Center for International Economics

Working Paper Series

No. 2010-08

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November 2010

Center for International Economics
University of Paderborn
Warburger Strasse 100
33098 Paderborn / Germany

Business Administration & Economics
University of Paderborn

Short- and long-term impact of remarkable economic events on the growth causes of China-Germany trade in agri-food products

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Abstract: This paper focuses on a systematic quantitative discussion of the short- and long-term impact of remarkable economic events on international trade in a two-stage framework. Firstly, procedures based on dummy variables are proposed to detect structural breaks, types and sizes of jumps caused by such events. Then we propose to apply a hierarchical CMS (Constant Market Share) model to all sub-periods defined by the detected change points to study the short- and long-term impact of those events on growth causes. Application to China-Germany trade in agri-food products shows that China's accession to WTO had a negative short-term impact on corresponding series. But its long-term impact on China's export competitiveness was definitely positive. The short-term impact of the EU's CAP (Common Agricultural Policy) reform on Germany's exports to China was also negative. Its long-term impact on export competitiveness was sometimes positive and sometimes negative. The financial crisis of 2008 caused a significant reduction of China's agri-food exports to Germany. But Germany's exports to China in 2009 were not affected by the financial crisis as much.

JEL code: Q17, C53

Keywords: Growth causes of agri-food trade; the CMS model; the EU's CAP reform; China's accession to WTO; financial crisis

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1. Introduction

Since the late 1990's the world economy has hosted a series of remarkable events, such as the official launch of the Euro in 1999, the EU's CAP (Common Agricultural Policy) reform in 1999, China's accession to WTO in 2001 and the global financial crisis of 2008. We will call those events remarkable economic events, because they have strongly affected the world economy and international trade (see e.g. Ianchovichina and Martin, 2006 and Wynne and Kersting, 2009). Because of their importance, studying the short- and long-term impact of them is always of great interest (see e.g. Rees and Tyers, 2004, Malouche, 2009, and Alessandria, Kaboski and Midrigan, 2010). To our knowledge, there is a lack of systematic quantitative analysis of both the short- and long-term impact of those events. We propose to close this gap using a two-stage framework, combining structural break detection in the first stage and a consequent detailed analysis using suitable economic models in the second stage. The former is mainly for detecting the short-term and the later for analyzing the long-term impact of some events. However, both impacts may be found in each stage, depending on the case.

Different techniques are introduced in the literature for detecting structural breaks in economic time series. One of them is the use of rolling dummy variables. This idea was e.g. used by Harvey and Mills (2005), Jiménez-Rodríguez and Sánchez (2005), Brown and Burdekin (2000) and Weidenmier (2002) to find out structural breaks and shocks in different macroeconomic time series. In this paper we first propose a procedure based on this idea to detect an unknown change point with a jump either in the level (level-shift) or in the growth rate (rate-shift) in the middle part of a short time series and to estimate the size of the break at the same time. Then the observations after the first change point will be used to detect a possible level-shift at the current end of a time series, a procedure specially proposed for analyzing the short-term impact of the financial crisis. In the next stage we propose to fit the CMS (Constant Market Share) model (see e.g. Tyszynski, 1951, Leamer and Stern, 1970, Jepma, 1986, 1989 and Milana, 1988) to all sub-periods and compare the results in detail, because one of our aims is to quantify the short- and long-term impact of China's accession to WTO or other policy reforms on the growth causes of international trade. The use of the CMS model is a suitable choice for this purpose (Bowen and Pelzman, 1984, Fagerberg and Sollie, 1987, Chen, Xu and Duan, 2000 and Simonis, 2000). In this paper we will apply the CMS model to the total and specific agri-food products, respectively (see Toh et al., 2004 and Lu and Mei, 2007). This method, called a hierarchical CMS model, fits the data structure under consideration very well.

The proposals are applied to China-Germany trade of total agri-food products and its sub-categories. It is shown that almost all of the above mentioned economic events exhibited negative short-term impacts on corresponding series. For instance, China's exports to Germany of total agri-food products had a significantly negative level-shift of -201.8 million US dollars between 2001 and 2002, just after its accession to WTO. And Germany's exports to China had a significantly negative structural break caused by the EU's CAP reform, and perhaps also the official launch of the Euro, which is dominated by a rate-shift with a coefficient of -9.1 million US dollars for $t = 7, ..., 15,$ corresponding to the years from 2000 to 2008. Whether a structural break has a long-term impact, depends on the further development of an economic time series. It is shown that the negative shifts in the middle part of the three China's series only have a short-term impact. The long-term impact of China's accession to WTO on its exports to Germany in agri-food products is definitely positive. Firstly, the growth rates of those series became higher and higher after the corresponding structural breaks. Secondly, the development of China's exports to Germany after those structural breaks became much more regular than before. But the long-term impact of the EU's CAP reform on the growth rate of Germany's exports to China in agri-food products is sometimes positive and sometimes negative. Results of the CMS model for total agri-food products show that the competitiveness and the second-order effect were two key factors to increase exports for China and Germany in the first sub-period, respectively. In the second sub-period, the import demand was the most important factor to promote exports for both countries, and the competitiveness was still an important factor for the development of China's exports to Germany. A further evidence for the positive long-term impact of China's accession to WTO is the higher yearly growth in the second period due to the improvement of its competitiveness, which is on average 2.5 times of that in the first period. Our results confirm well known findings in the literature (Zhang, 2004). But the financial crisis caused a great reduction of Germany's imports from the world, which in turn resulted in a sudden fall of China's agri-food exports to Germany. However, Germany's exports to China in 2009 were not affected by the financial crisis as much. The second-level hierarchical CMS model shows that for different types of agri-food products the growth causes were clearly not the same.

The paper is organized as follows. Procedures for detecting structural breaks in the middle part and due to the financial crisis, respectively, are proposed in Section 2, which are applied in Section 3 to chosen examples. The hierarchical CMS model is described in Section 4 and its application to the data examples is reported in Section 5. Final remarks in Section 6 conclude the paper.

2. Structural break detection

There is a huge number of proposals in the literature for detecting structural breaks in economic time series. One of them is the use of rolling dummy variables. This idea is widely applied in economic modeling. For instance, Harvey and Mills (2005) employ intercept and trend dummy variables in their study on common features in G7 macroeconomic time series. Jiménez-Rodríguez and Sánchez (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. In this paper a simple procedure is first proposed to detect an unknown time point in the middle part of an economic time series with 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 not only the change point, but also the type and the size of break can be estimated at the same time.

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

$$Y_t = f(t) + \varepsilon_t, \tag{1}$$

where ε_t is assumed to be independent identically distributed (i.i.d.) normal random variables with $\varepsilon_t \sim N(0, \sigma^2)$ and $f(t)$ is the 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 $f'(T_0^+) = f'(T_0)$. 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

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

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

$$y_t = f_0(t;\beta) + \theta(k) D^R_{tk} + \varepsilon_t, \tag{3}$$

where $D^R_{tk} = t * D^L_{tk}$ and $f_0(t;\beta)$ is a general linear model with unknown parameter vector β. If the sample size is large enough, it is better to use a single model with both rolling dummy variables, which will simplify the structural break detection.

Note that level-shift and rate-shift are only distinguishable at $k = 2, ..., n-1$, 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 $\hat{p}^L(k)$ and $\hat{p}^R(k)$ indicate the corresponding *p*-values of those coefficients. Define

$$\hat{T}^L = \arg\min \hat{p}^L(k) \text{ and } \hat{T}^R = \arg\min \hat{p}^R(k)$$

to be the change points detected in the level and in the growth rate, respectively. The final estimated $\hat{T}_0$ is the one of $\hat{T}_0^L$ and $\hat{T}_0^R$ with the smaller *p*-value. If this *p*-value 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. If the detected change point is at $\hat{T}_0 = \hat{T}_0^L$, the time series exhibits a level-shift with estimated size of jump $\hat{\Delta} = \hat{\gamma}(\hat{T}_0)$, and the finally fitted model is $\hat{y}_t = f_0(t;\hat{\beta}) + \hat{\gamma}(k) D^L_{t\hat{T}_0}$, 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 the finally fitted model is $\hat{y}_t = f_0(t;\hat{\beta}) + \hat{\theta}(k) D^R_{t\hat{T}_0}$.

Remark 1. *Using the p-values to decide the jump type is equivalent to the use of the residual sum of squares, because the number of coefficients in all models is fixed.*

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

Furthermore, the financial crisis of 2008 has 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. And we have to test whether the observation in 2009 exhibits a structural break. For this purpose we propose to use the observations after the first detected change point together with that in 2009 and another dummy variable which takes 1 for 2009 and zero otherwise. Then a model can be fitted. And the estimation and test results of the coefficient of this dummy variable can be used to show the size and significance level of the level-shift in 2009.

3. Detected structural breaks

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, shortly HS), agri-food products consist of four categories, called 1-digit HS categories: animal and animal products; vegetable products; animal or vegetable fats, oils and waxes; and foodstuffs. In this paper the value of the total agri-food products is discussed first. Then the first two categories, i.e. animal and animal products and vegetable products, are chosen to show different features, because the two categories are representative and both have obvious structural breaks during the study period. In the following, China's total agri-food exports to Germany ($US million, the same below) and Germany's total agri-food exports to China are denoted by Y_C and Y_G, respectively. And China's agri-food exports to Germany and Germany's agri-food exports to China in the two categories are denoted by Y_{C1} and Y_{C2}, and Y_{G1} and Y_{G2}, respectively.

3.1 Detected structural breaks in the middle part

For the implementation of the proposed structural break detection procedures, 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. 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 *p*-values in Y_C, Y_{C1}, Y_{C2}, Y_G, Y_{G1} and Y_{G2} are given in Table 1, where the finally chosen results are highlighted in bold.

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

Series	Y_C	Y_{C1}	Y_{C2}	Y_G	Y_{G1}	Y_{G2}
$\hat{T}_0^L$	9	9	7	7	12	7
Year	2002	2002	2000	2000	2005	2000
$\hat{\Delta}^L$	**-201.75**	**-131.58**	-46.539	-61.219	-7.4001	-62.098
t^L	**-3.1125**	**-3.1752**	-3.0039	-2.1321	-2.4381	-2.2115
p^L	**0.0099**	**0.0088**	0.0120	0.0564	0.0329	0.0491
$\hat{T}_0^R$	6	9	7	7	12	7
Year	1999	2002	2000	2000	2005	2000
$\hat{\Delta}^R$	-36.357	-14.579	**-7.2425**	**-9.0953**	**-0.6785**	**-9.7315**
t^R	-2.7806	-2.8139	**-3.4897**	**-2.2269**	**-2.7518**	**-2.5085**
p^R	0.0179	0.0169	**0.0051**	**0.0478**	**0.0188**	**0.0291**

The proposed procedure works very well in practice. In all cases we have $\hat{T}_0^L = \hat{T}_0^R$, except for Y_C, where the detected change point in the level with the smallest *p*-value occurred three years later than that in the growth rate with a slightly larger *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_C exhibits a significantly negative level-shift of -201.8 million US dollars in 2002, and Y_G is dominated by a rate-shift with a coefficient of -9.1 million US dollars for $t = 7, ..., 15$, which correspond to the years from 2000 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. This shows again that the proposed procedure works very well. Taking Y_G as an example, the reduction in 2000 caused by the rate-shift is -63.7 (-9.1*7) million US dollars, which is approximately equal to the estimated level-shift of -61.2 million US dollars, but that in 2008 is however -136.5 (-9.1*15) million US dollars. 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 points in different years. Y_{C1} shows a level-shift of -131.6 million US dollars in 2002, but Y_{C2} has a rate-shift with a coefficient of -7.2 million US dollars for $t = 7, ..., 15$, corresponding to the years from 2000 to 2008. Both of the Germany's categories, Y_{G1} and Y_{G2}, exhibit rate-shifts with coefficients of -0.68 and -9.7 million US dollars for

$t = 12, ..., 15,$ corresponding to the years from 2005 to 2008 and $t = 7, ..., 15,$ corresponding to the years from 2000 to 2008, respectively. 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.

The estimated coefficients of corresponding variables for all models based on the structural break detection are shown in Table 2. Detailed results for Y_C with a level-shift and Y_{C2} with a rate-shift are given as examples. According to the results in Tables 1 and 2, the finally fitted model for Y_C is:

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

$$\hat{y}_t = 516.54 - 85.716t + 11.197t^2, \ t \le 8, \text{or}$$
$$\hat{y}_t = 314.79 - 85.716t + 11.197t^2, \ t \ge 9;$$

and the finally fitted model for Y_{C2} is:

$$\hat{y}_t = 106.59 - 15.903t + 2.814t^2 - 7.243D_{t7}^R, \ t = 1, ..., 15, \text{corresponding to}$$

$$\hat{y}_t = 106.59 - 15.903t + 2.814t^2, \ t \le 6, \text{or}$$
$$\hat{y}_t = 106.59 - 23.146t + 2.814t^2, \ t \ge 7.$$

Table 2: The estimated coefficients of corresponding variables

	Y_C	Y_{C1}	Y_{C2}	Y_G	Y_{G1}	Y_{G2}
Type	Level	Level	Rate	Rate	Rate	Rate
Intercept	516.54	250.89	106.59	203.06	6.0920	11.554
t	-85.716	-40.492	-15.903	-28.172	-0.3861	8.2629
t^2	11.197	5.4663	2.8140	2.3390	0.2710	0.2421
$D_{t\hat{T}_0}^L$ or $D_{t\hat{T}_0}^R$	-201.75	-131.58	-7.2425	-9.0953	-0.6785	-9.7315

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 kind of change points by a letter "L" for level-shift or "R" for rate-shift. Also, the significance level is indicated by "*" or "**" for $\alpha = 0.05$ and $\alpha = 0.01$, 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. Two of the change points detected in the series related to China's exports to Germany occurred directly after that year and the other also happened near to this remarkable event. The highly significant level- or rate-shifts in Y_C, Y_{C1} and Y_{C2} 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_C and Y_{C1} became higher and higher after 2002. According to the fitted model for Y_C 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 was already over in 2003. And thereafter the impact became clearly positive. This is similar for Y_{C1}. According to the fitted model for Y_{C2} the estimated growth rates of it in the years 1999, 2000, 2001, 2002, 2005 and 2008 are e.g. 17.87, 16.25, 21.88, 27.51, 44.39 and 61.27 million US dollars, respectively. The growth rate of this series in 2001 was already higher than that in 1999, and the negative impact was over. Secondly, after China's accession to WTO the development of its exports to Germany became much regular than before. Finally, it will be shown in Section 5 that after its accession to WTO, China's competitiveness in Germany's agri-food market also improved clearly.

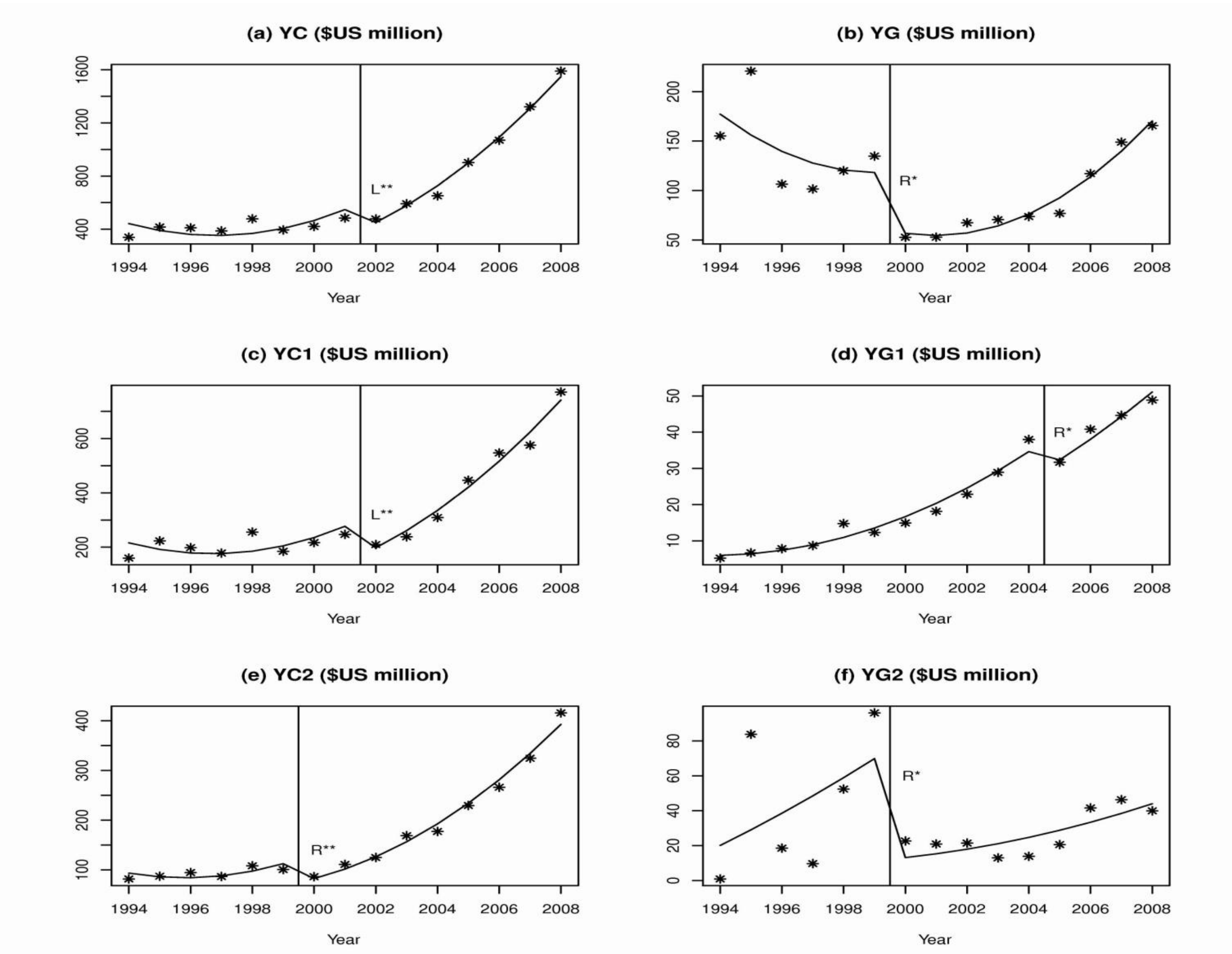

Figure 1: Structural breaks for Y_C, Y_G, Y_{C1}, Y_{G1}, Y_{C2} and Y_{G2} in the middle part of time series.

According to the historical background, the EU's CAP reform (Agenda 2000) (Ackrill, 2000) and the official launch of the Euro are so important that they must have affected Germany's export performance in some degree since 1999. Both Y_G and Y_{G2} exhibited a negative rate-shift in the next year. In addition, the change point in Y_{G1} appeared just after further reforms of the CAP in 2003 and 2004 (Kelch and Normile, 2004), with again a negative rate-shift. The significant rate-shifts in Y_G, Y_{G1} and Y_{G2} indicate that the EU's CAP reform first caused a negative impact on its exports to China in agri-food products. The development of Y_G and Y_{G2} are not so regular as Y_{G1}, particularly in the first sub-periods, hence the errors in the estimated models are very large which will not be discussed here. Based on the fitted model for Y_{G1} (see the second last column in Table 2), the estimated growth rates of it in the years 2004, 2005, 2006, 2007 and 2008 are e.g. 5.58, 5.44, 5.98, 6.52 and 7.07 million US dollars, respectively. The growth rate of this series in 2006 was already higher than that in 2004, and the negative impact was over. Therefore, the long-term impact was slightly positive. Also note that a negative rate-shift represents an adjustment in the growth rate, while the total exports may still increase.

3.2 Detection of possible structural breaks caused by the financial crisis

Following the method for detecting the possible structural break in 2009, estimated results of jumps, *t* and *p*-values for all series are given in Table 3. The used regression function is still a second order polynomial except for Y_{G1}, which is fitted by a simple linear regression because of the very small number of observations. From Table 3, it is clear to see that all estimated jumps are negative. Y_C and Y_{C2} have level-jumps of -454.39 and -102.41 million US dollars respectively, and both are highly significant at the 1% confidence level. Y_{C1} exhibits a jump of -160.89 million US dollars, which is only significant at the 10% confidence level. The estimated jumps of Y_G, Y_{G1} and Y_{G2} also show some reduction in 2009, which are however not significant. Furthermore, the estimated coefficients of corresponding variables for all models are shown in Table 4. For instance, the finally fitted model for Y_C is:

$$\hat{y}_t = 421.21 + 37.52t + 18.6t^2 - 454.39D_{t8}^L,\ t = 1, ..., 8, \text{corresponding to}$$

$$\hat{y}_t = 421.21 + 37.52t + 18.6t^2,\ t \le 7, \text{or}$$
$$\hat{y}_t = -33.18 + 37.52t + 18.6t^2,\ t = 8.$$

In order to show such structural break more clearly, Figure 2 is displayed, where the vertical solid line indicates a possible structural break caused by the financial crisis. The solid

Table 3: Jumps, *t* and *p*-values for all cases in 2009

	Y_C	Y_{C1}	Y_{C2}	Y_G	Y_{G1}	Y_{G2}
$\hat{\Delta}^L$	**-454.39**	**-160.89**	**-102.41**	-21.223	-1.6790	-16.680
t^L	**-7.6290**	**-2.2600**	**-5.0370**	-1.3970	-0.5470	-1.3420
p^L	**0.0016**	**0.0866**	**0.0024**	0.2120	0.6391	0.2282

Table 4: The estimated coefficients of corresponding variables in 2009

	Y_C	Y_{C1}	Y_{C2}	Y_G	Y_{G1}	Y_{G2}
Intercept	421.21	150.10	92.480	62.475	27.672	27.899
t	37.520	40.319	-1.2959	-8.3152	5.5361	-6.2239
t^2	18.600	6.5530	3.9635	2.2389	----	0.9444
D_{t8}^L	-454.39	-160.89	-102.41	-21.223	-1.6790	-16.680

curve represents the estimated model with one dummy variable using the observations after the first detected change point. The estimated model can also be extended to 2009 under the assumption of no structural break, which is indicated by a dashed line. Correspondingly, the actual observations are indicated by stars. All of the estimated models also fit the data very well. It is clear that all actual values in 2009 are less than the extended values ignoring the structural break. For China's exports to Germany, the estimated very large negative jumps are the difference between the actual value and the extended value in 2009, which show that there is an obvious structural break. So the short-term impact of the 2008 financial crisis was clearly negative on China's exports to Germany, which will be confirmed again using the CMS model in Section 5. However, even if Germany's exports to China show a slight rise in 2009, they are still less than the expected growth which can also be reflected by the estimated negative jumps. Since there is only one observation after the financial crisis, the estimated results are affected by large observation error, but can still provide useful information about the short-term impact of the 2008 financial crisis.

Overall, results in this section not only show that the above mentioned remarkable economic events did cause structural breaks with negative short-term impacts on corresponding series, but also provide useful information for defining different sub-periods to compare the results of the CMS model.

4. The hierarchical CMS model

The CMS model is a generally accepted method to calculate and decompose the sources of a

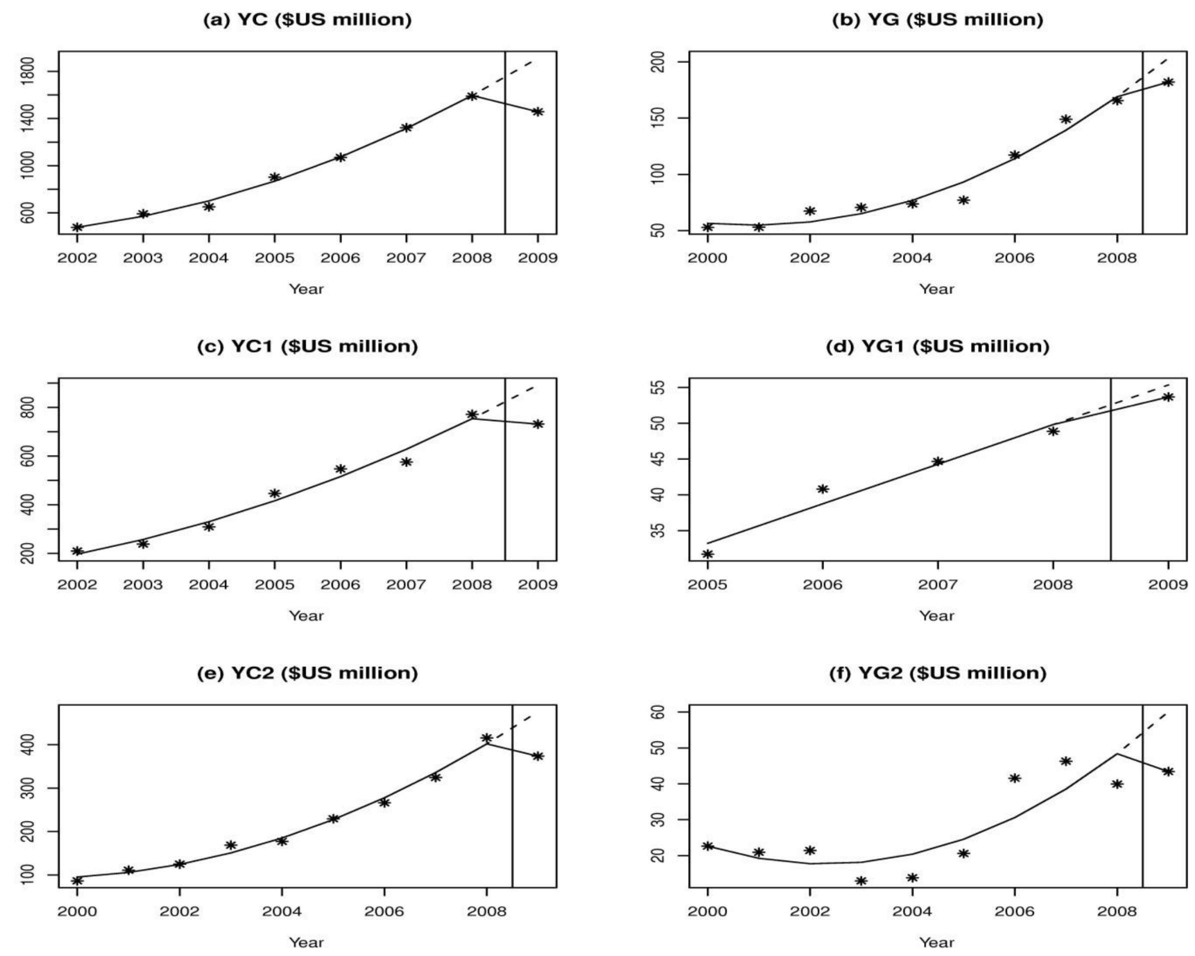

Figure 2: Structural breaks for Y_C, Y_G, Y_{C1}, Y_{G1}, Y_{C2} and Y_{G2} due to the 2008 financial crisis.

focus country's export growth, which indicates whether or not a country's comparative export performance reflects changing market shares or total market growth. It is also a technique for analyzing trading patterns and trends for the purpose of policy formulation. The traditional CMS model was first applied to the study of international trade by Tyszynski (1951). Merkies and van der Meer (1988), Jepma (1986), and Milana (1988) discuss the theoretical foundation of the CMS model and improve it in different ways. Bowen and Pelzman (1984), Fagerberg and Sollie (1987), Chen, Xu and Duan (2000) and Simonis (2000) use the CMS model to discuss the export growth causes on various commodities in different countries and different time periods. Especially, Chen, Xu and Duan (2000) employ an improved CMS model to investigate the performance of China's exports in agri-food products from 1980 to 1996.

The CMS model assumes that if a focus country's competitiveness with respect to a certain export product stays at the same level, its market share has to be constant as well. The traditional CMS model comes from shift-share analysis in the empirical studies of industrial and regional economics. Using the Laspeyres-type index, the most basic form of the CMS model with only one commodity exported to one destination is given by

$$\Delta q = s^0 \Delta Q + \Delta s Q^0 + \Delta s \Delta Q , \tag{4}$$

where superscript 0 stands for the initial year, q is a focus country's exports, Q is the world's total exports, which can also be replaced with total imports from the world, $s = q/Q$ is a focus country's share of the world and Δ denotes the change between the initial and the final years. The first term on the right-hand-side (rhs) stands for the "Structural Effect", the second for the "Competitive Effect" and the third for the "Second-order Effect". If there are n export commodities or n destinations, the change of export value can then be written as

$$\Delta q = \sum_i s_i^0 \Delta Q_i + \sum_i \Delta s_i Q_i^0 + \sum_i \Delta s_i \Delta Q_i , \tag{5}$$

where s_{i} and Q_{i} are the corresponding quantities for the i-th commodity/destination. The three sums on the rhs correspond to the three terms on the rhs of Model (4). Now, the changes in the three kinds of effects can be decomposed further (Jepma, 1986):

$$\begin{aligned}\Delta q = {} & s^0 \Delta Q + \left(\sum_i s_i^0 \Delta Q_i - s^0 \Delta Q \right) + \Delta s Q^0 + \left(\sum_i \Delta s_i Q_i^0 - \Delta s Q^0 \right) \\ & + \left(Q^1 / Q^0 - 1 \right) \sum_i \Delta s_i Q_i^0 + \left[\sum_i \Delta s_i \Delta Q_i - \left(Q^1 / Q^0 - 1 \right) \sum_i \Delta s_i Q_i^0 \right],\end{aligned} \tag{6}$$

where superscript 1 stands for the final year. Finally, if n commodities are exported to m destinations, we have

$$\Delta q = \sum_i \sum_j s_{ij}^0 \Delta Q_{ij} + \sum_i \sum_j \Delta s_{ij} Q_{ij}^0 + \sum_i \sum_j \Delta s_{ij} \Delta Q_{ij} , \tag{7}$$

where Q_{ij} is the i-th commodity exported to the j-th destination. The three parts on the rhs have the similar meanings as those of Models (4) and (5). In addition to Model (7), different formulations of Δq are also proposed in the literature (see e.g. Richardson, 1971a, b and Milana, 1988). Jepma (1986) then proposes an improved version of the CMS model based on Model (7), which decomposes the changes in the three kinds of effects further as follows

$$\begin{aligned}\Delta q = {} & s^0 \Delta Q + \left(\sum_i \sum_j s_{ij}^0 \Delta Q_{ij} - \sum_i s_{i\bullet}^0 \Delta Q_{i\bullet} \right) + \left(\sum_i \sum_j s_{ij}^0 \Delta Q_{ij} - \sum_j s_{\bullet j}^0 \Delta Q_{\bullet j} \right) \\ & + \left[\left(\sum_i s_{i\bullet}^0 \Delta Q_{i\bullet} - s^0 \Delta Q \right) - \left(\sum_i \sum_j s_{ij}^0 \Delta Q_{ij} - \sum_j s_{\bullet j}^0 \Delta Q_{\bullet j} \right) \right] + \Delta s Q^0 \\ & + \left(\sum_i \sum_j \Delta s_{ij} Q_{ij}^0 - \Delta s Q^0 \right) + \left(Q^1 / Q^0 - 1 \right) \sum_i \sum_j \Delta s_{ij} Q_{ij}^0 \\ & + \left[\sum_i \sum_j \Delta s_{ij} \Delta Q_{ij} - \left(Q^1 / Q^0 - 1 \right) \sum_i \sum_j \Delta s_{ij} Q_{ij}^0 \right],\end{aligned} \tag{8}$$

where $i\bullet$ and $\bullet j$ stand for sums of corresponding values over j destinations and i commodities, respectively. We refer the reader to Jepma (1986, 1989) for further interpretations of those decomposition items.

Our objective is to fit the CMS model to one country's exports to one destination at two levels of classification. The total exports are first composed of n 1-digit categories (i = 1, …, n) according to e.g. HS or Standard International Trade Classification (SITC). Each of them consists of m_i 2-digit sub-categories (j = 1, …, m_i) according to e.g. HS or SITC. It can be seen that Model (8) does not apply to such data structure, because the data are not summable over index i. Hence, we propose to apply Model (6) first to the total agri-food exports using 1-digit HS data, and then to all of the 1-digit HS categories using 2-digit HS data. This idea was e.g. used by Lu and Mei (2007) for analyzing the growth of China-EU agricultural trade. A related two-stage shift-share model was proposed by Toh et al. (2004) for analyzing growth causes of visitors to Singapore. We will call this a hierarchical CMS model, because it is easy to be extended to multi-level classified data. Now we will have 1 first-level model, n second-level models, m_1+ …+ m_n third-level models and so on. Theoretical evidence for this idea is as follows: The hierarchical CMS will provide us more detailed information and the results can also be summarized to a CMS formulation closely related to Model (8). To our knowledge, there is less research on this topic and it is very worthy of further exploration. Moreover, it is also possible to combine the hierarchical and the standard CMS models.

Following Models (5) to (6), the "Structural Effect" is broken down into the "Demand Growth Effect" and the "Commodity Structure Effect". The former reflects changes in China's (Germany's) exports of agri-food products arising from the change in import demand of Germany (China), and the latter reflects changes in China's (Germany's) exports of agri-food products arising from the change in export commodity structure of China (Germany). The "Competitive Effect" is decomposed into the "Pure Competitive Effect" and the "Static Structural Residual". The former reflects changes in China's (Germany's) exports of agri-food products resulting from the changing percent of China's (Germany's) total exports accounting for Germany's (China's) total imports, and the latter reflects changes in China's (Germany's) exports of agri-food products resulting from the changing percent of China's (Germany's) certain commodity exports accounting for Germany's (China's) certain commodity imports. The "Second-order Effect" consists of the "Pure Second-order Effect" and the "Dynamic Structural Residual". The former reflects changes in China's (Germany's) exports of agri-food products due to the change on interaction between China's (Germany's) export structure and Germany's (China's) import scale, and the latter reflects changes in China's (Germany's) exports of agri-food products due to the change on interaction between China's (Germany's) export structure and Germany's (China's) import structure. In the following the abbreviations "SE" for Structural Effect, "DGE" for Demand Growth Effect, "CSE" for Commodity Structure Effect, "CE" for Competitive Effect, "PCE" for Pure Competitive Effect, "SSR" for Static Structural Residual, "SOE" for Second-order Effect, "PSE" for Pure Second-order Effect, and "DSR" for Dynamic Structural Residual, will be used.

When using the CMS model, the observation period is usually divided into different sub-periods determined by some remarkable economic events. However, the sub-periods are usually decided by qualitative methods or experience. For example, Chen, Xu and Duan (2000) choose 1988 as a change point based on crude judgment. In this paper, we propose the use of the CMS model based on the results of structural break detection given in the last section. This provides a more rigorous analysis of a country's export growth causes. In this paper the decomposition is carried out yearly, so that the end of the period in each decomposition is also the beginning of the next period. The simple average of yearly decomposition results is then used to represent the chosen sub-period.

5. Decomposition and analysis of the growth causes

For each time series, the observation period 1994 to 2008 is divided into two sub-periods by the first detected change point in Section 3. Then we can analyze the long-term impact of China's accession to WTO, the EU's CAP reform in 1999 or other policy reforms on growth causes of China-Germany trade in agri-food products by comparing the changes between the first and second sub-periods. Although there are no obvious change points in 2009 in the series of Germany's exports to China, in order to compare different impacts of the 2008 financial crisis on growth causes in agri-food trade between China and Germany simultaneously, for all series in both countries the period 2008 to 2009 will be considered as a third sub-period. Results for the third sub-period reflect the growth causes from 2008 to 2009 and the short-term impact of the 2008 financial crisis can be found by comparing the changes between the second and third sub-periods.

China's and Germany's imports from the world ($US 100 million) from 1994 to 2009 in total agri-food products, in animal and animal products, and in vegetable products, to be used in the CMS model, are displayed in Figures 3(a) and 3(b), 3(c) and 3(d), and 3(e) and 3(f), respectively. The three series of China's imports from the world exhibited stable growth trends until 2008. However, the series of Germany's imports from the world all decreased initially and then increased until 2008. All of those series jumped down suddenly in 2009.

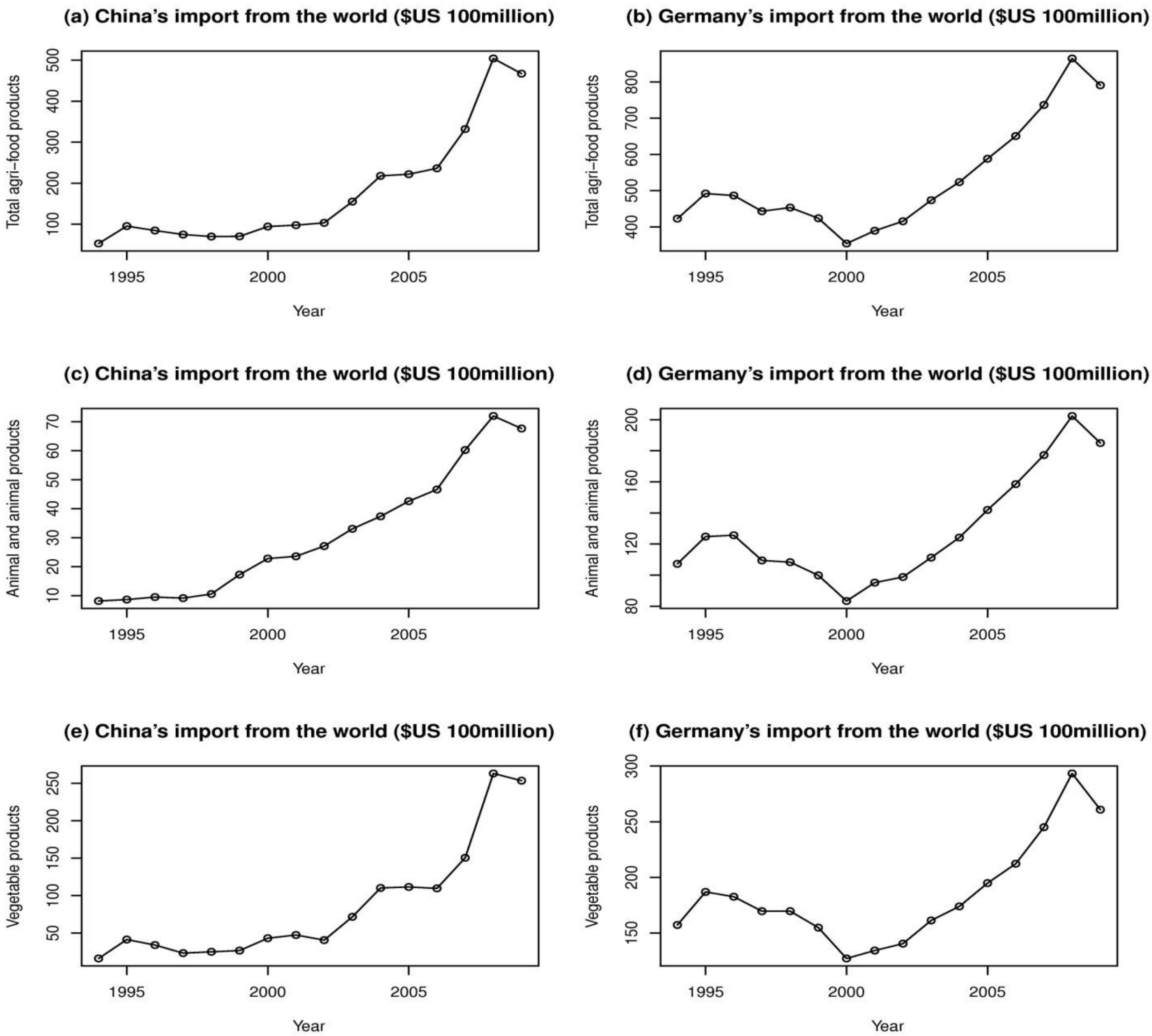

Figure 3: China's and Germany's imports from the world in agri-food products: 1994-2009.

5.1 The first-level CMS model for total agri-food products

The total agri-food products is composed of four 1-digit HS categories (i = 1, …, 4). According to the results in Section 3, we know that China's exports to Germany (Y_C) have two level-shifts in 2002 and 2009. The three sub-periods for this series are hence 1994 to 2001, 2002 to 2008 and 2008 to 2009. Average results of the yearly decomposition of the change in Y_C for these sub-periods are shown in Table 5. During 1994 to 2001, the competitive effect increased yearly exports by 27.0 million US dollars (on average, the same below), which accounted for 131.1% of the change in China's exports to Germany. Meanwhile, both the structural effect and the second-order effect were negative. In the second sub-period, the competitive effect only accounted for 36.4% of the change in China's exports to Germany. However, it promoted exports by 67.5 million US dollars per year, which was 2.5

times of that in the first sub-period. That is, China's export competitiveness of total agri-food products improved significantly after its accession to WTO. In addition, the demand growth effect accounted for 60.8% of the increase in China's exports to Germany, which means that Germany's import demand contributed most to the change. As it is known, China has been gradually integrating into international agri-food trade market after its accession to WTO, so the structural effect became more important than the competitive effect. Generally speaking, 1994 to 2001 was an initial stage with the yearly change of 20.6 million US dollars, and 2002 to 2008 was a rapid developing period with the change of 185.4 million US dollars per year. The above facts show that China's accession to WTO has definitely a positive long-term impact on China's exports to Germany. During 2008 to 2009, China's agri-food exports to Germany have greatly decreased with the change of -132.2 million US dollars because of the 2008 worldwide financial crisis. The reduction was mainly caused by the structural effect with a demand growth effect 102.7%, which indicates that Germany's demand scale was atrophying due to economic depression. Obviously, the 2008 financial crisis has a negative short-term impact on China's exports to Germany.

Table 5: The average results of the yearly CMS decomposition of the change in export value for Y_C and Y_G , ($US million)

Index	Y_C						Y_G					
	1994-2001		2002-2008		2008-2009		1994-1999		2000-2008		2008-2009	
	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%
Change	20.6	100	185.4	100	-132.2	100	-4.1	100	14.1	100	16.4	100
SE	**-4.3**	**-20.9**	**110.1**	**59.4**	**-131.8**	**99.7**	**0.5**	**-12.2**	**20.2**	**143.3**	**-4.2**	**-25.8**
DGE	-4.4	-21.4	112.8	60.8	-135.7	102.7	16.3	-399.7	24.8	175.9	-12.1	-73.9
CSE	0.1	0.5	-2.7	-1.5	4.0	-3.0	-15.8	387.4	-4.6	-32.6	7.9	48.1
CE	**27.0**	**131.1**	**67.5**	**36.4**	**1.3**	**-1.0**	**-13.2**	**323.8**	**-1.5**	**-10.6**	**21.3**	**129.3**
PCE	26.3	127.7	64.4	34.7	3.9	-2.9	-16.8	412.9	-5.7	-40.4	30.9	187.7
SSR	0.7	3.4	3.2	1.7	-2.6	1.9	3.6	-89.0	4.2	29.8	-9.6	-58.4
SOE	**-2.1**	**-10.2**	**7.8**	**4.2**	**-1.7**	**1.3**	**8.6**	**-211.7**	**-4.6**	**-32.6**	**-0.6**	**-3.5**
PSE	-1.6	-7.8	8.8	4.7	-0.1	0.1	-2.9	70.3	-2.8	-19.9	-1.6	-9.5
DSR	-0.5	-2.4	-0.9	-0.5	-1.6	1.2	11.5	-282.0	-1.8	-12.8	1.0	6.0

Accordingly, the three sub-periods considered for Germany's exports to China (Y_G) are 1994 to 1999, 2000 to 2008 and 2008 to 2009. Average results of the yearly decomposition of the change in Y_G for these sub-periods are listed in the second part of Table 5. During 1994 to 1999, the competitive effect decreased yearly exports by 13.2 million US dollars, which accounted for 323.8% of the reduction in Germany's exports to China. Particularly, the pure competitive effect was very largely negative. It indicates that Germany's export share in total agri-food products showed an obvious decline in the first sub-period. During 2000 to 2008, the change of exports became positive with the yearly increase of 14.1 million US dollars. The demand growth effect was the leading factor on the increment in Germany's exports to China, which accounted for 175.9%. From Figure 3(a) we can see that China's import demand of total agri-food products grew rapidly in this sub-period. Meanwhile, it shows that the EU's CAP reform in 1999 does not have a positive long-term impact on Germany's export competitiveness, which is reflected in the competitive effect with the change of -1.5 million US dollars per year. In the third sub-period, in contrast with China, Germany's agri-food exports to China still increased in 2009 slightly with the change of 16.4 million US dollars. This fact indicates from another side that Germany has benefited from China's market despite losses in other countries' markets during the financial crisis. The competitive effect was positive and accounted for 129.3%. Therefore the market share of Germany's agri-food exports to China accounting for China's agri-food imports from the world clearly grew in 2009. Hence the financial crisis does not affect Germany's exports to China so much.

5.2 The second-level CMS model for two categories of specific agri-food products

Now we will further analyze the growth causes of specific agri-food products and compare the differences between China and Germany. Only the results for the first two categories, i.e. animal and animal products and vegetable products consist of five (j = 1, …, 5) and nine (j = 1, …, 9) sub-categories based on the 2-digit HS, respectively, will be reported to save space. From Table 1 we know that Y_{C1} and Y_{G1} exhibit a structural break in 2002 and 2005, respectively, and from Table 3 Y_{C1} has another change point in 2009. Results for the first type of agri-food products based on the sub-periods defined by those change points and the financial crisis are listed in Table 6. For China's exports, we see a yearly increment of 93.6 million US dollars from 2002 to 2008, compared with 12.5 million US dollars per year from 1994 to 2001. It indicates that after its entry into WTO, the expansion of Germany's import demand (52.8%) and the improvement of China's export competitiveness (50.1%) became two equally important factors in the promotion of exports. The long-term impact of this remarkable event is clearly positive. After 2008, due to the extremely unbalanced export structure of animal and animal products, the commodity structure effect and the static structural residual are very large and offset each other. So the great reduction mainly resulted from the demand growth effect with the change of -66.3 million US dollars. However, the pure competitive effect was still positive. For Germany, during 2005 to 2008, the demand growth effect with the yearly change of 7.9 million US dollars, which accounted for 138.3%, was 2.92 times of that in the first sub-period. The change of the yearly dynamic structural residual from -0.4 to 0.7 million US dollars means that Germany had a more rapidly growing export share in animal and animal products where China's import demand was growing relatively rapidly. From 2008 to 2009, the increasing exports could be mostly attributed to the pure competitive effect (171.3%). Clearly, the short-term impact of the financial crisis is totally opposite between China and Germany.

Table 6: The average results of the yearly CMS decomposition of the change in export value for animal and animal products, ($US million)

Index	Y_{C1}						Y_{G1}					
	1994-2001		2002-2008		2008-2009		1994-2004		2005-2008		2008-2009	
	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%
Change	12.5	100	93.6	100	-40.1	100	3.3	100	5.7	100	4.8	100
SE	**-3.8**	**-30.5**	**44.3**	**47.3**	**-8.2**	**20.4**	**3.3**	**100.1**	**5.1**	**89.6**	**1.83**	**38.1**
DGE	-2.8	-22.2	49.4	52.8	-66.3	165.3	2.7	83.0	7.9	138.3	-2.9	-61.1
CSE	-1.0	-8.3	-5.1	-5.5	58.1	-144.9	0.6	17.1	-2.8	-48.7	4.8	99.2
CE	**13.5**	**107.8**	**46.9**	**50.1**	**-31.9**	**79.5**	**0.7**	**21.1**	**0.3**	**5.4**	**1.76**	**36.7**
PCE	15.9	127.4	38.9	41.5	28.7	-71.5	0.8	25.5	-1.5	-26.0	8.2	171.3
SSR	-2.4	-19.6	8.1	8.6	-60.5	151.0	-0.1	-4.5	1.8	31.4	-6.5	-134.6
SOE	**2.8**	**22.3**	**2.4**	**2.5**	**-0.04**	**0.1**	**-0.7**	**-21.9**	**0.3**	**5.4**	**1.2**	**25.2**
PSE	0.5	4.3	6.3	6.7	2.7	-6.8	-0.3	-9.6	-0.4	-7.7	-0.1	-2.2
DSR	2.3	18.1	-3.9	-4.2	-2.8	6.9	-0.4	-12.3	0.7	13.1	1.3	27.4

Table 7 shows results for the second type of agri-food products, that is vegetable products. The three sub-periods for both Y_{C2} and Y_{G2} are 1994 to 1999, 2000 to 2008 and 2008 to 2009. For China, the results show that the competitive effect increased exports by 16.1 million US dollars per year in 2000 to 2008, which was nearly 3.35 times of that in 1994 to 1999. During the second sub-period, the structural effect was also another important factor to promote exports which accounted for 60%. In the third sub-period, like total agri-food products, the reduction was mostly due to decreasing import demand in Germany with the change of -46.1

US million dollars per year. For Germany, both the competitive effect and the second-order effect had great drops during 2000 to 2008, which represents that the EU's CAP reform in 1999 exhibits a negative long-term impact on export competitiveness and the changes of Germany's export share in vegetable products cannot be consistent with the changes of China's import demand. At the same time, the yearly demand growth effect grew from -3.0 to 9.1 million US dollars which offsets the adverse effect. It indicates that the increasing exports were attributed to China's import demand. From 2008 to 2009, the pure competitive effect increased exports by 5.1 million US dollars. In addition, the second-order effect has risen, which suggests that the changes of export share in Germany's vegetable products has been gradually adapting to the changes of China's import demand. The financial crisis of 2008 does not affect Germany's exports to China.

Table 7: The average results of the yearly CMS decomposition of the change in export value for vegetable products, ($US million)

Index	Y_{C2}						Y_{G2}					
	1994-1999		2000-2008		2008-2009		1994-1999		2000-2008		2008-2009	
	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%
Change	3.8	100	41.2	100	-42.1	100	19.0	100	2.2	100	3.5	100
SE	**0.1**	**1.5**	**24.7**	**60.0**	**-46.7**	**110.8**	**-3.4**	**-17.8**	**7.7**	**352.2**	**3.33**	**95.3**
DGE	-0.5	-14.3	23.6	57.2	-46.1	109.4	-3.0	-15.9	9.1	412.0	-1.5	-41.9
CSE	0.6	15.7	1.1	2.7	-0.6	1.4	-0.3	-1.8	-1.3	-59.8	4.8	137.2
CE	**4.8**	**127.4**	**16.1**	**39.0**	**7.2**	**-17.1**	**3.7**	**19.4**	**-2.2**	**-97.8**	**-3.1**	**-89.2**
PCE	4.7	123.7	15.6	37.9	4.5	-10.6	8.6	45.1	-2.6	-117.1	5.1	147.2
SSR	0.1	3.7	0.5	1.2	2.7	-6.5	-4.9	-25.7	0.4	19.4	-8.2	-236.4
SOE	**-1.1**	**-29.5**	**0.4**	**0.9**	**-2.6**	**6.2**	**18.7**	**98.5**	**-3.44**	**-156.2**	**3.27**	**93.8**
PSE	-0.3	-8.8	1.9	4.6	-0.8	1.9	13.2	69.3	-3.37	-153.2	0.1	3.3
DSR	-0.8	-20.6	-1.5	-3.7	-1.8	4.4	5.6	29.2	-0.1	-3.0	3.2	90.5

6. Concluding remarks

This paper first proposes a structural break detection procedure as a tool for analyzing the short- or long-term impact of remarkable economic events. The results show that the time series under consideration have different kinds of change points in different years. In particular, it is shown that 1999 and 2001 are two important years, because of the EU's CAP reform and China's accession to WTO. It is worth mentioning that China's accession to WTO has had a negative short-term impact on its exports to Germany, but its long-term impact was definitely positive. Secondly, decomposition and analysis of growth causes using a hierarchical CMS model based on sub-periods divided by detected change points also provide valuable conclusions. By comparing the changes between different sub-periods, it is also shown that the long-term impact of China's accession to WTO was clearly positive, but the long-term impact of the EU's CAP reform was uncertain. Especially for China, since its accession to WTO, exports to Germany in agri-food products developed rapidly until 2008, and its competitiveness also improved clearly. It is shown that China-Germany trade relationship in agri-food products has become more and more close. However, the financial crisis caused an obviously negative short-term impact on China's exports to Germany. Since 2008, many unexpected changes of agri-food trade between China and Germany have occurred or are about to. Hence, the long-term impact of the financial crisis is unclear and discussion on this requires future observations. From the perspective of market share, although China's agri-food exports to Germany decreased strongly in 2009, the market share accounting for Germany's agri-food imports from the world still increased slightly. That is, China's share in Germany's market was not affected clearly by the financial crisis. Whether China's market share will continuously develop as in the last years is still an open question.

Acknowledgements

The paper was finished when the first author has been working as a Research Assistant at a cooperative project between the University of Paderborn and the China Agricultural University. We are grateful to the financial support of the Faculty of Business Administration and Economics, University of Paderborn, Germany. We would like to thank UN Comtrade for publishing the data.

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