly accessible to foreign players and this reveals China's ambitions to become, at the financial level, what it is on the seaborne physical markets: inescapable.

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⁶ "Iron ore futures now open to foreigners", www.dce.com.cn/DCE/Media_Center/Exchange%20News/6101848/index.html (Accessed May 18th 2020).

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