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# **Evolvement of Market Integration between EU and World Agricultural Markets**

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**Contributed Paper prepared for presentation at the 87th Annual Conference of the Agricultural Economics Society, University of Warwick, United Kingdom**

**8 - 10 April 2013**

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**[Abstract]** Since the MacSharry Reforms in 1992, the Common Agricultural Policy (CAP) has undergone various reforms. Prominent changes include consecutive reductions in intervention prices and the replacement of a range of coupled payments with a single decoupled payment. Such changes have led production to be more market-oriented and brought internal EU prices more in line with world prices. This study firstly examines the evolvement of wheat, barley, beef and butter prices in some EU key member states (i.e. the UK and France) and market integration between these countries. In particular, given the gradual progression of the reforms potential structural breaks are taken into account and allowed to be determined endogenously. Furthermore, market integration between the EU and world markets is investigated based on results of the first stage.

**[Keywords]** structural change; cointegration; Common Agricultural Policy

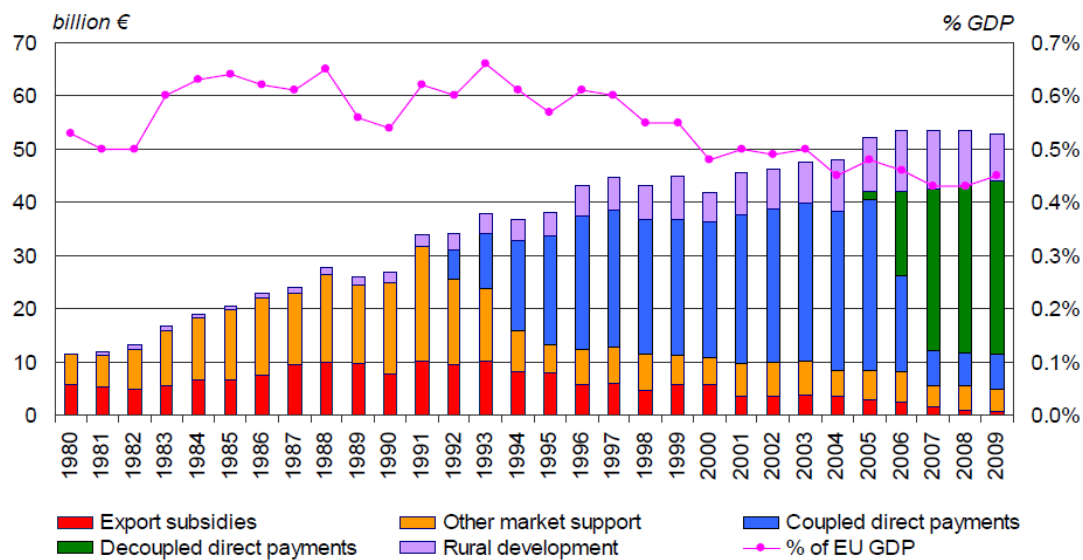
## **1 Introduction**

Since the MacSharry Reforms in 1992, the Common Agricultural Policy (CAP) has changed significantly with the focus switching from product support to producer support (see change in CAP expenditure over time in Figure 1). Intervention prices were initially reduced under the MacSharry Reforms in conjunction with the provision of direct payments linked to production to compensate for the reduced support prices. The Agenda 2000 reforms deepened the reduction in intervention prices. Later, financial support to farmers were further separated from the level of production under the Fischler reforms (agreed 2003, implemented 2005-2007), which replaced the coupled direct payments with the decoupled Single Farm Payment (SFP). The old price support regime heavily influenced production decisions in the sector and created a wedge between the EU market and the world market. With the focus of financial supports switching to producer support and the reduction of intervention prices, production decisions became more market-oriented. Furthermore, the wedge between the EU and world markets has gradually diminished, due to both the evolvement of the EU agricultural sector and the strong development of the world market.

CAP was originally created to integrate the agricultural market of different member states within the EU. The issue of EU market integration was the focus of early studies, such as such as Zanas (1993). In recent years, studies have switched to the interaction between the EU and the world markets, such as Mela and Canali (2012). However, it is beneficial to explicitly investigate the evolvement of the internal EU markets and the interaction between the EU and world markets together as the understanding of one builds on the other. Figure 2 shows the market and intervention EU prices and the representative world prices of wheat, beef and butter for the period from 1991. When the intervention prices were higher than the world price, market prices in the EU were supported by the intervention price and therefore remained stable over time. With the reductions in intervention prices, market prices became

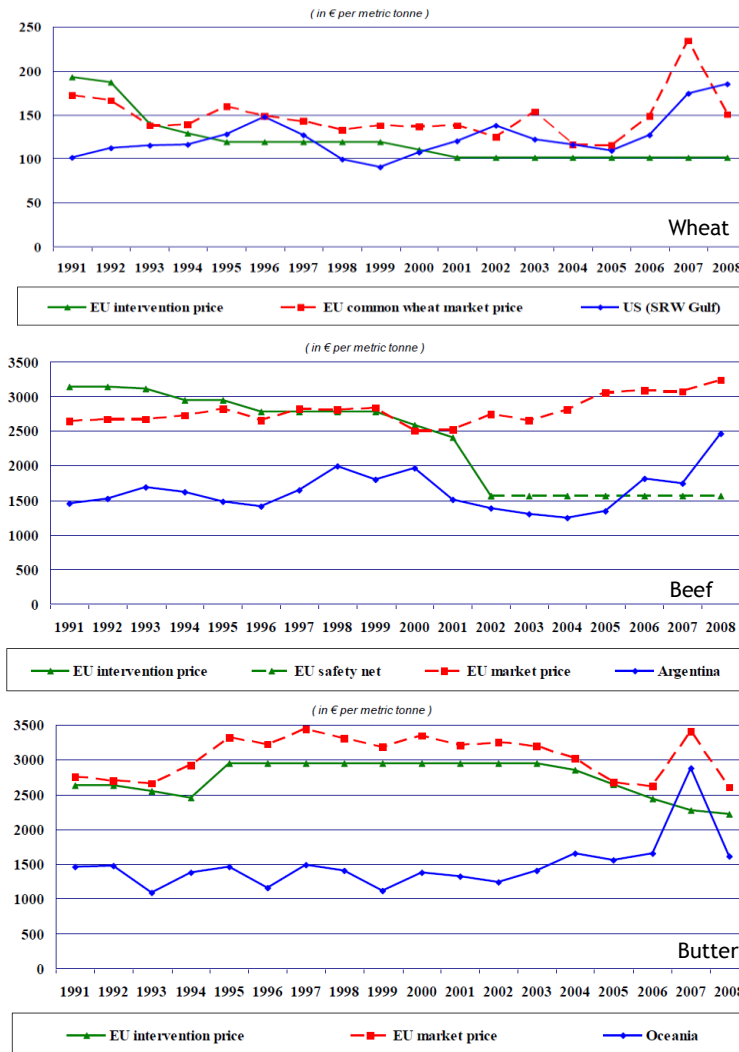
more in line with world prices and much more variable. During this process, the statistical properties of the market prices may have changed significantly, for example switching from stationary to non-stationary, which in turn has implications on the analysis of the interactions between the EU and world prices. To complicate matters, the timing of reduction in intervention prices varies across commodities. For example, that of wheat was reduced in 1993 and became irrelevant in determining the market price for most of the time after that, while intervention prices of beef and butter were not significantly reduced until after 2000 (Figure 2).

Figure 1 The Path of CAP Expenditure (1980-2009, billion current €)



Source: European Commission, DG AGRI

Figure 2 European Market and Intervention Prices versus Representative World Prices  
(Source: Haniotis, 2009)



This study examines the evolution of agricultural commodity prices in some EU key member states (i.e. the UK and France) and market integration between these countries and the world using the structural break and cointegration models. Cointegration techniques have been widely used in the examination of the EU agricultural markets (Zanias, 1993; Hanrahan 1999; Sanjuan and Gil, 2001; Ghosharay, 2002; Serra et al., 2006; Barassi and Ghoshray 2007; Ihle et al. 2012; Mela and Canali, 2012). The utilisation of cointegration model is underpinned by the Law of One Price, i.e. when the markets of two different geographical locations are fully integrated, their prices should be the same after accounting

for transaction costs. The questions investigated in this paper are closest to those in Mela and Canali (2012) and in Barassi and Ghoshray (2007). However, Mela and Canali (2012) uses a specific reform as an exogenous structural break. Whether such a structural break exists and the specific timing of the break, if there is one, are not clear as the CAP reform is comprised of a series of changes rather than a single reform. Barassi and Ghoshray (2007) utilises techniques allowing the cointegration to change endogenously. Nevertheless, cointegration analysis builds on the premise that individual series (EU and world agricultural prices in our context) are not stationary. Development in the time series literature suggests that the standard unit root tests are most of the time unable to reject the null hypothesis of unit root when the data follow a deterministic trend but there is a structural change in the trend (see Perron (2005)). In other words, structural change in a cointegrated system covers two regards: 1) structural change in the individual series; and 2) structural change in the cointegration relationship. The first regard should be investigated explicitly as it can render the results of the second step as invalid. In addition, it could provide additional insights on the evolvement of the EU agricultural markets in which price determination has undergone substantial changes under the progressive CAP reforms.

Therefore, this study uses models in which existence and timing of structural break are endogenously determined by the data. Furthermore, to obtain a more complete picture of the dynamic changes of market integration, this study calculates the rolling cointegration between the EU and world prices.

## **2 Data**

This analysis covers two cereals (wheat and barley), beef and butter. In the EU, the UK and French prices are used. Agricultural markets in the UK are believed to be highly

integrated with those of other member states despite the fact that a different currency is used.<sup>1</sup> Hence, the use of UK data provides insights on the impact of exchange rates in the agricultural sector. Monthly data of wheat, barley and beef cover the period 05/1987 to 05/2012, totalling 302 observations for each series.<sup>2</sup> Monthly data of butter include 295 observations of a slightly shorter period from 07/1987 to 12/2011. Weekly UK data are obtained from Department of Environment, Food and Rural Affairs (Defra)<sup>3</sup> and converted to monthly prices by taking simple averages. The beef price is represented by the liveweight price of clean cattle. Monthly French data are obtained from two sections of the European Commission website: EUROSTAT<sup>4</sup> and the Agriculture and Rural Development section.<sup>5</sup> The beef price is represented by the liveweight price of heifer.<sup>6</sup> World wheat, barley and beef prices are obtained from the World Bank pink sheet.<sup>7</sup> Butter prices are retrieved from the FAOSTAT database, starting from January 1995.

UK, French and world prices are denominated in British pounds, Euros and US dollars respectively. Exchange rates are also obtained to convert the agricultural commodity prices in to the same currency. Exchange rates between Euro and sterling (£/€) are obtained

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<sup>1</sup> This is also supported in the data graphs and our following analysis. The case of the beef sector is different due to the animal disease issue and subsequent restrictions on trade.

<sup>2</sup> In view of the long period covered, it is possible that multiple structural changes have happened. The sequential search of structural breaks procedure is followed. Therefore, the most prominent break will be identified first and whether the search continues depends on the timing of the first break.

<sup>3</sup> <http://www.defra.gov.uk/statistics/foodfarm/farmgate/commodity/>

<sup>4</sup> <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/>

<sup>5</sup> [http://ec.europa.eu/agriculture/index\\_en.htm](http://ec.europa.eu/agriculture/index_en.htm)

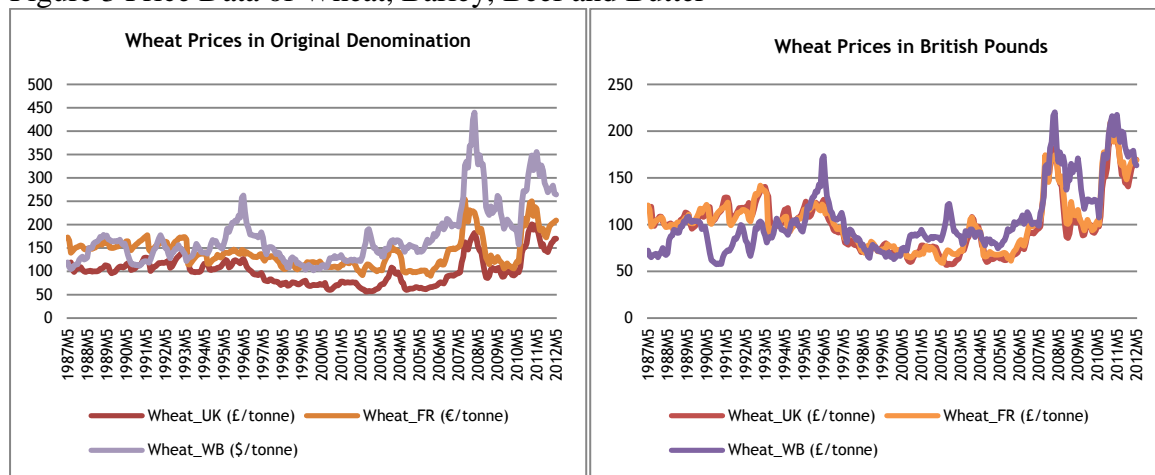
<sup>6</sup> Liveweight prices between May 1987 and December 2003 and deadweight prices between January 1997 and May 2012 are available. Therefore, deadweight prices are divided by 1.68 to obtain liveweight prices from 2004 onwards, where 1.68 is the average of the ratios of deadweight price to liveweight price in the period between January 1997 and December 2003.

<sup>7</sup> The World Bank reports prices of beef trade between Oceania and the U.S. as representative world beef prices.

from EUROSTAT. Exchange rates between sterling and US dollar (£/\$) are obtained from the Federal Reserve of the U.S.<sup>8</sup>

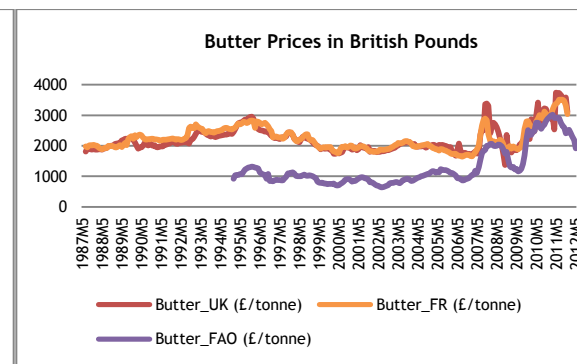
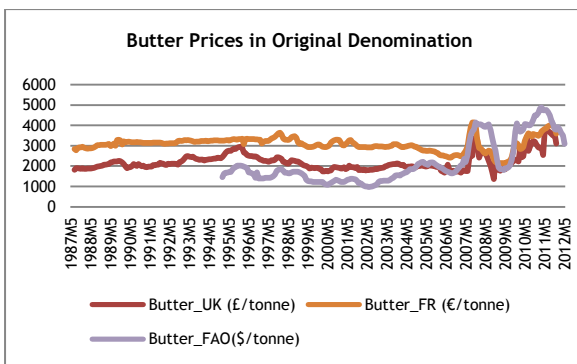
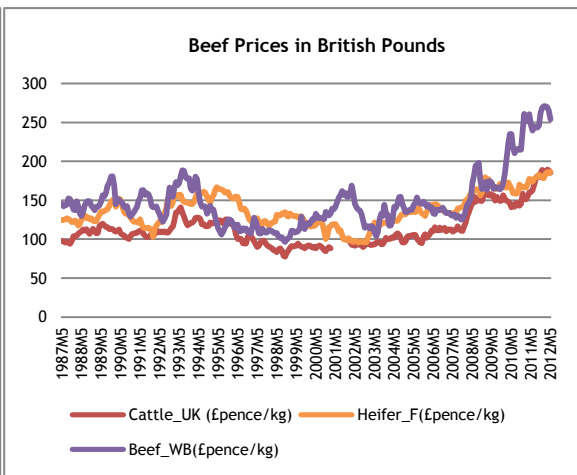
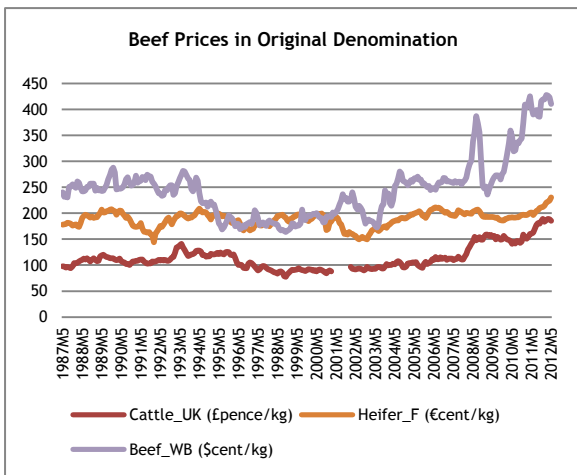
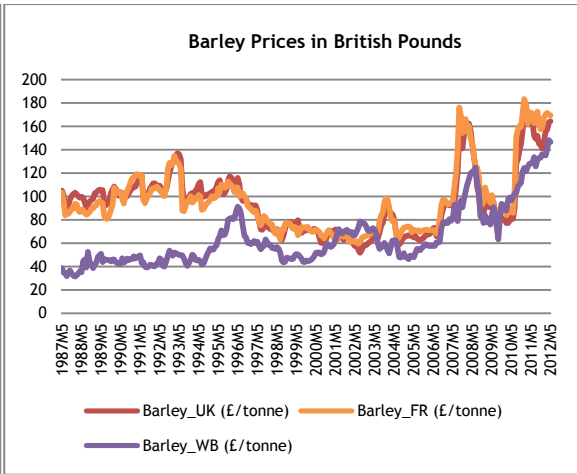
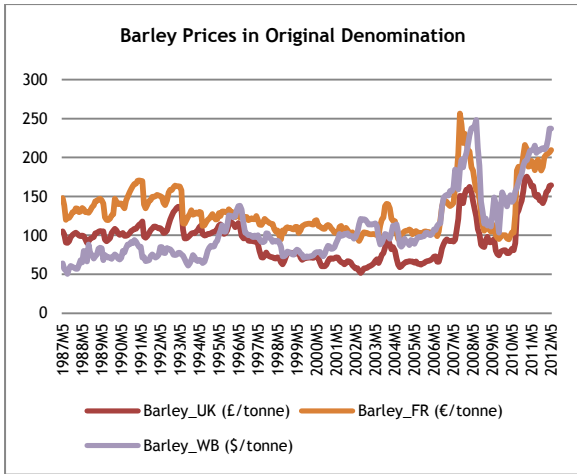
Price data in their original currencies and in British pound are shown in Figure 3. Prices of the UK and France track each other closely when converted into the same currency, except for beef. Disease outbreaks [bovine spongiform encephalopathy (BSE) in 1996 and food and mouth disease (FMD) in 2001] resulted in separation of the French and British beef markets. However, following the resumption of trade in 2006 the price series exhibit similar paths. The world crop and butter prices are lower than EU prices at the beginning of the investigation period. World wheat prices climbed to similar levels to EU ones since the early 1990's, corresponding with the reduction in the EU wheat intervention price. This does not happen to barley and butter until after 2000.

Figure 3 Price Data of Wheat, Barley, Beef and Butter



<sup>8</sup> <http://www.federalreserve.gov/releases/h10/hist/>





### 3 Methodology

#### 3.1 Unit root and structural change

The Augmented Dickey-Fuller (ADF) test of the following form is firstly applied to the full sample of each data series:

$$\Delta y_t = \mu + \tau t + \rho y_{t-1} + \sum_{j=1}^k C_j \Delta y_{t-j} + \epsilon_t \quad [1]$$

where  $y_t$  is the logarithm of price in our study and  $t$  represents the trend term. The null hypothesis is that there is unit root in the data. This test is widely used as a preliminary test for cointegration analysis. However, test results can be misleading when the data is actually stationary but there is structural change in the trend (Perron, 2005).

In view of this, a unit root test developed in Perron (1994) that incorporates potential structural change is also used. The test is performed with the following model:

$$\Delta y_t = \mu + \theta DU_t + \tau t + \gamma DT_t + \delta D(T_B)_t + \rho y_{t-1} + \sum_{j=1}^k C_j \Delta y_{t-j} + \epsilon_t, \forall t \in [\alpha T, \beta T] \quad [2]$$

where  $y_t$  and  $t$  have the same meaning as in Equation 1,  $T$  denotes the sample size and  $T_B$  denotes the breakpoint year. Because estimations are only possible when both segments have enough observations, the interval of possible periods at which the change occurs is restricted and denoted by  $[\alpha T, \beta T]$ . As in equation 3,  $DU_t$  shifts the intercept such that,  $DU_t = 1$  if  $t > T_B$ , 0 otherwise. The variable  $DT_t$  shifts the slope at time  $T_B$ , where  $DT_t = t - T_B$  if  $t > T_B$ , 0 otherwise. Finally,  $D(T_B)_t = 1$  if  $t = T_B + 1$ , 0 otherwise. The number of lags,  $k$ , is determined with a data dependent method: start with an upper bound  $k_{max}$  of  $k$ ; if the last lag included in the regression is significant, then use  $k = k_{max}$  otherwise reduce  $k_{max}$  by 1 and repeat [see Ben-David and Papell (1997)]. In this study,  $k_{max}$  is initially set at 12.

Since EU agricultural markets used to be heavily managed but are no longer so, another possibility is that EU agricultural prices changed from being stationary to being non-stationary at some point of time. In view of this, the recursive ADF tests are further applied to the sub samples whenever necessary. “Recursive” can be implemented forward (or backward), referring to the application of the test to the first (or last) sub-sample period of certain length and then repeating the test to expanded sub-sample periods in which one observation is added to the end (or the beginning) each time. By starting the test with a shorter period and continuing to add observations to the sample, this helps identify the situation in which dramatic variations in prices happen only in specific short periods versus the situation in which prices are consistently volatile.

Following the implementation of unit root tests, the structural change test is applied to each of the data series using the following model:

$$y_t = \mu + \theta DU_t + \tau t + \gamma DT_t + \sum_{j=1}^k C_j y_{t-j} + \varepsilon_t, \forall t \in [\alpha T, \beta T]. \quad [3]$$

The hypothesis to be tested is  $H_0: \theta = \gamma = 0$ , i.e. that there is no shift in the trend of  $y_t$  (or structural break) in the data. Following Ben-David and Papell (1997), the “SupF<sub>t</sub>” test statistic is used. This statistic is two times the maximum over all possible trend breaks of the standard F-statistics for testing  $\theta = \gamma = 0$ . The critical values for data with and without unit root are different and both are given in Vogelsang (1997).

### 3.2 Cointegration

When the data series is confirmed to be integrated of order 1, the cointegration test and estimation can be applied to the multiple series using the vector error correction model (VECM). Our analysis mostly involves two variable systems as follows:

$$\Delta y_{1,t} = c_1 + \alpha_1(c_3 + \beta_1 y_{1,t-1} + \beta_2 y_{2,t-1}) + \sum_{i=1}^p \Gamma_{i,1} \Delta y_{1,t-i} + \sum_{k=1}^p \Gamma_{k,2} \Delta y_{2,t-k} + \varepsilon_{1,t} \quad [4]$$

$$\Delta y_{2,t} = c_2 + \alpha_2(c_3 + \beta_1 y_{1,t-1} + \beta_2 y_{2,t-1}) + \sum_{n=1}^p \Gamma_{n,1} \Delta y_{1,t-n} + \sum_{j=1}^p \Gamma_{j,2} \Delta y_{2,t-j} + \varepsilon_{2,t} \quad [5]$$

where  $\{y_{1,t}\}$  and  $\{y_{2,t}\}$  denote the logarithms of two price series in question and  $p$  is determined by the Schwarz Information Criterion (SIC).  $(c_3 + \beta_1 y_{1,t-1} + \beta_2 y_{2,t-1})$  can be interpreted as the long-term equilibrium relationship between the two data series in which  $c_3$  is the constant term. In the two variable system with data transformed into their logarithms,  $\beta_1$  is normalised to one and  $\beta_2$  indicates the percentage change in  $y_1$  with respect to 1 per cent change in  $y_2$ . A negative value of  $\beta_2$  indicates the two prices move in the same direction. The coefficient  $\alpha_i$  (in absolute terms) can be interpreted as the speed that  $y_i$  adjust to the changes that disturb the equilibrium. Statistical significance of the cointegration relationship is tested using the procedure developed in Johansen (1991, 1995). The cointegration and significance test are applied to a rolling sub-sample in addition to the full sample. In a two variable system, the number of coefficients to be estimated is nine when only one lag is included. Therefore, the window of rolling is set at 90 months.

## 4 Results

### 4.1 The crop sector

In terms of the unit root tests, Table 1 shows the ADF, Perron unit root and structural change test results for wheat and barley prices of the UK, France and the world in their original denomination. There is strong evidence of unit root but no evidence of structural change in the crop prices, except for the French ones in Euro. According to the structural change test results, a structural break happened at the end of 2005 for the French wheat and barley prices in Euro. Careful inspection of the data in Figure 3 reveals that the French crop

prices seem to follow a downward trend with limited fluctuations before the break and follow an uptrend with much more dramatic variations after this point. This suggests the prices may be stationary before the break but non-stationary after the break. This is supported by the re-application of the ADF and Perron unit tests to the two sub-samples separated using the identified break date. Recursive ADF tests are further applied (Figure 4 shows the case of wheat), in which the hypothesis of unit root is frequently rejected before 10/2005 for the French data. While the date of the structural change in the European wheat market coincides with the implementation of the Fischler Reforms it is inappropriate to ascribe the change to these reforms as it usually takes some time for the reforms to take full effect. The structural changes are more likely to be driven by previous reforms or other factors, such as developments on the world market.

Table 1 Unit Root and Structural change Test Rests of Crop Prices

	Wheat_UK (£/tonne)	Wheat_FR (€/tonne)	Wheat_WB (\$/tonne)	Barley_UK (£/tonne)	Barley_FR (€/tonne)	Barley_WB (\$/tonne)
ADF test	-2.19	-2.77	-2.82	-1.72	-2.52	-3.19
Perron Unit Root Test	-4.76	-5.76**	-4.93	-4.72	-5.81**	-4.47
Structural Change Test	15.26	15.79**	16.07	18.80	17.53**	10.88
Break Date		2005M10			2005M7	
Note: ** and * denote statistical significance using critical values at 5 per cent and 10 per cent.						

Figure 4 Recursive ADF tests of wheat prices of UK, France and the world (unit root is rejected when the test statistics is below the critical value)

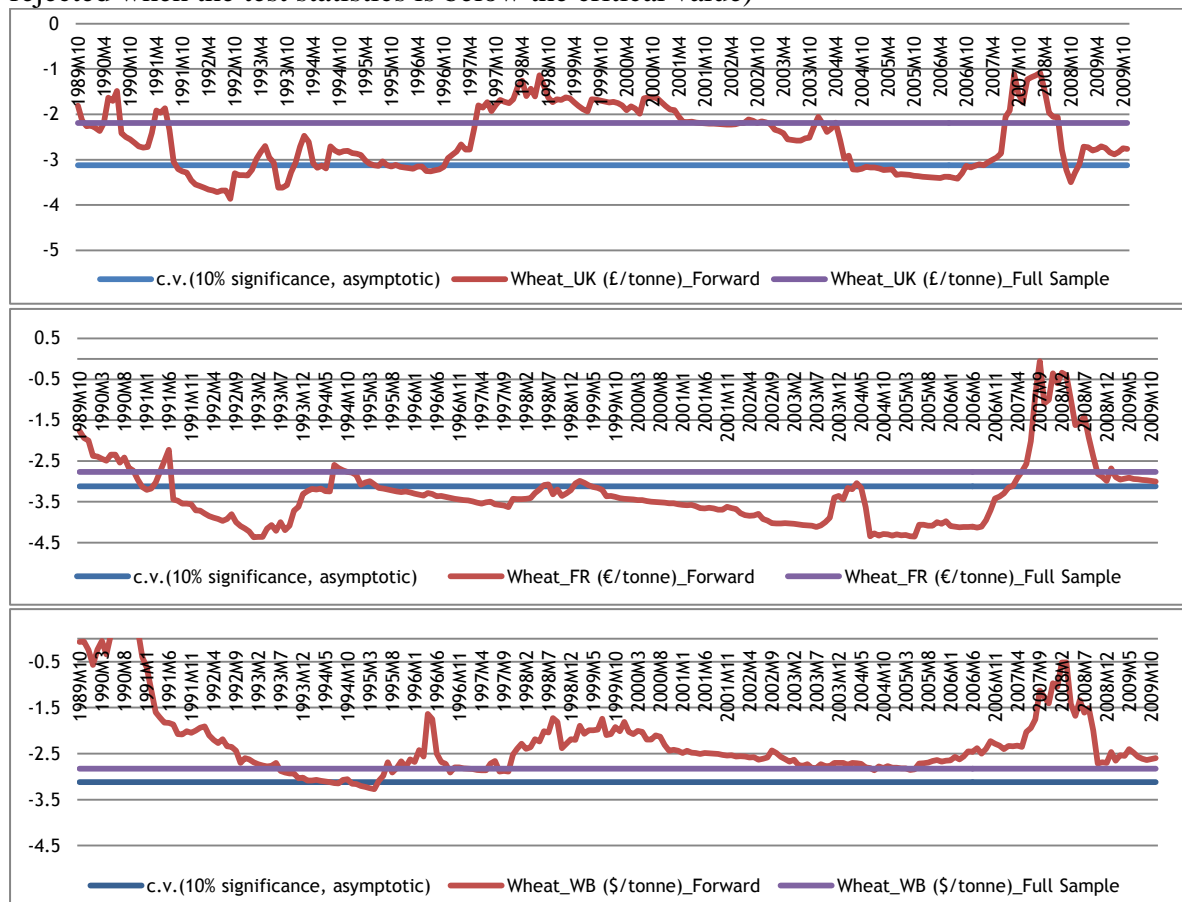
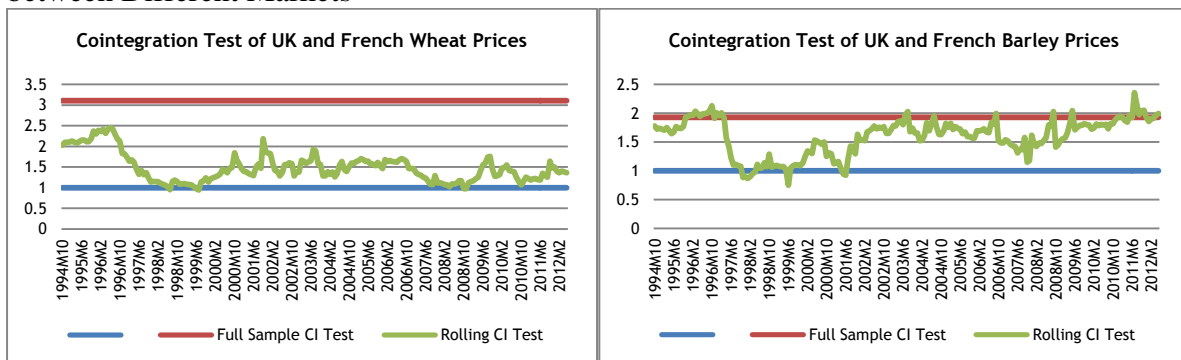


Figure 5 shows the ratios of the trace statistics of Johansen's cointegration test to the 10% significance level of wheat and barley prices between different markets (UK versus France, UK versus the world). A ratio value greater than 1 means that the null hypothesis of no cointegration is rejected at the 10% significance level. French prices are first converted into British pounds and become non-stationary most of the time, much like the UK prices. Crop prices between the UK and France are cointegrated throughout the whole period. Since the French prices in Euro before the break at 2005 are shown to be stationary, unit root in the UK crop prices for the same period is mostly a result of the volatile exchange rates. The cointegration test results between the UK and world prices are less clear (lower panel of

Figure 5). The rolling cointegration test results suggest that wheat prices are cointegrated more often than the barley prices.

Prices between wheat and barley are more cointegrated in the UK (and EU generally) compared to the world market; however, it may have become weaker in recent years as suggested by the fall in the trace statistics (Figure 6). Coefficient estimations of the rolling cointegration for wheat and barley prices in the UK are shown in Figure 7. In Figure 7, the left panel shows the adjustment coefficients (the  $\alpha$ 's in Equation 4 and 5) and the right panel shows the long-run equilibrium between the two prices (the  $\beta$ 's in Equation 4 and 5). The long-run equilibrium does not change over time apart from a few isolated months, but this is not clear for the adjustment coefficients. In particular, the adjustment coefficients in the wheat equation (the blue line) vary between -0.4 and -0.2 before mid-2002 and between -0.2 and 0 after this period. The reduction in the adjustment coefficient (in absolute terms) means the wheat price becomes less responsive to disturbances to the long run equilibrium between wheat and barley prices. This together with the reduction in the significance of the cointegration relationship suggests a potentially fundamental change in the wheat and barley relationship.

Figure 5 Cointegration Test Results of Crop Prices (All Converted into British Pounds) between Different Markets



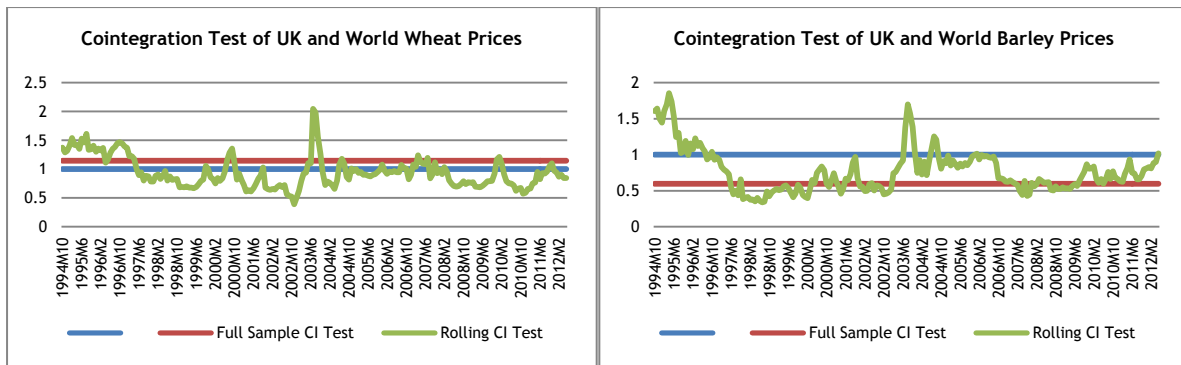


Figure 6 Cointegration Test Results between Wheat and Barley Prices of the UK and the World

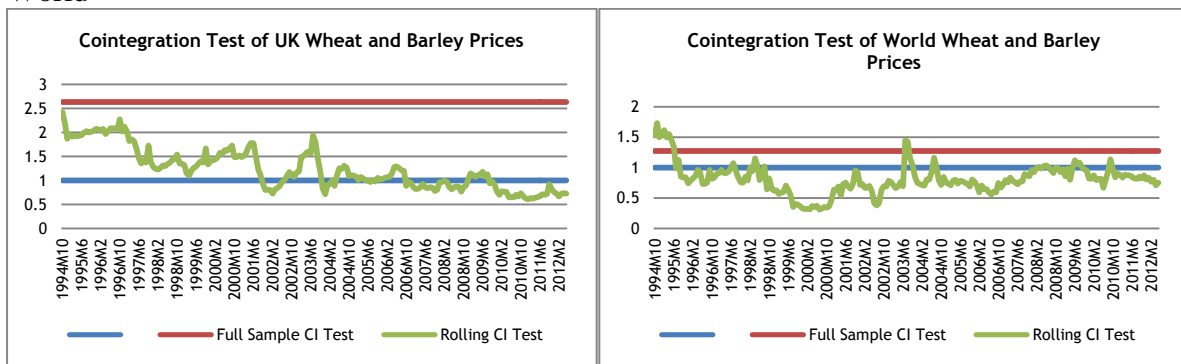
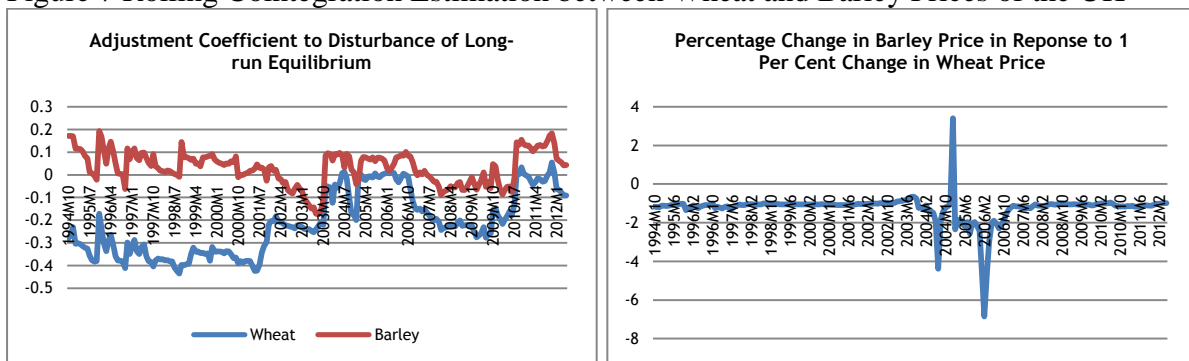


Figure 7 Rolling Cointegration Estimation between Wheat and Barley Prices of the UK



#### 4.2 The beef sector

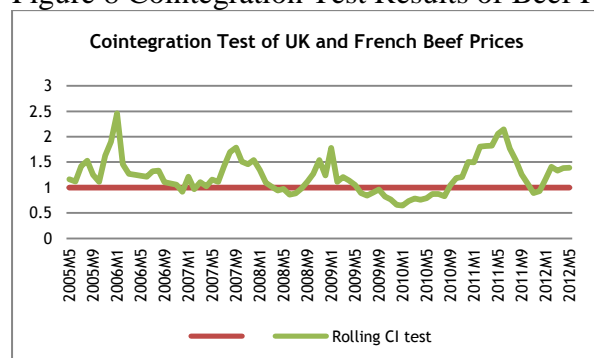
A distinct issue in the livestock market is animal disease. Outbreaks of animal diseases often lead to trade restrictions across borders, at least temporarily. These disturbances to the market result in more frequent structural breaks in the prices, which are,



therefore, more prone to show the characteristic of unit root and the disturbances also disrupt cointegration relationships among prices of different geographical markets, if there are any. For the representative world beef price reported by the World Bank, two structural breaks at December 1994 and July 2008 are identified. Coefficient estimations indicate a downward trend from 1987 to 1994 and an upward trend from 1995 to 2008 and a steeper upward trend from 2008 to 2012. There is no unit root in the post 1994 data when the structural break is taken into account. Therefore, it is not possible to undertake the cointegration test between the world price and EU prices.

The EU data are analysed in two cases: the full sample case and the post-2002 sample case. This is due to the fact that the beef market in the UK was closed between 2001 and 2002 following the outbreak of FMD. Another complication is that the BSE outbreak in 1996 in the UK resulted in a 10 year long break of UK beef exports to France. In the full sample case, only France data are analysed, which are shown to have unit root but no structural break. In the post-2002 sub-sample case, with the UK beef prices converted into Euro, cointegration between the UK and French prices are supported by the rolling cointegration test (Figure 8). Although structural breaks in the UK and French data are not statistically significant, break dates identified are October 2007 and July 2008 respectively, with a steeper upward time trend after the break, corresponding to the findings in the world prices.

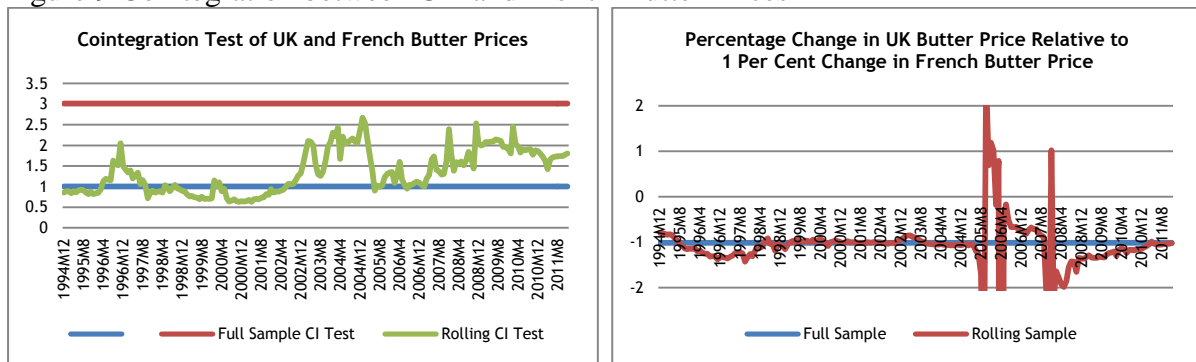
Figure 8 Cointegration Test Results of Beef Prices between the UK and France



### 4.3 The dairy sector- butter

Similar to the case of crops, unit root test results for the UK and French butter prices in their original denominations do not share much in common. Test results for the French butter prices are dependent on the sub-sample used. Nevertheless, a structural break at January 2007 is highly statistically significance.<sup>9</sup> Unlike the French data, butter prices in the UK show strong evidence of unit root but no statistically significant structural break. When the French/ UK prices are converted into British pounds/ Euros, they become more or less the same as their counterpart. This, again, shows that exchange rate can change the statistical properties of the data significantly. Rolling cointegration tests are applied to the two prices denominated in British pounds and there is strong evidence that they are cointegrated (Figure 9).

Figure 9 Cointegration between UK and French Butter Prices

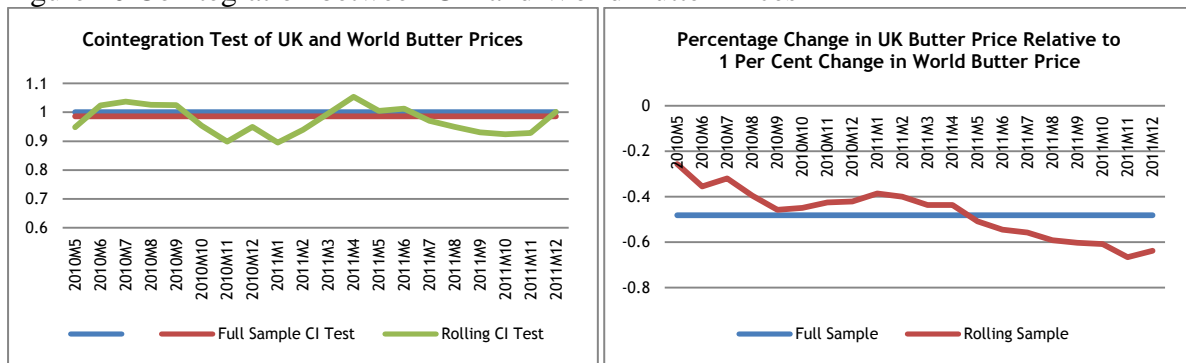


One statistically significant structural break at January 2002 is identified for the world butter prices. There is strong evidence that post break data have unit root. Therefore, rolling cointegration tests are applied to the UK and world prices in dollars. The ratios of the test statistic relative to the critical value fluctuate around 1, providing evidence of cointegration

<sup>9</sup> The hypothesis of no structural break is rejected regardless of the set of critical values used.

between the two to some extent. Furthermore, the percentage changes in the UK prices relative to 1 per cent change in the world price have increased in absolute terms from below 0.3 to over 0.6 over time indicating that integration has increased in recent years.<sup>10</sup>

Figure 10 Cointegration between UK and World Butter Prices



## 5 Conclusion and Discussion

The evolution of agricultural commodity prices in some EU key member states (i.e. the UK and France) and market integration between these countries and the world have been examined using structural break and cointegration models. The structural break test indicates that there is a structural break in French wheat, barley and butter prices denominated in Euros. The break date for crops is the end of 2005 and that of butter is the beginning of 2007. While the break date for crops coincided with the implementation of the Fischler reforms, it usually takes some time for a reform to fully take effect. Thus, the break may be caused by other factors, such as previous CAP reforms and developments on the world market. Furthermore, results of various unit root tests suggest crop prices in Euro before the break date are

<sup>10</sup> There are 32 rolling sub-samples in total with the window length being 90 months. The first-sub-sample covers the period of 2002M2 to 2010M5. It should be noted that the timing of reductions in EU butter intervention price and the structural break identified in the French data fall in between. There may be little co-movements between the EU and world butter prices in the early periods of the post-2002 phase. Therefore, the increase in the absolute value of  $\beta$  could be due to real changes in the equilibrium, or less cointegrated observations being continually removed and replaced by more cointegrated ones or a combination of the two. In any case, the qualitative result of increasing cointegration does not change.

stationary, but this is not the case after this point. This means they have become more stochastic.

Unlike the French price data, there is strong evidence of unit root but no evidence of structural change in the UK prices. Once the French prices (UK prices) are converted into British pounds (Euro), they exhibit the same paths as their counterpart. This implies that the exchange rate probably changes the statistical properties of the data significantly. The consistent statistical property of the price data in British pounds has facilitated further analysis. At the same time, it is important to take into consideration the potential impact of the exchange rate when reading results involving currency conversion. Denominated in British pounds, the French price is cointegrated with the UK price throughout for all the commodities investigated. The results also indicate that cointegration between wheat and barley prices within the EU has been weakening. In particular, wheat prices become less responsive to the disturbance of the long-run relationship between the two. Future analysis is needed to confirm and explain this development.

Cointegration relationships between the EU and world crop prices are different for wheat and barley. Wheat is shown to be more frequently cointegrated than barley. However, there is no sign of increasing cointegration. World beef prices are found to be stationary once account has been taken for the structural breaks. There are two structural breaks: December 1994 and July 2008. The tests suggest there is a possible structural break in EU beef prices and this coincides with the second break date of the world price.<sup>11</sup> The French, UK and world prices increase more rapidly after that. This points to stronger co-movement between the EU and world beef prices. When it comes to butter, there is strong statistical evidence that the EU prices have become more cointegrated with the world prices.

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<sup>11</sup> Possible structural break refers to the break date identified by the test, but not statistically significant.

With the use of statistical techniques that allow structural break to be determined endogenously, break dates in the EU crop, beef and butter prices are found but differ across sectors. This is unsurprising given the progressive nature of the CAP reforms and variable implementation across sectors. Furthermore, the analysis suggests the internal relationship between wheat and barley prices is changing. This highlights the benefits of explicitly investigating the evolution of the internal EU markets. Finally, stronger integration between the EU and world markets is supported by the butter data and the beef data to a lesser extent.

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