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Hedging House Price Risk in China

Jia He,* Jing Wu** and Haishi Li***,****

The increasing risk associated with China's housing prices is globally recognized. However, hedging this risk is challenging because of a lack of financial derivatives on China's housing assets. We suggest that the short sale of futures contracts for construction raw materials, *i.e.*, iron ore or/and steel, can act as useful tools to hedge the systematic risk of China's new home price. We first present evidence that there is a strong and stable correlation between changes in China's housing prices and global steel/iron ore prices. Using a hedging strategy model, we then show that, during the sample period between 2009 and 2015, 20.6% of the total unpredicted variance in Chinese housing prices can be hedged by shorting rebar and iron ore futures. We further examine this strategy with an event study based on the announcement of the "home-purchase restriction" policy in April, 2010. The cumulative abnormal returns show that both steel and iron ore prices reacted significantly to this negative shock, and therefore the proposed strategy could substantially help investors offset losses in the housing market. We finally provide some evidences that this strategy can also help investors in specific regional housing markets, or the resale housing markets.

Introduction

After a decade of continuous and rapid growth in the house prices of most Chinese cities, there is increasing concern about the risks associated with China's housing market. Several recent papers hint at a significant mispricing in the market, and a potential major correction of house prices. For example, Wu, Gyourko and Deng (2012) suggest the high price-to-rent ratios in major cities are mainly supported by market participants' expectations of higher future price growth, and a small change in these expectations might lead to a substantial drop in house prices.[1]

*School of Finance, Nankai University, Tianjin 300350, China or hejia@nankai.edu.cn.
**Institute of Real Estate Studies and Hang Lung Center for Real Estate, Tsinghua University, Beijing 100084, China or ireswujing@tsinghua.edu.cn.
***School of Economics and Management, Tsinghua University, Beijing 100084, China or lihsh.11@sem.tsinghua.edu.cn.
****Department of Economics, University of Chicago, Chicago, IL 60637

[1]See Wu, Gyourko and Deng (2015) for a review of more research on Chinese housing price risks.

In this article, we investigate this issue from a new perspective: for investors who have invested a substantial portion of their assets in China's housing market, we look at whether it is possible for them to hedge the systematic risk associated with house prices in their portfolio. Such a hedging instrument, if it exists, could be of great importance in the context of current China. Housing is not only the dominant component of household wealth in urban China, but also contributes to a substantial volume in the portfolios held by the corporate sector or institutional investors. As reported by China's central bank, by the end of 2014, the total volume of outstanding balance of real estate-related loans accounted for 21.3% in all commercial bank loans. Without an active secondary market, the commercial banks have to keep almost all these loans in their own portfolios. On the other hand, according to the latest National Economic Census in 2013, the total asset of real estate developers accounted for 15.6% in all the nonfinancial firms nationwide, with most of these assets as housing and residential land. In addition, there are also concerns about the potential diffusion of housing price risks to other sectors, such as local government debt, most of which has land parcels as collateral and requires land sales revenue for repayment (Brent, Deng and Wu, 2015). An effective hedging instrument can significantly help all these market participants reduce their exposures to housing price risks.

Most existing literature on hedging house price risks has focused on house price derivatives. Case, Shiller and Weiss (1993) and Shiller (1993) were among the first to raise the idea of creating house price derivatives including futures contracts, options, warrants, swaps and home equity insurances. The authors suggested that investors could hedge housing investment risks by holding short positions in such derivatives, or by purchasing home equity insurance. These derivatives and hedge strategies were further developed and outlined in works by Shiller and Weiss (1999), Fabozzi, Shiller and Tunaru (2010), and McDuff (2012). Several financial products have been developed accordingly. The most well-known of these is perhaps the Chicago Mercantile Exchange (CME), which started trading futures contracts in 2006 using the S&P/Case-Shiller Metro Area Home Price Index in 10 major U.S. cities.[2] The efficacy of such a hedging strategy has been supported by several empirical tests. Bertus, Hollans and Swidler's (2008) analysis based on CME futures contracts concluded these futures contracts help investment groups, mortgage holders as well as homeowners to hedge risk. Voicu and Seiler (2013) suggest that selling CME housing futures up to the full value of the home can help homeowners substantially hedge housing investment risks.

[2]Other housing price derivatives products are reviewed in Fabozzi, Shiller and Tunaru (2009) and Shiller (2009).

Iacoviello and Ortalo-Magne's (2003) research based on U.K. data also came to a similar conclusion.

Unfortunately, the creation of house price derivatives as hedge instruments is very difficult in China, at least in the foreseeable future. The largest challenge is the immaturity of China's financial market. Futures and options are still at an early stage of development, even those for the stock market. The second issue is that the housing market in most Chinese cities is still dominated by the new home sector.[3] It is more difficult to design derivatives, such as futures contracts, in the new home sector, and the hedging effect of such derivatives is not clear. For instance, Bertus, Hollans and Swidler (2008) found that CME futures contracts had almost no hedging effect for developers in the new home market. Finally, the house price indices currently available in China are not as accurate and reliable as those required for the development of derivatives (Wu, Deng and Liu 2014).

Another potential hedging opportunity is to short-sell securitized real estate. The only currently available option to do this in China is through the stocks of listed real estate developers, although short sales remain restricted in Shanghai and Shenzhen's exchanges.[4] However, the previous research did not arrive in a consistent result on its effectiveness. Using data of Stockholm, Englund, Hwang and Quigley (2002) found this to be an effective strategy for home owners to hedge house price risks; however, Hinkerlmann and Swidler (2008) found that shorting S&P 500 could not help hedge house price risks in United States. In addition, the relationship between house prices and the stock market remains an open question. Gyourko and Keim (1992) showed that the returns on a portfolio of real estate stocks could help predict the future returns of appraisal-based real estate indices. However, Goetzman (1993) and Flavin and Yamashita (2002) reported that the correlations between housing and financial assets were generally small and negative. A later part of our article reveals that there is empirically no significant correlation between monthly housing price appreciation and monthly returns for a composite index of real

[3]During the past decade, market share of the new home sector in the housing markets in 35 major cities kept around 65–75% by floor area, without any remarkable trend of increasing or decreasing.

[4]As of June 2014, there were over 130 real estate companies listed in mainland China, but only 52 of them were open for short sales. Besides, naked short selling in the stock market is strictly prohibited in mainland China. In addition, although index futures and options have been developed in the Shanghai Exchange, no index futures/options for the real estate industry are available in the market. Finally, currently foreign investors are only permitted to invest in China's stock market via the QFII (Qualified Foreign Institutional Investors) scheme, which further increases the transaction costs for individual foreign investors who want to hold a short position.

estate developers listed in mainland China, which further restricts the usage of this hedge strategy.

We suggest a new instrument for hedging house price risk in China, specifically that of holding short positions of steel and iron ore futures. The underlying logic is straightforward: because the new home sector still constitutes a major part of China's housing market, fluctuations in house prices would affect housing construction, which would in turn affect the demand for raw materials such as steel and iron ore. As discussed later, housing construction in China has become one of the largest sources of demand for steel around the world. Our calculations show that in 2012, housing construction in China consumed 78.4 million tons of steel, accounting for about 5.5% of steel consumption globally.

Using data between April 2009 and March 2015, we find that iron ore and rebar futures prices had a much higher correlation with housing prices than the stock prices of listed developers. This suggests the viability of using these futures as an effective hedge strategy. Our calculations show that holding short sales in rebar future contracts alone could reduce the total variance in housing prices by 14.8%, while shorting iron ore commodities would reduce housing price variance by 20.4%. A total of 20.6% of the variance in housing prices could be hedged using a portfolio of futures contracts on both iron ore and rebar. In contrast, effectively none of the volatility in housing prices could be hedged by shorting listed real estate developers' stock.

We provide further evidence on the effectiveness of the hedging strategy in the wake of the "home-purchase restriction" measures unfolded by the Chinese central government in April 2010. Under this unexpected and exogenous negative shock, the aggregate house price index in 35 major Chinese cities decreased by 2.0% in the month after the announcement. We conduct an event study analysis and find a –16.1% accumulative abnormal return (CAR) on rebar futures within 30 trading days of the event, and –35.7% CAR on iron ore price indices. These results imply that if an investor had adopted the hedging strategy as suggested above, the loss in the unexpected negative shock could be reduced by as much as 50.0%, which well supports the effect of our hedging strategy.

While the hedging strategy proposed in this article mainly aims at the systematic risk associated with the new home sector, we also extend its application to other sectors. On the one hand, we test the effectiveness of the hedging strategy in each of the 35 major Chinese cities. The strategy is proved to be effective in several of the most important housing markets such as Beijing, Shanghai, Shenzhen, and Chongqing. For instance, in Beijing, the newly built housing price variance would reduce 13.6% by holding a portfolio with futures contracts on both iron ore and rebar. On the other hand, the case of Beijing suggests that it is also possible to adopt this strategy to help investors mainly involved in the resale housing markets. Specifically, the resale housing price variance in Beijing has reduced 17.0% by shorting both rebar and iron ore futures contracts.

In the next section of the article, we outline key facts of the relationship between China's housing market and the steel and iron ore markets. The third section presents our proposed hedging strategy and tests its effectiveness. The fourth section provides further empirical evidence of the validity of the strategy with an event study on a negative policy shock to the housing market. The fifth section provides some evidences on the efficiency of this hedging strategy in the regional housing markets and the resale housing market. The last section concludes the article.

Stylized Facts on the Intermarket Relationship

Contribution of Housing Construction in China to Global Steel Consumption

The spillover effect of the housing sector on the market for raw and processed material inputs is well-documented based on evidence from multiple economies. By studying housing supply elasticity in United States, Green, Malpezzi and Mayo (2005) argued that the strong growth of housing construction in the national market led to shortages in material and labor, thus inducing substantial price increases. Bardhan and Kroll (2007) showed that urbanization and growth in emerging markets led to rapid growth in the demand for building materials and other inputs, and increased global inflation.

In particular, with the rapid urbanization and the booming housing market, the housing construction sector in China has become one of the largest consumption portions of global steel and iron ore output. Hu *et al.* (2010) pointed out that in 2004, 20% of China's steel was used in its residential buildings. Hatayama *et al.* (2010) concluded that civil engineering and building activities accounted for about 65% of the steel consumed between 1990 and 2005, and were the main reasons for the surge in steel consumption in China.

We next provide a rough estimate of the amount of steel consumed by the Chinese housing construction sector based on a set of assumptions. Steel consumption depends on conditions such as the location and type of buildings being constructed, as stipulated by China's building codes. We take 60 kg/m^2 of floor area as the average amount of steel used in residential buildings across areas. Examining the statistics on the annual national volume of urban housing

Figure 1 ■ Volume of steel used by China's housing construction sector.

Source: Authors' calculations based on data released by National Bureau of Statistics, China.

starts by real estate development, published by China's National Bureau of Statistics, enables us to roughly estimate the total steel consumption by the housing construction sector in China. As depicted in Figure 1, the amount of steel used to build houses in China grew gradually from about 26 million tons in 2003, to nearly 79 million tons in 2012. The compound annual growth rate was about 12% in the decade. We also calculate the proportion of this consumption volume relative to total steel consumption both in China and around the world.[5] For example, in 2012, the housing construction sector was responsible for 11.9% of total steel consumption in China, or 5.5% of global steel consumption.[6]

[5]The data on total steel consumption in China and the world steel consumption is from "*World Steel Statistical Data*" published by the World Steel Association.

[6]Besides the floor area of housing starts, we also try adopting the floor area of housing under construction and completed housing as indicators of annual housing construction activities. Using the floor area of housing under construction, the amount of steel used to build housing in China would be 310 million tons in 2012, about 47.0% of the total amount of steel used in China or 21.7% of global steel consumption. The corresponding figures are 64 million tons, 4.5% and 9.8% if we use housing completions as an indicator of housing construction activity.

At the same time, the real estate literature has provided both theoretical and empirical evidence that housing construction activities are greatly affected by current and expected housing prices. Poterba (1984) took an asset market approach to model housing net investment as a function of real house prices, and concluded that the price of housing is the major determinant of new construction. Topel and Rosen (1988) developed a supply-determined model of housing investment, and concluded that price volatility has a significant impact on the construction of new homes. Dipasquale and Wheaton (1994) proposed a simple housing construction model by combining a stock adjustment process with a spatially based definition of the equilibrium volume of housing stock in the long-run. They argued that long-term increases in housing prices lead to a permanent increase in the flow of construction.

In summary, changes in the price of housing substantially affect housing construction activity. Considering that China's housing construction sector uses a remarkable proportion of global steel output, it is reasonable to expect that fluctuations in the housing sector would have a significant effect in turn on the consumption and price of steel (or even the price of iron ore).

Correlation between Chinese Housing Price and Steel/Iron Ore Futures Price

Several data sources are used to test the relationship between Chinese housing prices and steel/iron ore prices. Since March 27, 2009, the continuous contract for rebar (the most widely used type of steel in residential buildings) futures has been listed on China's Shanghai Futures Exchange (SHFE), whose price information is available on SHFE's official website. We then use the iron ore futures traded on the Chicago Mercantile Exchange (CME) with the Bloomberg code TIO CMDTY as an indicator of iron ore prices.[7] As this iron ore future was only introduced in May 2011, we use the TSI iron ore price for the two year period between April 2009 and May 2011 (Bloomberg code TSIPI062). The TSI iron ore price is the underlying iron ore commodity

[7]Investors from mainland China can trade CME futures through brokers in Hong Kong, or their branches in mainland China. See the official website of CME for more details: http://www.cmegroup.com/cn-s/brokers.html. These brokers will charge investors a commission, most of which is negotiable. The CME will also charge a $0.50 fee per contract per trade. The minimum unit of iron ore futures transaction on CME is 500 dry metric tons, which equals to $4890 by the end of July 21, 2015. In addition, trading commodity futures also requires a margin deposit, which varies with the contract. In October 2013, Dalian Commodity Exchange, another major futures exchange in mainland China, has also launched the iron ore futures. Although we cannot include it in the current paper due to the short period of available data, this new product could make it more feasible for investors from mainland China to short iron ore futures.

spot price for TIO futures. Finally, we use the monthly constant-quality price index for newly built housing units developed by Wu, Deng and Liu (2014) as the housing price indicator, which, to the best of our knowledge, can provide the most accurate information on price fluctuations in China's new home sector. We use the aggregated index of 35 major cities as the indicator of national level house price changes.[8]

In addition, we use the CSI 300 Index to represent the overall performance of the Shanghai and Shenzhen stock exchanges,[9] and also include the composite stock price index of real estate firms listed in mainland China in the analysis.[10] These two indicators are derived from Wind, a Compustat-style database in China.

All the aforementioned price series are converted to log normal monthly returns for the following analysis. A summary statistics of these variables is presented in Table 1, and Figure 2 depicts the monthly return series for all these assets between April 2009 and March 2015.

Table 2 shows the correlations between these assets, listing their coefficients and significance based on a simple regression. The results in Columns (1) and (2) show that the return rates of housing prices are positively related to the return rates of iron ore/rebar futures prices. The relationships are significant at the 1% level. However, as indicated in Column (3) to (4), we find no significant correlation between the housing price index and the composite index of the whole stock market in mainland China, or the composite index of listed real estate firms.[11] These results provide preliminary support for a potential hedging instrument with shorting iron ore and/or rebar futures, instead of holding short position in the stock market.

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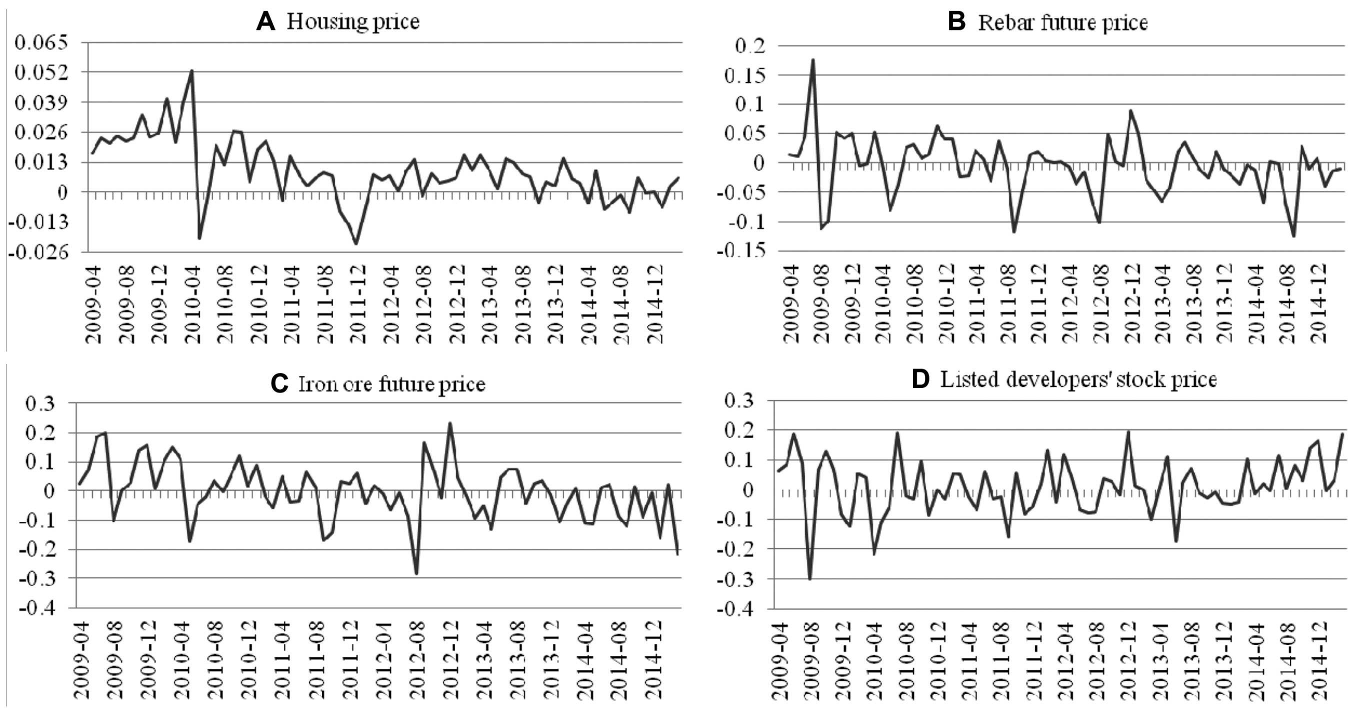
[8]The 35 cities are: Beijing, Tianjin, Shijiazhuang, Taiyuan, Hohhot, Shenyang, Dalian, Changchun, Harbin, Shanghai, Nanjing, Hangzhou, Ningbo, Hefei, Fuzhou, Xiamen, Nanchang, Jinan, Qingdao, Zhengzhou, Wuhan, Changsha, Guangzhou, Shenzhen, Nanning, Haikou, Chongqing, Chengdu, Guiyang, Kunming, Xi'an, Lanzhou, Xining, Yinchuan, and Urumqi. These cities account for 40–50% of China's newly built housing market.

[9]We also use the Shanghai Composite Stock Index and Shenzhen Composite Stock Index to run the same regressions, and the results are consistent.

[10]Besides these two exchanges in mainland China, we also use the corresponding indicators of the Hong Kong stock market for the following analysis, and the results are generally consistent.

[11]This finding is consistent with several previous research studies in China. He (2005) found very weak correlation between the housing market and stock market in China, and concluded that there was no integration between these two markets. Sheng, Li and Liu (2005) and Zhao, Fang and Wang (2011) also concluded very similar results.

Figure 2 ■ Return rates of housing, rebar, iron ore and listed developers' stock.



Source: See the text for more details.

Table 1 ■ Summary statistics.

Variables	Description	Obs.	Mean	Std. Dev.
HI	Monthly growth rate of the aggregated constant-quality newly built housing price index in 35 major Chinese cities.	72	0.0092	0.0134
REBAR	Monthly return rate on continuous contract of rebar futures traded on the SHFE; see text for more details.	72	–0.0055	0.0493
IRONORE	Monthly return rate on the iron ore futures contracts traded on CME; see text for more details.	72	–0.0017	0.0975
MARKET INDEX	Monthly return rate on China's Shanghai-Shenzhen CSI 300 Index.	72	0.0067	0.0797
REAL ESTATE	Monthly return rate on the composite index of China's listed real estate firms.	72	0.0099	0.0945

The Hedging Strategy and its Effectiveness

In this section, we design our hedging strategy based on the correlation patterns revealed above, and test its efficiency using market data. As we mainly focus on the systematic risks in the new home sector, here we assume that an investor, such as a national-level housing developer, as well as its investors, holds a well-diversified portfolio that includes housing-related assets across the 35 major cities in China. Under this assumption, all idiosyncratic risks associated with any specific investment projects or cities should have already been hedged. Our question is whether and to what extent he/she can use the short sale of steel or iron ore futures contracts to hedge the systematic risk associated with his/her investments.

Following the method developed by Ederington (1979) and Myers and Thompson (1989), which was recently adopted by Hinkerlmann and Swidler (2008) and Bertus, Hollans and Swidler (2008), we use the OLS

Table 2 ■ Correlations between the various asset return rates.

	(1) *HI*		(2) *HI*		(3) *HI*		(4) *HI*	
REBAR	0.08***	(2.7)						
IRON ORE			0.06***	(4.0)				
MARKET INDEX					0.01	(0.4)		
REAL ESTATE							–0.01	(–0.6)
Constant	0.01***	(6.4)	0.01***	(6.5)	0.01***	(5.8)	0.01***	(5.9)
Observations	72		72		72		72	
R^2	0.09		0.19		0.00		0.01	

Note: t-Statistics are reported in parentheses.
***Significant at the 1% level.

method to estimate the optimal hedge ratio for one unit of housing asset, with the target of a minimum variance of this portfolio. As suggested by Ederington and Salas (2008), Viswanath (1993) and Myers and Thompson (1989), we use a conditional mean, instead of an unconditional mean in the model, and thus control for other available information, such as seasonality dummies and the lagged term of housing price changes. The model is set as:

$$h_{it} = \alpha + \sum_i \beta_i R_{it} + \gamma h_{i\,t-1} + \sum_{j=1,\ 2,\ 3} \delta_j D_{jt} + \varepsilon_t, \tag{1}$$

where h_{it} is the monthly return (in logarithm terms) of the aggregate constant-quality housing price index across the 35 major Chinese cities; R_{it} is the monthly return (in logarithm terms) of the hedging tool; β_i is the slope coefficient of the corresponding hedging tool, which could be interpreted as the optimal hedge ratio (*i.e.*, the value of this asset contained in a portfolio with unit values of the underlying housing index); D_{jt} is a set of seasonal dummies denoting seasonality; and ε_t is white noise.

Five hedging strategies are tested here, namely, short sales of rebar futures, short sales of iron ore futures, short sales of a combination of rebar and iron ore futures, short sales of the CSI 300 Index, and short sales of the composite stock price index of listed housing developers.[12] The results are listed in Table 3.

[12] All the series are stationary according to the Dickey–Fuller test (Dickey and Fuller, 1979).

Table 3 ■ The optimal hedging ratios.

	(1) *HI*		(2) *HI*		(3) *HI*		(4) *HI*		(5) *HI*	
REBAR	0.09^{***}	(3.4)			0.02	(0.4)				
IRON ORE			0.06^{***}	(4.1)	0.05^{**}	(2.2)				
MARKET INDEX							0.02	(0.9)		
REALE STATE									0.00	(0.1)
L.HI	0.49^{***}	(5.0)	0.43^{***}	(4.5)	0.44^{***}	(4.5)	0.51^{***}	(4.9)	0.51^{***}	(4.8)
Constant	0.00	(0.2)	0.00	(0.3)	0.00	(0.2)	0.00	(0.6)	0.00	(0.7)
Season Dummies	Yes		Yes		Yes		Yes		Yes	
Observations	71		71		71		71		71	
R-square	0.39		0.43		0.43		0.29		0.28	

Note: t-Statistics are reported in parentheses.
**Significant at the 5% level.
***Significant at the 1% level.

Columns (1) to (2) show that the positive correlation between housing prices and commodity futures remains robust, with both coefficients of our hedging instruments are significant at the 1% level. According to the results, one unit value of housing could be hedged with 0.06 units of iron ore futures, or 0.09 units of rebar futures. In Column (3), we introduce both of these two futures contracts. Due to the strong correlation between the price changes of these two commodities, while the coefficient of the iron ore index is still significant at the 5% level, the coefficient of rebar futures is statistically insignificant. This suggests that, if an investor is able to short both iron ore and rebar, it would be more effective to adopt shorting iron ore futures as the hedging strategy. The results in Columns (4) and (5) indicate that the short sale of stocks and the composite stock price index of listed housing developers cannot be used to hedge housing price risk, with all the estimated coefficients being insignificant.

We then calculate the hedging efficiency of each potential instrument. Here we define hedging efficiency as the percentage of reduction in the variance of the unpredicted residual (*i.e.*, the change in housing price that cannot be explained by seasonality and momentum). More specifically, the benchmark value of the variance of unpredicted residuals without the use of a hedging tool is derived from the model using only lagged house price changes and seasonal dummies, or:

$$h_{it} = \gamma' h_{it-1} + \sum_{j=1,\ 2,\ 3} \delta'_j D_{jt} + \varepsilon'_t. \tag{2}$$

Table 4 ■ Effectiveness of the hedging strategies.

Tools	Variance Before Hedging	Variance After Hedging	Variance Reduction
Rebar futures	0.0001298	0.0001106	14.8%
Iron ore futures	0.0001298	0.0001033	20.4%
Rebar and iron ore futures	0.0001298	0.0001030	20.6%
Stock market index	0.0001298	0.0001282	1.2%
Listed developers' stocks	0.0001298	0.0001297	0.1%

The variance of the unpredicted residuals with the effect of a specific hedging instrument can be derived from Equation (1) with the corresponding instrument included. Thus, the hedging efficiency for this instrument can be calculated as:

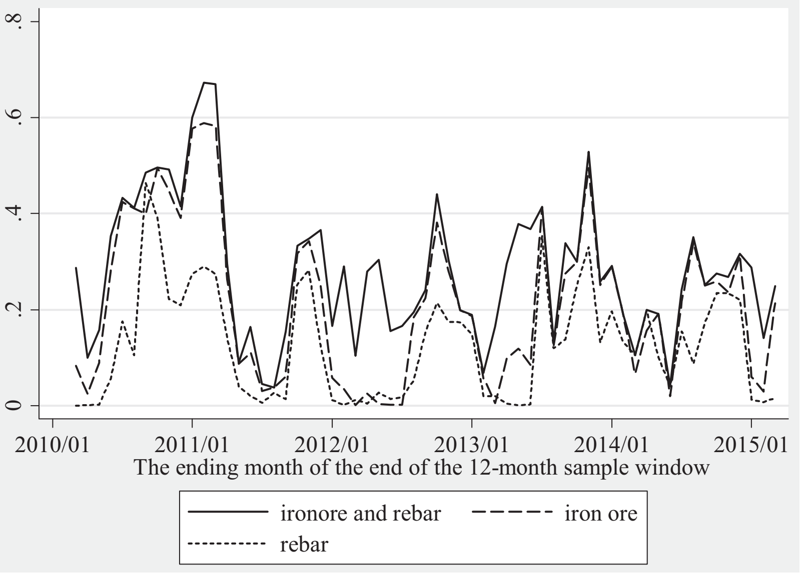
$$HE = 1 - \frac{VAR(\varepsilon_t)}{VAR(\varepsilon'_t)}. \tag{3}$$

As outlined in Table 4, the iron ore futures alone hedges 20.4% of the unpredicted risk of housing prices, and the rebar futures alone hedges 14.8% of the risk. A combination of rebar and iron ore futures hedges 20.6% of the variances of housing prices, which is slightly higher than that of shorting iron ore futures alone. Again such facts highlight that shorting iron ore futures contracts is the most effective strategy against the systematic risks associated with housing price in China. Shorting rebar futures can also be helpful, although less efficient compared with iron ore; in particular, it may be more feasible for some investors because it is traded on the exchange in mainland China.[13] Not surprisingly, shorting stocks hardly hedges any of the unpredicted risk of housing price.

Figure 3 depicts the stability in effectiveness of the hedging strategy, which is measured alongside volatility in terms of the percentage of variance reduction resulting from the use of rebar futures, or iron ore futures, or a combined portfolio of rebar and iron ore futures over a rolling, 12-month window respectively. This value is plotted against the ending month of the window in Figure 3. The percentages of all these hedging strategies concentrate in

[13]Following Hinkerlmann and Swidler (2008), we also try introducing a bundle of futures contracts including agricultural commodities, precious metals, energy, and foreign currency into the hedging model. The results show that the coefficients of these other futures contracts are insignificant, which is consistent with the findings of Hinkerlmann and Swidler (2008). The results are available upon request.

Figure 3 ■ Hedging efficiency with rebar futures, iron ore futures, and an optimal portfolio of rebar and iron ore futures.



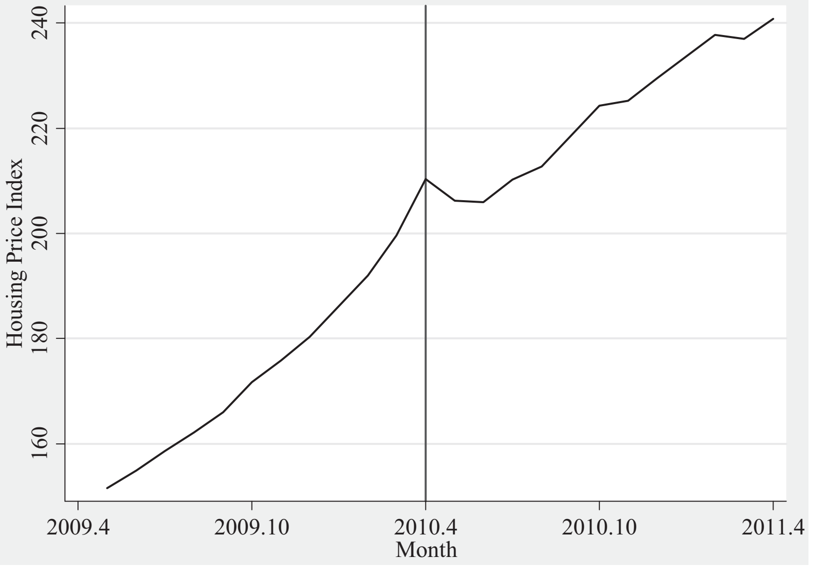
20%-40% with temporary fluctuations occurring during the sample period. A more precise conclusion as to whether this hedging strategy could remain effective over a longer horizon requires more observations, which we leave for future research.

Evidence Based on a Negative Shock to the Housing Market

In this section, we provide further evidence about the effectiveness of the hedge strategy by examining its performance under an unexpected, exogenous negative shock to the housing market. As the key role of a hedging instrument is to (at least partially) offset losses in the event of a negative shock, if steel/iron ore prices did move in the expected direction after the exogenous shock, this evidence could well validate our hedging strategy.

The exogenous shock adopted in the analysis is the announcement of the intervention policy on April 17, 2010. This policy, which was then widely known as the "home-purchase restriction," was aimed specifically at cooling the national housing market and outlined in the State Council's "Document

Figure 4 ■ Housing price index around the event.



Source: Constant-quality price index on new housing units developed by Wu, Deng and Liu (2014).

Number 10."[14] We select this event for three reasons. First, it is the best available example of an (unexpected) exogenous negative shock to the housing market. Beginning in the last quarter of 2008, the Chinese central government actively fueled the housing market by adopting several stimulus policies which resulted in an unprecedented surge in house prices in most major cities. However, with concerns over the overheating housing market increasing, the central government suddenly swung to the opposite direction in April 2010 by releasing the strictest cooling measure ever. Second, the shock had a conspicuous national effect on the housing market. Figure 4 depicts the aggregated housing price index as outlined by Wu, Deng and Liu (2014) for the period before and after April 2010. The figure clearly shows a sharp decrease associated with the announcement of the intervention policy. In May 2010, the national-level housing price index decreased by 2.0% over the previous month, which was the first negative month-on-month growth rate since December 2008. Third, since the event would not affect the demand or price of steel and iron ore via channels other than the housing market, the

[14] Among others, see Naughton (2010) or Du and Zhang (2015) for more details of this intervention policy.

response of steel/iron ore prices to this event can well indicate the effect of housing market conditions on the market of steel or iron ore.

Baseline Results

We first test the existence and magnitude of the cumulative abnormal return (CAR) of the steel and iron ore price index during the 10, 15, 20 and 30 trading days after April 17, 2010.[15] Two methods have been developed in the existing literature to calculate the normal return of commodity futures that serves as the benchmark, and both are adopted in the following analysis. First, following the mean return model by Milonas (1987) and McKenzie, Thomsen and Dixon (2004), we use the average return over a length of time (from 30 trading days to 11 trading days before the event, which is in total 20 trading days) to determine what would otherwise be the normal return if the event had not occurred. The abnormal rate of return was calculated as the real return minus the normal return. The second approach, the market adjusted model developed by Pruitt, Tawarangkoon and Wei (1987), is to select a bundle of commodities not affected by the event as the control group. In this article, we adopt the Dow Jones UBS Index. This index is constructed with a weighted average of daily prices for 24 commodities from six industries,[16] all of which have been proven to be irrelevant to the housing market (Hinkerlmann and Swidler, 2008).

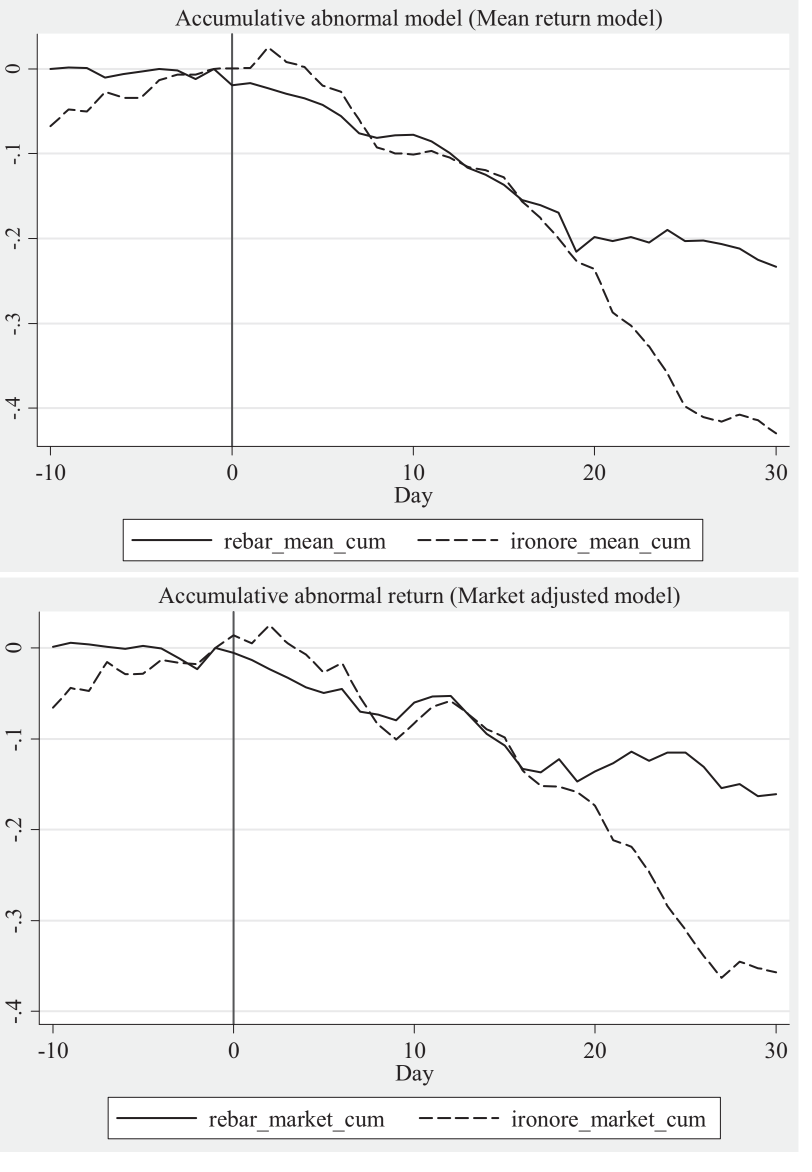
The calculation procedures are described in detail in the Appendix. The results for both methods are listed in Table 5. Figure 5 visually presents the CARs on each trading day using both methods.

The results are consistent across the mean return model and the market adjusted model for both rebar and iron ore futures. Significant and negative cumulative abnormal returns were observed over all four event windows. In general, the iron ore price suffered a larger loss under the shock. For example, in the 30 trading days after the event (*i.e.* till May 31st), the CAR was –43.0%

[15]The document was formally disclosed to the public on April 17, which was on Saturday with the capital markets closed. So April 19 is the first trading day after the policy announcement.

[16]The 24 commodities are: Crude Oil (WTI and Brent), ULS Diesel (HO), Natural Gas and Unleaded Gasoline in the Energy industry; Gold, Platinum and Silver in the Precious Metals industry; Aluminum, Copper, Lead, Nickel, Tin and Zinc in the Industrial Metals industry; Live Cattle and Lean Hogs in the Livestock industry; Corn, Soybeans, Soybean Oil, Soybean Meal and Wheat (Chicago and KC HRW) in the Grains industry; Cocoa, Coffee, Cotton and Sugar in the Softs industry. See http://www.djindexes.com/mdsidx/downloads/ubs/DJ_UBS_Commodity_Index_Methodology.pdf for more details of the index.

Figure 5 ■ Cumulative abnormal returns after the event



Note: These two figures report accumulative abnormal returns on each day after the event date. On day (–1), the accumulative abnormal return is set to 0.

Table 5 ■ Accumulative abnormal returns on rebar and iron ore futures prices.

Event Window Length	Mean Return Model				Market Adjusted Model			
	REBAR		*IRON ORE*		*REBAR*		*IRON ORE*	
10	-0.08^{**}	(−2.2)	-0.10^{***}	(−3.0)	-0.06^{*}	(−1.6)	-0.08^{**}	(−2.3)
15	-0.14^{***}	(−3.2)	-0.13^{***}	(−3.1)	-0.11^{***}	(−2.4)	-0.10^{**}	(−2.3)
20	-0.20^{***}	(−4.1)	-0.24^{***}	(−5.0)	-0.14^{***}	(−2.6)	-0.17^{***}	(−3.4)
30	-0.23^{***}	(−3.9)	-0.43^{***}	(−7.5)	-0.16^{***}	(−2.5)	-0.36^{***}	(−6.0)

Note: t-Statistics are reported in parentheses.
*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.

for the iron ore price index based on the mean return model, or –36% based on the market adjusted model. The rebar future price decreased less, falling 23% when we used the mean return model, and 16% when we used the market adjusted model. Nonetheless, the losses were both statistically and economically substantial. Figure 5 also shows that rebar price responded more quickly to the negative policy shock than the iron ore price in both models. This is consistent with the fact that rebar is more directly related to housing construction than iron ore.

These results well support the effect of our hedging strategy. During the sample of 30 trading days after the intervention event, our strategy was successful in hedging 48.86% of the housing price risk arising from the cooling measures from the short sale of iron futures, 38.2% from the short sale of rebar futures, or 50.04% from the short sale of both iron and rebar futures.[17]

Robustness Tests

The above results remained consistent when subject to several checks of robustness; the detailed results are omitted here to save space, but are available upon request. First, we estimated the normal rate of return using several

[17]Following our hedging strategy, to hedge one unit value of housing, we need a portfolio that includes shorting 0.018 unit of rebar futures and 0.048 unit of iron ore futures. Facing the negative shock of housing market on April 17, 2010, the return on our optimal hedging portfolio with both iron ore and rebar futures in May is $0.018^{*}0.081 + 0.048^{*}0.175 = 0.9858\%$. At the same time, the housing price decreases by 1.97% in May 2010. Then the hedging ration can be calculated as: 0.9858%/1.97% = 50.04%. The hedging ratio for short sales of iron ore or rebar futures alone can be calculated in the same way.

periods before the event, such as (–20, –1), (–25,–6) and (–35,–16). Significant negative cumulative abnormal returns were observed for both rebar and iron ore futures under all these alternative specifications.

Second, we ran a set of placebo tests by replacing the event day with alternate dates 30, 50 and 100 days before and after the cooling measures were announced. We maintained the previously adopted (T-31, T-11) time period for estimating normal return and calculate the abnormal return within a ten day (T, T+10) event window. It was only on the actual date of the event that the two futures contacts demonstrated significantly negative accumulative abnormal returns at the same time. The placebo tests suggest that the negative abnormal returns associated with iron ore and steel futures did not happen by chance.

Moreover, we have also done a set of placebo tests for the 24 commodities other than iron ore and rebar introduced before in the market adjusted model, and examine their response on the negative shock of the China housing market. The results show that there are no abnormal returns for those "nontreated" commodities around the announcement of intervention policy.

Extension in Usage of the Hedging Strategy

The hedging strategy proposed above mainly aims at reducing the systematic risks in the new home sector. In this section, we test whether we can further extend its usage, such as hedging the risks associated with housing price in a specific major city, or the risks in the resale housing markets.

Hedging Risks in Specific Cities

We start with investigating whether the hedging strategy suggested above could help an investor whose housing-related investments only concentrate in one specific city, instead of diversified across all the cities. Local housing developers are representative examples of such investors. The answer is yes, although only in some largest markets. Table 6 lists results using the capital city of Beijing as an example. The price of the rebar and iron ore futures are still strongly and positively correlated with housing prices in this first tier city. Hedging with rebar futures could reduce the risk arising from Beijing house prices by about 12.3%. Using iron ore futures reduces it by 12.2% and an optimal combination of iron ore futures and rebar futures reduces the risk by 13.6%. The hedging strategy is also found to be effective in several of the most important markets, such as Shanghai (the risk can be offset by 16.9% by an optimal combination of iron ore and rebar futures), Shenzhen (13.6%), Chongqing (18.8%), and Nanjing (26.1%), although much less effective in

Table 6 ■ Hedging strategies and their effectiveness in the newly built housing market in Beijing.

Hedging Strategy	(1) *HI_BJ* Rebar Futures		(2) *HI_BJ* Iron Ore Futures		(3) *HI_BJ* Rebar& Iron Ore		(4) *HI_BJ* Market Index		(5) *HI_BJ* Listed Developers' Stocks	
Panel A: Optimal Hedge Ratios										
REBAR	0.24^{***}	(3.0)			0.14	(1.0)				
IRON ORE			0.12^{***}	(3.0)	0.07	(1.0)				
MARKET INDEX							0.02	(0.3)		
REAL ESTATE									−0.00	(−0.1)
Panel B: Hedging Effectiveness										
Variance before hedging	0.0010605		0.0010605		0.0010605		0.0010605		0.0010605	
Variance after hedging	0.0009307		0.0009302		0.0009161		0.0010591		0.0010605	
Variance reduction	12.3%		12.2%		13.6%		0.1%		0.0%	

Note: *t*-Statistics are reported in parentheses.
***Significant at the 1% level.

other 2nd or 3rd tier cities. Therefore, such results at least suggest that the hedging strategy proposed is helpful for investors in several most important housing markets in China. Again shorting stocks cannot help to reduce risks in any of these 35 housing markets.[18]

These results can be well explained by a remarkable relationship between the city-level house price paths and the national-level common trend as revealed earlier by Wu, Gyourko and Deng (2012, 2015), which could result from the macroeconomic environment, market sentiment and/or the central government's housing market intervention policies. As highlighted in these research studies, typically such correlation is especially strong in the top tier cities, due to the leading roles of these cities in the county.

Hedging Risks in Resale Markets

Next we test whether the hedging strategy can also be suitable for the resale market. It would be particularly important for commercial banks which hold massive amount of housing mortgages, because the default risks are affected by dynamics of resale housing prices.

Currently there is no reliable resale housing price index for the national level in China, and we use the resale market in Beijing as an example, where the constant-quality price index for the resale market is available from Wu, Deng and Liu (2014). We replicate the hedging strategy using the resale house price data in Beijing, and the results are shown in Table 7. All results are consistent with the results for the new home sector. Specifically, 17.0% of the unpredicted risk of housing prices of Beijing resale market could be hedged by a combination of rebar and iron ore futures. The rebar futures alone hedges 8.4% of the risk, and the iron ore futures alone hedges 16.7% of the total variance. Consistent with the main results, the hedging effect is very poor by shorting stocks.

Although the underlying logic of the linkage between the housing market and raw material markets only exists in the new home sector theoretically, the results above are not surprising. In China typically there exists a strong relationship between prices in the new home and resale housing sectors, because these two sectors are almost perfect substitutes. Taking Beijing as the example, the correlation between the monthly return of new home price and the corresponding indicator in the resale market is positive and significant at 1%. Therefore it is very likely that, in other markets where the hedging

[18]The results of each specific city-level models are all available upon request.

Table 7 ■ Hedging strategies and their effectiveness in the resale housing market in Beijing.

Hedging Strategy	(1) *HI_BJ* Rebar Futures		(2) *HI_BJ* Iron Ore Futures		(3) *HI_BJ* Rebar & Iron Ore		(4) *HI_BJ* Market Index		(5) *HI_BJ* Listed Developers' Stocks	
Panel A: Optimal Hedge Ratios										
REBAR	0.21**	(2.4)			–0.06	(–0.5)				
IRON ORE			0.15***	(3.6)	0.17**	(2.6)				
MARKET INDEX							0.04	(0.7)		
REAL ESTATE									–0.00	(–0.1)
Panel B: Hedging Effectiveness										
Variance before hedging	0.0011593		0.0011593		0.0011593		0.0011593		0.0011593	
Variance after hedging	0.0010624		0.0009656		0.0009625		0.0011509		0.0011592	
Variance reduction	8.4%		16.7%		17.0%		0.7%		0.0%	

Note: t-Statistics are reported in parentheses.
**Significant at the 5% level.
***Significant at the 1% level.

strategy is effective in the new home sector, this strategy would also be helpful in the resale sector, although we have to leave more conclusive analysis to the future studies when high-quality resale house price indicators are available for other markets.

Conclusion

In light of the global concern over the possibility of a major correction in the Chinese housing market, this article focuses on whether there is a feasible instrument for investors involved in the Chinese housing sector to hedge the systemic risk associated with China's house prices. Our idea is to take advantage of the spillover effect of the housing market on raw construction materials such as steel and iron ore, and hedge the housing market risk by holding short positions in these two futures.

In general, the empirical results are encouraging. The correlation analysis suggests a significant correlation between Chinese housing price changes and global steel/iron ore price changes. Accordingly, at least during our sample period, the hedging strategy of shorting rebar and/or iron ore futures contracts was proven effective in hedging the unpredicted risk in the housing market. A portfolio of the aforementioned commodity futures could hedge about 20.6% of the variance in China's average house price. At the very least, this strategy has been shown to be superior to the alternative, which is to hold short positions in the stock market. We also found that if our strategy had been applied when cooling measures were announced in April 2010, it would have helped offset a significant proportion of the losses arising to investors in that time. In addition, this hedging strategy can also help investors concentrating in several largest housing markets such as Beijing, Shanghai, and Shenzhen, or investors in the resale housing market to partially hedge risks.

We acknowledge that our hedging strategy could be improved in several ways. First, the stability and effectiveness of the hedging strategy needs to be tested over a longer period. Second, with a longer study period, it would be prudent to study more advanced hedging strategies such as the dynamic hedging model proposed by Myers and Thompson (1989) which can adjust optimal hedging positions over every period. Finally, as China's financial markets mature and more real estate-related securities, in particular the house price derivatives, are developed, more hedging tools can be designed and tested to optimize the efforts of prudent investors to hedge against the risks of the Chinese property market.

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Appendix : Procedures of the Event Study Analysis

We calculate daily logarithmic return on commodity futures:

$$R_t = \ln(P_t / P_{t-1}). \tag{A.1}$$

We assume t $= -T_1, -T_1 + 1, \ldots, -T_2$ is the normal period, while the event day takes place on $t = 0$ and $t = 0, \ \ldots, \ T_3$ is the event window. After we get the normal return index, $R_{n,t}$ (of which two methods are discussed below), which we assume is the counter-factual return on the futures contact that captures all macroeconomic shocks except the real estate industry shock, we could calculate the abnormal returns for the commodity future:

$$AR_t = R_t - R_{n,t} \qquad \text{t} = -T_1, -T_1 + 1, \ldots, -T_2, \ 0, \ \ldots, \ T_3. \tag{A.2}$$

Following a statistical method similar to that used by Pruitt, Tawarangkoon and Wei (1987), McKenzie and Thomsen (2001) and McKenzie, Thomsen and Dixon (2004), the standard deviation s_t for each event day:

$$s_t^2 = s^2\left(1 + \frac{1}{T_1 - T_2 - 1} + \frac{\left(R_{n,t} - \overline{R_n}\right)^2}{\sum_{\tau=-T_1}^{-T_2}\left(R_{n,\tau} - \overline{R_n}\right)^2}\right), \ t = 0, \ \ldots, \ T_3. \tag{A.3}$$

We use two methods to construct daily normal/abnormal returns and standard deviations:

Mean Return Method

In the mean return model, the normal return is assumed to be constant and equal to the mean return over the normal period:

$$R_{n,\ t} \equiv \bar{R}. \tag{A.4}$$

So now the variance over the normal period, s^2 is constant and equal to the sample variance of daily returns. Further, s_t^2 simply collapses to:

$$s_t^2 = s^2\left(1 + \frac{1}{T_1 - T_2 - 1}\right). \tag{A.5}$$

Market Adjusted Method

The market adjusted model uses Dow Jones UBS Index, a portfolio of real estate irrelevant commodity futures, as the normal return index. In addition, taking into account the difference in underlying risk free rate for different commodity futures, a difference-in-difference like structure is laid down:

$$R_{n,t} = \left(\bar{R} - \overline{R_p}\right) + R_{p,t}, \tag{A.6}$$

where $\bar{R}$ is the average return for the commodity we are interested in, over the estimation period, while $\overline{R_p}$ is the average return for the controlled market portfolio. So the difference in the bracket measures the difference in risk free rate and other “normal” differences between the real estate industry and others. $R_{p,t}$ is the market return on each event day.

So the abnormal return on day t is:

$$AR_t = R_t - R_{n,t} = \left(R_t - R_{p,t}\right) - \left(\bar{R} - \overline{R_p}\right). \tag{A.7}$$

Therefore the normal period sample standard deviation could be calculated as:

$$s^2 = \frac{1}{T_1 - T_2 - 1} \sum_{\tau=-T_2}^{-T_1}$$

$$AR_t{}^2 = \frac{1}{T_1 - T_2 - 1} \sum_{\tau=-T_2}^{-T_1} \left(\left(R_t - R_{p,t}\right) - \left(\bar{R} - \overline{R_p}\right)\right)^2 \tag{A.8}$$

$$\text{sothat} s_t^2 = s^2\left(1 + \frac{1}{T_1 - T_2 - 1} + \frac{\left(R_{p,t} - \bar{R}_p\right)^2}{\sum_{\tau=-T_2}^{-T_1}\left(R_{p,t} - \bar{R}_p\right)^2}\right). \tag{A.9}$$

After the daily abnormal return and the standard deviation are calculated, based on any of the above two methods, we calculate the accumulated abnormal return for event window from T_1, starting date of the event window, to T_2, ending date of event window:

$$CAR_{T_1,T_2} = \sum_{t=T_1}^{T_2} AR_t. \tag{A.10}$$

We standardize daily abnormal return:

$$SAR_t = \frac{AR_t}{s_t}. \tag{A.11}$$

We use cumulative standardized abnormal return to examine if the impact of event is significant over a certain horizon $t = A,\ A+1,\ \ldots,\ B$. The Null hypothesis is that $SCAR_{A,\ B}$ follows an asymptotically standard normal distribution.

$$SCAR_{A,\ B} = \sum_{\tau=A}^{B} \frac{SAR_\tau}{\sqrt{T_2 - T_1 + 1}}. \tag{A.12}$$