UNIVERSITÄT PADERBORN
Die Universität der Informationsgesellschaft

CENTER FOR INTERNATIONAL ECONOMICS

Working Paper Series

Working Paper No. 2013-15

Changes of China's agri-food exports to Germany caused by its accession to WTO and the 2008 financial crisis

Zhichao Guo, Yuanhua Feng, Thomas Gries

November 2013

CENTER FOR
INTERNATIONAL
ECONOMICS

Changes of China's agri-food exports to Germany caused by its accession to WTO and the 2008 financial crisis

Zhichao Guo^{1*}, Yuanhua Feng² and Thomas Gries²

¹School of Economics, Beijing Technology and Business University, China

²Faculty of Business Administration and Economics, University of Paderborn, Germany

Abstract

The purpose of this paper is to investigate changes of China's agri-food exports to Germany caused by China's accession to WTO and the global financial crisis in a quantitative way. The paper aims to detect structural breaks and compare differences before and after the change points. The structural breaks detection procedures in this paper can be applied to find out two different types of change points, i.e. in the middle and at the end of one time series. Then time series and regression models are used to compare differences of trade relationship before and after the detected change points. The methods can be employed in any economic series and work well in practice. The results indicate that structural breaks in 2002 and 2009 are caused by China's accession to WTO and the financial crisis. Time series and regression models show that the development of China's exports to Germany in agri-food products has different features in different sub-periods. Before 1999, there is no significant relationship between China's exports to Germany and Germany's imports from the world. Between 2002 and 2008 the former depends on the latter very strongly, and China's exports to Germany developed quickly and stably. It decreased however suddenly in 2009, caused by the great reduction of Germany's imports from the world in that year. But China's market share in Germany still had a small gain. Analysis of two categories in agri-food trade also leads to similar conclusions.

Keywords: Agri-food trade; structural breaks; China's accession to WTO; financial crisis; change of trade relationship

Paper type: Research paper

JEL classification: C13; F14; Q17

*Corresponding author with Tel:+86 10 68984016; Fax:+86 10 68983276; E-mail:sxguozc@hotmail.com.

1 Introduction

Germany is one of the most important markets for China's exports in agri-food products. Not only the export value increases together with Germany's demand, but the market share also increases quickly, particularly in recent years except 2009 (Shan, 2012). The interest lies in whether there were structural breaks caused by some remarkable economic events to affect China's exports to Germany in agri-food products, and in how such events affected the development of China's exports to Germany in agri-food products between different sub-periods. The two points have not been studied clearly yet in the literatures.

Significant policy reforms or significant changes of the economic environment always have some short or long periodic influence on economic development. For instance, China's accession to WTO in December 2001 was such a remarkable economic event, which has caused obvious changes in China's international trade. Since then, China's market has become more open and more free, and China's economy has become substantially more integrated into the world economy (Ianchovichina, Martin and Fukase, 2000). In the long run, the accession to WTO actually did more good than harm to China's agriculture even if China's agricultural sector has been greatly harmed by increased foreign competition and unemployment rate during the early years of the accession (Lin, 2000, Chang et al., 2001 and Shafaeddin, 2002). The major gains from WTO accession would accrue to China itself, but the rest of the world would also benefit (Wang, 2003). The financial crisis of 2008 was also such an event. As is known, the sub-prime mortgage crisis induced the financial crisis, which led to a worldwide economic decline. One of the main reasons for the decrease of China's export trade speed was shrinking foreign demand (Wang et al., 2009 and Hu et al., 2010). Adverse effects of the global financial crisis on China's international trade were very clear (Fan, 2011), as well as China's agricultural trade, e.g. the slowing growth rate of export, the expanding adverse balance of trade, declining export competitiveness, intensifying export market competition and so on (Liu et al., 2009 and Zhang et al., 2013). The impacts of remarkable economic events are so clear that they have already caused some structural breaks (also called change points) in the development of China's exports to or imports from other countries. We will show that this is true for China's exports to Germany in agri-food products, not only for the total but also for some sub-categories. Questions to be answered here are e.g.: Is there a structural break in a given time series? Where does it happen? Which kind of structural breaks is it? And, how large is the effect of this structural break? Literatures on these important topics are limited, hence it is worthwhile to discuss the topics in a systemetically way, e.g. a quantitative way in this paper.

In summary, this paper’s main contribution is introducing two statistical algorithms for detecting different kinds of structural breaks in the middle part and at the end of a short time series, respectively, which work well in practice. Application to China’s exports to Germany and China’s market share in agri-food products indicates that significant structural breaks in 2002 and 2009 were caused by China’s accession to WTO and the financial crisis, respectively. Further analysis based on time series and regression models shows that the development of China’s exports to Germany in agri-food products has quite different features in different sub-periods. Before 1999, there is no significant relationship between China’s exports to Germany and Germany’s imports from the world. Between 2002 and 2008 the former depends on the latter very strongly, and China’s exports to Germany developed quickly and stably. It decreased however suddenly in 2009, caused by the great reduction of Germany’s imports from the world in that year. But China’s market share in Germany still had a small gain instead of loss. Analysis of two categories in agri-food trade also leads to similar conclusions.

The rest parts of the paper is organised as follows. Section 2 will describe two statistical procedures in detail, which are for structural break detection in the middle part and at the end of a short time series, respectively. Section 3 will apply the first method to find out structural breaks for all cases, then analyze the short-term impact of China’s accession to WTO on its agri-food exports to Germany. Section 4 will further discuss the long-term impact of China’s accession to WTO based on time series and regression models to compare the change of relationship between two sub-periods. Section 5 will analyze the different impacts of the 2008 financial crisis on export value and market share, and briefly discuss the change of trade relationship before and after this important event. Some concluding remarks will be given in Section 6.

2 Structural break detection

2.1 Structural break detection in the middle part

Different techniques for detecting structural breaks in linear regression are introduced in the literature. Two well known proposals are e.g. the CUSUM test (Brown et al., 1975) and the Bai-Perron approach (Bai and Perron, 1998, 2003). The former is particularly well studied and widely used (see e.g. Kramer et al., 1988 and Kramer and Sibbertsen, 2002). However, these approaches are not suitable for detecting a partial change point considered in this paper. Hence, a procedure based on rolling dummy variables is proposed for detecting jumps either in the intercept or in the slope while keeping the other parameters constant. This idea is also widely applied in the

literature. For instance, Harvey and Mills (2005) employ intercept and trend dummy variables in their study on common features in G7 macroeconomic time series. Jimenez-Rodriguez and Sanchez (2005) assess empirically the impact of oil price shocks on the real GDP growth of some OECD countries by means of rolling dummy variables. And Brown and Burdekin (2000) and Weidenmier (2002) use this technique to detect the turning point due to the US civil war. Similarly, a simple procedure is first proposed in this paper to detect an unknown time point in the middle part of an economic time series with a possible structural break caused by some economic event and to quantify its short-term impact. Long-term impact in some sense can also be found. An advantage of this procedure is that the change point, the type and the size of jump, and the p-value can all be estimated at the same time.

Assume that the time series Y_t , $t = 1, \dots, n$, follows the model:

$$Y_t = f(t) + \epsilon_t, \quad (1)$$

where ϵ_t are independent identically distributed (i.i.d.) normal random variables with $\epsilon_t \sim N(0, \sigma^2)$ and $f(t)$ is a deterministic regression function. Furthermore, it is assumed that $f(t)$ is continuously differentiable until a suitable order except for an unknown change point at T_0 , where either $f(T_0^+) \neq f(T_0^-)$ or $f'(T_0^+) \neq f'(T_0^-)$. Without loss of generality, we assume that $f(T_0^+) = f(T_0^-)$ and $f'(T_0^+) \neq f'(T_0^-)$. Let $\Delta^L = f(T_0^+) - f(T_0^-)$ and $\Delta^R = f'(T_0^+) - f'(T_0^-)$ represent the jump in $f(t)$ and $f'(t)$, respectively. Then $\Delta^L \neq 0$ stands for a change point with a level-shift and $\Delta^R \neq 0$ for a change point with a rate-shift. In this paper only one change point in the middle part of the time series with either a level-shift or a rate-shift is considered, because the time series under consideration are relatively short. The size of jump will be simply denoted by Δ , which is either Δ^L or Δ^R , depending on the type of the structural break.

For detecting the change point, we propose the use of a suitable parametric regression model with only a single rolling dummy variable either for the intercept or for the slope. Let D_{tk}^L and D_{tk}^R denote the rolling dummy variables at some time point k for the intercept and for the slope, respectively. It is assumed that the true model is either

$$y_t = f_0(t; \beta) + \gamma(k)D_{tk}^L + \epsilon_t, \quad (2)$$

where $D_{tk}^L = 1$ for $t \geq k$ and $D_{tk}^L = 0$ for $t < k$, or

$$y_t = f_0(t; \beta) + \theta(k)D_{tk}^R + \epsilon_t, \quad (3)$$

where $D_{tk}^R = t^*D_{tk}^L$ and $f_0(t; \beta)$ is a general linear model with unknown parameter vector β . If the sample size is large enough, a model with both rolling dummy variables or with rolling dummy variables corresponding to all regressors can be employed.

Note that level-shift and rate-shift are only distinguishable at $k = 3, \dots, n - 2$, which are the values of k to be considered in this paper. The obtained coefficients of the dummy variables $\hat{\gamma}(k)$ and $\hat{\theta}(k)$ are the estimated jumps in the intercept and in the slope, respectively. Let $RSS^L(k)$ and $RSS^R(k)$ denote the residual sums of squares under Models (2) and (3), respectively. The detected change point is then given by

$$\hat{T}_0 = \arg \min_{2 \leq k \leq n-1} \{\min[RSS^L(k), RSS^R(k)]\}. \quad (4)$$

Furthermore, denote the detected change points under Models (2) or (3) by $\hat{T}_0^L$ or $\hat{T}_0^R$, respectively. If the minimal RSS in Equation (4) is $RSS^L(\hat{T}_0^L)$, the time series exhibits a level-shift with $\hat{T}_0 = \hat{T}_0^L$, estimated size of jump $\hat{\Delta} = \hat{\gamma}(\hat{T}_0)$ and finally fitted model $\hat{y}_t = f_0(t; \hat{\beta}) + \hat{\gamma}(k)D_{t\hat{T}_0}^L$, otherwise $\hat{T}_0 = \hat{T}_0^R$, the time series exhibits a rate-shift with estimated size of jump $\hat{\Delta} = \hat{\theta}(\hat{T}_0)$ and finally fitted model $\hat{y}_t = f_0(t; \hat{\beta}) + \hat{\theta}(k)D_{t\hat{T}_0}^R$. If the partial p-value of the estimated size of jump is smaller than the given significance level α with e.g. $\alpha = 0.05$, the null hypothesis of no structural break will be rejected and therefore implies the existence of a significant structural break in the time series. Otherwise it means that no structural break is detected.

Remark 1. *The proposed structural break detection procedure has very nice theoretical properties. Under regularity conditions it can be shown that this procedure is consistent (as $\sigma^2 \rightarrow 0$ for fixed n), such that: 1. The detected type of change point is correct in probability; 2. $P(\hat{T}_0 = T_0) \rightarrow 1$ and 3. For any $\epsilon > 0$, $P(|\hat{\Delta} - \Delta| > \epsilon) \rightarrow 0$.*

Remark 2. *The procedure is proposed for detecting a partial change point in a small sample. The decision rule is similar to that defined in (6) and (7) of Zeileis et al., (2003). Hence there is a close relationship between the current procedure and the approach of Bai and Perron (1998, 2003). But our proposal allows us to detect coefficient breaks of certain regressors. If rolling dummy variables for all regressors are introduced, the approach becomes a special case of that of Bai and Perron with only one change point. See also Zeileis et al. (2003).*

Remark 3. *In practice the type of jump can be wrongly detected. If a level-shift is detected as a rate-shift, we will have $\hat{\theta}(\hat{T}_0) \approx \gamma(T_0)/T_0$. If a rate-shift is detected as a level-shift, we will have $\hat{\gamma}(\hat{T}_0) \approx T_0\theta(T_0)$.*

2.2 Structural break detection at the end

Furthermore, the financial crisis of 2008 no doubt had a great impact on most economic time series. Malouche (2009) confirms that the global financial crisis has constrained trade finance

for exporters and importers in developing countries. Wynne and Kersting (2009) illustrate the crisis' impact on world trade and present evidence that international trade has fallen by more than expected given the course of the current business cycle. Alessandria, Kaboski and Midrigan (2010) show that international trade declined more drastically than trade-weighted production or absorption and there was a sizeable inventory adjustment. Due to this fact, the above detection procedure should be first run without the observation in 2009. Hence we have to test whether the observation in 2009 exhibits a structural break.

To detect the impact of the 2008 financial crisis, we want to test whether there is a structural break at the end of a time series, i.e. between observations of 2008 and 2009. For this purpose a suitable model will be fitted to observations after the first detected change point until 2008. To this end Guo et al. (2011) proposed to use a second order polynomial as in the first step. It is however found that, in most of the cases, some of the coefficients are insignificant and the fitted models are unstable, because now the number of observations is much smaller than that in the first step. Hence we propose to choose the well known Box-Cox model for the sub-series in the second sub-period under the function form:

$$Y_t = a + b\tilde{t}^\lambda \quad \text{for } 0 < \lambda \leq 2 \quad \text{or} \quad Y_t = a + b\ln(\tilde{t}) \quad \text{for } \lambda = 0, \tilde{t} = t - n_f = 1, \dots, n_s, \quad (5)$$

where n_f and n_s are the numbers of observations in the first and second sub-period, respectively. In Sections 3.2 and 4.2 we will see that this Box-Cox model is also very suitable for analyzing the trade relationship between China and Germany. For simplicity, λ will be chosen from $\lambda = 0, 0.25, 0.50, \dots, 2$, by minimizing the RSS (residual sum of squares). Here, the use of the RSS is equivalent to the use of the AIC (Akaike's information criterion) or BIC (Bayesian information criterion). Under the null-hypothesis of no structural break in the future, we can extend Model (5) to the next time point. Under the normality assumption, a corresponding prediction interval with cover probability $1 - \alpha$ can also be calculated for the given α . A level-shift at the confidence level exists, if the observation of 2009 lies outside this prediction interval.

A possible rate-shift caused by the financial crisis cannot be detected, because now there is only one observation after 2008. This idea is closely related to the well known "leave-one-out" rule and can also be applied to detect some outliers in the middle part of a time series. The proposed method can also be adapted for the detection of a possible rate-shift at the end of a time series. This will not be discussed here, because we are mainly interested in whether the past financial crisis did cause some level-shift in a time series under consideration or not.

3 Structural breaks of China's accession to WTO

Yearly data downloaded from the United Nations Commodity Trade Statistics Database (UN Comtrade) within the period from 1994 to 2009 are used as examples. According to the Harmonized Commodity Description and Coding System (HS1992), agri-food products consist of four categories: animal and animal products; vegetable products; animal or vegetable fats, oil and waxes; and foodstuffs. In this paper, the value of the total agri-food products, animal and animal products (01-05) and vegetable products (06-14) are to be considered. Because the two categories both have obvious structural breaks during the study period. Denote the time series as Y , Y_1 and Y_2 for China's exports to Germany in the total agri-food products and in the two categories, respectively, and S , S_1 and S_2 for China's market share accounting for Germany's imports from the world in the corresponding series.

For implementation of the proposed structural break detection procedure in Section 2.1, codes in the programming language R are developed and first applied to all examples from 1994 to 2008. For simplicity, we assume that $f_0(t; \beta)$ is a second order polynomial. The main reason is that a simple linear regression may cause clear misspecification and a more complex regression model may suffer from a very large sample variation, because the sample size is not large enough. Here the role of t^2 in fitted models is to determine if the shape of the curve is concave or convex, and to correct the growth rate together with the t term. Note that the detected year with a change point is the beginning of the second sub-period. For instance, a change point in the year 2002 does indeed mean a change point between 2001 and 2002. The estimated $\hat{T}_0$, the corresponding year, the estimated shifts $\hat{\Delta}^L$ and $\hat{\Delta}^R$, the associate t -statistics and (partial) p -values in Y , S , Y_1 , S_1 , Y_2 , and S_2 are given in Table 1, where the finally chosen results are highlighted in bold.

The proposed procedure works very well in practice. In all cases we have $\hat{T}_0^L = \hat{T}_0^R$, except for Y , where the detected change point in the level occurred three years later than that in the growth rate with a slightly larger RSS (and hence a slightly larger partial p -value). Following the proposed method, $\hat{T}_0 = \hat{T}_0^L = 9$ with a level-shift is chosen. By means of a further diagnose procedure it can be shown that the other time point $t = 6$, corresponding to the year 1999, might exhibit another change point. But this will not be further discussed. From Table 1 we can see, Y exhibits a significantly negative level-shift of -201.8 million US dollars in 2002, and S is dominated by a rate-shift with a coefficient of -0.0002 for $t = 9, \dots, 15$, which correspond to the years from 2002 to 2008. The difference between a level shift and a rate-shift is that the impact of a level-shift stays constant after the change point, but that of a rate-shift becomes larger and larger (in absolute value). Furthermore, we have $\hat{T}_0 * \hat{\theta}(\hat{T}_0) \approx \hat{\gamma}(\hat{T}_0)$ in all cases (see Remark 3 in Section

Table 1: $\hat{T}_0$, year, jumps, t and p -values of change points for all series

Series	Y	S	Y_1	S_1	Y_2	S_2
$\hat{T}_0^L$	9	9	9	9	7	8
Year	2002	2002	2002	2002	2000	2001
$\hat{\Delta}^L$	-201.75	-0.0019	-131.58	-0.0076	-46.539	0.0010
t^L	-3.1125	-2.6371	-3.1752	-2.9935	-3.0039	2.5500
p^L	0.0099	0.0231	0.0088	0.0122	0.0120	0.0270
$\hat{T}_0^R$	6	9	9	9	7	8
Year	1999	2002	2002	2002	2000	2001
$\hat{\Delta}^R$	-36.357	-0.0002	-14.579	-0.0009	-7.2425	0.0001
t^R	-2.7806	-2.6857	-2.8139	-2.9363	-3.4897	2.6270
p^R	0.0179	0.0212	0.0169	0.0135	0.0051	0.0235

2). This shows again that the proposed procedure works very well. Taking S as an example, the reduction in 2002 caused by the rate-shift is -0.0018 (-0.0002×9), which is approximately equal to the estimated level-shift of -0.0019, but that in 2008 is however -0.003 (-0.0002×15). Hence, a rate-shift may also be some kind of long-term impact. Table 1 also shows that different types of agri-food products exhibit different kinds of change point in different years. On the one hand, Y_1 shows a level-shift of -131.6 million US dollars in 2002, but Y_2 has a rate-shift with a coefficient of -7.2 million US dollars for $t = 7, \dots, 15$, corresponding to the years from 2000 to 2008. On the other hand, the market share, i.e. S_1 exhibits a negative level-shift of -0.0076 in 2002, and S_2 shows a slightly positive rate-shift with a coefficient of 0.0001 for $t = 8, \dots, 15$, corresponding to the years from 2001 to 2008. Although the total agri-food products are composed of four categories, each category has its own feature and shows different characteristics. So the above results are not surprising. Detailed results for Y with a level-shift and S with a rate-shift are given as examples. The finally fitted model for Y is:

$$\hat{y}_t = 516.54 - 85.716t + 11.197t^2 - 201.75D_{t9}^L, \quad t = 1, \dots, 15, \text{ corresponding to,}$$

$$\hat{y}_t = 516.54 - 85.716t + 11.197t^2, \quad t \leq 8, \text{ or } \hat{y}_t = 314.79 - 85.716t + 11.197t^2, \quad t \geq 9; \quad (6)$$

and the finally fitted model for S is:

$$\hat{s}_t = 7.799 \times 10^{-3} + 9.823 \times 10^{-5}t + 5.829 \times 10^{-5}t^2 - 2.23 \times 10^{-4}D_{t9}^R, \quad t = 1, \dots, 15, \text{ corresponding to,}$$

$$\hat{s}_t = 7.799 \times 10^{-3} + 9.823 \times 10^{-5}t + 5.829 \times 10^{-5}t^2, \quad t \leq 8, \text{ or}$$

$$\hat{s}_t = 7.799 * 10^{-3} - 1.248 * 10^{-4}t + 5.829 * 10^{-5}t^2, \quad t \geq 9; \quad (7)$$

Table 2: Results of the Jarque-Bera and Durbin-Watson test for all cases

Models	Y	S	Y_1	S_1	Y_2	S_2
$X - squared$	0.0761	1.4090	0.4047	0.9246	0.6979	0.6871
$p - value$	0.9627	0.4944	0.8168	0.6298	0.7054	0.7092
DW	1.5380	2.8823	2.2653	2.8414	1.9804	2.7735
$p - value$	0.0466	0.3104	0.7066	0.3614	0.3237	0.4563

The detected change points in all cases are also displayed in Figure 1 together with the estimated models (solid curves) and the observations (stars), where the detected position of break is indicated by a vertical solid line and the type of change points by a letter “L” for level-shift or “R” for rate-shift. Also, the significance level is indicated by “*” or “**” for $\alpha = 0.05$ or $\alpha = 0.01$, respectively. We see, the model fits the data in all cases very well.

As we all know, China’s accession to WTO in 2001 is such a milestone that this economic event has affected China’s export performance from then on (Rees and Tyers, 2004). Four of the change points detected in the series under consideration occurred directly after that year and the other two also happened near to this remarkable event. Looking at the above Models (6) and (7), the significant level- or rate-shifts in Y and S indicate that China’s accession to WTO first caused a negative impact on its exports to Germany in agri-food products. But its long-term impact was clearly positive. Firstly, the growth rate of Y and S became higher and higher after 2002. According to the fitted model for Y the estimated growth rates of it in the years 2001, 2002, 2003, 2005 and 2008 are e.g. 93.4, 115.8, 138.2, 183 and 250.2 million US dollars, respectively. The negative impact of the level-shift, which may be caused by trade protectionism of E.U. or substitution effect due to the rapid development of trade relationships with other countries (Chen, 2003), was already over in 2003. And thereafter the impact became clearly positive. According to the fitted model for S the estimated growth rates of it in the years 2001, 2002, 2003, 2005 and 2008 are e.g. $1.03 * 10^{-3}$, $0.93 * 10^{-3}$, $1.05 * 10^{-3}$, $1.28 * 10^{-3}$ and $1.63 * 10^{-3}$, respectively. The growth rate of this series in 2003 was already higher than that in 2001, and the negative impact was over. Secondly, after China’s accession to WTO the development of its exports to Germany became much more regular than before without obvious structural breaks till 2008.

The structural break detection used above is based on the assumption that the errors (ϵ_t) are i.i.d. normally distributed. In the following we will show that two conditions of this assumption, namely that ϵ_t are normally distributed and independent of each other, are about fulfilled by all

data sets used above. The question, whether ϵ_t are identically distributed, will not be discussed because of the small sample size. For this purpose, the well known Jarque-Bera (JB) test of normality and Durbin-Watson (DW) test of serial correlation are carried out. In particular, the test results of correlation are further confirmed by correlograms. The corresponding figures are omitted to save space.

The results of the JB test are given in the upper part of Table 2. We see that in all cases the p -values are much greater than 5%. That is the errors in all of the cases are about normally distributed. The results of the DW test are listed in the lower part of Table 2. We can see that the p -values are also clearly bigger than 5% for all series except for Y with a p -value 0.0466, which is slightly smaller than 5%. That is the assumption of no serial correlation in the errors, equivalent to the assumption of independence for normal processes, is acceptable in most of the cases. In addition, the correlogram shows that the serial correlation in the residuals of Y is insignificant at the 5% level. Hence the errors in this case are also about independent.

4 Change of relationship due to China's accession to WTO

Furthermore, the development patterns of China's exports to Germany before and after the detected change points are clearly different. To show this we can fit two regression models to the first and second sub-periods and compare the fitted models to explore the long-term impact of China's accession to WTO on its agri-food exports to Germany. There are two types of models mainly being discussed in this paper. One is time series models based on China's exports to Germany itself, and the other is regression models based on Germany's imports from the world.

4.1 Models based on China's exports to Germany

The selection process of the models in both sub-periods is the same as the Box-Cox model, i.e. Model (5) with the observation time t and $\tilde{t}$ in the first and second sub-period, respectively. Detailed results for the series Y (in millions of US dollars) are given in the following. The selected models are

$$\hat{y}_t = 354.11 + 46.94 \ln(t), \quad t = 1, \dots, 8,$$

for the first sub-period with the coefficient of determination $r^2 = 0.4849$ and $p = 0.05502$, and

$$\hat{y}_t = 438.688 + 38.245 \tilde{t}^{1.75}, \quad \tilde{t} = 1, \dots, 7, \quad (8)$$

Figure 1: Detected structural breaks in the middle part of all series under consideration.

for the second sub-period with $r^2 = 0.9960$ and $p = 3.472 * 10^{-7}$. It is clear that the two models selected are quite different. The first is not significant and the second is very highly significant with a p -value which is practically zero. This kind of change caused by China's accession to WTO varies from one example to another. But a common fact is that the level of significance of all models for the series related to China's exports to Germany in the second sub-period is much higher than that for the corresponding models in the first sub-period. According to the selection process, like Y , the corresponding equations for Y_1 , Y_2 in the two sub-periods are as follows:

$$\hat{y}_{1t} = 172.70 + 26.68 \ln(t), \quad t = 1, \dots, 8,$$

for the first sub-period with $r^2 = 0.3103$ and $p = 0.1515$, and

$$\hat{y}_{1t} = 165.24 + 31.59\tilde{t}^{1.5}, \quad \tilde{t} = 1, \dots, 7 \quad (9)$$

for the second sub-period with $r^2 = 0.9767$ and $p = 2.823 * 10^{-5}$.

$$\hat{y}_{2t} = 74.366 + 7.560t^{0.75}, \quad t = 1, \dots, 6,$$

for the first sub-period with $r^2 = 0.6495$ and $p = 0.05284$, and

$$\hat{y}_{2t} = 89.9041 + 3.8402\tilde{t}^2, \quad \tilde{t} = 1, \dots, 9 \quad (10)$$

for the second sub-period with $r^2 = 0.9899$ and $p = 3.056 * 10^{-8}$.

Using the same procedure, the chosen models for China's market share S , S_1 and S_2 are as follows:

$$\hat{s}_t = 0.0079 + 0.00007t^2, \quad t = 1, \dots, 8,$$

for the first sub-period with $r^2 = 0.8745$ and $p = 0.0006486$.

$$\hat{s}_t = 0.0098 + 0.0013\tilde{t}, \quad \tilde{t} = 1, \dots, 7 \quad (11)$$

for the second sub-period with $r^2 = 0.9533$ and $p = 0.0001631$.

$$\hat{s}_{1t} = 0.0154 + 0.0002t^2, \quad t = 1, \dots, 8,$$

for the first sub-period with $r^2 = 0.7435$ and $p = 0.005875$.

$$\hat{s}_{1t} = 0.0143 + 0.0054\tilde{t}^{0.75}, \quad \tilde{t} = 1, \dots, 7 \quad (12)$$

for the second sub-period with $r^2 = 0.91$ and $p = 0.0008533$.

$$\hat{s}_{2t} = 0.0048 + 0.00004t^2, \quad t = 1, \dots, 7,$$

for the first sub-period with $r^2 = 0.8473$ and $p = 0.003281$.

$$\hat{s}_{2t} = 0.0074 + 0.0008\tilde{t}, \quad \tilde{t} = 1, \dots, 8 \quad (13)$$

for the second sub-period with $r^2 = 0.9772$ and $p = 3.733 * 10^{-6}$.

Note that the level of significance for these models of China's market share in the second sub-period is also higher than that for the corresponding models in the first sub-period. According to the above models, for example, the growth rate of China's market share in total agri-food products from 1994 to 2001 is $0.00014t$, which becomes 0.0013 from 2002 to 2008. We see that, in the second sub-period, the growth rate of China's market share in total agri-food products increases in a linear way. We also see that this development is even not affected so much by the financial crisis. Furthermore, two common features are that China's market share in the second sub-period increases steadily and its growth rate is still faster than that in the first sub-period, which again confirms the positive long-term impact of China's accession to WTO.

Because the models in the second sub-period are for the structural break detection at the end of a short time series in Section 5, we need to test if the errors are from normal distribution and independent of each other. Hence the Jarque-Bera and Durbin-Watson test in R are carried out. The test results are listed in Table 3:

Table 3: Results of the Jarque-Bera and Durbin-Watson test

Models	Y	Y_1	Y_2	S	S_1	S_2
$X - squared$	0.7257	0.7531	0.8135	2.0566	0.9253	0.0818
$p - value$	0.6957	0.6862	0.6658	0.3576	0.6296	0.9600
DW	3.4819	2.6924	2.2224	2.3816	2.3645	3.4434
$p - value$	0.0372	0.6130	0.9292	0.9933	0.9869	0.0306

From Table 3, we find that the errors of chosen models are all from normal distribution. Furthermore, the results of Durbin-Watson test show that the null hypothesis, i.e. the errors are independent cannot be rejected for all cases at the significance level 5% except the model for Y and S_2 , which cannot be rejected at the significance level 1% due to extreme values. Based on the results of Jarque-Bera and Durbin-Watson test, it indicates that this method is correct and has

solid theoretical foundation. All the models are selected so that they are optimal. It is very clear that all of the selected models have a quite close relationship with detected change points.

4.2 Models based on Germany's imports from the world

Furthermore, the development pattern of China's exports to Germany before and after China's accession to WTO is clearly different. To show this we can fit two regression models of China's exports to Germany on Germany's imports from the world to the data for the first and second sub-periods separately and compare the fitted models. This will also help us to explore the long-term impact of China's accession to WTO on its exports to Germany. In both sub-periods Model (5) is applied, but with the observation time being replaced by corresponding values of Germany's imports from the world, where λ is again selected from 0, 0.25, 0.5,..., 1.75 and 2. This is again an application of the Box-Cox model.

According to the structural break detection procedure described in Section 2.1, the detected change points for the related series of Germany's imports from the world are displayed in Figure 3 (a), (c) and (e) in Appendix. For total agri-food products, the first and second models are fitted from 1994 to 1999 and 2002 to 2008, respectively. The two observations, 2000 and 2001, are removed due to the different years of detected change points in Y and X . The selected model for the first sub-period is

$$\hat{y}_t = -1562.3 + 321.6 \ln(x_t), \quad t = 1, \dots, 6,$$

with a correlation coefficient of $r^2 = 0.218$ and $p = 0.3505$. For the second sub-period, the following simple linear regression is selected:

$$\hat{y}_t = -638.6102 + 2.6036x_t, \quad t = 9, \dots, 15 \tag{14}$$

with $r^2 = 0.9908$ and $p = 2.73 * 10^{-6}$.

Analogously, the selected models for Y_1 and X_1 , and Y_2 and X_2 are given as follows:

$$\hat{y}_{1t} = -302.8 + 106.5 \ln(x_{1t}), \quad t = 1, \dots, 6,$$

for the first sub-period with $r^2 = 0.07928$ and $p = 0.5888$.

$$\hat{y}_{1t} = -349.4514 + 5.4646x_{1t}, \quad t = 9, \dots, 15 \tag{15}$$

for the second sub-period with $r^2 = 0.9816$ and $p = 1.577 * 10^{-5}$.

$$\hat{y}_{2t} = 98.98 - 0.000198x_{2t}^2, \quad t = 1, \dots, 6,$$

for the first sub-period with $r^2 = 0.007828$ and $p = 0.8676$.

$$\hat{y}_{2t} = -145.4381 + 1.9167x_{2t}, \quad t = 8, \dots, 15 \quad (16)$$

for the second sub-period with $r^2 = 0.9978$ and $p = 3.32 * 10^{-9}$.

In addition, the results of Jarque-Bera and Durbin-Watson test for the three models in the second sub-period are given in Table 4. It shows that all errors are from normal distribution and independent of each other.

Table 4: Results of the Jarque-Bera and Durbin-Watson test

Models	Y and X	Y_1 and X_1	Y_2 and X_2
$X - squared$	0.9095	0.7491	2.3795
$p - value$	0.6346	0.6876	0.3043
DW	2.0043	2.6268	2.6644
$p - value$	0.5860	0.6855	0.5659

Based on the above models, we can see that in the first sub-period, the relationship between China's exports to Germany and Germany's imports from the world is not obvious, especially in vegetable products. However, in the second sub-period, China's exports to Germany depend very strongly on Germany's imports from the world in a linear way in all cases with very large values of r^2 and very small p -values. It shows that the dependence level between China's exports to Germany and Germany's imports from the world becomes much higher and more obvious after China's accession to WTO. This change is particularly clear in vegetable products. It is mainly due to China's relatively young growing free market and its deeper integration into the international market. This is another clear statement for the positive long-term impact of China's accession to WTO on China's agri-food exports to Germany.

5 Structural breaks and change of relationship due to the financial crisis

Now we will further analyze the impact of the 2008 financial crisis by fitting the Box-Cox model to detect this kind of structural breaks and compare the change of the trade relationship before and after this remarkable economic event.

5.1 Detected change points due to the 2008 financial crisis

Model (5) is now applied to test whether the 2008 financial crisis caused a structural break on China's agri-food exports to Germany or China's market share. Based on Models (8)~(13) in the corresponding second sub-periods, we can obtain the predicted value of 2009 and the corresponding prediction intervals. A structural break between 2008 and 2009 is detected with the observation of 2009 lying outside the prediction intervals at the chosen confidence level. The results are shown in Table 5. Taking Y as an example, the observation of 2009 is 1457 million, which is much less than the predicted lower limit 1730 million at the 1% confidence level. Then taking S as another example, the observation of 2009 is 1.84%, which falls within the prediction intervals at the 5% confidence level. Table 5 indicates that both Y and Y_2 exhibit a very highly significant structural break at the 1% confidence level due to the 2008 financial crisis, and Y_1 also has a structural break in 2009 but is only significant at the 5% confidence level. The market shares, i.e. S , S_1 and S_2 , do not show a structural break in 2009, which all developed stably after the 2008 financial crisis.

Figure 2 (see (a) to (f)) gives a more clear illustration of this kind of structural breaks. The solid curve represents the fitted model in the second sub-period and the last point on it is the predicted value for 2009. The dashed curves with points and dashed curves stand for two pairs of prediction intervals at the cover probability 95% and 99%, respectively. The actual observations are denoted by stars.

Table 5: Comparison of the predicted results and the observations in 2009 (\$US 100million, %)

Series	Y	S	Y_1	S_1	Y_2	S_2
<i>Upper(99%)</i>	20.58	2.35	10.71	5.12	5.29	1.66
<i>Upper(95%)</i>	19.99	2.23	10.02	4.71	5.11	1.60
<i>PredictedValue</i>	18.94	2.00	8.80	3.99	4.74	1.50
<i>Lower(95%)</i>	17.90	1.78	7.58	3.28	4.36	1.39
<i>Lower(99%)</i>	17.30	1.65	6.89	2.87	4.18	1.34
<i>Observations</i>	14.57	1.84	7.31	3.95	3.73	1.43

To make the analysis more complete, the results of Germany's imports from the world are also displayed in Figure 3 (b), (d) and (f) in Appendix. It indicates that for both total agri-food products and its two categories, not only China's exports to Germany but also Germany's imports from the world exhibit very highly significant structural breaks due to the 2008 financial crisis, which implies that this remarkable economic event indeed had a significant negative short-term impact on international trade.

5.2 Change of trade relationship before and after the financial crisis

Moreover, the change of the trade relationship between China and Germany before and after the 2008 financial crisis is also worthy of further exploration. The relationship between China's exports to Germany and Germany's imports from the world in total agri-food products and its two categories are displayed in Figure 2 (g), (h) and (i), respectively, where the predicted values of China's exports to Germany in 2009 are denoted by "o". We see that the actual observations in 2009 are all nearly within the prediction intervals at the 1% confidence level. This indicates that although China's exports to Germany had a great drop due to the 2008 financial crisis, their relative reduction was still less than that of Germany's imports from the world. Hence the financial crisis had a slightly positive but not significant impact on the trade relationship between China and Germany in agri-food products. Comparing to the rest part of the world, China had a small gain instead of loss in Germany's market according to the perspective of the trade relationship.

6 Concluding remarks

In summary, this paper conducts a very detailed analysis of changes of China's exports to Germany in agri-food products caused by its accession to WTO and the 2008 financial crisis. Firstly, applying the proposed procedure introduced in Section 2.1, we detect the structural breaks in the middle part of all series caused by remarkable economic events, e.g. China's accession to WTO in 2001. From the results, we know that China's accession to WTO often has had a negative short-term impact on its exports to Germany, including export value and market share. And then in order to further discuss the long-term impact of China's accession to WTO, two types of models are fitted, which can be used to show changes of relationship before and after the detected change points. The regression models show that the development of China's exports to Germany in agri-food products has quite different features in different sub-periods. Moreover, the dependence level between China's exports to Germany and Germany's imports from the world has become much more significant after China's accession to WTO, not only in total agri-food products but also in the two categories. The former depends on the latter very strongly. Therefore, the long-term impact of China's accession to WTO is clearly positive. Following the method described in Section 2.2, the 2008 financial crisis is also a significant structural break. Such event has greatly reduced China's exports to Germany in agri-food products. However, China's market share was not affected at all but showed a slight rise. It indicates that the relationship of agri-food trade between China and Germany was developing stably.

Figure 2: Detected structural breaks and change of trade relationship due to the financial crisis.

Figure 3: Detected structural breaks in the middle part and at the end of X , X_1 and X_2 .

References

- Alessandria, G., Kaboski, J.P. and Midrigan, V. (2010). The great trade collapse of 2008-09: an inventory adjustment?, *Federal Reserve Bank of Philadelphia*, WPS No. 10-18.
- Bai, J. and Perron, P. (1998). Estimating and testing linear models with multiple structural changes, *Econometrica* 66, 47-78.
- Bai, J. and Perron, P. (2003). Computation and analysis of multiple structural change models, *Journal of Applied Econometrics* 18, 1-22.
- Brown Jr. W.O. and Burdekin, R.C.K. (2000). Turning points in the U.S. civil war: a British perspective, *The Journal of Economic History* 60, 216-231.
- Chang, C., Fleisher, B. and Parker, E. (2001). Editorial: Introduction, *China Economic Review* 1, 319-322.
- Chen, Y. (2003). Accession to WTO and the development of economic relationship between China and Germany, *Journal of Yunnan Finance & Economics University* 17, 8-11.
- Fan, Y. (2011). Chinas services policy reform: pre- and post- global financial crisis, *ADB-PECC Conference*, 1-35.
- Guo, Zh., Feng, Y. and Tan, X. (2011). Short- and long-term impact of remarkable economic events on the growth causes of China-Germany trade in agri-food products, *Economic Modelling* 28, 2359-2368.
- Harvey, D. and Mills, T. (2005). Evidence for common features in G7 macroeconomic time series, *Applied Economics* 37, 165-175.
- Hu, Q. and Li, H. (2010). Empirical analysis on influence of financial crisis to trade of China, *Journal of International Trade* 3, 3-11.
- Ianchovichina, E., Martin, W. and Fukase, E. (2000). Comparative study of trade liberalization regimes: the case of China's accession to the WTO, *Paper presented at the third conference of Global Economic Analysis*, Melbourne, Australia, June 20-30.
- Jimnez-Rodrguez, R. and Snchez, M. (2005). Oil price shocks and real GDP growth: empirical evidence for some OECD countries, *Applied Economics* 37, 201-228.

- Kramer, W., Ploberger, W. and Alt, R. (1988). Testing for structural change in dynamic models, *Econometrica* 56, 1355-1369.
- Kramer, W. and Sibbertsen, P. (2002). Testing for structural changes in the presence of long memory, *International Journal of Business and Economics* 1, 235-242.
- Lin, Y. (2000). WTO accession and China's agriculture, *China Economic Review* 11, 405-408.
- Liu, R. and Hui, L. (2009). Impact of financial crisis on export of China agricultural products, *Journal of International Trade* 10, 3-8.
- Malouche, M. (2009). Trade and trade finance developments in 14 developing countries post September 2008 – A World Bank Survey, *The World Bank*, WPS 5138.
- Rees, L. and Tyers, R. (2004). Trade reform in the short run: Chinas WTO accession, *Journal of Asian Economics* 15, 1-31.
- Shafaeddin, M. (2002). Some implication of accession to WTO for China's economy, *International Journal of Development Issues* 1, 93-128.
- Shan, X. (2012). The analysis of China-Germany bilateral trade (2001-2011), *Science & Technology Information* 25, 35-37.
- Wang, C. and Zhang, H. (2009). The impact of the financial crisis on China's export trade and countermeasures, *International Economics and Trade Research* 25, 37-41.
- Wang, Z. (2003). The impact of Chinas WTO accession on patterns of world trade, *Journal of Policy Modeling* 25, 1-41.
- Weidenmier, M.D. (2002). Turning points in the U. S. civil war: views from the grayback market, *Southern Economic Journal* 68, 875-890.
- Wynne, M.A. and Kersting, E.K. (2009). Trade, globalization and the financial crisis, *Economic Letter* 4, 1-8.
- Zeileis, A., Kleiber, C., Kramer, W. and Hornik, K. (2003), Testing and dating of structural changes in practice, *Computational Statistics & Data Analysis* 44, 109-123.
- Zhang, J. and Fan, W. (2013), Cause analysis of changes of Chinese agricultural product exports to EU under the financial crisis, *International Economics and Trade Research* 29, 17-26.

Recent discussion papers

2013-15	Zhichao Guo Yuanhua Feng Thomas Gries	Changes of China's agri-food exports to Germany caused by its accession to WTO and the 2008 financial crisis
2013-14	Eugen Dimant Tim Krieger Margarete Redlin	A Crook is a Crook ... But is He Still a Crook Abroad? - On the Effect of Immigration on Destination-Country Corruption
2013-13	Eugen Dimant	The Nature of Corruption – An Interdisciplinary Perspective
2013-12	Yuanhua Feng Lixin Sun	A Semi-APARCH approach for comparing long-term and short-term risk in Chinese financial market and in mature financial markets
2013-11	Joe Cox Daniel Kaimann	The Signaling Effect of Critics - Evidence from a Market for Experience Goods
2013-10	Eugen Dimant Tim Krieger Daniel Meierriecks	The Effect of Corruption on Migration, 1985-2000 <i>[Published in Applied Economics Letters 20(13), 2013]</i>
2013-09	Yuanhua Feng Sarah Forstinger Christian Peitz	On the iterative plug-in algorithm for estimating diurnal patterns of financial trade durations
2013-08	Yuanhua Feng	Double-conditional smoothing of high-frequency volatility surface in a spatial multiplicative component GARCH with random effects
2013-07	Sonja Brangewitz Claus-Jochen Haake	Cooperative Transfer Price Negotiations under Incomplete Information
2013-06	Mark Schopf	Preserving Eastern or Offshore Oil for Preventing Green Paradoxes?
2013-05	Mark Schopf Hendrik Ritter	Unilateral Climate Policy: Harmful or even Disastrous? <i>[forthcoming in: Environmental and Resource Economics]</i>
2013-04	Volker Seiler	Comment on Ameriks, Caplin, Leahy & Tyler (2007): Measuring Self-Control Problems
2013-03	B. Michael Gilroy Anastasia Heiman Mark Schopf	Gibt es eine optimale Frauenquote?
2013-02	Yuanhua Feng Chen Zhou	Forecasting financial market activity using a semiparametric fractionally integrated Log-ACD
2013-01	Berno Buechel Nils Röhl	Robust Equilibria in Location Games
2012-11	B. Michael Gilroy Mark Schopf Anastasia Semenova	Grundeinkommen und Arbeitsangebot: Die Perspektive Deutschlands
2012-10	N. Bilkic B. Carreras Painter T. Gries	Unsustainable Sovereign Debt - is the Euro Crisis only the Tip of the Iceberg?