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Modeling of the impact of the financial crisis and China's accession to WTO on China's exports to Germany ☆

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ABSTRACT

We focus on discussing the impact of China's accession to WTO and the financial crisis on China's exports to Germany, particularly in agricultural products, based on some most recent proposals. Firstly, structural breaks caused by those events are detected. Then the Box–Cox model and a new tree-form Constant Market Share (CMS) model are fitted to discover the long-term impact of those events on the trade relationship between China and Germany and the growth causes of China's exports to Germany. We found that China's accession to WTO had a negative short-term impact on China's exports and its market share in agricultural products, but a positive short-term impact on its market share in industrial products and a positive long-term impact on its exports and market share in both classes. The tree-form CMS model shows the growth of China's exports to Germany due to competitiveness after this event was much higher than before. The financial crisis exhibited a negative short-term impact on China's exports to Germany, but a positive short-term impact on China's market share and the trade relationship between both countries in industrial products. China's market share in agricultural products was not affected by the financial crisis.

1. Introduction

It is well-known that some remarkable events, such as China's accession to WTO in 2001 and the global financial crisis of 2008 have had substantial impacts on China's exports and its imports from other countries. Because of their importance, studying the short- and long-term impacts of those events is of great interest (see e.g. Malouche, 2009; Rees and Tyers, 2004). This paper focuses on a systematic quantitative discussion of the short- and long-term impacts of China's accession to WTO and the financial crisis on China's exports and imports using a two-stage framework. Here, the short-term impact exerts an influence which happens at certain time point and decays quickly. However, the long-term impact will last for several years. The application will be illustrated using bilateral trade between China and Germany. The reason for this is that China and Germany have become each other's largest trade partner in Europe and Asia since 2002. According to official statistics, China–Germany trade accounted for nearly 30% of the total trade between China and the EU in 2010. Furthermore, we will mainly focus on analyzing China's export to Germany in agricultural products, because agricultural products play a significant strategic role for China's exports to Germany and there seems to be a lack of detailed study in the literature on this topic. But the proposed methodologies can be applied to any other related context. This is shown by a brief discussion on China's exports to Germany in industrial products and the difference between China's exports to Germany in industrial and agricultural products.

In the first stage, the short-term impact of those events is discovered by means of structural break detection. Different techniques are introduced in the literature for detecting structural breaks in economic data, such as the CUSUM test (Brown et al., 1975; Krämer et al., 1988) and the Bai–Perron approach (Bai and Perron, 1998, 2003). However, those proposals are not suitable for detecting structural breaks considered in this paper. In this paper we will adapt the proposal of Guo et al. (2011) using dummy variables to solve this problem (see also e.g. Brown and Burdekin, 2000; Harvey and Mills, 2005; Jiménez-Rodríguez and Sánchez, 2005; Weidenmier, 2002). This idea is closely related to the Bai–Perron approach. Firstly, rolling dummy variables are employed to detect an unknown change point with a jump either in the intercept (level-shift) or in the slope (rate-shift) in the middle part of a short time series and to estimate the size of jump at the same time. Then we introduce a suitable model for the sub-series after the first change point to detect a possible level-shift at the current end of a time series, a procedure especially developed for quantifying the short-term impact of the financial crisis and discussing the change of the trade relationship between China and Germany before and after a remarkable event. Our proposal clearly improves that of Guo et al. (2011) and has been successfully applied in this paper.

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In the second stage, we first propose to fit the well-known Box–Cox model to sub-series before and after the first structural break for comparing the change in the development of China's exports to Germany and the change in the trade relationship between China and Germany. The analysis continues by fitting Constant Market Share (CMS) models (see e.g. Jepma, 1986; Milana, 1988; Tyszynski, 1951) to all sub-periods determined by the detected structural breaks to discover the long- or short-term impact of the abovementioned events on the growth causes of China's exports to Germany. In this paper, data classified at three levels will be used. For data classified at two levels, the so-called hierarchical CMS model (Guo et al., 2011, see also e.g. Lu and Mei, 2007; Toh et al., 2004) can be applied. But this model has some limitations in theory and practice and its results are not directly comparable with those of a standard CMS model. Most recently, Feng et al. (2011) introduced a so-called tree-form CMS model based on data classified at several levels, which is widely applicable and can provide us detailed information for decision making. Their proposal will hence be applied to the data sets under consideration and we propose to analyze the outputs of the tree-form CMS model for further using suitable econometric methods.

Our proposals work well in practice and main findings on impacts of the two economic remarkable events are as follows. Firstly, China's accession to WTO had a negative short-term impact on China's exports to Germany and its market share in agricultural products, but a positive short-term impact on its market share in industrial products. The long-term impact on China's exports to Germany and its market share in both classes was proved positive by different econometric models. Results of the tree-form CMS model indicate that the average yearly growth of China's exports to Germany due to competitiveness improvement after China's accession to WTO was much higher than before, which confirms again that this event has had a positive long-term impact on China's export competitiveness. Secondly, the financial crisis exhibited a negative short-term impact on China's exports to Germany resulting from a great reduction of Germany's imports from the world in 2009, but a positive short-term impact on China's market share and the trade relationship between both countries in industrial products. Moreover, China's market share in agricultural products was not affected by the financial crisis. In summary, this paper reviews and applies a new structural break detection procedure and the new tree-form CMS model. It also contributes by employing the Box–Cox model for quantifying the short- and long-term impacts of remarkable economic events on trade relationship. It is also shown that it is worthy to employ the outputs of a CMS model as the inputs of further economic models.

The paper is organized as follows. Procedures for detecting structural breaks are described in Section 2. Detected change points and the change of trade relationship caused by China's accession to WTO are analyzed in Section 3. Impacts of the 2008 financial crisis are explored in Section 4. The tree-form CMS model is introduced in Section 5 and applied to analyze the growth causes of China's exports to Germany and the outputs of industrial products in Section 6. Final remarks in Section 7 conclude the paper.

2. Structural breaks detection

In the following we consider the detection of a jump either in the intercept or in the slope, but not in both, in the middle part of a time series, and another jump in the intercept at the current end of a time series, respectively. Our proposal is similar to that of Guo et al. (2011), but with clear improvements in the second step.

Firstly, for detecting an unknown change point in the middle part of a time series, the time series is assumed to follow the model

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

where $\varepsilon_t \sim N(0,\sigma^2)$ are i.i.d. errors 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 $\Delta^L = f(T_0^+) - f(T_0^-)$ and $\Delta^R = f'(T_0^+) - f'(T_0^-)$ represent the jump either in $f(t)$ or $f'(t)$, respectively. $\Delta^L \neq 0$ stands for a change point with a level-shift and $\Delta^R \neq 0$ for a change point with a rate-shift. Let D_{tk}^L and D_{tk}^R denote the rolling dummy variables at time point k for the intercept or the slope, respectively, where $D_{tk}^L = 1$ for $t \geq k$, $D_{tk}^L = 0$ for $t < k$ and $D_{tk}^R = t * D_{tk}^L$. 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. In the application in Section 3.1, $f(t)$ is assumed to be a second order polynomial except for the structural break. The main reason is that a simple linear regression may cause clear misspecification and a more complex regression model may be suffered from a very large sample variation, due to the small size of the used sample. 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 in each model, respectively. The final estimated $\hat{T}_0$ is the year with the smaller values of $RSS^L\left(\hat{T}_0^L\right)$ and $RSS^R\left(\hat{T}_0^R\right)$. 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. 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 $\hat{\Delta} = \hat{\gamma}\left(\hat{T}_0\right)$. Otherwise we have $\hat{T}_0 = \hat{T}_0^R$ and the time series exhibits a rate-shift with estimated size of jump $\hat{\Delta} = \hat{\theta}\left(\hat{T}_0\right)$.

To detect the impact of the 2008 financial crisis, we want to test whether there is a structural break at the current end of a time series, i.e. between observations of 2008 and 2009. For this purpose a suitable model should be fitted to observations after the first detected change point until 2008. It is found that if a second order polynomial is fitted to this sub-series, either the linear term or the squared term is often insignificant, because the sample size is now very small. This means that we should either use a simple linear regression or a quadratic regression with the squared term only. This motivated us to use the following Box–Cox model for the sub-series in the second sub-period, which includes both of the abovementioned models as special cases:

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

where n_f and n_s are the numbers of observations in the first and second sub-periods, respectively. In Sections 3.2 and 4.2 we will see that this simple econometric 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, …, 2, by minimizing the RSS (residual sum of squares). Here, the use of the RSS is equivalent to the use of the AIC (Akaike information criterion) or BIC (Bayesian information criterion). Under the null-hypothesis of no structural break in the future, we can extend Model (2) 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 α 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.

3. Impact 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. In this paper, not only China's exports to Germany and China's market share, but also Germany's imports from the world will be discussed. According to the Harmonized Commodity Description and Coding System (HS1992, shortly HS), total exports are firstly divided into two categories, i.e. agricultural and industrial products. In the following, China's exports to Germany in total, agricultural and industrial