Recent Experiences of Copper on the Shanghai Futures Exchange: Some Lessons for Warehouse Monitoring

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The Theory of Storage of Working (1949) and Brennan (1958) predicts that demand shocks reduce inventories, raise convenience yields and generate negative forward spreads. The goals of the paper are threefold: i) Analyze the Shanghai Exchange copper forward curves over the period 2008 when the trading volumes of metals Futures contracts grew in a remarkable manner; ii) Exhibit the unprecedented dynamics of the Shanghai Exchange copper forward curve ahead and at the time of the uncovering of the problem of forged warehouse receipts related to a large warehouse located in the Chinese port of Qingdao; iii) Show that the Theory of Storage is validated on this new Exchange over the period of analysis, with weaker results when exchange inventories are augmented by stockpiles of metals stored in 'bonded warehouses' with duties unpaid and no immediate availability for consumption. These findings may contribute to reinforce in the direction of policy makers messages on the importance of the constant scrutiny of the forward curve changes and the role of warehouse monitoring on the other hand.

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1. INTRODUCTION

The world metal markets have been marked in the last few years by two categories of events, partly correlated:

- The move towards East of the center of gravity of the trading activity, both of raw materials – with China continuing to increase its share of the world consumption of copper and other metals – and of financial instruments, as reflected by the acquisition for $1.3 billion of the 136-year old London Metal Exchange by the Hong Kong Exchange, and the growing importance of the Shanghai Futures Exchange. This one, built in 1999, went from being ranked in 2011 the 14th largest derivatives Exchange by volume to the sixth largest one in 2016 (source, Futures Industry Association), with more than 1.6 billion contracts traded per year, *all settled by physical delivery.* Note that, still today, there is no LME- registered warehouse.
- Recent problems involved with warehouses in the US and Europe, where queues in the delivery process at maturity to those who had taken long positions in metal Futures reached unprecedented lengths in some LME – registered warehouses; we refer to the paper by Stevens and Zhang (2016) for a thorough analysis of these events.
- The risks of forgery involved in the current paper form of warehouse receipts, as exhibited in the so-called 'Qingdao scandal' that erupted in June 2014 in a large state-owned bonded warehouse in Eastern China, where the same stockpiles of copper and aluminium were committed multiple times. This crisis was followed by another case of embezzlement related to the Asian warehousing company Access World in March 2017 – in this case, it seems that no metal at all was backing the warehouse receipts. Both events combined led to many hundreds of millions of dollars of losses for major banks involved in trade finance, namely the US bank Citi, the UK-headquartered Standard Chartered, the Australia- New Zealand bank and the French bank Natixis. Trade finance is arguably a useful activity for the world population and Chinese authorities recently expressed

their commitment to support and extend the infrastructure around what has been known for a long time as 'The Silk Road'.

Lending against commodities stored in in a warehouse- the modern version of the Monte di Pieta founded in Perugia, Italy, in the 15th century - has been increasingly favoured by banks involved in trade finance, a $ multi-trillion industry that includes traditional export finance and spans the whole supply chain of commodities, including logistics and shipping, hence central to the world economy. In the early days of the use of commodities as collateral, this one was anything from precious metals and stones to grain and rubber. Copper, the world's oldest mined commodity, has the merit of not degrading with time and being storable at a reasonable cost.

Our goal in the paper is to investigate from several perspectives the Chinese copper markets in the period 2008 to 2015 during which the trading activity of metals on the Shanghai Futures Exchange vastly increased across maturities and forward curves, a key source of information to our view, became available. At the same time, the Chinese economy was growing fast, and so was copper consumption for buildings and electricity networks. In parallel, there was an explosion of so-called Commodity Collateral Financial Deals (CCFDs) involving the use of a metal as collateral to borrow at a preferred rate and invest the proceeds in the high-return housing market. Copper was the main collateral, often stored in 'bonded warehouses', state - owned or not, in order not to pay the taxes and duties right at the moment when the metal was imported from Australia or another exporting country.

On a subject close to ours, Tang and Zhu (2016) analyse commodity inventory financing in China through copper, aluminum and six other commodities. Aggregating the official SHFE inventories and the bonded warehouses, they introduce a new 'Theory of Inventory' that leads to prices and convenience yields that increase with inventory, in contrast to the 'Theory of Storage' of Working (1945) and Brennan (1958), further tested by Fama and French (1987).

The remaining of the paper is as follows. Section 2 provides a description of copper markets in the period 2008 to 2015 and the use of commodities as collateral. Section 3 discusses the Shanghai Exchange inventories and forward curves, as well as the bonded warehouses' data. Section 4 recalls in details the

Theory of Storage and displays the correlations of forward spreads to different inventory measures. Section 5 concludes the paper.

2. World Copper Markets

Copper was identified very early on in various parts of the world, from India to Chile and Africa, as a crucial metal, because of its storability and conduction properties. The world copper market, both spot and derivatives, has been very large for a long time. The London Metal Exchange came to existence in 1877, less than 30 years after the Chicago Board of Trade, and has always been the reference place where mining companies and metal consumers would hedge their risks. The COMEX (Commodity Exchange) was founded in New York in 1933 and became in 1974 a major exchange for gold Futures. The LME kept its leading position for the six base metals and developed a network of licensed warehouses over the world (China still does not have any LME/HKEX warehouse on its soil as of today); these warehouses are the place of delivery of the metal for the long positions in Futures held until maturity by large consumers such as car and aircraft manufacturers or producers of aluminum- canned drinks and have to be located in various countries in order to attract to the LME trading orders from all over the world.

By 1985, the copper market was already very large, as reflected by the size of the trading activities made by the Japanese metal trading firm Sumitomo - both in spot and physical trading – that ended in a loss of two billion dollars or more, a large amount of money at the time and today. Krugman (1994) explains that the regulators in charge were difficult to identify between Japan, where the company was based; Britain, where the London Metal Exchange was located and the United States, where much of the copper Sumitomo owned through LME Futures was delivered. All three groups of regulators should have wondered at the time why a Japanese corporation requested *delivery* of very large amounts of Futures - related copper in Long Beach, California; arguably not to help Toyota and Honda produce their cars,

since their manufacturing plants were essentially all based in Japan at the time. Together with forward curves, warehousing issues are the primary focus of this paper.

China emerged as a major consumer of copper over the years 2000 to 2015. Construction, electricity grids and infrastructure pushed the country's demand for copper rise from 1.8 million tons in 2000 to over 10 million tons in 2015 and account in 2015 for 44% of the world global demand, up from 12% in 2000, according to the World Bureau of Metal Statistics. Construction and infrastructure combined represented 54% of the copper consumption in 2015. The boom of the Chinese construction sector at the beginning of the decade 2010 was illustrated by the famous statement made by Bill Gates in his blog in 2014, that China had consumed more cement over the three years 2011 to 2013 than the US had over the entire 20th century. An illustration, non-less interesting, pictured two cubes of cement, one small and one very large standing against the Chicago skyscraper outlines and was produced by Rhett Allain in Science, in June 2014.

The financial activity in Chinese metal markets exploded in a parallel manner, through the Futures contracts traded on the Shanghai Futures Exchange, as well as the growth of so-called 'Commodity Collateral Financial Deals (CCFDs) where Chinese investors would borrow at better rates, to generally invest in the real estate market, against a metal used as collateral and often stored in bonded warehouses after having been imported from Australia for example. As in the case for Bourbon and other alcohols stored in bonded warehouses in Kentucky (USA), the payment of duties and taxes did not take place until the moment when the metal came into the market (or was re-expedited to the producing country if the deal failed).

Copper Spot Prices and Spot Volatility

We display in Figure 1 the price trajectory of the copper spot price in China over the period 2003 to 2015. After the sharp decline that followed the financial crisis of 2009, prices rebounded in 2010 and 2011 to levels as high as those of May 2008, with gigantic imports of copper for the Chinese construction

and electrification. As of 2012, prices declined continuously (see Figure 1), probably because of the reduced pace of growth of the Chinese and world economy.

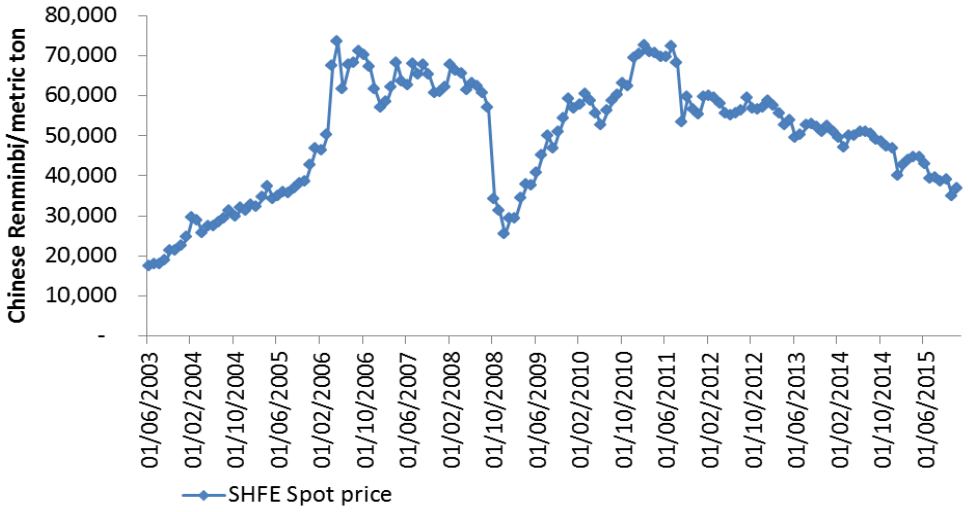

FIGURE 1: SHFE SPOT PRICES IN RENMINBI/TON OVER THE PERIOD 2003 TO 2015

Volatility - classically computed as the standard deviation of price returns and plotted in Figure 2 – exhibited in 2008 a large spike similar to the one observed in all commodity markets but was also above 20% during most of the period 2006 to 2015, and a high volatility of volatility. Changes in volatility are in agreement with the time-varying inventories displayed in Figure 3 and the Theory of Storage.

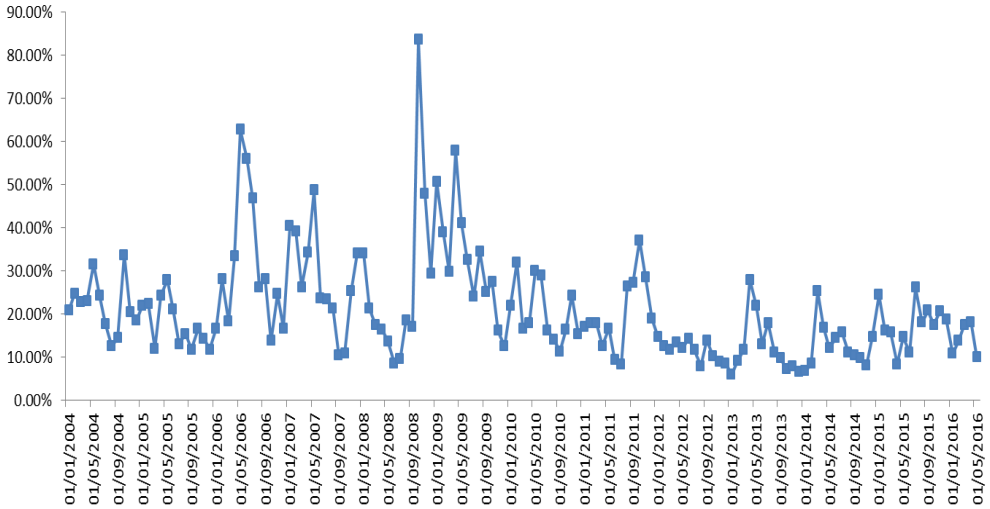

FIGURE 2: ONE- MONTH VOLATILITY BASED ON DAILY SHANGHAI COPPER SPOT PRICES (ANNUALIZED)

Source: Shanghai Futures Exchange and Authors' calculations

3. Chinese Copper Inventories and Shanghai Exchange Forward Curves

3.1. The SHFE Inventories

The Shanghai Exchange started trading copper Futures as of 1999; according to the rule followed by any Exchange, the warehouse volumes started being published daily. As a representation of the growing importance of the SHFE compared to the LME in London/ Hong Kong and the COMEX in Chicago, the SHFE inventories went from representing 4.22% of the world exchange inventories in January 2009 to 33.17% in April 2015 (sources LME, COMEX, Bloomberg). Figure 3 shows the official Exchange copper inventories, which fluctuated between 100,000 tons and 250,000 tons during the period 2009 to 2015. We can observe a large collapse in the first part of 2014 when the inventory volume was divided by more than one half and the SHFE forward curve exhibited unprecedented moves, as discussed later in the paper.

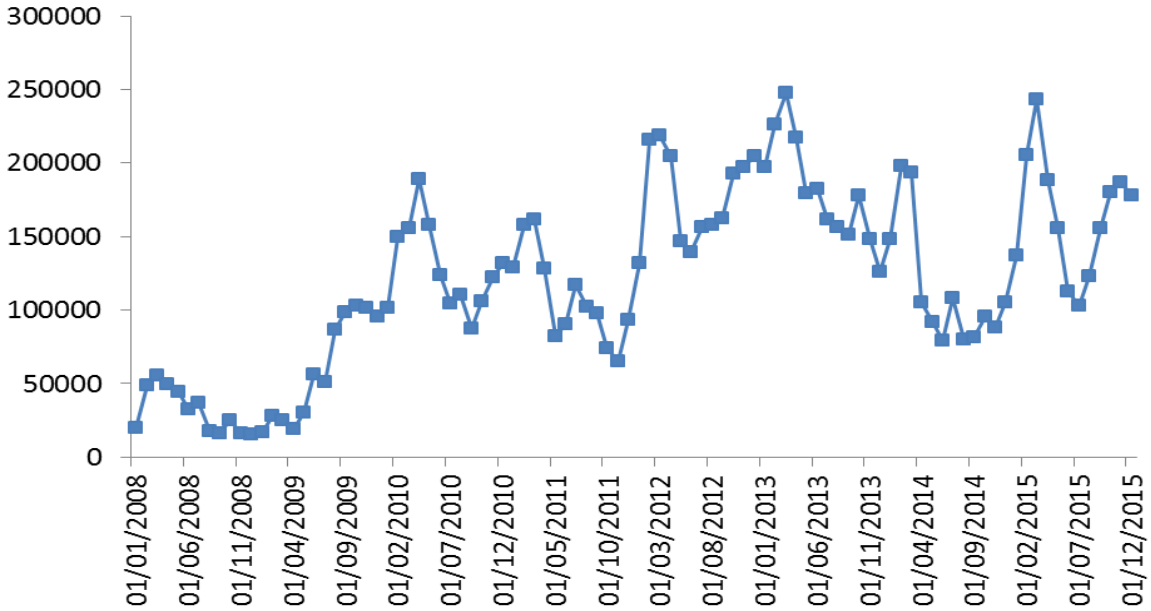

FIGURE 3: SHANGHAI EXCHANGE COPPER INVENTORIES FROM 2008 TO 2015 (IN TONS)

Source: Shanghai Futures Exchange

3.2. Bonded Warehouses in China

Bonded warehouses have been famous in the US history for old whisky and other alcohols. The terminology irrupted in the actuality of metal markets in June 2014 at the time of the so-called 'Qingdao scandal', when it emerged that warehouse receipts had been issued multiple times against the same copper and aluminum collateral in a state-owned bonded warehouse of a port in Eastern China. Essentially no official data were produced by China on the stockpiles in bonded warehouses. As said before, these played a central role in the CCFDs whereby Chinese investors were able to borrow at a better rate than the SHIBOR (Shanghai Inter Bank Offered Rate). Probably because of the difficulty of finding reliable data for bonded warehouses (the present authors do not claim theirs are immune to criticism), Tang and Zhu (2016) infer their stockpiles from their 'Theory of Inventory' on one hand, CCFDs' volumes and interest rates' differentials between LIBOR and SHIBOR; some practitioners' articles use currencies instead of interest rates to perform a similar derivation. We find these approaches too much model-based,

hence possibly hazardous since the model needs to be validated later on using the same data (and leads to surprising results); moreover, the amounts at stake in commodity financing deals had to be estimated, a matter at least as difficult. Instead, we chose to confront the data exhibited on bonded warehouses' volumes by the information providers trusted by mining companies, metal consumers and market participants worldwide, namely the data produced by CRU (Commodity Research Bureau) on one hand and Bloomberg on the other hand. The two sets of data over the whole period 2008 to 2016 were so close that we collapsed them into the single graph displayed in Figure 4.

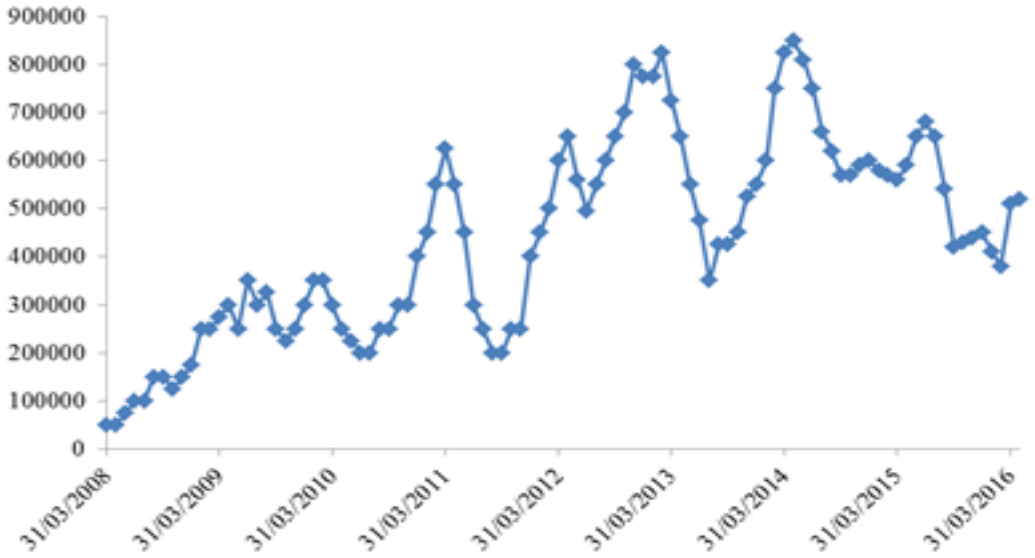

FIGURE 4: BONDED WAREHOUSES (IN TONS)

Sources: Bloomberg and CRU data averaged by the authors

According to its website and the reports of 'Bloomberg Intelligence', the company conducts each month a survey of ten to fifteen bonded warehouses, copper traders and other industry participants; the results are aggregated to an overall bonded warehouse number that has been published by Bloomberg since 2014, including those data prior to 2014. CRU is an independent consulting firm which sells specialized information on metals markets after deploying expert teams 'in key locations worldwide, including in hard-to-reach markets such as China', according to CRU website. Both sources converge in

indicating an all-time peak of roughly 870,000 tons of copper in Chinese bonded warehouses at the end of April 2014, two months before the Qingdao metals' multiple commitments were revealed.

D. Shanghai Exchange Forward Curves

We plot below some forward curves observed on the Shanghai Exchange and compare them to those of the London Metal Exchange at the end of 2013 and 2015. Note that the shapes of forward curves are central in capturing a commodity market beyond the simple spot price; they depict at which prices market participants are willing to trade for future dates and also uncover possibly profitable strategies, such as 'cash and carry'. Tilton et al (2011) analyze whether a strong investors' demand in the Futures markets has a direct and comparable effect on spot prices and conclude in the case of copper that the result holds only in the case of a strong contango. The authors also mention the popularity of 'financing deals' and note that the investors involved in these deals were 'natural shorts'. We did not try to launch the challenging exercise of identifying the relative weights on the SHFE of these 'shorts' we also mentioned earlier, versus asset managers worldwide taking long positions in copper because of the growth of the Chinese economy and the housing explosion. Instead, we take the SHFE forward curves as the reflection of these various forces, and obviously, compare them below to those of the reference LME. We do not believe, however, that any 'arbitrage opportunity' – in its classical definition – is feasible between the two Exchanges as long as there are no LME- registered warehouses on the Chinese soil (still the case today).

Figure 5 shows that the LME copper forward curves were in 'normal backwardation' in December 2013 and December 2015. Figure 6 displays a change from contango in December 2013 to 'normal backwardation' in December 2015 of the SHFE forward curve.

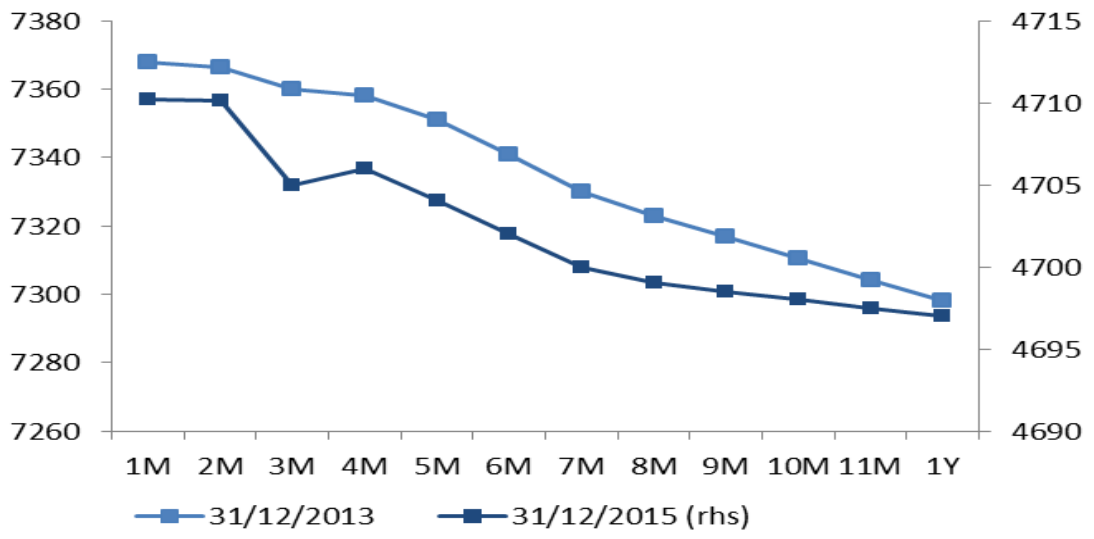

FIGURE 4: LME COPPER FORWARD CURVES AS OF 31/12/2013 AND 31/12/2015 (USD PER TONNE): BOTH CURVES ARE IN 'NORMAL' BACKWARDATION'

Source: LME and author's computations

Note that after 2010, the liquidity on the Shanghai Futures Exchange became quite satisfactory. As of that moment, the big difference for any market participant in taking a Future position on the London Metal Exchange versus the SHFE was related to the location of physical delivery. We do not believe that any 'arbitrage opportunity' – in its classical definition – is feasible between the two Exchanges as long as there are no LME- registered warehouses on the Chinese soil (still the case today). South Korea is the usual delivery point used instead by LME participants, but there is a transit time of three days for a vessel to cover the distance between Seoul and Shanghai .From Seoul to Qingdao the closest Chinese port to Seoul – a location that possibly explains the attractiveness of its metals' warehouses -, the transit duration is two days; during that time window, prices of Futures contracts on the LME and/ or the SHFE may rapidly change and the 'financial arbitrage' turn into a severe loss.

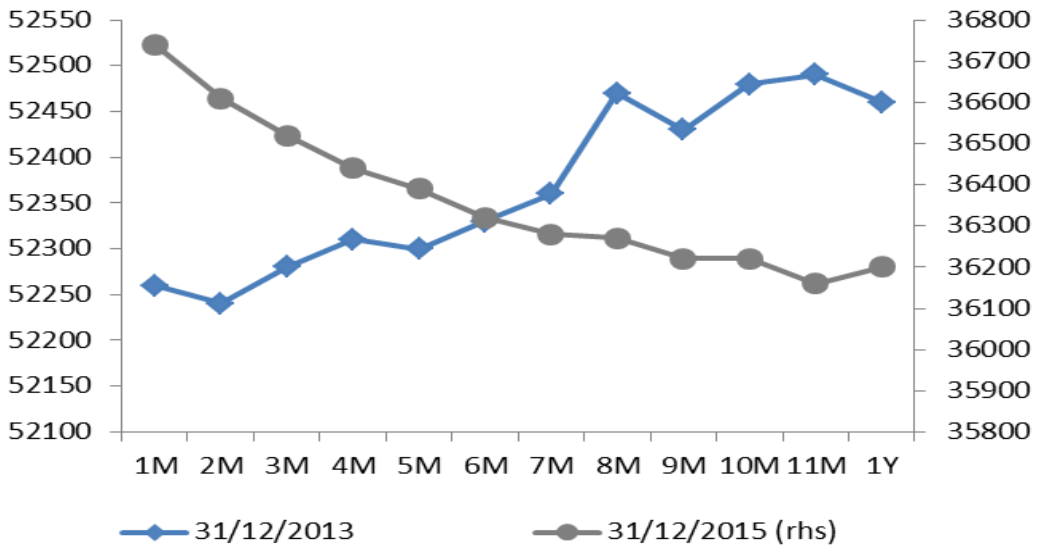

FIGURE 6: SHANGHAI COPPER FORWARD CURVES AS OF 31/12/2013 AND 31/12/2015 (SCALE OF TEN YUAN PER TON): THE SHAPE WENT FROM CONTANGO IN DECEMBER 2013 TO 'NORMAL BACKWARDATION' IN DECEMBER 2015

Source: Shanghai Futures Exchange

Figure 7 shows the interesting similarity between the curves on the two Exchanges in December 2015, after the activity in CCFDs had greatly receded. In both places, prices had collapsed – necessitating the use of two different scales in Figure 6.

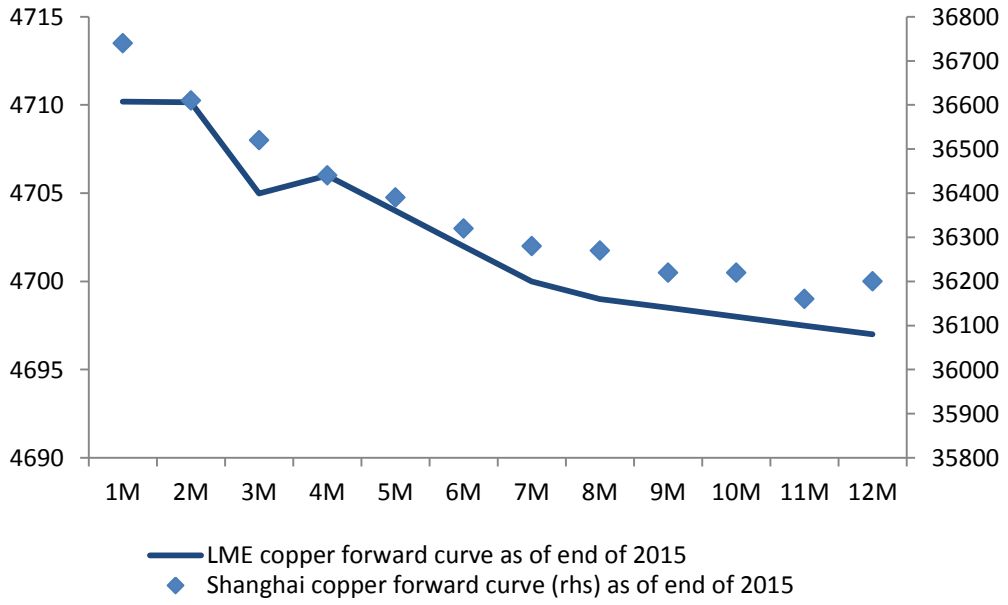

FIGURE 8: SHANGHAI AND LME COPPER FORWARD CURVES AS OF 31/12/2015, BOTH EXHIBITING 'NORMAL BACKWARDATION'

Sources: LME, Shanghai Futures Exchange and authors' computations

Figure 8 illustrates that the monthly volume of the 6-month Shanghai copper Future contract sharply increased first in 2008, then in 2011 onwards, one of the possible explanations being the large number of CCFDs traded at the time (mostly with 6-month duration), and the corresponding positions put in place by the traders to hedge the price risk of the metal in storage.

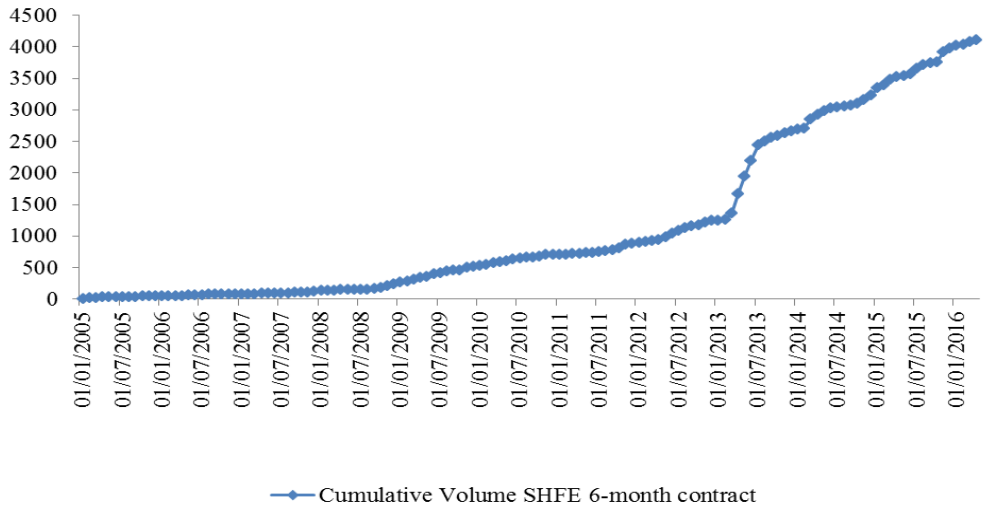

FIGURE 9: 6-MONTH SHANGHAI COPPER FUTURE CONTRACT VOLUMES (CUMULATIVE, IN THOUSAND CONTRACTS) AND ITS LARGE INCREASE IN 2008

Source: Shanghai Futures Exchange, Bloomberg

For comparison, we represent in Figure 9 below the volumes traded on the London Metal Exchange over the same period 2005-2016, namely a gradual increase in the cumulative volume. The amount of trading activity is known to be a first indicator of the depth of a market;

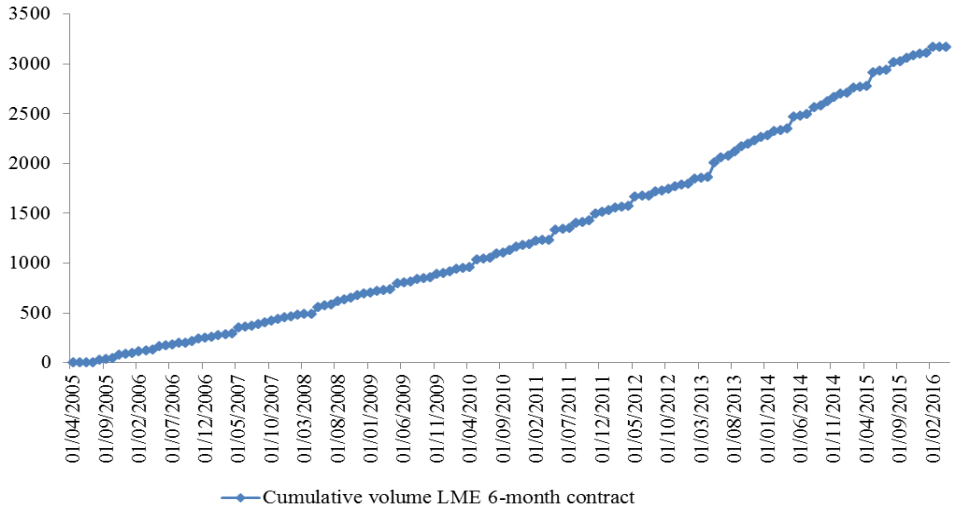

FIGURE 9: 6-MONTH LME COPPER FUTURE CONTRACT VOLUMES (CUMULATIVE, IN THOUSAND CONTRACTS)

Source: London Metal Exchange, Bloomberg

4. Theory of Storage, Shanghai Exchange Inventories and Bonded Warehouses

4.1. Normal Backwardation, Inventory and Theory of Storage

We recall below the major elements of the Theory of Storage as it has existed for the last 85 years, as well as the property of 'normal backwardation', which is also relevant in our discussion.

4.1.1. "Theory" of Normal Backwardation

In his Treatise of Money (1930), Keynes argues that, in commodity markets, the forward curve is in 'normal backwardation', like the LME curves in December 2013 and December 2015, since producers of commodities are more prone to hedge their price risk - by selling Futures contracts - than consumers, and accept lower prices for distant maturities, hence the decreasing/ backwardated shape.

The 'theory' was empirically validated in the oil market by Gabillon (1991) and Geman (2005), and indeed observed most of the time in forward curves of all commodity markets until 2008 (except for gold, which plays a particular role among commodities, as demonstrated by history). We can observe in Figure 6 that the forward curve of the Shanghai Exchange was not in 'normal backwardation' in December 2013,

at the peak of the CCFD activity. The shape of the forward curve is a key feature that is too little discussed to our view in the large recent academic literature on the so-called 'financialization' of commodity markets. Its importance was however emphasized by the founding literature on the subject, as recalled below, and is related to the 'convenience yield', defined as the benefit provided by the ownership of the physical commodity versus a paper contract written on it.

4.1.2. Theory of Storage

The role of inventory in explaining the shape of the forward curve and spot price volatility is central in the Theory of Storage developed by Holbrook Working while he was a researcher as of 1927 at the Food Research Institute of the University of Stanford. The institute had decided to focus on wheat, a crucial agricultural commodity, and large amounts of data were collected. Working carefully plotted the spread between the 3-month Future and the spot price against the existing inventory and developed his findings in a paper published in 1933. His work was extended in 1939 by Kaldor, who introduced the notion of convenience yield, a yield gained by the owner of the physical commodity as opposed to a paper contract written on it. Brennan (1958) confirmed for a number of agricultural markets the results exhibited introduced by Working in his remarkable 'Theory of the Price of Storage' in 1949. Fama and French (1987) assumed the results of the Theory in order to analyze some of its implications in the context of base and precious metals

The founding results are centered on inventories and can be simply described as follows:

i. If inventories are high (like in the oil markets of 2015 and 2016, after the price collapse of 2014), the convenience yield (net of storage costs) is negative and the forward curve tends to be in contango like the SHFE copper in December 2013 (Figure 6).

ii. In the case of normal to low inventories, the convenience yield (net of storage costs) is positive and the forward curve tends to be in backwardation like the LME and SHFE curves in December 2015 (Figure 7).

4.1.3. Inventory and Spread of the Forward Curve

The shape of the yield curve of interest rates at a date of analysis represents a key piece of information about the bond market at that date, and the modeling of its dynamics has been the subject of a remarkably (and deservedly) large academic literature over the last 25 years, after the limitations contained in the assumption of parallel moves could not be ignored any longer by both academics and practitioners. In a similar way, the forward curve and its slope at date t summarize a number of crucial properties of a given commodity market and represent a major tool for practitioners – whether they are engaged in trading activities or in the management of commodity indexes - and academics alike.

Working (1949) introduced in a founding paper the 'relative spread' of the forward curve that he defined as

$$\text{Spread} = \{F(t, T) - S(t)\}. 1/ S(t) \qquad (1)$$

where F(t,T) is the price at date t of a Future contract maturing at date T (chosen at the time to be three months) . Working showed that the spread is positively correlated to inventory, a low inventory being characterized by a negative spread, in agreement with the points i) and ii) above. The important paper of Brennan (1958) confirmed this result. In their reference paper, Fama and French (1987) observe that 'it is usually unclear how aggregate inventory should be defined'; instead, they directly adopt the spread of the forward curve (which they call 'basis') as a proxy for inventory for LME base metals in order to study its relationship to price volatility. Geman and Smith (2013) add all inventories licensed by the London Metal Exchange and display, in the case of the six base metals over a 24-year period (1988 to 2011) a strong relationship between the spread and inventory.

4.2. Testing the Theory of Storage on SHFE Inventories, with and without the addition of bonded warehouses' volumes

We suggest in this section that the theory of storage, as expressed by the correlations between the forward spread and inventory, is validated during the period 2008 to 2015 by the Shanghai Exchange forward curves and SHFE inventories, after some years of existence of the SHFE as of December 1999. We also show that adding the bonded warehouses prevailing at a given date of analysis to the Exchange inventories weakens the relationship, confirming that bonded copper does not qualify as inventory immediately available for consumption. We find the result in line with our expectations. To draw a comparison with the remarkably liquid oil market, be it WTI or Brent, spot prices immediately adjust to the arrival of news on inventories (which also trigger also today many 'High Frequency Trading' activities by oil traders) and with a change opposite to the inventory adjustment. These inventory announcements never include the *reserves* of oil companies, even though these reserves (well documented in the annual reports of oil companies and in the applications for funding by banks) may become inventory at a later *random* time, exactly like the metals stored in bonded warehouses. It is interesting to note that, in the case of Bourbon and whisky stored in bonded warehouses in the US, evaporation creates what is called in the industry 'shrinkage' and the volume of precious liquor derived from corn is unknown until it comes out of the bonded warehouse.

Returning to the test of the Theory of Storage, we choose to define the 'relative spread' of the forward curve with a maturity of six months for the Future - as it is standard in the academic literature when there are no seasonality issues - and proceed as follows with 'absolute' inventory:

i. Compute the correlations between the forward spread, defined as (6-month Future minus spot) divided by spot, and changes in SHFE inventories.
ii. Repeat the exercise with the addition of changes in bonded warehouses to the SHFE inventories, quantities we qualify as 'aggregate' inventories.

We also compute rank (Spearman) correlations as well since they are more robust to the existence of outliers, which may happen with non-fully transparent quantities, and find the following correlations over the period.

Correlation Results

The correlation results over the period of analysis are the following:

Pearson correlations: In the case of the forward spread versus SHFE Inventories, the estimated correlation coefficient is 0.30 with a confidence interval of (0.35;0.25). For the forward spread versus the aggregation of SHFE inventories and bonded warehouses, the estimated correlation coefficient is lower at 0.22 with a confidence interval of (0.30;0.15).

Spearman (rank) correlations: In the case of the forward spread versus SHFE Inventories, the estimated correlation coefficient is 0.32. For the forward spread versus the aggregation of SHFE inventories and bonded warehouses, the estimated correlation coefficient is lower at 0.27.

We see that the addition of bonded warehouses clearly weakens the Working (1949) relationship and wish to observe that we did not 'demonstrate' any causality.

4.3. Testing the Theory of Storage with Inventories expressed in days of copper consumption

We represent in Figure 10 the Inventory-to-Demand ratio expressed in days of Chinese consumption for the SHFE inventories and their addition to bonded warehouses' volumes.

Geman and Smith (2013) who tested the Theory of Storage in the case of the six base metals on LME data over the period 1998 to 2012 proposed to also analyze the inventories in terms of days of consumption. We repeat their approach here by dividing the numbers by Chinese annual consumption and express the results into days for both types of inventories. It is valuable to note that the volume of copper

in bonded warehouses was of the order of 10% on average of the annual Chinese consumption during the period of analysis. SHFE inventories fluctuate around seven days of consumption; the number exhibited by Geman and Smith (2013) as a threshold of 'scarcity' for the six base metals on the LME was a six-day inventory.

The new correlation numbers are fairly similar to the previous ones:

i. Rank correlation between the forward spread and SHFE inventories measured in days of consumption = 0.30.

ii. Rank correlation between the forward spread and aggregate inventories measured in days of consumption = 0.21.

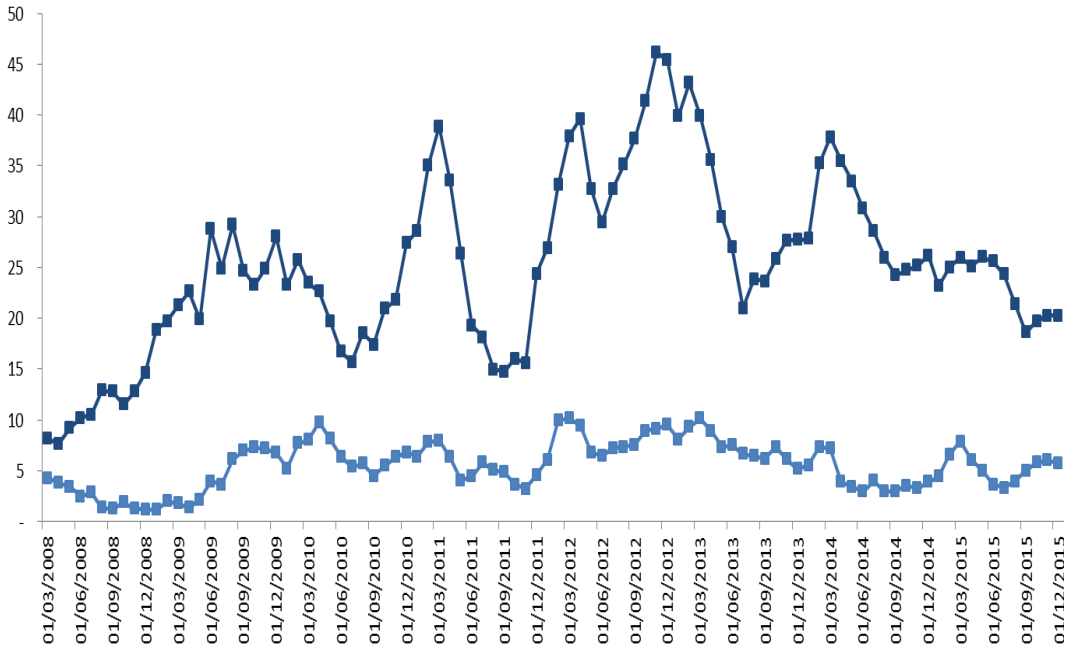

FIGURE 10: CHINESE INVENTORIES EXPRESSED IN DAYS OF COPPER DEMAND EXCLUDING AND INCLUDING BONDED WAREHOUSES

Source: Shanghai Futures Exchange, Authors' calculations

4.4. The extraordinary moves of the SHFE forward curves and SHFE inventories in the second quarter of 2014

We wish in this sub-section to emphasize, from yet another angle, the remarkable information embedded in forward curves, in relation to inventory changes but also in terms of *signaling* possible tensions and/or wrong activity in a commodity market.

We plot below the copper forward curves observed on the Shanghai Exchange at the end of each quarter of the eventful year 2014. Figure 11 below displays a very rare move of the forward curve between March and June 2014, with all Future prices jumping upward by nearly 10%. As observed before, all sources (LME, Bloomberg, and CRU) converge on exhibiting all times- high values of 820, 000 to 880,000 tons for the bonded warehouses volumes over the months of March, April and May 2014. Prices then went down rapidly, as exhibited by the September and December forward curves, probably after the Qingdao events were fully absorbed by the markets.

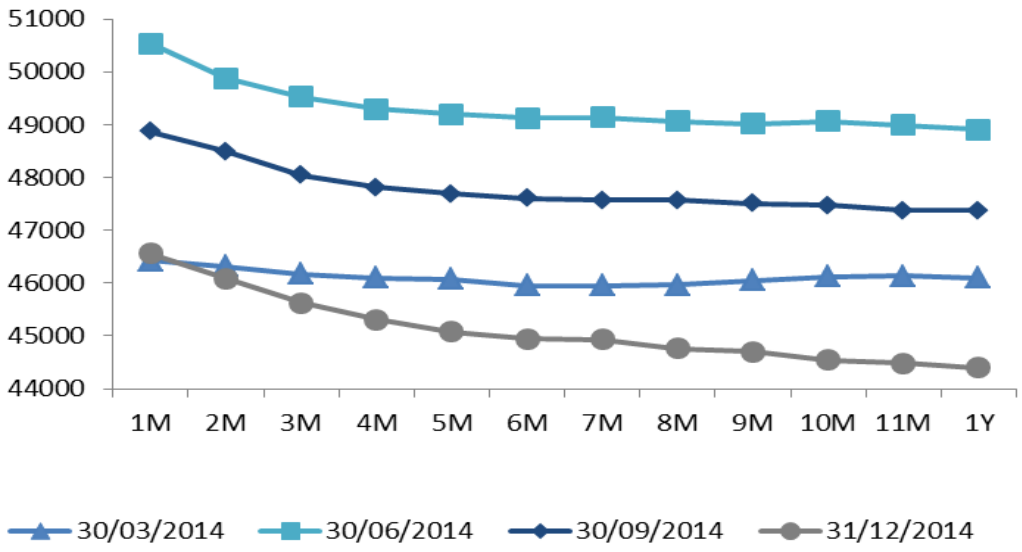

FIGURE 11: THE UNPRECEDENTED DYNAMICS OF THE SHFE FORWARD CURVE DURING THE YEAR 2014 (SCALE OF TEN YUAN PER TON)

Source: Shanghai Futures Exchange and Authors' calculations

As a result of the very rare moves described above, the forward curves observed in September and December 2014 are located *between* the March and June ones, an unprecedented situation that we could not find documented in the literature (referenced or not) we surveyed, in particular in relation to the collapse of oil prices in the second half of 2014.

Recent Developments

The story of Qingdao was never fully clarified, except for the fact that the same collateral copper was pledged multiple times. No conclusions on the Qingdao case have been published yet by the Chinese Central Commission. As of September 2017, China had not yet allowed the LME/HK Exchange to have licensed warehouses in China, and metal destined to China continues to be shipped from Singapore or South Korea. The Chinese president however reaffirmed in May 2017 the central positioning of the country in global trade by launching in Beijing the Belt and Road Forum for International Cooperation.

Forged warehouse receipts were used again three years later in 2017 in a case of fraud seemingly related to the Asian company Access World. Remarkably, warehouse receipts - a crucial instrument in the world trade together with Bills of Lading - continue at this time of blockchains to be mostly made out of paper, hence fairly easy to forge. Exchanges and market participants seem to be working together for their replacement by electronic orders. Hieronymus, both an economist and a trader, had insisted in his 1977 book on the key role of independent and reliable warehousing companies.

6. Conclusion

We have extensively discussed in this paper the central role in metals markets of the proper monitoring of warehouses, a subject which has received little attention in the academic literature. We also tried to shed some light on the notion of ‘bonded warehouses’, which played/play a significant role in the Chinese copper and aluminum markets during the years 2008 to 2014. Extending the results of Geman

and Smith (2013) on the LME base metals, we find that the Theory of Storage of Working (1949) is validated in the case of copper during the years 2008 to 2015 on the more recent Shanghai Exchange. Confronting many sources of data on the opaque volumes of bonded warehouses and using a variety of correlation measures, we have shown that the link between the spread of the forward curve and inventory was weaker when the transparent Exchange inventories' numbers were augmented with bonded warehouses' stocks. We suggest they bring their attention to the remarkable message of Hieronymus (1977) - both an economist and a trader- on the key role of independent warehousing companies, and also to the information carried at all times in forward curves.

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