Price transmission in the European tomatoes and cauliflowers sectors

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Abstract
The paper explores the characteristics of spatial price movements for fresh vegetables. The analysis is conducted on tomatoes and cauliflowers prices collected on main production and consumption European markets. It is based on the estimation of an asymmetric threshold autoregressive econometric specification that is shown capable of providing estimates of transaction costs and speeds of price transmission among spatially separated markets. We provide an assessment of the average elapsing time for the transmission of price shocks. Our findings, suggesting that spatial price transmissions in the EU vegetable sector is barely symmetric, lead to interesting policy considerations for the fresh vegetables sectors.
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1. Introduction

The European Union (EU) is both the largest importer and one of the largest producers in the fresh fruits and vegetables (F&V) world market. Production is concentrated in a few countries, namely Italy, Spain, and France. A vast majority of the EU fresh F&Vs trade is intra-EU and imports from third countries are rather limited, especially for vegetables, in that the prohibitive transportation costs reduce extra-EU trade. Germany and the United Kingdom are large importers, whilst Belgium and Netherlands represent the main actors for intra-EU trade: the latter imports and re-exports to many EU countries.

Seasonality, supply sensitiveness to climate conditions, and products perishability are relevant peculiarities of EU F&Vs. Arguments of this kind have enjoyed a particular vitality and have become important to discussion of agricultural policies. According to the European Commission Council Regulation (EC 1182/2007), «the production of fruit and vegetables (is) unpredictable *[…]* and surplus on the market, even if (they are) not too great, can significantly disturb the market». Production variability might influence price dynamics, leading to market instability and the onset of market crises, which tend to be exacerbated by product perishability, sensitiveness of production or consumption to climate variations, and lack of sustainability (EC, 2007a). In order to stabilize the markets, the F&V Common Market Organization reform has introduced instruments for risks management (EC, 2007b) whose efficacy is largely affected by the spatial and temporal prices dynamics. In such a context deepening the understanding of fresh F&Vs price dynamics would lead to interesting policy implications such as guidelines to plan interventions aimed at preventing and managing market crises, or aimed at increasing the sector sustainability.

During the last decade, several scholars have dedicated much attention to applied analysis of the degree and speed of price transmission, in view of their wide and relevant policy implications (*e.g.* Brümmer *et al.*, 2009; Ubilava, 2012; Santeramo and Cioffi, 2012). Moreover, there is a growing interest of researches for aspects concerned with the asymmetries: most scholars have paid attention to empirical validations (*e.g.* Meyer and von Cramon-Taubadel, 2004 for a survey; Capps and Sherwell, 2007) and to theoretical speculations (*e.g.* Weldegebriel, 2004, Fousekis, 2008 and Xia 2009, among others). As far as the fruits and vegetables sectors is concerned, the vast majority of articles on spatial price dynamics are not related to the European Union (*e.g.* Jordan and VanSickle, 1995; Padilla-Bernal, Thilmany and Loureiro, 2003; Ihle *et al.*, 2010) and, except for very few papers (*e.g.* Goetz and von Cramon-Taubadel, 2008, Reziti and Panagopoulos, 2008), the characteristics of spatial price transmission in the EU F&Vs sectors are still underinvestigated.

Therefore, the purpose of the present paper is to explore the dynamics of vegetable prices among EU spatially separated Regions. In particular, we aim at answering some still debated questions: to what extent are price shocks in vegetable markets transmitted across separated markets? How fast price dynamics in the EU vegetable sector are transmitted across Regions?

A comparison between the price transmission phenomenon in two of the main EU vegetables by volume of production, namely cauliflowers and tomatoes, may be a helpful way to proceed. Empirical results are obtained by mean of a non-linear specification which allows one to estimate transaction costs and (asymmetric) speeds of adjustment to price shocks.

The remainder or the paper is as follows: in section 2 we outline the features of the EU (F&Vs) sectors, with particular emphasis on the vegetables under analysis; section 3 describes methodology and data; section 4 presents and discusses empirical results; the last paragraph offers some concluding remarks and policy reflections.

2. An overview of the European Union Fruits and Vegetables sectors

The European Union is one of the biggest global producers of Fruits and Vegetables: despite a recent declining trend, its production accounts for more than 8% of world production (more precisely, the EU supplies respectively 12% and 7% of world fruits and vegetables). Grapes, the largest fruit, are produced in Italy (30%), France (25%) and Spain (22%), followed by Germany, Portugal and Greece. 30% of total EU vegetables production is represented by tomatoes which are largely produced in Italy and Spain. Carrots, cabbages, lettuces and cauliflowers show also conspicuous volumes of productions: more than 2 millions of tons per year (Table 1).

< TABLE 1 ABOUT HERE >

EU members are characterized by different consumption profiles: Italy and Spain, both large producers and large consumers, have rather limited volumes of imports; France shows large volumes of production and trade, while Germany and United Kingdom are net-consumers and importers since their production is minimal; Belgium and Netherlands play an important role in F&Vs trade, especially through re-exports.

Italy and Spain are the largest EU fresh tomatoes producers. Spanish fresh tomatoes are traded to Northern Europe, mainly toward France, United Kingdom, Germany and Netherlands. In some cases imports from Spain cover a large share of total import of destination countries. In other terms, Spain plays a dominant role in fresh tomato intra-EU trade and is certainly defined as net-producer and net-exporter. Almeria and Murcia are the first and second provinces by export volume, respectively: the former concentrates its exports during winter, the latter shows a more stable and wider export season (de Pablo Valenciano and Perez Mesa, 2004). French production amounts to 700.000 tons per year and seems minimal compared to import volumes. The largest part of French production is concentrated in Southern areas while in Northern France the largest part of production is realized in Chateau-Renard rural areas[1].

[1] In 2006-2008 Spanish yearly exports to France, the United Kingdom and Ireland amounted respectively to 153,000, 172,000 and 4,500 tons. During the same period France exported 9,500 tons per year to Spain, 7,600 tons in the United Kingdom, and 400 tons to Ireland.

EU cauliflower production is mainly concentrated in six Countries (in descending order of production volume: Italy, Spain, France, Poland, Germany and United Kingdom), accounting for more than 90% of total EU production. The main Spanish production areas are Murcia, Navarra, Valencia and La Roja, which satisfy 85% of total Spanish production. The United Kingdom production is located in Southern England and Lincolnshire county. Spanish exports serve United Kingdom (40%), Germany (15%), France (13%), Netherlands (13%), as well as other EU countries (*e.g.* Ireland, Belgium, etc.). United Kingdom export mainly to Ireland, besides to the Netherlands, Italy, Germany and Spain[2].

< TABLE 2 ABOUT HERE >

As regard the EU supply chain, we can distinguish three different levels: a quite fragmented supply, with few multinationals (*e.g.* Chiquita) and a majority of small producers; the second level consists of importers and wholesalers, with the formers handling import formalities, directly selling products or benefiting from re-export, and the latter buying from producers and importers, as well as supplying specialist retailers, supermarkets and foodservice outlets; the third level consists of multiple or specialized retailers showing a high degree of concentration, particularly in Northern Regions (*e.g.* in France, United Kingdom, Netherlands and Scandinavia retailers supply more than 70% of the market). During last decades the concentration of buyers has been growing consistently, leading to imbalanced market power along the food supply chain. Nowadays, despite an increasing number of fixed contracts, the vast majority of fresh fruits and vegetables are still traded in spot markets where prices are directly negotiated among sellers and buyers (CBI, 2009) and market power might largely influence price formation.

[2] During 2006 and 2008 Spain exported, on average, 96,000 tons to United Kingdom, 32,000 tons to the Netherlands and more than 5,000 tons to Ireland. The United Kingdom served Ireland (8,000 tons per year), the Netherlands (1,200 tons per year) and Spain (200 tons per year).

3. The economics and econometrics of price transmission: our methodological approach

According to the well-known Law of One Price (LOP), prices in separated markets tend do differ by no more than shipping costs incurred in moving a good from one market to the other[3]:

$$(1) \qquad |P^A - P^B| \leq min\,\{T^{AB}, T^{BA}\}$$

where P^A and P^B are prices observed in markets A and B respectively, T^{AB} and T^{BA} are transactions costs[4] for trade, respectively, from A to B and from B to A. If price spreads exceed transaction costs - regardless the trade direction -, arbitrageurs' activity will reduce the spread letting prices move toward condition (1).

Threshold models, allowing to explicitly take into account transaction costs (*e.g.* Goodwin and Piggott, 2001), offer a successful empirical framework to validate the LOP. In particular, the equilibrium model proposed by Balke and Fomby (1997) has been widely adopted in price transmission analysis[5]; we adopted the following specification:

$$(2) \qquad \Delta \boldsymbol{X}_t = \boldsymbol{I_t} \cdot \left\{\sum_{\mathrm{i=1}}^{\mathrm{p-1}} \boldsymbol{\beta} \Delta \boldsymbol{X}_{t-i} + \boldsymbol{\rho} \boldsymbol{X}_{t-p}\right\} + \boldsymbol{\varepsilon}_t$$

where $\Delta\mathbf{X}_t$ and $\mathbf{X}_t = {P_t}^B - {P_t}^A$ are $(T \times 1)$ vectors of price spreads and price spreads first-order difference, with $t = 1, \dots, T$ (total observations). Prices and price spreads are expected to be respectively *I(1)* and *I(0)*. $\boldsymbol{\beta}$ and $\boldsymbol{\rho}$ are the coefficients matrices to be estimated, $\boldsymbol{\varepsilon}_t$ is a $(T \times 1)$ vector of *i.i.d.*~ $N(0, \sigma^2)$ error terms, $\boldsymbol{I}$ is the Heaviside indicator or the "switching variable". The indicator $I_t(\hat{\theta})$, which assumes value 0 or 1, is analytically defined as follows:

$$I_t(\hat{\theta}) = \begin{cases} I_t(\hat{\theta}) = 1 & if\ \mathrm{X}_t \geq \hat{\theta} \\ I_t(\hat{\theta}) = 0 & if\ \mathrm{X}_t < \hat{\theta} \end{cases}$$

where $|\hat{\theta}|$ is an estimate of transaction costs. By defining $\mathbf{X}_t = {P_t}^B - {P_t}^A$ we assume that $\hat{\theta}$ would be a proxy for T^{AB}, and $-\hat{\theta}$ would be a proxy for T^{BA}. We restrict $|\hat{\theta}| = |-\hat{\theta}|$ which implies

[3] A formal definition is provided by Stiglitz (1993) who stated "*there is a uniform price in the market and price differences are quickly eliminated by arbitrage [opportunities]*".

[4] Transactions costs include both transfer costs (*i.e.* transportation, loading and unloading costs, taxes, *etc.*) and other costs of trade, such as the cost of acquiring price and other market information, or maintaining market networks.

[5] For example, recent applications in spatial price transmission regard wheat (Brosig *et al.*, 2011), paddy (Baulch *et al.*, 2008), peaches (Raper *et al.*, 2009) and tomatoes markets (Ihle *et al.*, 2010) among others.

symmetry in transaction costs. The band $[-\theta, \theta]$ represents the so called symmetric “inactivity band” where no arbitrageurs’ activity takes place.

The band is a proxy for transaction costs, which can be expressed in currency term with the ratio of band width and average import price. Dependent variable ($\Delta \boldsymbol{X}_t$) is generally positive, since it is computed subtracting export prices from import prices. The model assumes that arbitrage opportunities drive prices toward the inactivity band edges, where LOP is satisfied with equality. Deviations in the upper regime signal excessive increases in import prices (${P_t}^B$), while deviations in the lower regime are due to export prices decreases (${P_t}^A$). The outer regimes – particularly, the upper regimes determined by $\boldsymbol{X}_{t-1} > \hat{\theta}$ and the lower regimes occurring when $\boldsymbol{X}_{t-1} < -\hat{\theta}$ - follow an autoregressive process and the $\hat{\rho}$ coefficients indicate the expected speeds of adjustment: the farther the deviation from the band edge, the stronger the adjustment[6]. Balke and Fomby (1997) showed that, despite a possible local random walk inside the band, the process is globally stationary. By assuming a random walk in the inner regime it is also assumed that prices are not linked to each other. According to our econometric specification, when shocks occur and price spreads exceed the band, in absolute value, prices tend to converge toward the equilibrium point and to equalize. From this perspective, the specification seems coherent with the formulation of the LOP stated by Alfred Marshall[7].

An underlying assumption of specification (2) is that parameters $\hat{\rho}$ assume the same values both for the upper regime and for lower regime. However, it is worth stressing that such a restriction is satisfied only when two conditions are jointly satisfied: 1) both the upper and lower regimes contain observations; 2) coefficients estimated for the two outer regimes are not statistically different. Moreover, this restriction implies that a similar process drives prices

[6] When ΔP exceeds the band edge, e.g. the export price (${P_t}^A$) falls and prices spread moves into lower regime, there are only two ways for price spread to be reduced and return to be lower than the band width: 1) the deviating price (${P_t}^A$) raises and price spreads return within the band; 2) import price (${P_t}^B$) falls accordingly, such that prices spread return within the band. The former way does not imply a price transmission, the latter does, and the faster the reaction of the other price, the faster the deviation returns inside the band.
[7] Alfred Marshall (1980) argued that the more an area is characterized by free commerce and perfect competition, the more the prices for the same goods will tend to converge on a common level.

dynamics in two different cases: a) when import price is “too high” and ${P_t}^B - {P_t}^A > \theta$ (upper regime); b) when export price is “too low” and ${P_t}^A - {P_t}^B < -\theta$ (lower regime). Some considerations cast doubts on the restrictions imposed on parameters $\hat{\rho}$: firstly, when trade does not occur in both directions there might be no observations in one of the two outer regimes; secondly, even when trade occurs in both directions, price dynamics can differ in the two outer regimes[8] in that the characteristics of the EU vegetable sector supply chain, with fragmented suppliers and concentrated buyers, are likely to lead to asymmetries in prices transmissions. Meyer and von Cramon-Taubadel (2004) argued that there might be several explanations for asymmetries in price transmission: among others, market power and adjustment costs (Ward, 1982), non-equivalence of demand and supply shocks (von Cramon-Taubadel, 1998), distorted price reporting process (Bailey and Brosen, 1989), asymmetric information (Abdulai, 2000), product perishability (Ward, 1982). Moreover, in a context of spatial price transmission among net exporters and net importers, the asymmetries in prices transmission might depend on whether the disequilibria are due to shifts in the (importer) demand or the (exporter) supply - regardless the underlying assumptions on perfect or imperfect competition (Gardner, 1975; Kinnucan and Forker, 1987; Holloway, 1991)[9] - as well as on changes in transaction costs[10]. It is worth to note that studies using threshold models are generally descriptive rather than analytic and usually are not based on a rigorous theory of price determination (Obstfelfd and Taylor, 1997; Minot, 2010). Despite some limitations in the approach, analysis of spatial price transmission in the vegetables sectors through threshold models is groundlessly missing in the literature (Capps and Sherwell, 2007).

[8] More precisely, if trade occurs mostly from the export market (A) to the import market (B) we would estimate ρ only in the upper regime. Moreover, when trade occurs in both directions, we might observe different price dynamics in the “normal” outer regime (*i.e.* when ${P_t}^B - {P_t}^A > \theta$ and trade occurs from the export to the import market) and in the less frequent outer regime (*i.e.* when ${P_t}^A - {P_t}^B < \theta$ and trade reverses from the import to the export market).

[9] Such a theory is tellingly supported by Aguilar (2002) and Capps and Sherwell (2007), among others.

[10] A referee suggested that, if price movements are due to changes in transaction costs, the transmission elasticity would converge to zero for “small” importers – as the price changes would be fully absorbed by the import price - and would be negative for “large” importers: changes in transaction costs would imply a rise in the import price and a fall in the export price.

As a preliminary analysis we tested for unit root in price levels and price spreads, expecting unit-root processes in price levels and stationarity in price spreads. Secondly, we tested for asymmetries in prices transmission and estimated an asymmetric threshold model.

Following Goodwin and Piggot (2001) and Van Campenhout (2007) we simplified specification (2) by excluding the autoregressive terms of the dependent variable[11]:

$$(3) \qquad \Delta \boldsymbol{X}_t = \boldsymbol{I_t} \cdot \{\boldsymbol{\rho} \boldsymbol{X}_{t-1}\} + \boldsymbol{\varepsilon}_t$$

where $\boldsymbol{\rho}$ is a (3×1) vector with unrestricted elements ($\rho_1 \neq \rho_3$). Parameters ρ_1 and ρ_3 are estimated only if observations are respectively in the upper and lower regime. We imposed a unit root behaviour inside the band where the coefficient ρ has been set equal to zero, that is $\rho_2 = 0$.

Coefficients ρ_1 and ρ_3 have a clear economic interpretation being *proxies* of adjustment forces after deviations from equilibrium have exceeded the inactivity band edges. The lower the coefficients, in absolute value, the weaker the adjustment forces and the higher the price inertia. Conversely, high coefficients imply that price deviations are strongly and rapidly corrected toward the equilibrium.

The threshold θ is estimated by solving the following minimization problem:

$$(4) \qquad \hat{\theta} = \min_{\theta}(\Delta \mathbf{X}_{\boldsymbol{t}} - \boldsymbol{I_t}(\hat{\theta}) \cdot \{\textstyle\sum_{\mathrm{i}=1}^{\mathrm{p}-1} \boldsymbol{\beta} \Delta \boldsymbol{X}_{t-i} + \boldsymbol{\rho} \boldsymbol{X}_{t-p}\})^2$$

The estimation is conducted by imposing a minimum percentage (trimming parameter) of observations in the inner and outer regimes. Andrews (1993) argues that percentageS between 5% and 20% should be considered good choices for trimming parameters. Following Seo (2003) we require that both the inner and the outer regimes contain at least 10% of the total observations, therefore the trimming parameter is set to 0.1. Threshold estimations are computed through a grid search, and coefficients are estimated by least squares. Tsay (1998) showed that, under regularity conditions, least squares estimates are consistent, a characteristic that greatly simplifies the modelling and estimation process of TAR models.

[11] Moreover, in our analysis, we noted that including the autoregressive terms of the dependent variable does not affect the results.

The testing procedure for threshold effects is conducted through tests of linear versus non-linear models (Hansen, 1999). In particular, a feasible approach to infer on asymmetry is to compare the sum of squared residuals of linear and non-linear models (Hansen, 1997, 1999). Therefore we test for non-linearity by computing a likelihood ratio test as follows:

$$(5) \qquad LR = -2ln\left[\mathcal{L}\left(\omega_{|\hat{\theta}}\right)\mathcal{L}(\Omega_{|\hat{\theta}})^{-1}\right]$$

where $\hat{\vartheta}$ represents the estimated threshold, ω and Ω stand for the symmetric and asymmetric models, respectively [12]. The test rationale is to assess whether the outer regimes are statistically not different from each other: failure to reject the null hypothesis suggests to adopt a symmetric model, while if the null is rejected a 3-regimes asymmetric model should be preferred.

The estimation results of specification (3) offer useful insights of vegetables prices dynamics. Firstly, the estimated transaction costs, proxied by $\hat{\theta}$, provide a benchmark to understand the markets efficiency in transmitting price signals. In particular, the larger the $\hat{\theta}$ with respect to the expected transaction costs, the lower the estimated transmission elasticity[13] and the market efficiency[14]. Secondly, it is worth deepening on the estimates of coefficients (ρ) in that they are directly interpretable as speeds of adjustment for deviations that exceed upper or lower edge of the inactivity band.

In particular, estimations provided by specification (3) are interpreted by computing the adjustment periods, the average time for series to achieve partial adjustment to the new equilibrium after a deviation has occurred. More precisely the adjustment periods indicate the time required for prices to achieve ε% adjustment to their new equilibrium levels following an exogenous shock and are expressed at same time series frequency of prices series (*e.g.* weekly, monthly, *etc*.). For AR(1) process a ε% adjustment period is computed dividing the logarithm of ε by the logarithm of 1+ ρ

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[12] We estimated a symmetric model by imposing $\rho_1 = \rho_3$.

[13] The expected (E[τ]) and the estimated ($\hat{\tau}$) transmission elasticity are calculated respectively as follows: $E[\tau] = T/\overline{P^B}$ and $\hat{\tau} = \hat{\vartheta}/\overline{P^B}$

[14] In particular, as market efficiency is defined as « the degree to which markets *[…]* match supply with demand » (Rashid and Minot, 2010), large transportation cost implies a large band in which no price adjustments, and no matches among (export) supply and (import) demand occur (Minot, 2010).

(e.g. $\varepsilon = 50\%$ is computed by $\frac{\ln(0.5)}{\ln(1+\hat{\rho})}$). As ρ appears in the denominator of the formula of adjustment period, the latter is inversely related to the coefficient.

4. Data and empirical results

The analysis has been conducted on cauliflowers and tomatoes, two of the main vegetables by volume of production for which data were available[15]. The products are very suited for the analysis both due to the large volume of production and trade within the EU, and the relative differences characterizing these products. In particular, they differ by degree of perishability and by incidence of fixed costs on total transportation costs: cauliflowers are classified "highly perishable" (Thorne and Meffert, 1979), as their shelf-live are around one week, and their trade shows high incidence of fixed costs on total transportation costs[16]; tomatoes are "half-hardly storable" (Thorne and Meffert, 1979) and their shelf-lives are around four weeks. The dataset consists of weekly prices (in €/100 Kg) spanning from 1996 to 2006 and extracted from the AgriView database of the European Commission[17]. For perishable products weekly data seem more appropriate than monthly data as the latter might fail to capture price movements due to the rapid marketing (Aguiar, 2002). In order to avoid the potential bias deriving from nationally aggregated data (von Cramon-Taubadel et al., 2006), prices have been collected on significative markets in six different EU countries: cauliflower prices have been collected on markets of Den Bosch (Netherlands), Dublin (Ireland), La Roja (Spain) and London (United Kingdom); tomatoes prices have been collected on markets of Almeria (Spain), Chateau-Renard (France), Dublin (Ireland) and London (United Kingdom).

[15] More precisely, the analysis has been conducted on tomatoes and cauliflowers due to the lack of continuous weekly prices collected on the main European markets. The results neither comprehensive not exhaustive of the EU vegetables sector, provide useful insights on price dynamics in markets of perishable goods.

[16] More precisely, traders of perishable produce experience investments to improve the logistic before and during the shipments (e.g. produce preparation, specific packaging, refrigeration cells, etc.) in order to reduce the expected losses for spoilage and preserve the quality of the produce.

[17] Due to the missing data issue, we selected the markets on which to carry out according to data availability, in particular we selected the longest series with smallest percentages of missing price data (generally less than 8%). Series with gaps have been merged to obtain continuous time series.

< TABLE 3 ABOUT HERE >

4.1 Cauliflower

As a preliminary analysis we tested for stationarity in the individual price series by implementing the KPSS test (Kwiatkowski et al., 1992). For all series we reject price stationary at a 5% significance level[18]. Moreover, we performed ERS unit-root tests (Elliott et al., 1996) and KPSS stationary tests on prices spreads: results suggest no unit roots in price spreads[19], a preliminary condition to estimate our threshold models. In most cases the tests on threshold effects reject linearity in favour of non-linear specifications[20].

< GRAPH 1 ABOUT HERE >

Estimation results of specification (3) are collected in table 4[21]. In order to test for robustness in parameters estimations we increased/decreased the estimated band by 10%: the results are not affected by the sensitivity analysis[22].

We found values of inactivity band ranging from 4.7 €/100 Kg - which accounts for 12% of the average London import price - to 47.4 €/100 Kg - which reflects 72% of the Den Bosch prices. These findings on estimated thresholds require further comments, as we found a low correlation (0.12) among inactivity band width and geographical distances. Excluding the estimated value for the London – La Roja pair from the set the correlation raises to 0.28 which still seems a low value to support the existence of any significant relationship among markets' physical distance and transaction costs. In particular, we found large transaction costs for markets very close to each other (*e.g.* Dublin and London), while we observed low transaction costs for markets relatively far from each other (*e.g.* Dublin and LaRoja; London and La Roja). Such an evidence supports the

[18] Test statistics (and p-values) are respectively 0.596 (0.022), 0.603 (0.022), 1.064 (0.001) and 1.057 (0.001) for Den Bosch, Dublin, La Roja and London.
[19] Results are omitted for simplicity and available upon request.
[20] P-values of linearity test (1 *vs* 2 regimes), calculated based on 1000 bootstrap replications, are smaller than 0.1 in all but one case (Dublin and La Roja).
[21] In order to deal with potential bias due to missing values, we introduced several dummies for seasonal gaps. Dummies are statistically not significant and results are not affected by dummies. For simplicity, we do not present dummies in tables of econometric results.
[22] Results are omitted for simplicity and are available upon request.

mentioned concept that in cauliflower trade the fixed portion of total transaction costs are likely to have high incidence (*cfr.* Mkendaa and Van Campenhout, 2011): it is worth observing that the trade of high perishable products requires specific logistic (*e.g.* packaging, refrigeration, ventilation, etc.) in order to avoid spoilage losses and to preserve the product quality (James e*t al.*, 2006). As far as market efficiency is concerned, we found that the estimated transmission elasticities are not statistically different from the expected transmission elasticities (except for the price transmission between Dublin and La Roja). Our results allow to conclude on the market efficiency in cauliflower markets.

In all but one case price transmission seems to not be symmetric. In particular, only for the pair of London and La-Roja markets, two locations close to main production zones, deviations occur in both outer regimes. We fail to reject the null hypothesis of asymmetry, suggesting that adjustments occur with similar speed[23]. The other cases do not present deviations in the lower regime hence coefficients cannot be estimated.

< TABLE 4 ABOUT HERE >

4.2 Tomato

The null hypothesis of stationarity is rejected for individual prices series (at 10% significance level) [24] as well as for prices spreads (at 1% significance level)[25]. In most cases threshold effects are statistically significant[26].

< GRAPH 2 ABOUT HERE >

[23] Test statistics of two versus three regimes is 13.937, corresponding to 0.383 p-value.
[24] Test statistics (and p-values) are respectively 0.479 (0.046), 0.043 (0.009), 0.531 (0.035), 0.763 (0.001) and for Almeria, Chateau-Renard, Dublin, London.
[25] Results are available from authors upon request.
[26] P-values of linearity test are smaller than 0.1 for three out of five cases: test statistics are respectively 25.83, 37.91, 34.44, 12.47 and 12.74.

Table 5 presents estimates for the tomatoes markets[27]. In order to test for robustness in parameters estimations, we replaced the estimated band with a 10% larger/smaller band, finding that results are almost identical[28].

The inactivity band, a *proxy* for transaction costs, accounts for 38% of average import prices: highest values are observed among far locations, in particular among Spanish and English or Irish markets. We fail to reject the null hypothesis of no statistical difference between the expected and estimated transmission elasticities in all but two cases: the results suggests market inefficiency between London and Almeria and for London and Chateau-Renard. The correlation (0.46) among distances and transaction costs suggests that variable costs are a not-negligible part of total transaction costs. In order to quantify the effects of distance on the inactivity band, we regressed the former on the latter. Based on results, we can state that increasing distance to destination by 10 Km would lead to a 0.1% increase in incidence of variable transportation costs on total costs. As a clarifying example, if transport costs from location A to B, which are distant 200 Km from each other, have incidence of 15% on final prices realized in location B, the shipping costs to reach a location 210 Km far from A would account for 15.1% of final selling price.

< TABLE 5 ABOUT HERE >

Price transmissions among Almeria, leading market for Spanish tomatoes production and trade, and other EU markets predominantly occurs in one direction. Similarly, deviations in price transmissions between London and Chateau Renard occur only in the upper regime. Finally, prices in Dublin and Chateau Renard are symmetrically transmitted[29].

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[27] In order to deal with potential bias due to missing values, we introduced several dummies in to take into account seasonal gaps, from the end of a season to the beginning of the following season. Dummies are statistically not significant and results not affected by dummies. For simplicity, we do not present dummies in tables of econometric results.

[28] Results of this sensitivity analysis are available upon request.

[29] The asymmetry might be due to the different role played by United Kingdom and France within the EU trade framework: the former has very low production and its production is almost entirely satisfied by imports, the latter has considerable production which satisfies more then 70% of domestic consumption.

4.3 On the adjustment periods

Price adjustments in the vegetables sectors have been interpreted by computing the adjustment periods, that is the time required for price series to achieve a partial adjustment to the new equilibrium (Table 6).

< TABLE 6 ABOUT HERE >

As far as cauliflowers are concerned, we found that the adjustments are slower in the upper regime than in the lower regime. In the former, the *half-lives* ($\varepsilon=0.5$) range from 1.9 to 3.6 weeks, being 3 weeks on average, while in the lower regime the highest value is 0.7 weeks. Full adjustments ($\varepsilon=0.9$) would take two or three months in the upper regime and two weeks in the lower regime. The findings suggest that disequilibria due to excessive import prices rises require a longer time for the adjustment than disequilibria due to sudden export price decreases. As expected, a vast majority of deviations occur in the upper regime (22% at minimum) and only 14% are in the lower regime. Different speeds of price adjustments, with lower transmission of price rises, suggest that retailers might exert their market power delaying price rises and avoiding reduced sales that would result in larger spoilage (Ward, 1982).

For tomatoes markets, we observed heterogeneous speeds of adjustment: tellingly, Spanish prices halve rises in import prices within three weeks, while French prices require less than two weeks to achieve a 50% adjustment. Deviations in the lower regime tend to achieve a 50% adjustment within one week, and prices fully adjust in less than two months. Coherently with previously mentioned results, deviations in the upper regime (30% on average) are more frequent than deviations in the lower regime (6%), and, in general, asymmetries in price transmission seem less evident for tomato markets.

5. Conclusive remarks

Price transmission in the European vegetables sectors is still underinvestigated. Our paper has focused on price dynamics of two main vegetables within the EU F&V sector: cauliflowers and tomatoes. We have adopted a prices transmission model by using weekly data collected on different EU Regions. In particular, we have provided an assessment of the estimated transaction costs and of the average elapsing time for transmission of prices shocks.

The analysis shows that transaction costs account only for 12% of variable costs in cauliflowers trade, and for more than 35% of import prices in the tomatoes sector; distance and transaction costs are positively correlated. In most cases prices transmission is unidirectional, since trade flows occur from Regions with large production volumes to net-importer Regions. Moreover we have found that prices rises tend to be transmitted within two or three weeks, while deviations due to prices decreases are corrected within a week.

On the grounds of the mentioned findings we can conclude that price rises due to scarce harvests or unexpected increases in demand tend to be slowly transmitted and might barely interest distant Regions; on the contrary market perturbations originated by price decreases - due to unexpected over-productions, large imports increases, consumption decline, etc. – spread across several EU Regions. Such a phenomenon is more evident for the cauliflowers than for the tomatoes sectors: as Ward (1982) has convincingly demonstrated, the high perishability (of cauliflowers) and the inability to delay sales through temporary storage implies that decreases in wholesale (or net-exporters) prices have a larger effect on retail (or net-importers) prices than increases.

The results of our analysis lead to interesting policy considerations. A first implication is related to the degree of market integration of the EU vegetable sector that emerged from our study. Since transfer costs are rather held down, European markets tend to partially adjust to price shocks in few weeks, achieving a full adjustment in few months. The European market of vegetables are integrated and price signals are transmitted in few weeks: on one hand, this implies that market stabilization policies can be planned at the EU level, or, at most, at a national level; on the other hand, despite market disequilibria tend to affect the whole EU market, their effects (in terms of magnitude) are spanned to several Countries with reduced intensity. Secondly, we found clearer evidence of asymmetry in prices transmission and faster transmission of low prices in cauliflowers markets. The findings would suggest that markets of perishable products tend to be more sensitive to market crises, and that, for highly perishable products, public intervention at the common level, aimed at ensuring an adequate management of sudden market crises, would be desirable.

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Table 1 – Vegetables[a] most produced in EU (1000 tons)

	Annual production		
	2005	**2007**	**2009**
Tomatoes	23,049	20,973	23,195
Cabbages	12,527	10595	11745
Carrots	8,857	7,855	8,481
Lettuce	3,479	3,425	3,332
Cauliflower	2,305	2,301	2,335

[a] Includes both vegetables for direct consumption and for processing.

Source: our calculations from FAOSTAT data.

Table 2 – Production and trade of cauliflowers and tomatoes by Countries, 2004-2008 (tons).

	Cauliflowers			
	Netherlands	**Ireland**	**Spain**	**United Kingdom**
Production	*54,500*	*7,440*	*443,617*	*204,500*
Import	*29,653*	*8,934*	*6,045*	*117,532*
Export	*23,646*	*1,459*	*246,363*	*4,549*
Apparent consumption [a]	*60,507*	*14,915*	*203,299*	*317,483*
	Tomatoes			
	France	**Ireland**	**Spain**	**United Kingdom**
Production	*713,873*	*10,600*	*4,199,606*	*83,244*
Import	*463,872*	*27,129*	*95,103*	*416,960*
Export	*135,514*	*1,908*	*950,685*	*4,659*
Apparent consumption [a]	*1,042,232*	*35,821*	*3,344,025*	*495,545*

[a] Apparent consumption is: (production + import) – export.

Source: Our elaboration from FAOSTAT

Table 3 - Descriptive statistics of market prices

	Observations	Mean (€/100 Kg)	Median (€/100 Kg)	Std. dev.
Cauliflowers markets				
Den Bosch	233	65.3	54.73	42.01
Dublin	339	47.07	44.91	13.57
La Roja	469	30.23	28.93	8.86
London	469	40.83	36.91	16.59
Tomatoes markets				
Almeria	221	58.47	49.66	28.58
Chateau Renard	221	84.65	79.51	32.45
Dublin	221	108.32	99.45	40.04
London	221	90.66	77.68	42.94

Table 4 - Prices transmission in cauliflowers markets

	T^{a}	θ [% of $\overline{P^B}$]	*t-stat*	*Trasmission elasticity* *Expected*	*Trasmission elasticity* *Estimated*	ρ_1 (# of obs.)	ρ_3 (# of obs.)	Symmetry / Asymmetry [a]	Km
Den Bosch – LaRoja	35	47.4 [72%]	1.94	0.46	0.28	-0.117 (65)		A	1,450
Dublin – LaRoja	17	21.3 [45%]	2.81	0.64	0.55	-0.179 (113)		A	2,050
London – LaRoja	11	4.7 [12%]	-4.18	0.74	0.88	-0.228 (294)	-0.623 (67)	S	1,452
Den Bosch – London	24	25.6 [26%]	0.16	0.63	0.74	-0.174 (71)		A	481
Dublin – London	6	6.1 [13%]	0.04	0.87	0.87	-0.305 (215)	-0.888 (32)	A	584

[a] *The expected transaction costs are* $T = E[P^B - P^A]$

[b] *Letters S and A indicates respectively symmetry and asymmetry*

Table 5 - Prices transmission in tomatoes markets

	T^a	θ [% of P^B]	*t-stat*	*Trasmission elasticity* *Expected*	*Trasmission elasticity* *Estimated*	ρ_1 (# of obs.)	ρ_3 (# of obs.)	Symmetry / Asymmetry [b]	Km
Chateau Renard – Almeria	26	32.3 [38%]	0.72	0.69	0.62	-0.251 (92)	-0.591 (6)	A	1,810
Dublin – Almeria	50	53.4 [57%]	0.63	0.54	0.43	-0.222 (45)		A	2,908
London – Almeria	32	62.9 [58%]	7.20	0.64	0.42	-0.178 (66)		A	2,310
Dublin – Chateau Renard	24	8.1 [9%]	-7.42	0.78	0.91	-0.499 (107)	-0.639 (54)	S	1,910
London – Chateau Renard	6	32.1 [30%]	3.29	0.93	0.7	-0.341 (62)		A	593

[a] *The expected transaction costs are* $T = E[P^B - P^A]$

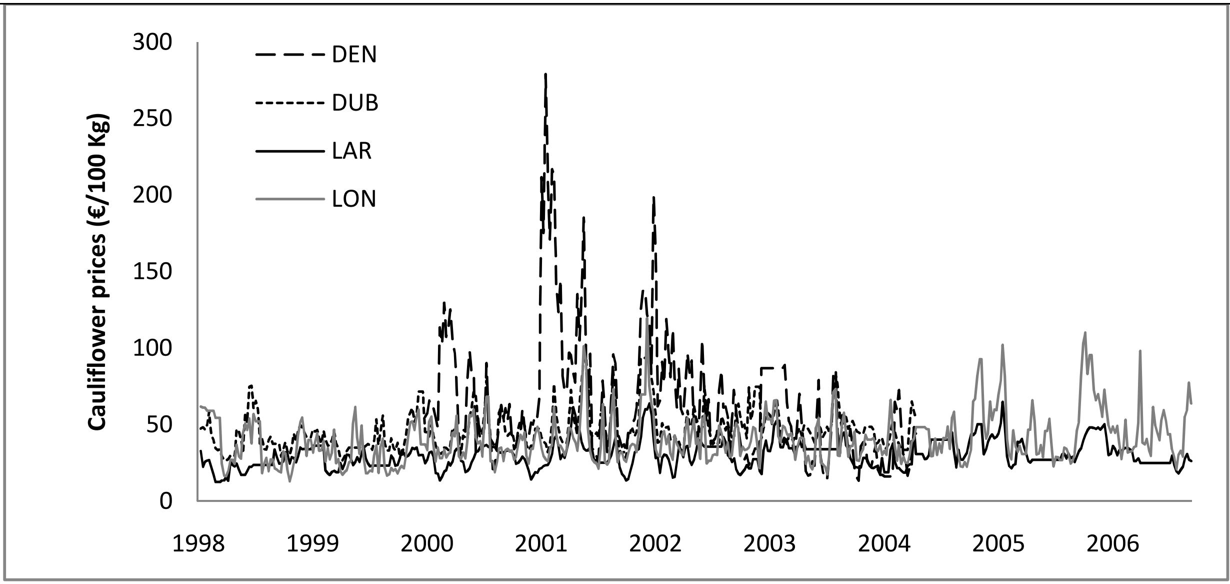
[b] *Letters S and A indicates respectively symmetry and asymmetry*

Table 6 - Adjustment periods in cauliflowers and tomatoes markets

	ρ_1	*Adjustment period (weeks)*			ρ_3	*Adjustment period (weeks)*		
		ε = 50%	*ε = 75%*	*ε = 90%*		*ε = 50%*	*ε = 75%*	*ε = 90%*
Cauliflowers								
Den Bosch – LaRoja	-0.117	5.6	11	19				
Dublin – LaRoja	-0.179	3.5	7	12				
London – LaRoja	-0.228	2.7	5	9	-0.623	0.7	1	2
Den Bosch – London	-0.174	3.6	7	12				
Dublin – London	-0.305	1.9	4	6	-0.888	0.3	1	1
Tomatoes								
Chateau Renard – Almeria	-0.251	2.4	5	8	-0.591	0.8	2	8
Dublin – Almeria	-0.222	2.8	6	9				
London – Almeria	-0.178	3.5	7	12				
Dublin – Chateau Renard	-0.499	1.0	2	3	-0.639	0.7	1	3
London – Chateau Renard	-0.341	1.7	3	6				

The half-life measure is equibvalent to a 50% adjustment.

Graph 1 - Cauliflower prices series



Graph 2 - Tomatoes prices series