**The lean hog future research for China future development**

In 2018, the pork price soared in China due to African swine fever. The first case was found in August 3, 2018. In the following months, millions of pigs were killed because of the disease and hundreds of millions CNY loss was incurred. As a necessity on the table of Chinese people, pork has always affected the CPI index. After transmission, it is directly related to the expectations of inflation and the direction of macro-control policies. After the crazy increase of the price, people were talking more to establish a pork-related future market to prevent the price inflation in the future.

China, as the country with the largest number of slaughter pigs in the world, has a market size of over one trillion CNY, accounting for about 57.46% of the world's total slaughter. The upstream and downstream industrial chain of pigs involves feed, breeding, veterinary medicine, slaughter, food and other fields. There are tens of thousands of directly connected enterprises and more than 100 million employees. After the listing of hog futures, it will play an important role in improving China's hog price formation mechanism and assisting the industry to stabilize business profits. First, hog futures can provide a fair forward price for the industry. Breeding enterprises can adjust the scale of breeding by referring to the forward price to avoid cyclical sharp price fluctuations caused by blindly increasing or decreasing the number of stocks. Second, hog futures will provide risk management tools for the hog industry.

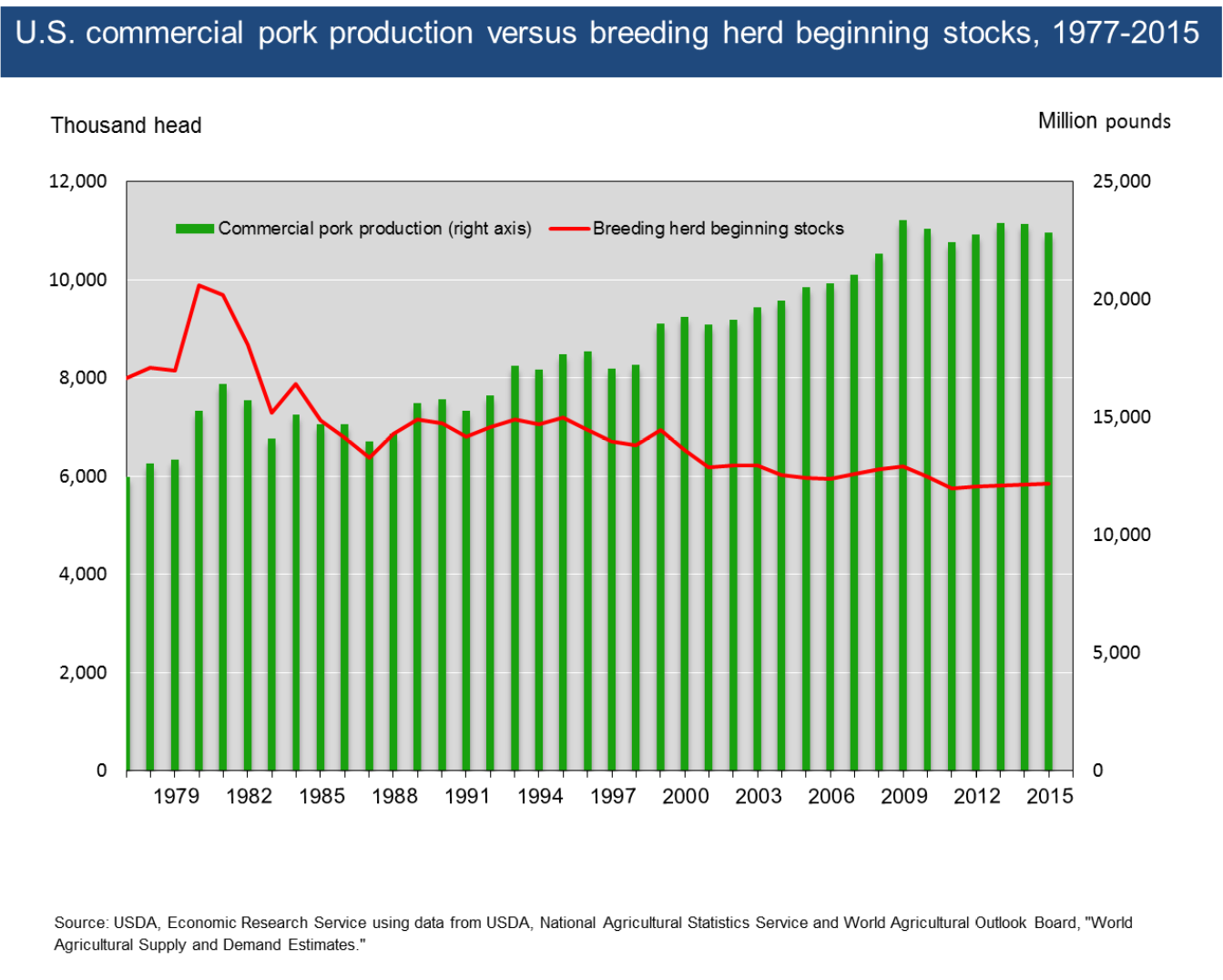
The United States is the second largest country in the world for hog breeding and consumption. The development of hog large-scale breeding and hog futures was earlier than China for many years. The pig industry chain mainly includes three links: production, slaughter, processing and consumption. From 1960s, USA had already launched the frozen pork belly future contract and the hog futures. After years of development, the market in USA is mature and provides lots of lessons for China market.

In recent years agricultural commodity markets have experienced heightened price volatility which can have significant implications on production, marketing, and risk management practices (Wang, Fausti and Qasmi, 2012). In this environment, Isengildina, Irwin and Good (2004) indicate many individuals rely on agricultural forecasts in their decision making and that the value of accurate information can be substantial.

In this paper, we will first introduce the history of pig industry in USA, Secondly, we will test the ARIMA-GARCH seasonality model and volatility for lean hog future. The third part mainly focuses on the confirmation of relationship between lean hog, corn and wheat. The fourth part is about the B-S model developed for lean hog future and the model calibration. In the fifth part, we will pay attention to the difficulties China will meet in the future.

1. Pig industry history in USA

The production link can be subdivided into feed, veterinary medicine and animal husbandry, and aquaculture. The division of labor in the US pig breeding sector is very professional. According to the growth cycle of pigs, it is divided into breeding pigs, piglets feeding, and fattening pigs (commercial fat pigs for slaughter). Feeding is carried out in specialized stages. Only a small part of the traditional "breeding" is retained. "Integrated" farming. The upstream feed supply in the aquaculture sector is mainly controlled by several large feed companies with a high concentration of feed industry. In the veterinary drug protection sector, there are specialized veterinary service companies in the United States that generally serve multiple farms and carry out computerized management. The concentration of pig vaccines in the animal protection industry is very high. Companies such as Zoitis, Elanco + Novartis, Merk (MSD) in the United States have a high market share in the United States and even the world.



In the slaughtering and processing sector, with the large-scale transformation of American pigs, pigs and slaughtering and processing enterprises have been vertically integrated. Backward, contract purchases were made from large-scale farms through agreement procurement or self-invested construction and acquisition of farms for vertical integration and expansion. At the same time, horizontal mergers and acquisitions have become the industry's super leading companies, such as Smithfield Foods, Tyson, JBS S / A and so on.

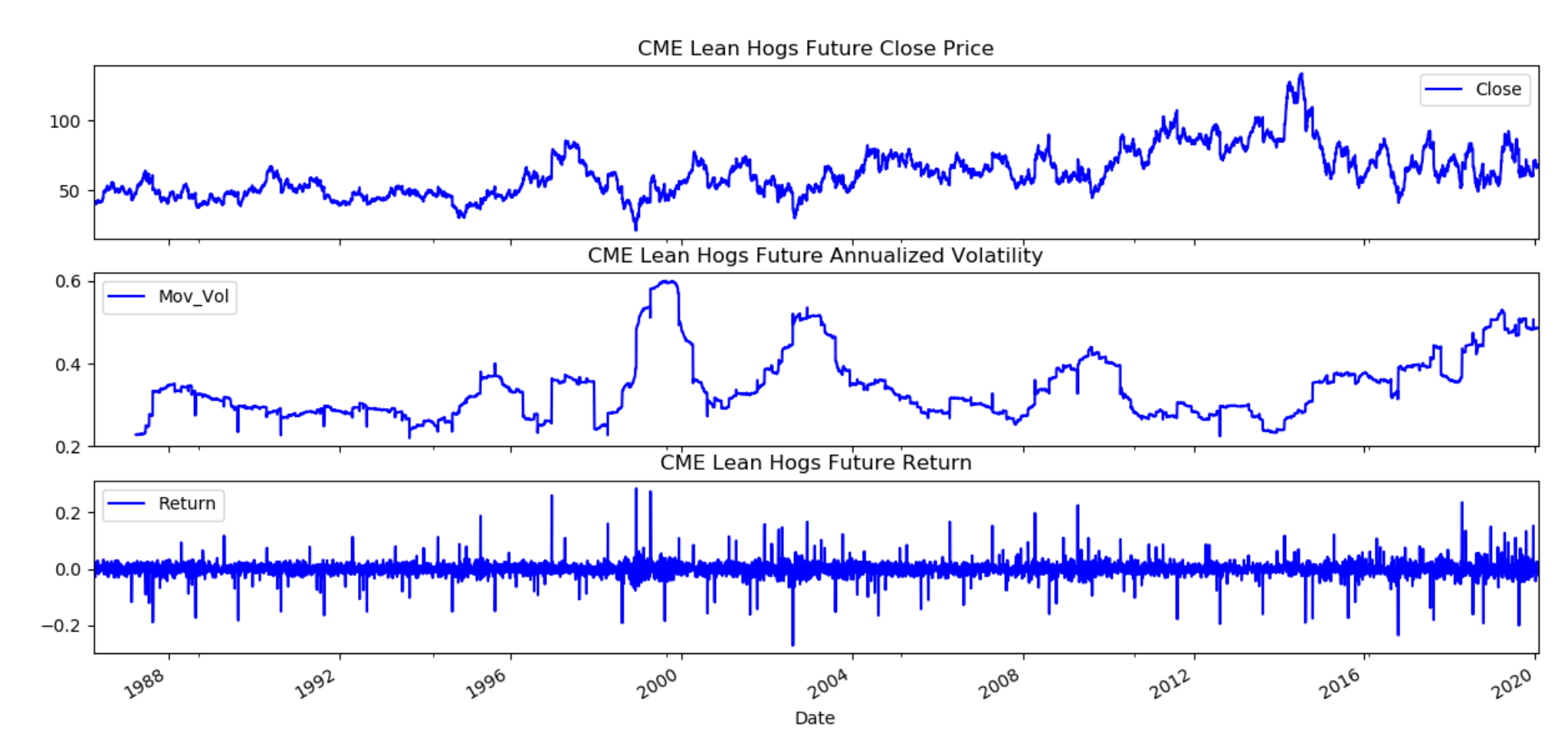
Consumption: According to US meat consumption data, chicken and beef consumption account for a relatively large proportion, and pork consumption ranks third in meat consumption. Its consumption has maintained a steady and small increase in recent years. In terms of pork consumption, US pork consumption methods mainly include: (1) Home consumption: This part of consumption accounts for 78% of pork consumption in the United States. (2) Consumption outside the household: refers to consumption in the food service industry, including restaurants and food suppliers, agencies involved in supplying processed pork products to commercial properties, such as universities, companies, hospitals and related institutions. In this part of the consumption, restaurant consumption accounts for 17% of pork consumption in the United States, and food suppliers to various institutions account for 5% of pork consumption in the United States.

Contract Specs

Some important characteristics of the lean hog futures contract are as follows. (Source: Bloomberg)

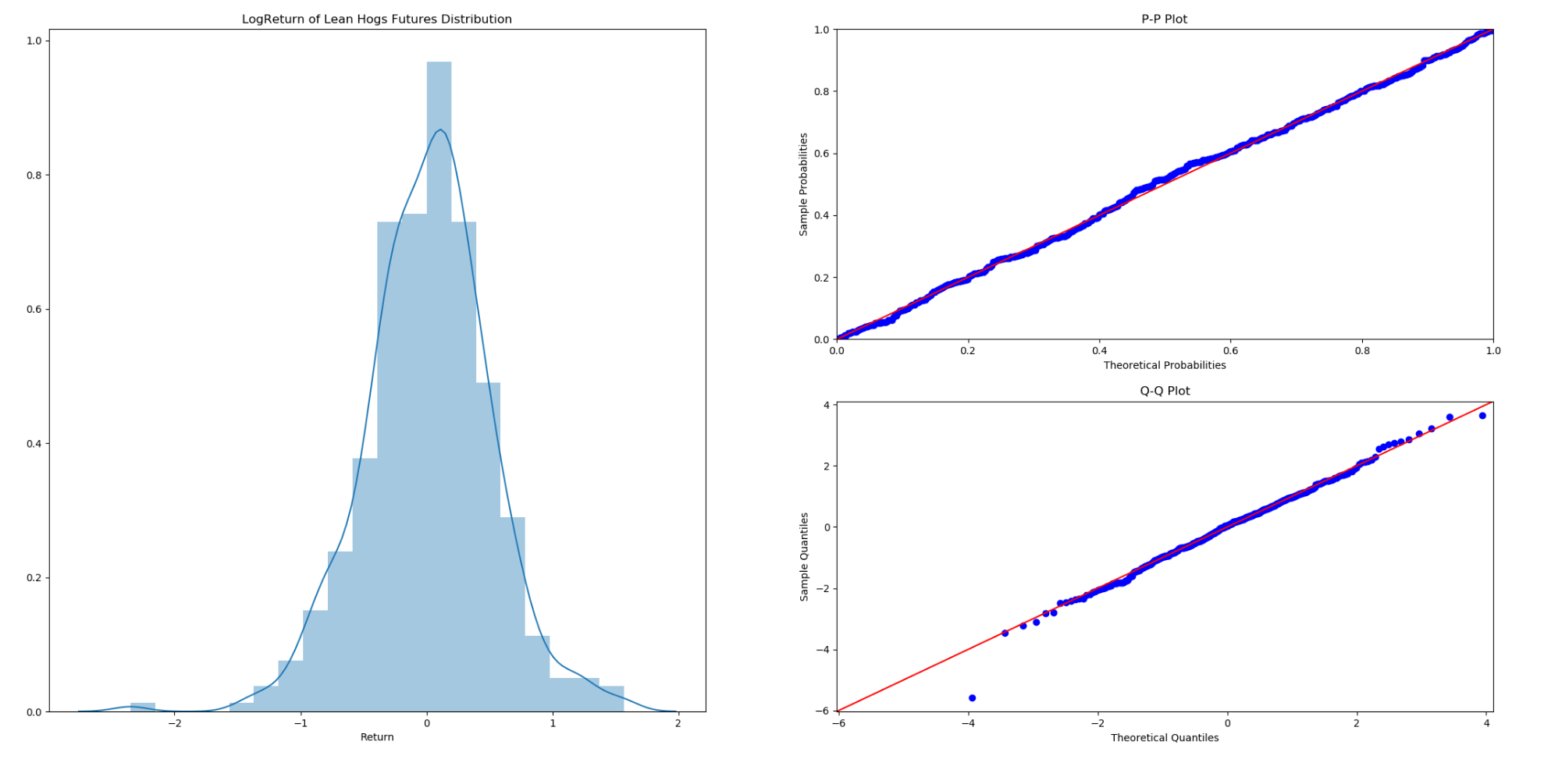
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| --- | --- |
| **Item** | **Contract Specs** |
| Ticker Symbol | LH |
| Exchange | Chicago Mercantile Exchange (CME) |
| Trading Hours | 10:05 AM to 2:00 PM EST |
| Contract Size | 40,000 pounds |
| Contract Months | Feb, Apr, May, Jun, Jul, Aug, Oct, and Dec. |
| Price Quote | price per pound |
| Tick Size | $0.00025 or 2.5 cents per pound = $10.00 (0.00025 x 40,000 lbs). |
| Last Trading Day | The tenth business day of the contract month |

The Lean hogs futures’ daily data are collected from Bloomberg from 1988 to 2019. The below image shows the futures’ daily movement, moving average volatility and daily return. The first image is about daily close price. The daily close price is not stationary and has no obvious trend. The second part is annualized volatility. The volatility has strong clustering effect according to the image. The lower part is about future return. The future return is calculated by log return and is seemingly stationary. The following article will test the future return for Seasonal ARIMA and GARCH model for more details.



the daily log return is resampled to monthly data and multiple 100. The monthly data summary information is also shown as below. The skewness is between -0.5 and 0.5, the data are fairly symmetrical. The kurtosis is greater than zero, then the distribution has heavier tails. The distribution image shows that the distribution is fairly symmetrical and has heavy tail.

|  |  |
| --- | --- |
| **Summary** | **Details** |
| Count | 406 |
| Mean | 0.011480 |
| Std | 0.496453 |
| Min | -2.349821 |
| 25% | -0.271369 |
| 50% | 0.035296 |
| 75% | 0.307121 |
| Max | 1.566891 |
| Skewness | -0.203338 |
| Kurtosis | 1.430991 |



In order to confirm the lean hogs futures log return is stationary, several unit root tests are conducted as below. Before unit root tests, VR tests was performed to test whether the return series is a pure random walk versus having some predictability. P-value is smaller than 0.05 and the null hypothesis that the series is a pure random walk is rejected. The tests of unit roots and stationarity with ADF, KPSS, DFGLS, PP and ZA statistics are all shown that the time series is stationary.

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| --- | --- | --- | --- | --- | --- | --- |
|  | **Variance-Ratio Test** | **Augmented Dickey-Fuller** | **KPSS** | **Dickey-Fuller GLS** | **Phillips-Perron** | **Zivot-Andrews** |
| **Test Statistic** | -4.532 | -5.584 | 0.030 | -2.145 | -24.684 | -5.838 |
| **p-value** | 0.000 | 0.000 | 0.977 | 0.032 | 0.000 | 0.001 |
| **Lags used** | 12 | 15 | 9 | 15 | 18 | 15 |
| **1%** |  | -3.45 | 0.74 | -2.62 | -3.45 | -5.28 |
| **5%** |  | -2.87 | 0.46 | -2.00 | -2.87 | -4.81 |
| **10%** |  | -2.57 | 0.35 | -1.68 | -2.57 | -4.57 |

1. Seasonality ARIMA test for lean hogs future

According to US meat consumption data, chicken and beef consumption account for a relatively large proportion, and pork consumption ranks third in meat consumption. Its consumption has maintained a steady and small increase in recent years. (美国猪肉消费周期性的统计数据证据)

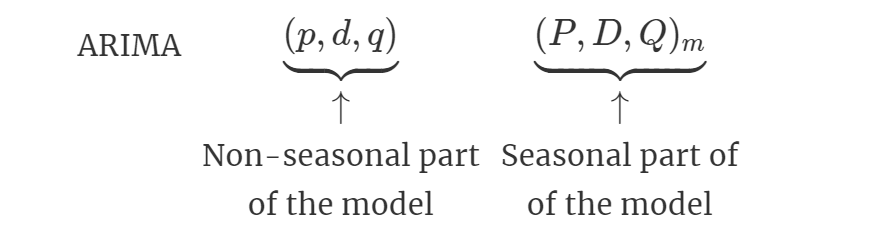
2.1 Seasonal ARIMA Introduction

ARIMA is an acronym for AutoRegressive Integrated Moving. The full model can be written as

Where is the differenced series (it may have been differenced more than once). The “predictors” on the right hand side include both lagged values of and lagged errors. This is an **ARIMA(p, d, q) model**, where

|  |
| --- |
| p = order of the autoregressive part; |
| d = degree of first differencing involved; |
| q = order of the moving average part. |

A seasonal ARIMA model is formed by including additional seasonal terms in the ARIMA models. It is written as follows:



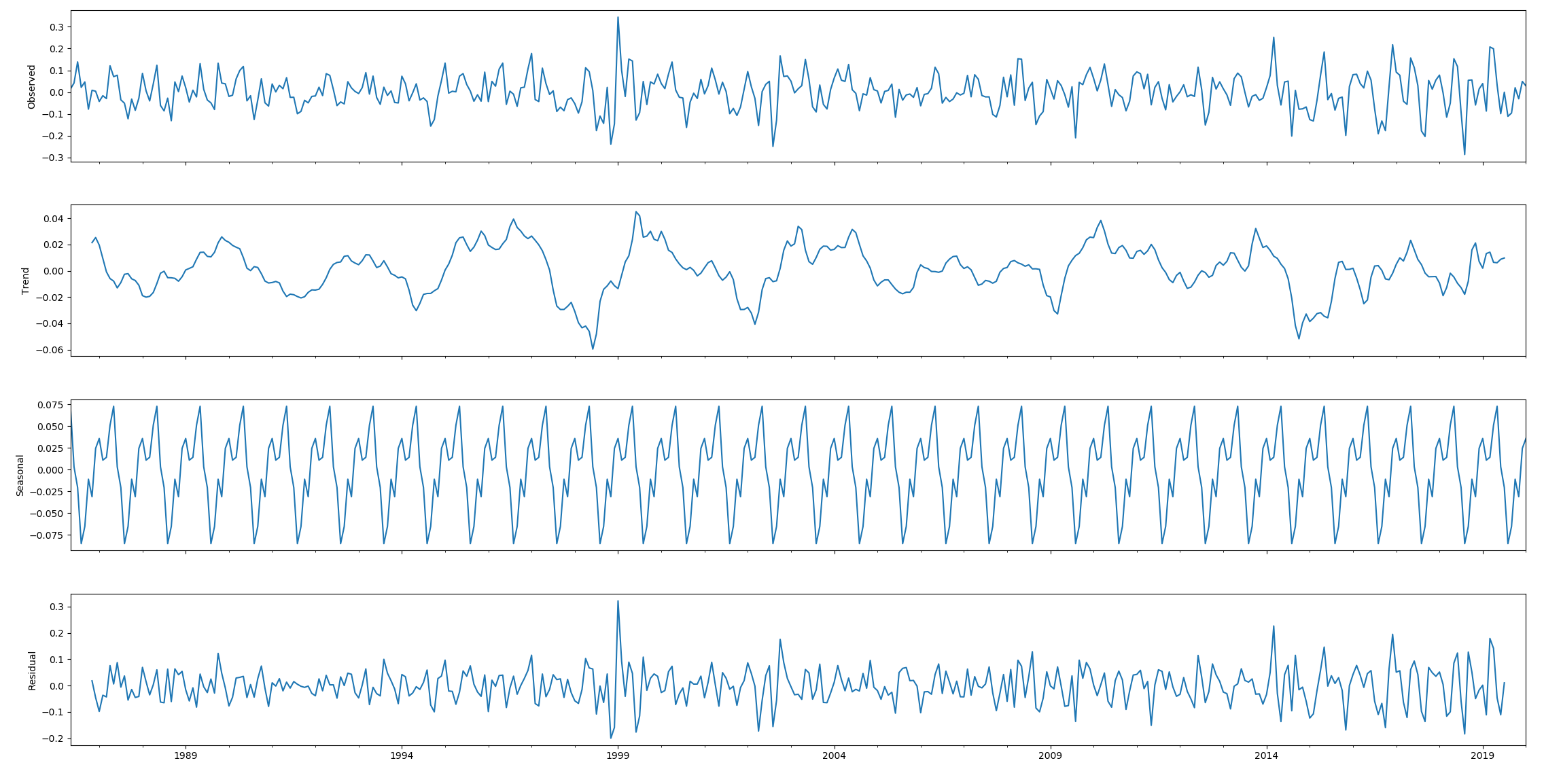
where . We use uppercase notation for the seasonal parts of the model, and lowercase notation for the non-seasonal parts of the model.

The seasonal part of the model consists of terms that are similar to the non-seasonal components of the model but involve backshifts of the seasonal period. For example, an model (without a constant) is for quarterly data ( ), and can be written as

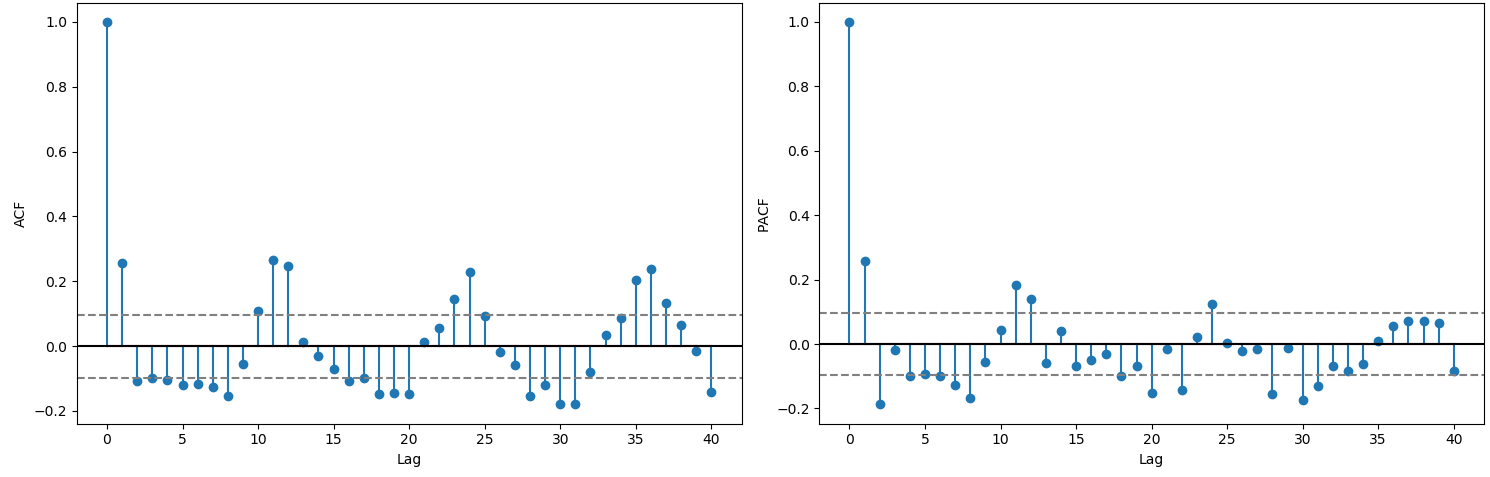
The additional seasonal terms are simply multiplied by the non-seasonal terms.

2.2 Seasonal ARIMA Test

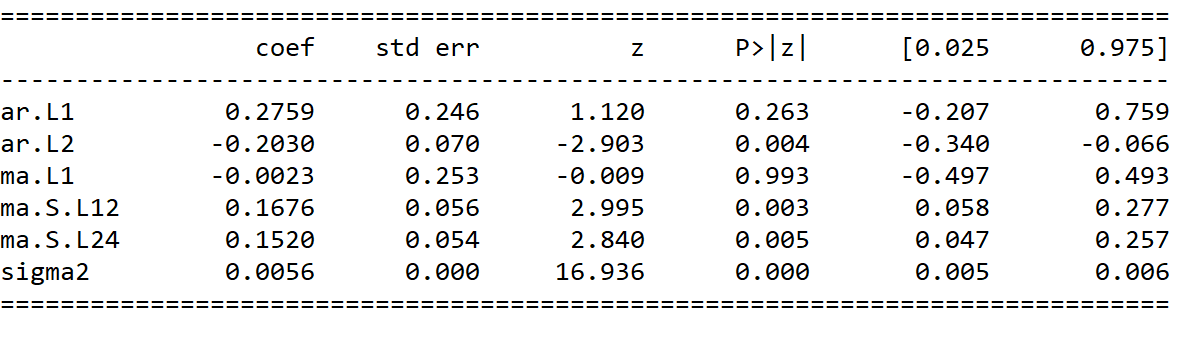
The test data is monthly log return of lean hogs future, which is stationary shown in the part 1. The below image is generated by sm.tsa.seasonal\_decompose command. This image decomposes the lean hogs future return time-series into three distinct components: trend, seasonality, and noise. Analyzing the chart, the time-series has seasonality pattern is obviously observed. First quarter in each year has a peak of price for years. There is a random trend over the years.



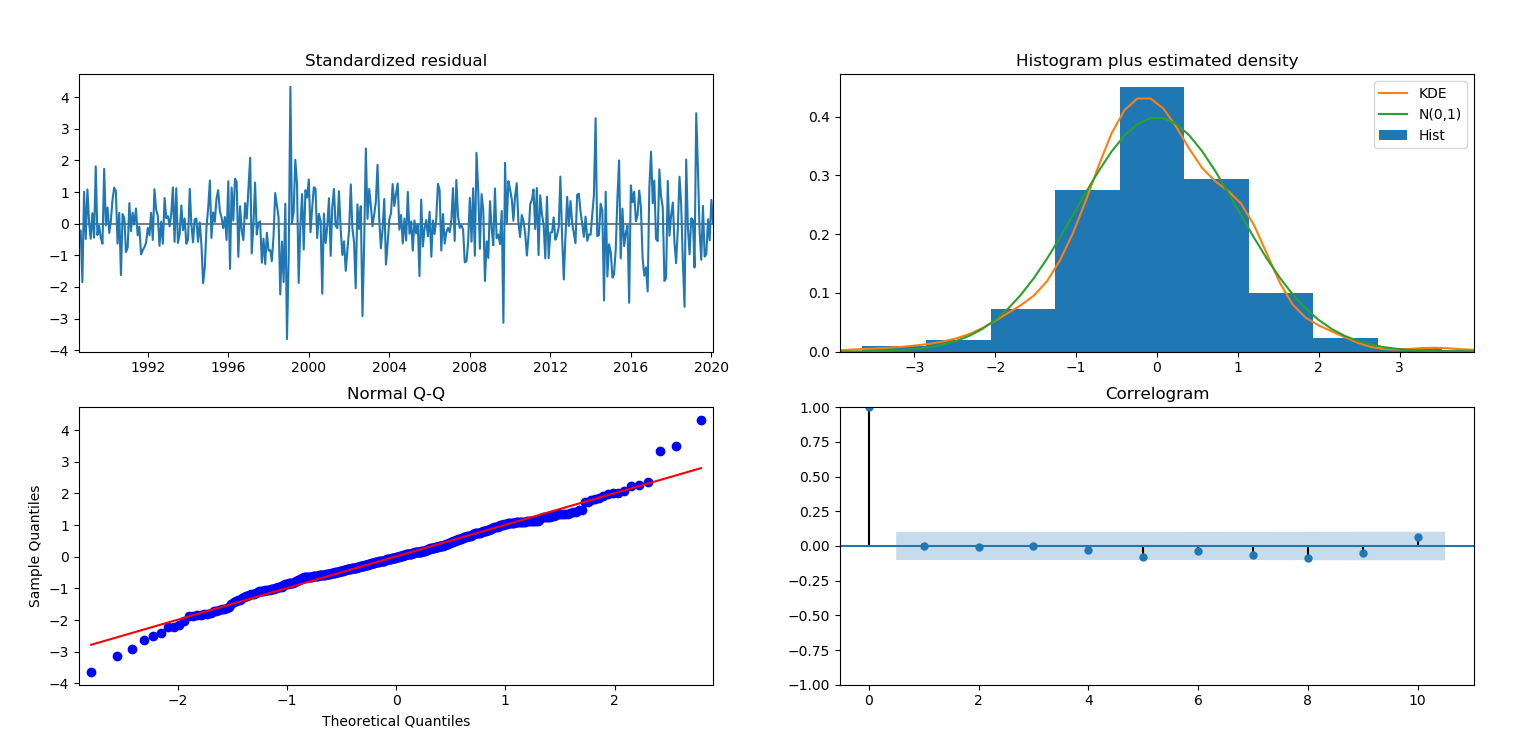
The left figure gives the ACF of log return of Lean Hogs Futures series. The significant spike at lag 1 in the ACF and PACF suggests a non-seasonal MA(1) component, and the significant spike at lag 12 in the ACF suggests a seasonal MA(1) component. Notice that in the regular part there is decay in the AR structure, whereas in lags 12, 24, 36, a slow decay is observed in the coefficients, indicating the presence of a 12 period seasonal component. The right figure shows an exponential decay occurs in the seasonal lags of the PACF. Therefore, model is selected.



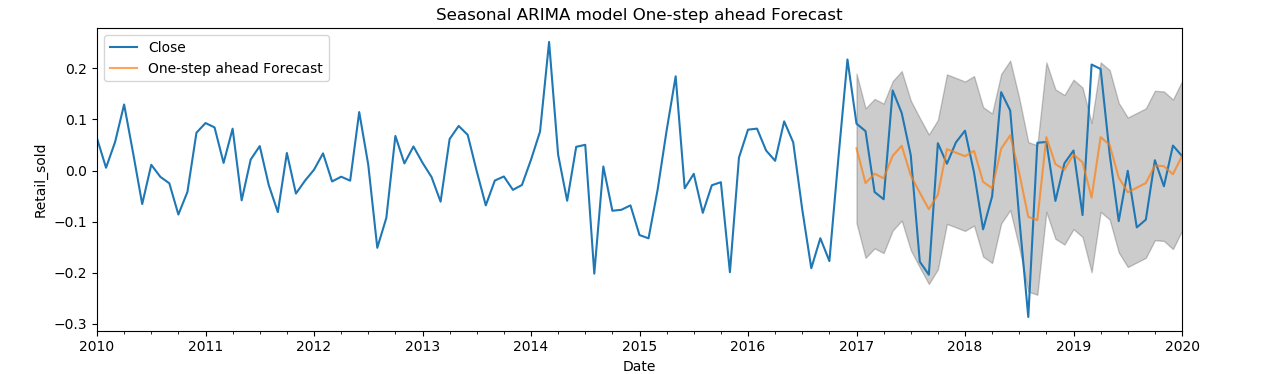
The fitted model coefficient and other information are displayed below.



The residual of the model is stationary, but has volatility clustering effect in sub-figure 1. It means that lean hogs future may accommodate to GARCH model. The residual is conform to Normal distribution but has heavy tails based upon the sub-figure 2 and sub-figure 3. ACF of residual shows no obvious autocorrelation effect. In third part, the article will test the GARCH model.



One step ahead forecast consists in comparing the true values with the forecast predictions. The below figure shows that the data trend is well predicated. In seasonal ARIMA model, the Mean Squared Error is 0.01, and the Root Mean Squared Error is 0.09.



According to this part, lean hogs future shows strong seasonal effect. The price starts to go high at the beginning of year. After the first quarter, the price then goes down. Pork is one of major meat consumed in China. The seasonal effect will bring huge influence to China market. When China decides to begin lean hogs future, it is best for Chinese investors to be careful about the cyclical effect in lean hog future. The investors should hedge the future before the price goes high.

Seasonal ARIMA model predicts a right trend of future return and has a good performance in predication. As a precautionary method, investors should use advanced tools to predicate the fluctuation in case of market disorder.

Government should establish an ordering market and prevent the investors from disrupting the market. Government should employ an efficient method to curb the price when price has momentum to become abnormal.

1. GARCH Volatility Tests for lean hogs future

Conclusion

However, it is very difficult to start the lean hog future from scratch. The first obstacle is that the future contracts is very hard to standardize. Due to the large and scattered production of pigs in China and the limitation of the trading radius brought by the regional production of pigs, there is a large difference in pig breeds and quality. It is not easy to standardize the indicators of pig breeds, weight, and thickness thing. These differences bring difficulty to the setting of the delivery grade in the contract design. In the actual delivery process after the contract is launched, how many pig products can meet the delivery standards is also unknown. The second reason is the delivery difficulties. As a livestock and fresh agricultural product futures, hog futures are different from the traditional storage-resistant futures varieties. In the process of physical delivery, there are often more operational obstacles and risks. For example, the storage problem of live pigs during live transportation, and the more difficult risk of pig epidemic transmission. May wish to learn from other countries. In the 1960s, the US hog futures contract was listed, and the delivery method was physical delivery. By the end of the last century, the subject matter of the contract had changed from hogs to lean ketones, and the delivery method had become cash settlement. For 30 years, pigs were the target. In addition, the German Hannover Exchange (RMX) and the Korean Exchange (KRX) also have lean hog futures listed on the exchange, and the two have adopted cash delivery since the launch. The settlement price mainly depends on the spot price. index. In fact, these obstacles exist more or less in other countries, but they have not affected the United States, Germany and South Korea and other countries to eventually launch pig futures. Facts have shown that the listing of pig futures on the Chicago Mercantile Exchange in February 1966 further accelerated the scale operation and industrial integration of the pig industry. Thirty years later, in the mid-1990s, 70% of the pigs in the United States were able to meet futures delivery standards. Similar results have been seen in other varieties of futures markets in China.

Schulz, L. 2019, "Lean hog futures overly positive", Corn & Soybean Digest (Online Exclusive), .