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## DEMAND-DRIVEN MARKETS AND THE IMPORTANCE OF DEMAND RATIONING

Sören Prehn<sup>1</sup>, Thomas Glauben and Jens-Peter Loy

### Zusammenfassung

Whenever supply falls short or actual consumption rates exceed projected consumption rates grain markets call for demand rationing. In recent years, in particular high demand made demand rationing more than once necessary. Here, we develop a theory of how demand rationing functions. Theory implies that agricultural futures markets not only fulfill a hedging and information function but also a market coordination function. Speculators always have a rational economic incentive to bring demand down to fit with supply conditions. Empirical evidence for the US corn market emphasizes the importance of demand rationing for the functioning of grain markets.

### Keywords

Corn market, price discovery, basis trading, spread trading, demand rationing.

## 1 Introduction

Those of us, who follow the discussion on grain markets very closely, will have recognized that grain markets always call for demand rationing whenever supply falls short or actual consumption rates exceed projected consumption rates. Although the whole discussion on demand rationing is more abstract the aim of demand rationing is clear: The market wants to avoid the risk of running out of grain at the end of the crop year. Demand rationing is indispensable for the functioning of grain markets. What makes it all the more astonishing is that demand rationing has never been discussed in agricultural literature.

There is no theory of how demand rationing functions. However, a profound knowledge of its functioning is indispensable. Only a complete understanding of all processes of price discovery allows market participants to make the right production, storage, and marketing decisions.<sup>2</sup> In order to fill this gap, we develop a theory of demand rationing.

Our theory emphasizes the importance of spread trading for price discovery on grain markets. It not only initializes demand rationing but also bridges the gap between grain trading and storage. Spread trading impacts forward bases<sup>3</sup>, so forward sales and purchases and thus storage. Accordingly, our theory complements WORKING's (1949) *theory of the price of storage* which focuses on the relationship between calendar spreads and storage.

In addition, our theory indicates that it is the futures market that takes over the task of market coordination and brings it back to equilibrium. That futures markets have this task has not been discussed in literature before.

When developing our theory of demand rationing, we focus on a demand-driven market. On the one hand, we focus on a demand-driven market because it is demand that is fluctuating over the crop year, and on the other hand, because a demand-driven market model allows us

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<sup>1</sup> Corresponding author: [sprehn@jamo.de](mailto:sprehn@jamo.de), Department of Agricultural Markets, Marketing and World Agricultural Trade, Leibniz Institute of Agricultural Development in Transition Economies, Theodor-Lieser-Str. 2, 06120 Halle (Saale), Germany.

<sup>2</sup> Although we focus on demand rationing, this does not imply that no other processes can take place on grain markets at the same time.

<sup>3</sup> In the following basis always refers to forward basis.

to consider strategic storage beside normal storage. Demand rationing is only required when strategic inventories are effectively reduced. Otherwise, no demand rationing is required.

In order to illustrate the importance of demand rationing for the functioning of grain markets, we analyze the recent price peaks on the US corn market in 2007/08, 2010/11, and 2012/13. Empirical evidence reveals that corn was rationed in all three crop years. However, pointwise marginal effects taken from kernel-based regularized least squares (HAINMUELLER & HAZLETT, 2014) regression indicate that ethanol production is more rigid to changes in corn price than export sales are. While export sales reach a maximum in rationing by 500 cents per bushel, ethanol production not even reaches a maximum by 750 cents per bushel.

The remainder of the paper is organized as follows. First, we develop a price discovery model for a demand-driven market. This model in turn serves as the starting point for the development of our theory of demand rationing. For illustration, we analyze the US corn market confirming the importance of demand rationing. Finally, we conclude.

## 2 A demand driven market model

WRIGHT (2011) develops a price discovery model where price changes are explained by changes in supply. The lower grain inventories are the stronger is the price reaction to a change in supply. In the end, Wright develops a supply-driven market model. But supply-driven markets are not characterized by high volatility. Usually, the crop size is decided in July for corn and in August for soybeans, respectively, and it only marginally changes afterwards. The average price for the crop year is decided prior to harvest.

The current market situation, however, is characterized by high volatility. Prices are not only volatile during the growing season, in particular in July/August, but also they fluctuate in the winter season. The major price peaks in the crop year 2007/08 occurred in winter, not prior to harvest. It is not supply that is fluctuating over the crop year, but it is demand. Particularly, when grain inventories are short and demand does not adjust there is always an immanent need for demand rationing, i.e. the temporary increase in prices to reduce demand.

Similar to WRIGHT, one can develop a price discovery model for a demand-driven market, see figure 1. The length of the abscissa depicts the size of the pre-defined harvest quantity<sup>4</sup> and the ordinates the price. In the figure strategic storage and storage is drawn. The strategic storage is steeper as it is elementary; there is a minimum amount of inventory required to be able to compensate unexpected shortfalls in supply. Beyond that, there is no further need for strategic storage. ‘Normal’ storage accounts for all grain which is neither consumed nor required for strategic storage. Equilibrium is achieved when the whole harvest is distributed between storage, strategic storage, and demand. The equilibrium price is defined by the intersection of demand and (strategic) storage.

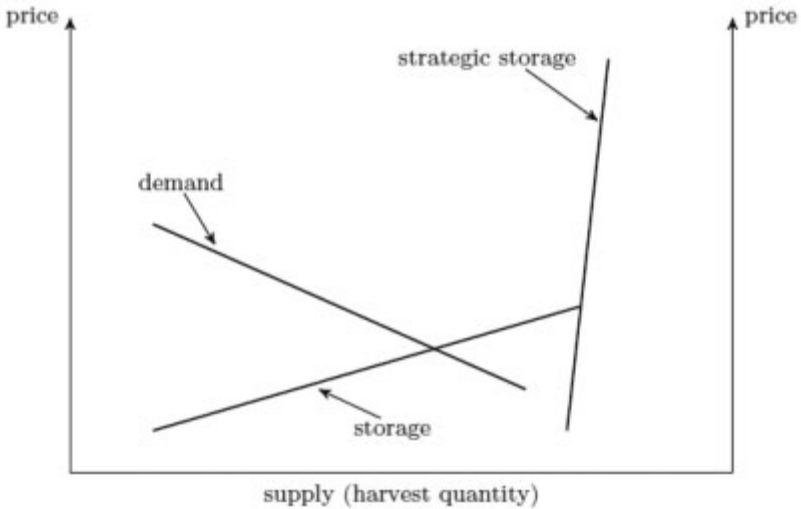
A shortfall in supply can be analyzed, too. A shortfall in supply just shifts the right ordinate leftwards.

Our demand-driven market model has the appeal that it is consistent with WORKING’s (1949) *theory of the price of storage*. WORKING indicates that even on inverted markets, where the nearby futures price is higher than the n-nearest, a minimum amount of grain is stored. So, our model predicts. We refer to it as strategic storage.

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<sup>4</sup> Supply also includes ending stocks of the last crop year.

**Figure 1: Demand-driven market and the importance of rationing**



According to our model, an intersection of demand and storage to the left corresponds with a supply-driven market situation. There is plenty of grain and no customer has to fear a non-delivery. Hence, changes in demand will only marginally change prices. Accordingly, volatility will be low. The market situation is different if the intersection of demand and storage lies to the right (i.e., demand-driven market situation). Inventories are quite low and when in this situation demand further increases and inventories reach critical levels (i.e., strategic storage) then prices sharply react and significantly increase. This increase is necessary to initialize demand rationing. Prices only come down when demand adjusts and strategic inventory is not reduced.

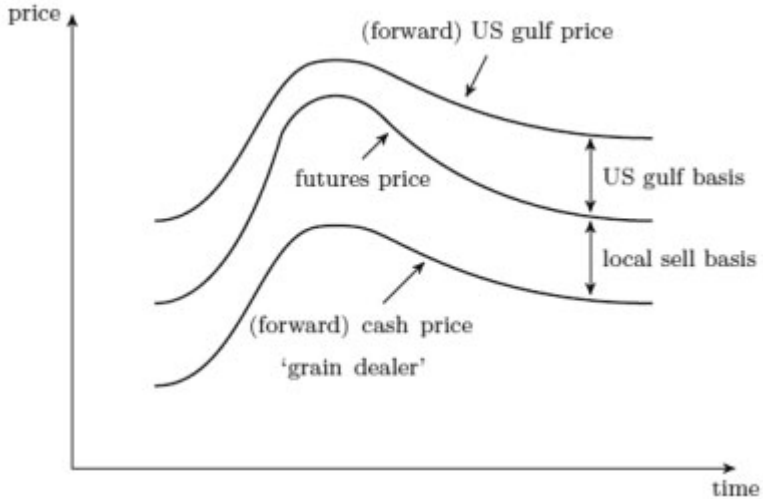
Demand rationing is an elementary part of the price discovery process on agricultural futures markets. It makes sure that grain markets never run out of grain.

### 3 A theory of demand rationing

In practice demand rationing works as follows: When speculators (i.e., spread traders) realize that grain dealers are selling too much grain for delivery (i.e., forward sales), i.e., the grain market risks to run out of grain at the end of the crop year, then they enter into bull spreads, i.e. they go long in the nearby contract and short in the n-nearest contract. This increases in particular the futures price in the nearby contract. Because the futures price usually reacts stronger than the cash price (at least during price rallies), the sell bases in export regions weaken what disfavors forward sales. This applies for the US gulf region as well as any other local export region. Contemporary, the higher prices lower the willingness to buy at the demand side. Thus, starting from the futures market demand is rationed. Because 'physical' demand comes down, spread traders clear their bull spreads what again brings down futures prices. The corresponding price patterns are depicted in figure 2.<sup>5</sup>

<sup>5</sup> The basis patterns here are highly stylized. Usually, bases strengthen over the crop year accounting for increasing storage costs.

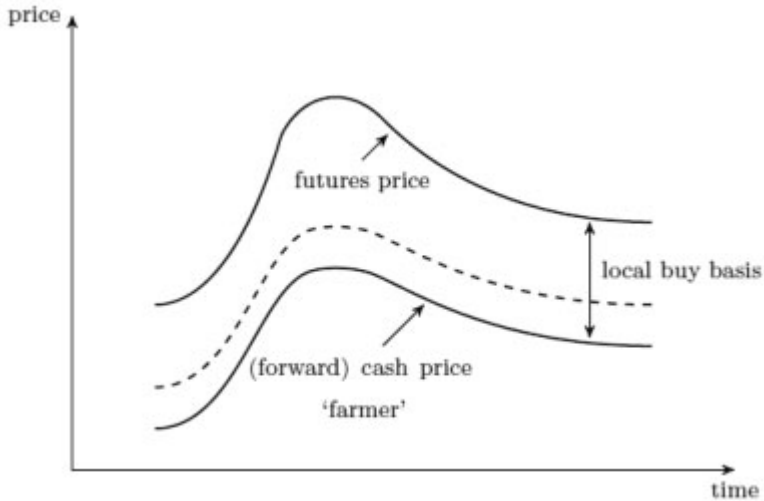
**Figure 2: Impact of demand rationing on the US gulf/local sell basis**



At the same time, the increasing futures price also weakens local buy bases what again favors forward purchases. More forward purchases, however, bring up cash prices. The corresponding price patterns are depicted in figure 3. In addition, forward purchases are also favored by weaker calendar spreads - bull spreads usually lower calendar spreads. Farmers have less incentive to store grain that is why they deliver more grain to local elevators (WORKING, 1949). In the end, grain delivery<sup>6</sup> and demand reapproach.

<sup>6</sup> While grain delivery refers to the grain delivered in the nearby contract period, supply refers to the whole harvest quantity which is distributed over the whole crop year and (strategic) storage.

**Figure 3: Impact of demand rationing on the local buy basis**



How much less grain is delivered to each import region – domestic or abroad - depends on the development of the local sell basis. The more grain is needed in a region and the lower (inter-)national inventories are the higher the local sell bases have to go. The whole process, as outlined above, can be regarded as the mechanism of demand rationing on grain markets.

The above discussion reveals that agricultural futures markets fulfill beside the tasks of price forecast and hedging an additional task: the coordination of the market. Agricultural futures markets work in that way, that speculators always have a rational economic incentive to bring demand down to fit with supply conditions.<sup>7</sup> Agricultural futures markets have a direct impact on grain delivery and demand at spot markets.

Our theory of demand rationing can be seen as a complement to WORKING's (1949) *theory of the price of storage*.<sup>8</sup> As indicated above, bull spreading lowers calendar spreads and thus disfavors storage. This in principle is the central message of WORKING's theory: calendar spreads indicate the favorability of storage; the higher calendar spreads are the more favorable storage is. Our theory complements WORKING's theory insofar as we bridge the gap between storage and grain trading by focusing on spread trading. Our theory indicates how spread trading impacts forward sales and purchases and thus storage.

#### **4 The practical importance of demand rationing**

That futures prices ration demand is also supported by data. The 2007/08 US corn crop year is a good example. Although the 2007/08 corn crop was not something unexpected, crop size was in the normal range and an increase in ending stocks was expected, early season corn export sales were so high that demand rationing became necessary. The situation got even worse by the steady increasing demand for corn by ethanol plants. Corn prices sharply increased after October what ultimately led to a significant reduction of corn export sales (see figure 4). That early season export sales were extremely high is also supported by a compari-

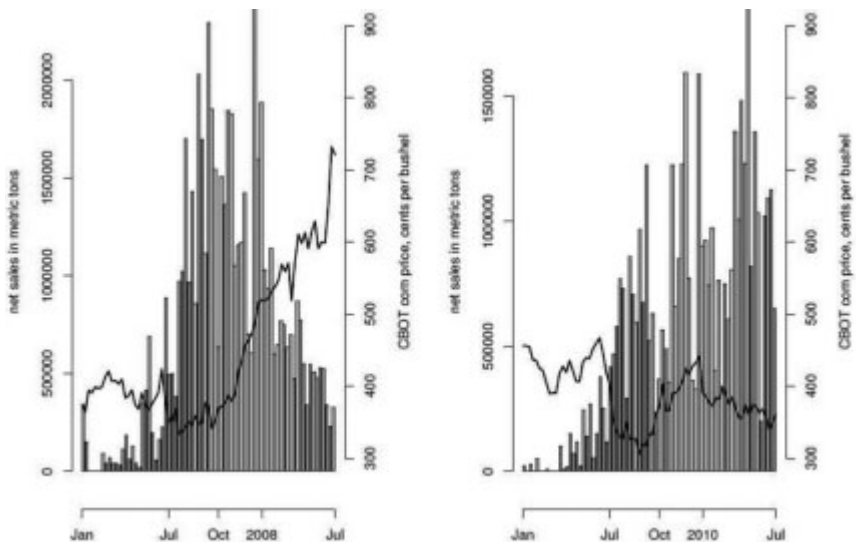
<sup>7</sup> Similar to demand rationing, speculators also have incentives to bring up demand when there is too much grain on the market. The corresponding demand finding process is not discussed here, but its development should be straightforward.

<sup>8</sup> BRENNAN (1958) develops a formal model of WORKING's (1949) *theory of the price of storage*.



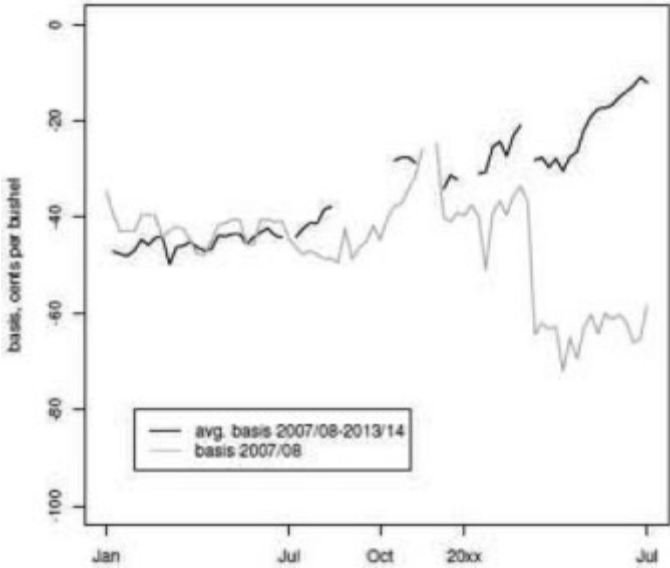
son with the 2009/10 US corn crop year. In 2009/10 early season export sales were only half the size of 2007/08. Lower prices even had to stimulate demand at the end of the crop year. The big floods in April/May 2008 in the Midwestern, the major growing area for corn and soybeans in the US, explain the price peak at the end of the crop year.

**Figure 4: Weekly US corn export sales in 2007/08 vs. 2009/10**



That the rationing process functioned is also indicated by the development of the buy basis in Illinois, the second largest corn producer of the US. When demand (i.e. corn export sales) finally adjusted, also Illinois' buy basis weakened indicating sufficient corn supply for the rest of the crop year (see figure 5). Hence, grain delivery and demand reapproached.

Figure 5: Development of buy basis in Illinois in 2007/08 (region 1)



The 2007/08 crop year is an ideal example that not only a shortfall in supply can cause demand rationing but also high demand can do so. Contrary to 2006/07 where a short crop might have initialized the demand rationing process, high export sales and a fast growing ethanol industry made rationing necessary in 2007/08. Thus, 2007/08 is an example for a demand-driven market. Price discovery is not primarily driven by supply conditions but by changing demand conditions.

**Figure 6: Pointwise marginal effects of CBOT corn price on net export sales**

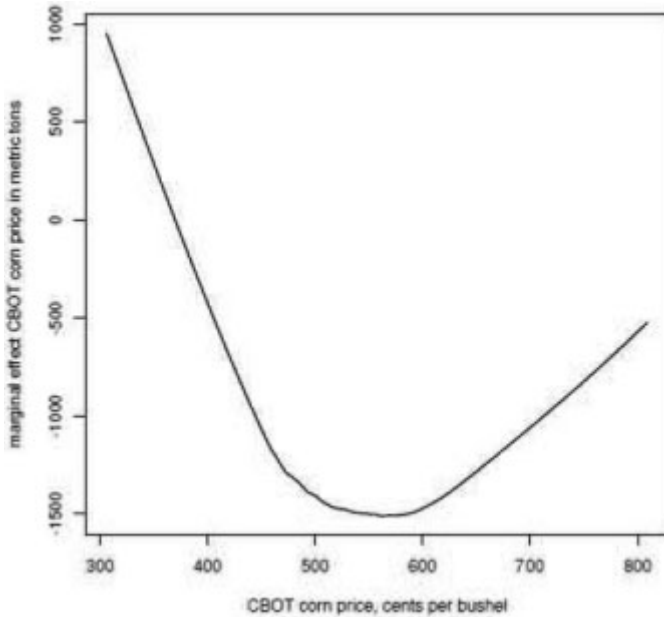
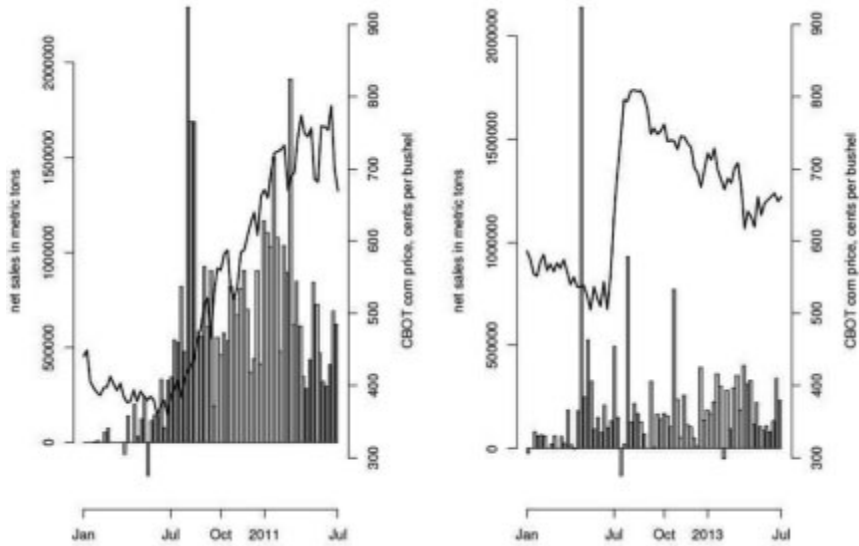


Figure 6 provides additional insights into the price discovery process on agricultural futures markets. The figure displays the pointwise marginal effects of Chicago Board of Trade (CBOT) corn price on net export sales. The marginal effects are taken from kernel-based regularized least squares (KRLS) regression of weekly US corn export sales on CBOT corn prices (see Appendix).<sup>9</sup> The marginal effects reveal that rationing of export sales in particular occurs in the price range from 500 to 600 cents per bushel what also fits with observations for 2007/08. The results also show that lower corn prices, lower than 375 cents per bushel, stimulate demand (see also figure 4, left panel). This indicates demand finding (see footnote 6). Also in 2010/11 corn had to be rationed. On the one hand, rationing was required because of high export sales not only at the end of 2009/10 but also at the beginning of 2010/11 (see figure 4 and 7). On the other hand, the mandatory renewable fuel standard (RFS) for ethanol production increased from 10.5 to 12 billion gallons (SCHNEPF & YACOBUCCI, 2013). As before, export sales significantly decreased when corn prices reached price levels of 500 cents per bushel and above. This time, however, prices did not flatten out but increased to price levels of up to 750 cents per bushel indicating a sustained strong demand. This picture is also supported by the Illinois buy basis which did not noticeably weaken when export sales adjusted (see figure 9).

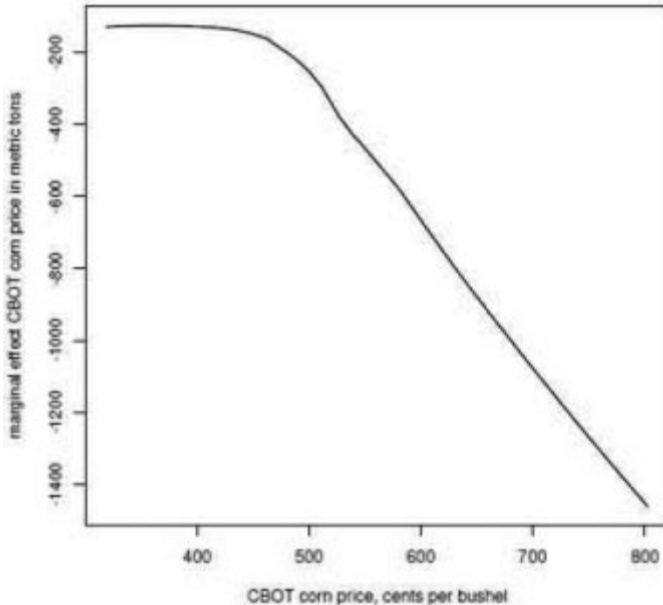
<sup>9</sup> For more information on kernel-based regularized least squares (KRLS) regression see HAINMUELLER & HAZLETT (2014). Empirical implementation is discussed in FERWERDA ET AL. (2013).

Figures 7: Weekly US corn export sales in 2010/11 and 2012/13



The sustained strong demand has two reasons where both reasons are mutually dependent. The first reason is that the increase of the RFS from 10.5 to 12 billion gallons of ethanol meant an additional demand for corn by ethanol plants of approximately 275000 metric tons per week. This further intensified the competition for corn. And the second reason is the rigidity of ethanol production to changes in corn price. As pointwise marginal effects of CBOT corn price on ethanol production reveal ethanol production only marginally reacts to price changes below 450 cents per bushel and even for higher corn prices never reaches a maximum in rationing like export sales do (see figure 8). The corresponding KRLS regression of ethanol production on CBOT corn price and additional explanatory variables is given in the appendix. In order to facilitate comparison, pointwise marginal effects are converted to metric tons at a weekly basis.

**Figure 8: Pointwise marginal effects of CBOT corn price on ethanol production (converted to metric tons)**



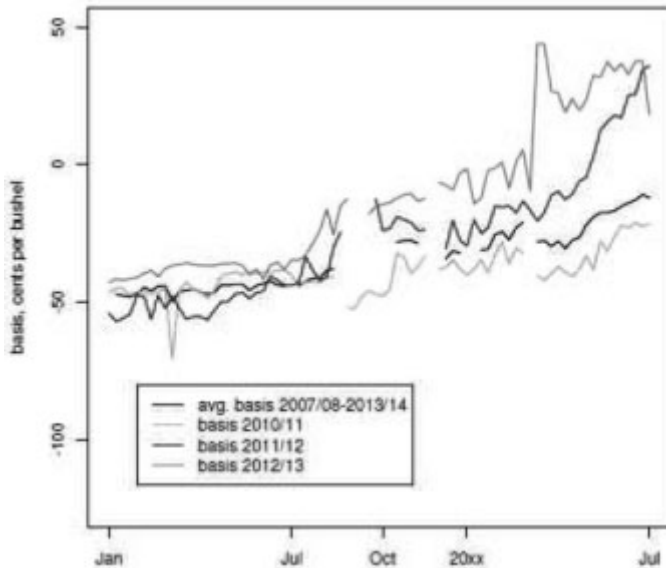
The extremely high prices of 2010/11 suggest that in 2010/11, despite rationing, consumption rates were so high that ending stocks were in the region of strategic storage. With reference to figure 1, demand would intersect strategic storage but not storage.

The last price peak occurred in 2012/13. Disastrous weather conditions and a prospect of a short crop made rationing necessary. The futures price pattern of 2012/13 reminds very much of a ‘short crops have long tails’ price pattern, i.e., a sharp price increase is followed by a moderate price downturn (see figure 7). However, this is only one part of the story the development of the Illinois buy basis is the other part. Although the futures price declined after the price peak in October 2012, the buy bases significantly grew compared to other crop years (see figure 9).<sup>10</sup> The former implies that the futures and spot market saw the supply situation differently: Whereas the futures market saw ‘relative’ enough supply to satisfy demand, the strengthening of the basis indicated an insufficient supply. This is a problem because if the CBOT corn contract is representative for US corn both futures and spot price should go in one direction, i.e. either they indicate ‘relative’ enough supply or insufficient supply. Otherwise, arbitrage should bring one price up or the other down. However, the situation lasted for the whole crop year. Usually, the basis should follow the spread, but spreads were in inversion. GOOD & IRWIN (2012) refer to this situation as the *corn basis mystery*.<sup>11</sup>

<sup>10</sup> For 2011/12, a similar phenomenon was observed.

<sup>11</sup> There is an exhaustive discussion of the *corn basis mystery* on farmdoc daily by Good and Irwin (GOOD, 2012a,b; GOOD & IRWIN, 2011, 2012).

Figures 9: Development of buy bases in Illinois from 2010/11 to 2012/13 (region 1)



Recently, PREHN & GLAUBEN (2014) revisit the *corn basis mystery* and show graphically that both prices are correct. The reason for the divergence of the futures and spot price is that the CBOT corn price is no longer representative for the US corn price but for the world market price. Provided that PREHN & GLAUBEN (2014) are right, the Brazilian record corn crop in 2013 and the fact that the Illinois buy basis in particular strengthened after February 2013 explains the decreasing futures price. The prospect of a better supply situation and temporary hedging pressure caused by Brazilian farmers hedging their corn crop could be a solution for the *corn basis mystery*. However, whatever explanation is right the fact remains, that in 2012/13 corn was rationed.

In summary it can be said that demand rationing is important for the functioning of the US corn market and the world corn market in general. Demand rationing takes over the task of market coordination. It controls for that grain delivery and demand always reapproach. Empirical evidence, however, reveals that the rigidity of ethanol production to changes in corn price can lead to significant price increases. The latter implies that ethanol production played an important role in the recent corn price developments (WRIGHT, 2014).

## 5 Conclusions

Demand rationing has always been a discussion on grain markets. In particular, in recent years there was more than once the talk that grain has to be rationed. Given the practical importance of demand rationing for the functioning of grain markets, we develop a theory of demand rationing. This has been done for the first time and our theory provides new insights into the functioning of grain markets.

Our theory stresses the importance of spread trading for the functioning of grain markets. It not only initializes demand rationing but also impacts bases and thus grain trading and storage. Insofar, our theory complements WORKING's (1949) *theory of the price of storage* which focuses on the relationship between calendar spreads and storage.

In addition, our theory emphasizes the important role futures markets play in the coordination of the market. Futures markets work in that way, that spread traders always have a rational, economic incentive to bring demand down to fit with supply conditions. Our theory has important political implications. Demand rationing is an important regulatory mechanism that is elementary for the functioning of grain markets. It should be by no means confounded with ‘bubbles’. A regulatory intervention in the process of demand rationing could have severe consequences for price discovery on grain markets.

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