Dipartimento di Scienze Economiche
Università degli Studi di Firenze

Working Paper Series

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Working Paper N. 04/2013
March 2013

DISEI, Università degli Studi di Firenze
Via delle Pandette 9, 50127 Firenze, Italia
www.dse.unifi.it

Stampato in proprio in Firenze dal DISEI
(Via delle Pandette 9, 50127 Firenze) nel mese di Marzo 2013,
Esemplare Fuori Commercio Per il Deposito Legale
agli effetti della Legge 15 Aprile 2004, N.106

Speculative Cotton Pricing in the 1920s. A Nonlinear Tale of Noise Traders and Fundamentalists

Giulio Cifarelli[+] and Paolo Paesani*

Abstract

The paper investigates the role of speculation in the Liverpool cotton futures market between 1921 and 1929. The analysis is based on historical descriptions of the working of speculation in commodity markets and is related to the tenets of behavioural finance. The model posits the existence of two categories of speculators, noise traders and fundamentalists, who react (differently) to deviations of market prices from their fundamental value. The empirical analysis is based on original data drawn from the online archives of *The Times.* The empirical findings allow us to conclude that whereas noise traders tend to herd, fundamentalists are more affected by risk aversion and react asymmetrically more to underpricing than to overpricing of the cotton contracts. As expected, the presence of fundamentalists stabilizes the market. Interestingly our results seem to be consistent with the observations of expert witnesses of those markets.

Keywords: behavioral finance, speculation, historical cotton futures markets
JEL Classification: F31, F33, N13, N23
February 2013

The authors are grateful to Annalisa Rosselli for useful suggestions.

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Introduction

The paper investigates the role of speculation in the Liverpool cotton futures market of the 1920s, a period in which staple commodity trading resumes a relevant role in the resurgent post World War I British financial system. The analysis is based on historical descriptions of the working of speculation in commodity markets and is related to the tenets of behavioural finance.

Recent empirical studies detected nonlinearities in the dynamics of the price of assets traded in stock, exchange rate, and commodity markets. Indeed, a rapidly expanding literature suggests that agent heterogeneity may cause nonlinear mean reversion in the asset pricing mechanism. Brock and Hommes (1997, 1998) and Westerhoff (2004), among many others, assume that different groups of agents condition their behavior on differing types of information. The resulting market price is a weighted average of the expectations of these different groups. The basic intuition here is that the weights given to the various strategies shift over time as agents react to their performance.

A related strand of research builds on the original intuition of Frankel and Froot (1986) and focuses on the interaction between chartists (or noise traders) and fundamentalist speculators, which is considered a major determinant of short term price dynamics. Here too the behaviour of agents depends on past profit and the price is driven by an endogenous nonlinear law of motion.

The model set out in this paper analyses commodity price behavior focusing on cotton prices registered in the Liverpool future markets between 1921 and 1929. It differs from previous studies by Westerhoff and Reitz (2005) and Reitz and Westerhoff (2007) in that the strength of both noise and fundamentalist trading varies over time as speculators react – with differing dynamics – to the same information set, viz. to deviations of the previous period's price from its normal long run value. The empirical results are satisfactory and provide an informative behavioural finance insight in a time period and in a market that received but scant scholarly attention.

Interestingly our results seem to be consistent with the observations of expert witnesses of those markets.

The paper improves upon previous research for the following reasons.

First, it provides – to the best of our knowledge – the first behavioural analysis interpretation of commodity speculation in the 1920s, a period in which sophisticated financial operators had to cope with the volatility of market prices using but limited (by our standards) technical and statistical tools. The analysis is based on original data drawn from the online archives of *The Times.*

Second, it introduces a realistic model which posits that both noise traders and fundamentalists react (differently) to the same information set, viz. to the deviation of the previous week's market price from its fundamental value, proxied by a three-month price moving average. The former extrapolate price changes and the latter adopt a contrarian behavior.

Third, it identifies a clear-cut difference between the reaction of noise traders, that tend to herd as they react rapidly and simultaneously to price deviations from their normal values, and fundamentalists. The former tend to destabilize the market while the latter react more slowly, are risk averse, and bring about stabilizing price adjustments that dampen the short term impact of noise trading.

Based on these considerations, the rest of the paper is organised as follows. Section 1 discusses the Liverpool cotton futures market in the 1920s and defines the historical and institutional background of the analysis. Section 2 constructs a heterogeneous agent model of cotton price fluctuations. Section 3 contains the statistical analysis of the data. Section 4 investigates the main differences in the trading strategies of fundamentalists and noise-traders. Section 5 concludes the paper.

1. Historical and institutional background

In the second half of the nineteenth century, organised futures markets were created for the main commodities, including cotton. This happened mainly in response to developments in communication technology, extended use of warehouse receipts, standardisation of grading systems, expansion of foreign trade and developments in transportation technology (on this see Williams 1982). Developments in communication (e.g. the laying of the Trans-Atlantic cable in 1866) enabled merchants to anticipate market movements and to trade in advance of delivery. Extended use of warrants and warehouse receipts made it easier to transfer ownership without transferring the assets that underlied the futures contracts. Secondarily, it facilitated the advances of capital against the goods held. The establishment of official grading systems permitted to write contracts for the delivery, within a specified future period of time, of given quantities of standard-grade commodities which did not exist until the time of delivery. Codification of rules on weighing, warehousing, inspection, delivery, centralisation of trading, and the establishment of clearing houses transformed the established practice of forward sales of goods "to arrive" into fully fledged future trading (on this see Williams 1982 and the reference cited). The creation of organised futures markets extended the scope of speculation. "Without a system of grades and receipts there could be no short-selling, and without short-selling there could be no operations […] in which the dealer seeks to secure profit by selling for forward delivery at one price and by making the delivery with goods bought later at a lower price. Under the old methods 'bull' speculation alone was possible; the speculative market is not complete till the machinery for bear 'speculation' is added" (Emery 1896, p. 39).

In the 1920s, there were eight cotton futures markets in the world; three were located in the USA (New York, New Orleans and Chicago), three in Europe (Liverpool, Bremen, Havre), one in Egypt (Alexandria) and one in India (Bombay). As a result of rapid communication and of the activity among arbitrageurs, "The price of American cotton tends to be a world price. It is made primarily in the futures markets of the world, which are based on American cotton, because the American crop is the most highly standardized and the most liquid [...] The futures markets are the clearing houses for all information which affects either the supply of cotton or the demand for it"

(Cox 192, p. 176). The Liverpool market played a very prominent role in the World cotton market as discussed in more detail in Section 1.1 below.

1.1. The Liverpool cotton futures market in the 1920s

Until the early nineteenth century British cotton imports came mainly from the British West Indies (75% in 1786-90) and from Mediterranean countries (19% in 1786-90). At the beginning of the twentieth century the situation had dramatically changed and Britain mainly depended on imports of American cotton (77% in 1901-1904, against less than 1% in 1786-90).[1]

The development of organized cotton markets started in late eighteenth century, when British cotton trade began to grow quickly in volume, importance, and technical organization and when cultivation of cotton was first attempted in North America, to lead the USA soon to become the most important producer in the world (Cristiano and Naldi 2012).

In the 1920s Europe as a whole imported approximately 50 percent of the American crop yearly and Britain took up more than all other European countries put together, with the exception of Germany. British imports of American cotton were mostly handled in Liverpool, the largest port closest to the Manchester mills. The Liverpool cotton futures market had been formally organized in 1882 by the Liverpool Cotton Association, twelve years after the New York cotton futures exchange (the largest in the world) and two years after New Orleans (Baffes and Kaltas 2004).[2]

It hosted different categories of merchants including: 1) importing houses, 2) selling brokers (assisting importers in reselling the cotton after its arrival in Liverpool), 3) Spinners' buying brokers (buying cotton on behalf of mills), 4)

[1] Source Chapman and McFarlane (1907). On early Liverpool cotton imports and the organization of the cotton market in the XVIII century see Dunbell (1923). On the development of commodity futures markets in London and Liverpool see also Cranston (2007).

[2] As Williams (1982, p. 306) recalls: "Although the year 1869 has been given as the earliest date for written rules in Liverpool, the minutes of the Liverpool Cotton Brokers Association for 19 April and 17 June 1864 mention the voting into force of rules for cotton 'to arrive'. For a early account of the creation of the Liverpool Cotton Market and of the Liverpool Broker's Association see Ellison (1886).

merchant brokers (who imported and sold cotton to their own spinners). Merchants were divided into two groups: full members, who set the policies of the Association, and associate members. Full membership was limited to 600 and reserved to British citizens. There were no fixed limits for associate members, who were divided in seven distinct categories.

In the period which our analysis refers to (1921 – 1929), the futures contract in Liverpool prescribed the delivery of 100 bales of American Cotton net weight (equivalent to 48,000 pounds) of Fully Middling Cotton or of any grade not lower than Low Middling (Liverpool classification standards), "with additions or deductions on the agreed price for such qualities as are within the contract according to their value as compared with the spot value of fully middling […] on the day the cotton is tendered" (Hubbard 1923, p. 290). Delivery was possible in every month of the year.[3] The price was made in pence and hundredths of pence per pound (1/100 of pence was equivalent to 1 Liverpool point). The farthest ahead a contract could specify was one year and one month ahead. Contracts bore an interest calculated as the difference between the agreed price and the price set by the Future Committee at 11 A.M. on the first Monday following the transaction. Interests were settled weekly (on Thursdays) through the Cotton Bank, a clearing institution managed by the Bank of England (on this see Hubbard 1923, pp. 293 – 294).

As Cox (1927) observes, before World War I Liverpool was known for making cotton standards for Europe and virtually for the whole world as it was the only market where futures on both American and non American cotton were traded. Most cotton bought and sold in Europe, was traded and sold on Liverpool contract forms and according to Liverpool rules. Settlement disputes were nearly always referred to Liverpool for arbitration. Much of the international business of Liverpool was lost during and after World War I due to exchange rate instability and to a more aggressive policy on the part of the American markets, New York in particular. The two markets were closely

[3] For a description of cotton futures contracts prior to the 1919 reform see Chapman and Koop (1904) and Hubbard (1923), Ch. XXV.

connected with fluctuations in parity mainly due to difference in the wording of contracts, settlement rules, relative supplies and rates of change[4]. Both markets were characterized by the presence of hedgers and speculators, professional and non professional, as discussed in more detail in Section 1.2 below.

1.2. Speculation and pricing in cotton futures markets

In the 1920s the study of the relationship between futures markets and speculation was in its early stages. Emery (1896) contains one of the first systematic treatments of the subject. The fact that Hubbard (1923) referred to it in the context of his analysis of speculation on the cotton futures market makes it particularly interesting and worth of a brief discussion.

After relating the emergence of speculation (the operation of *buying and selling commodities, or securities or other property, in the hope of a profit from anticipated changes of value*) to the establishment of organized futures markets, Emery discusses its relationship with gambling. "In gambling one party must lose just what the other wins. In speculation this is not necessarily so. […] Both depend on uncertainties, but, whereas gambling consists in placing money on artificially created risks of some fortuitous event, speculation consists in assuming the inevitable economic risk of changes in value. It is in this element of risk that we have the key to the function of speculation" (Emery 1896, pp. 100-101).

Emery sees professional speculators as playing two main roles in the economy: 1) promote efficient allocation over time and space through their influence on prices, 2) relieve producers and traders of ordinary business risks . Speculators' activity is mainly based on the intelligent examination of market fundamentals. Speculators discount all relevant news and are as successful as rapid and accurate their forecasts are. At times, prices may deviate from fundamentals either because of the public reacting to

[4] On this see Cox (1927) and Hubbard (1923) Chapters XXV and XXXI.

unpredictable excitement or panic or as a consequence of manipulation (e.g. through corners, squeezes, was sales, spreading of false rumors) but these episodes tend to be short-lived. On the whole, the presence of professional speculators tends to reduce price volatility and to moderate the size if not the frequency of price changes. Based on empirical investigation, Emery claims that in principle there is no reason to expect speculation to exert any systematic influence neither on the level nor on differential between spot and futures prices.[5]

Building among other reference on Emery's analysis of speculation, Hubbard (1923) investigates the cotton industry and cotton futures market both in the USA and in Britain. Hubbard coincides with Emery in seeing cotton prices as mainly determined by fundamentals and in expecting deviations to be short-lived. "There exists in the cotton market no such thing as a good 'tip' and no such thing as 'inside information'. When all is said and done, prices move according to supply and demand. Sometimes the momentary demand may prove to be merely excited speculative buying and not real demand from consumers; sometimes the selling may be mere liquidation and not the actual pressure of cotton. In either case the force in the market is purely temporary and not to be seriously considered as a reason for permanent change in prices. […] It is always the supply of cotton and the demand for cotton which are the real fundamentals of the market. Any speculator who allows his attention to be distracted by momentary excitement is apt to miss the important truth behind the market", Hubbard (1923, p. 436 – 437).[6]

Hubbard also agrees with Emery on the difference between speculation and gambling but differs from him in assigning hedgers a more prominent role in determining futures prices.

[5] On this see Emery (1896, pp. 113 – 143).

[6] Interestingly, Hubbard observes that speculation seems to be more intense when prices are high than when prices are low, and more intense on spot rather than on futures markets (SI) (p. 457 and following). Killough and Killough (1926, p. 47 - 48) agree with Hubbard (and Emery) when they write "The speculator uses the futures market as a place to pit his judgment of supply, demand, and price movements against the judgments, better or worse, of other speculators. His function is to bring together all the available facts, to act upon them, and thus to turn the balance of influence toward the maintenance of a fair competitive price".

Hubbard defines hedging as a form of *trade insurance* by which merchants, selling (buying) cotton of quality x spot, in advance of delivery, can protect themselves against price rises (falls) by buying (selling) contracts for future delivery (futures) of standard quality cotton[7]. Both categories of hedgers, buyers and sellers, are simultaneously present in the futures markets all the time, and most transactions originate with them and often offset each other. If "the methods of hedging were entirely perfect speculation would be utterly eliminated" (Hubbard 1923, p. 310). In this context, the main role of speculation in the futures market, the activity which aims to make profit from conjectural fluctuations in prices rather than from ordinary trade, is to equalize imbalances between supply and demand coming from hedgers.

Hubbard identifies two types of speculators: competent and incompetent and notes that merchants, producers and spinners become speculators themselves if they sell or buy cotton spot without offsetting this transaction by a reverse transactions in the future market.

Competent speculators operate on the basis of market fundamentals to whose investigation they devote *much reasoning taking the form of prolonged and systematic analysis*. *Competent speculators are calm and patient. When they reverse their positions but they do so gradually.* Their presence contributes to stabilize the market. Incompetent speculators, instead, constantly shift their position, often reversing it when they incur losses. They tend to be *convinced by the force of the market itself*, are prone over-enthusiasm and over-trading. Over-trading, in particular, is responsible for the confusing upward and downward zigzag patterns which can be observed on price charts[8].

[7] On this see also Hubbard (1931).

[8] Hubbard's observations confirm those of Chapman and Knoop (1907) as to the existence of expert and inexpert speculators in the Liverpool cotton futures market with the former having a stabilising influence on prices whereas the presence of the latter, possibly concomitant with market manipulation could have destabilising if short-lived effects on prices. Chapman and Knoop define inexpert speculators as follows "the public apt to be influenced as a crowd, to give way to panic or become unduly sanguine ... and easily misguided by bulling and bearing operations" (Chapman and Knoop 1907, p. 324 – 325).

2. Heterogeneous agent model of cotton price fluctuations

Hubbard's analysis of the cotton futures market, as discussed in Section 1 above, may be synthesized as follows: 1) speculation is based on market fundamentals and plays an essential role in determining futures prices, 2) two types of speculators exist: professional (fundamentalists) and non professional (noise traders), 3) deviations from fundamentals are mainly due to the public and to non professional speculators entering into the market.

We empirically test the validity of this description by extending the chartist-fundamentalist approach of Reitz and Westerhoff (2003) which, in turn, relies on previous analyses by Day and Huang (1990) and Lux and Marchesi (2000), among others.

As shown in Cifarelli and Paesani (2012), in the time period under investigation commodity markets are not informationally efficient in the sense of Fama (1970) and cotton price rates of change are serially correlated. Taking this into account, the present study posits that prices do not react only to exogenous news but have also a relevant endogenous driver which is attributed to the interaction of two groups of speculators, noise traders and fundamentalists that belong to two distinct and partially overlapping pools of variable size.

It is assumed that both fundamentalists and noise traders react – admittedly in a highly differing way – to a perception of market mispricing. Noise traders extrapolate the existing price trend and, introducing a positive feedback loop in the dynamics, raise price volatility. Fundamentalist contrarian behavior usually reduces price deviations from their normal (equilibrium) value and dampens market variability.[9]

Prices are set in an order driven market. Every period traders revise their long/short positions; price changes from t to $t+1$ are a function of their

[9] Assuming that the two groups of speculators partially overlap allows us to take into account the possibility that the same speculator shift from one behavior to the other according to the size of market disequilibrium. Interestingly, recent analysis of Keynes' ledgers and trading activity (Marcuzzo 2013) on the Liverpool cotton markets seems to identify a similar pattern.

excess demands and can be parameterized by the following log-linear function

$$p_{t+1} = p_t + a(D_t^N + D_t^F) + e_{t+1} \tag{1}$$

where p_t is the logarithm of the cotton spot/future price and a is a positive market reaction coefficient. The residual e_{t+1} accounts for additional agents that may impact on prices, such as hedgers, consumers and producers.
The demand of noise traders at time t is given by

$$D_t^N = a_1 S_{1it}(p_t - p_{t-1}) \tag{2}$$

where coefficient a_1 is positive as noise traders expect the existing price trend to persist in the subsequent time period. They will buy the commodity if Δp_t is positive and sell it if Δp_t is negative. Their overall impact is nonlinear and is given by $a_1 S_{1it}$ where S_{1it} is assumed to measure the fraction of the set of noise traders entering the market at time t, fraction which, in turn, will depend upon market conditions.
It is parameterized by the following logistic function

$$S_{1it} = \left[1 + \exp\{-\gamma_1(|N - p_{t-i}|/\sigma_{t-i})\}\right]^{-1} \qquad i = 0,...,l \tag{3}$$

N is the normal (equilibrium) price of the commodity spot/futures contract.[10]
It is assumed throughout that $N = \sum_{r=0}^{11} p_{t-r}/11$, i.e. that both fundamentalists and noise traders base their assessment of the normal equilibrium price on past observations up to three months.

[10] Following Schwartz and Smith (2000) and Ellen ter and Zwinkels (2010) we posit that the cotton price can be treated as the algebraic sum of two stochastic components: an equilibrium level *N* and a temporary deviation (N-p_t).

The larger the deviation of p_{t-i} from N, the stronger the perception of market disequilibrium and the larger the fraction of noise traders that will post orders on the market. The denominator of the signal to noise ratio, σ_{t-i}, is an index of price variability.[11] It accounts for the impact of risk. A higher (lower) risk associated with higher (lower) price volatility will reduce (increase) for a given perception of market disequilibrium, the willingness of speculators to enter the market. As in Reitz and Slopek (2009) S_t can take any value in the [0.5-1] interval as $|N - p_{t-i}|$ ranges from 0 (when $N = p_{t-i}$) to $+\infty$. It is assumed thus that at least 50 percent of potential noise traders operate in the market at any time t. Coefficient γ_1 is positive and captures the dynamics of the nonlinear behavior. The higher the synchronization of traders' reaction to price deviations from their normal level (a symptom of herding behaviour), the larger the value of γ_1. On the contrary, a low absolute value of γ_1 will reflect idiosyncratic reactions of traders to price disequilibria, possibly due to differing degrees of risk aversion.

The demand of fundamentalist speculators reads as

$$D_t^F = a_2 S_{2jt}(N - p_t) \tag{4}$$

where a_2 is a positive reaction coefficient. Fundamentalists posit that cotton prices are mean reverting i.e. that any deviation from their normal value N will but be temporary. They will buy cotton contracts whenever they deem them underpriced ($(N - p_t) > 0$) and sell if they believe them to be overvalued ($(N - p_t) < 0$), dampening in this way price fluctuations. Also the overall stabilizing impact of fundamentalists $a_2 S_{2jt}$ is assumed to be nonlinear. S_{2jt} measures the time varying fraction of the set of fundamentalist

[11] The value of the delay parameter *i* is determined empirically. On this see section 3.3. It depends upon the properties of the nonlinearity of the cotton price time series.

speculators that will enter the market at time t. It is parameterized by the following logistic function

$$S_{2jt} = \left[1 + \exp\left\{-\gamma_2 \left(\left|N - p_{t-j}\right| / \sigma_{t-j}\right)\right\}\right]^{-1} \qquad j = 0,...m \qquad (5)$$

which has the same properties of equation (3) above. Coefficient γ_2, however, reflects the dynamics of the fundamentalists' reaction to price deviations from N, which, as shall be seen in the empirical analysis, differs significantly from that of noise traders. Here too we assume thus that at least 50 percent of fundamentalist speculators are active in the market at any time t.

Combining equations (1) to (5) the impact of noise trader and fundamentalist speculators on cotton spot/futures trading is parameterized by the following nonlinear relationship

$$\Delta p_{t+1} = \frac{c_1}{1 + \exp\left\{-\gamma_1 \left(\left|N - p_{t-i}\right| / \sigma_{t-i}\right)\right\}} \Delta p_t + \frac{c_2}{1 + \exp\left\{-\gamma_2 \left(\left|N - p_{t-j}\right| / \sigma_{t-j}\right)\right\}} (N - p_t) + e_{t+1} \qquad (6)$$

where $c_1 = aa_1 > 0$, $c_2 = aa_2 > 0$, $i = 0,...l$, and $j = 0,...m$.[12]

3. Statistical analysis of cotton price dynamics

3.1 Empirical specification of the model

Cotton spot and futures price rates of change are heteroskedastic when the data are sampled, as is the case in this paper, with a weekly frequency. A

[12] The selection of the smooth transmission parameterization of equations (3), (5) and (6) is justified, according to Teräsvirta (1994), by the plurality of the agents that are involved in the decision process. Even if the single speculator takes a dichotomous decision, it is unlikely that all agents act simultaneously. Since the price series provide information on the aggregate decision process only, the overall impact will be smooth rather than discrete.

GARCH procedure is therefore used – following Lundberg and Teräsvirta (1998) – in order to estimate the second moments of the model.
The following system is used in the empirical investigation, where the specification of the conditional mean of the spot/futures cotton price rates of change is given by equation (6'), while the corresponding conditional second moments are parameterized as a GARCH(1,1) relationship

$$\Delta p_t = c_0 + \frac{c_1}{1+\exp\{-\gamma_1(|N-p_{t-1-i}|/h_{t-1-i})\}}\Delta p_{t-1}$$

$$+\frac{c_2}{1+\exp\{-\gamma_2(|N-p_{t-1-j}|/h_{t-1-j})\}}(N-p_{t-1})+e_t \qquad (6')$$

$$i=0,...l\,,\quad j=0,...m$$

$$h_t^2 = \omega + \alpha e_{t-1}^2 + \beta h_{t-1}^2 \qquad (7)$$

where $e_t = \nu_t\sqrt{h_t^2}$, and $\nu_t \sim IIDN(0,1)$

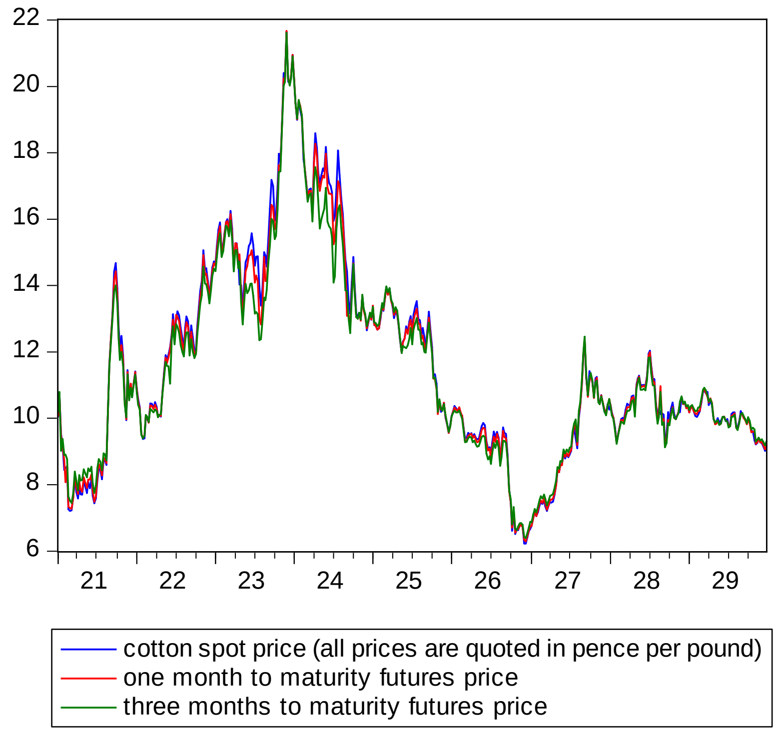
3.2 Preliminary Statistical Analysis

We employ weekly data on spot,[13] one month and three month futures prices for cotton, observed over the 7 January 1921 – 31 December 1929 time period. Weekly prices are Friday closing prices as recorded the following day. The prices come from the online archives of *The Times* (Sections: home commercial markets). They refer to the Liverpool American Future Contract, discussed in Section 1.1, and are quoted in pence and hundredths of a pence per pound. As can be seen from the graph set out in Figure 1, prices exhibit a cyclical behaviour, characterized by uneven bouts of volatility clustering;

[13] We use as spot price the price of the futures contract closer to delivery, that is with maturity in the current month.

whenever noise traders enter the market, we expect price variability to rise, whilst fundamentalist dominance is likely to exert a dampening pressure.

Figure 1. Cotton prices, 1921 – 1929



Price trends reflect underlying changes in demand, supply and total stocks. Between 1921 and 1924, stocks fell, as a result of damaged crops and increasing consumption, pushing prices up. Two large crops followed in 1925 and 1926 which led to lower prices and increasing stocks, in spite of sustained consumption. Finally, with a short crop in 1927 and an average crop in 1928 and 1929 the growth of stocks was reversed, contributing to the recovery and stabilisation of prices. [14]

[14] On this see Rowe (1936, pp. 102 - 103) and the section devoted to cotton in The *Special Memoranda on stocks of staple commodities*, written by J.M. Keynes for the London and Cambridge Economic Service (Keynes 1983) and Cifarelli and Paesani (2012), Appendix 1.

Summary statisics are presented in Table 1. Returns are computed as first differences of the logarithms of the price levels. The time series distributions are asymmetric and leptokurtic.

Table 1. Descriptive statistics

1921 – 1929			
	Δs_t	Δf_t^1	Δf_t^3
Mean	0.0004	0.0004	0.0004
Std.dev.	0.0374	0.0376	0.0364
Skew	0.2027	0.0926	0.1478
E.Kurt	1.3729	1.2606	2.2163
JB	39.1098 [0.0000]	30.9797 [0.0000]	29.8999 [0.0000]
Auto (1)	8.6581 [0.0030]	7.0993 [0.0080]	6.1570 [0.0130]
Auto (3)	9.4981 [0.0230]	7.5765 [0.0560]	7.6078 [0.0550]
ARCH (1)	51.5140 [0.0000]	40.9950 [0.0000]	34.358 [0.0000]
ARCH (3)	103.810 [0.0000]	81.6560 [0.0000]	69.6120 [0.0000]
JTA	36.8115 [0.0000]	41.5863 [0.0000]	25.9199 [0.0000]

Notes: Probability values in square brackets; Skew: Skewness; E.Kurt: Excess Kurtosis; JB: Jarque-Bera normality test; Auto (n): Ljung-Box test statistic for n-th order serial correlation; ARCH (n): Ljung-Box tests statistic for n-th order serial correlation of the squared time series; JTA: Joint Wald test of the null hypothesis of no asymmetry distributed as χ^2 with 3 degrees of freedom (Engle and Ng, 1993). The data have a weekly frequency over the sample period 7 January 1921 – 31 December 1929.

Intertemporal dependency of weekly returns seems to be stronger for cash than for futures weekly returns. Volatility clustering affects the time series, as shown by the significant serial correlation of the squared weekly returns. This finding supports the choice of a GARCH parameterization of the conditional second moments.

Howell (1939) contains extensive analysis of cotton production and trade in the 1920s and 1930s.

3.3 Quasi-ML model estimates

Parsimonious ML estimates of the nonlinear model, equations (6′) – (7) are set out in Table 2. The specification of the system is justified by an accurate preliminary investigation which follows the procedure suggested by Teräsvirta (1994). At first the order of the cash/spot return autocorrelations is selected on the basis of the Akaike Information Criterion; a one week lag provides uniformly the best fit. A test of linearity against the nonlinear parameterization of equation (6′) is then performed adopting the procedure of Luukkonen et al. (1988), as modified by Wan and Kao (2009). The transition functions S_{1it} and S_{2jt} are replaced in equation (6′) by third order Taylor series approximations and the following auxiliary equation is estimated

$$\Delta p_t = \lambda_0 + \lambda_1 \Delta p_{t-1} + \lambda_2 \Delta p_{t-1} w_{t-1-i} + \lambda_3 \Delta p_{t-1} w_{t-1-i}^2 + \lambda_4 \Delta p_{t-1} w_{t-1-i}^3$$
$$+ \delta_1 (N - p_{t-1}) + \delta_2 (N - p_{t-1}) w_{t-1-j} + \delta_3 (N - p_{t-1}) w_{t-1-j}^2 + \delta_4 (N - p_{t-1}) w_{t-1-j}^3 + u_t$$
$$k = i, j \qquad (8)$$

where $w_{t-k} = (N - p_{t-k})$, $\quad k = i, j$

We test linearity against STAR modeling - for various values of i and j - with the help of LM tests of the null hypothesis H_0: $\lambda_2 = \lambda_3 = \lambda_4 = \delta_2 = \delta_3 = \delta_4 = 0$. When $i = j = 0$, H_0 is uniformly rejected, as can be seen from the F-test statistics set out in the LM-NLT row of Table 2. The nonlinear parameterization is justified by the data. The time-varying fractions of noise traders and fundamentalists entering the market are thus parameterized in equation (6′) as S_{10t-1} and S_{20t-1}.

The overall quality of fit is satisfactory. The parameters of both the conditional mean and conditional variance relationships have the appropriate signs and are significantly different from zero. The usual misspecification tests suggest that the standardized residuals v_t are well behaved and that the serial correlation and heteroskedasticity of the original return time series are captured by the model ($E(v_t)=0$, $E(v_t^2)=1$, and both v_t and v_t^2 are

Table 2. Estimates of the nonlinear model: equations (6') – (7)

	Spot price i=0, j=0	One month futures price i=0, j=0	Three months futures price i=0, j=0
c_0	0.0002 (0.1305)	-0.0001 (-0.0987)	-0.0003 (-0.2241)
c_1	0.1777 (3.3157)	0.1813 (3.7764)	0.1563 (2.7812)
c_2	0.0933 (2.2487)	0.0937 (5.1898)	0.0689 (2.4154)
γ_1	3.3619 (2.0544)	2.4714 (2.0212)	1.6553 (2.0356)
γ_2	0.2153 (2.9473)	0.2480 (2.6484)	0.2787 (2.7919)
ω	0.58e10-5 (2.1022)	0.68e10-5 (2.0707)	76e10-5 (3.0610)
α	0.1920 (5.1078)	0.2021 (5.0730)	0.2200 (6.3950)
β	0.7729 (18.7141)	0.7589 (17.6260)	0.7358 (18.1371)
LLF	898.0678	889.4270	904.7378
Standardized residuals diagnostics			
$E[v_t]$	0.0046	0.0065	0.0085
$E[v_t^2]$	0.9730	0.9684	0.9683
Skew	0.1489	-0.0308	0.02400
E.Kurt	0.6934	0.8564	1.0112
Auto(1)	0.9450 [0.3310]	0.5640 [0.4527]	0.8430 [0.3586]
Auto(3)	3.477 [0.3237]	1.3370 [0.7205]	2.4240 [0.4893]
ARCH(1)	0.1089 [0.7414]	0.3971 [0.5286]	0.3351 [0.5627]
ARCH(3)	3.5247 [0.3176]	6.8239 [0.0777]	2.1407 [0.5437]
JTA	7.7999 [0.0503]	7.6157 [0.0547]	4.1759 [0.2431]
JB	11.1287 [0.0038]	14.4085 [0.0007]	20.0258 [0.0000]
LM-NLT	4.4227 [0.0002]	4.1432 [0.0004]	4.2941 [0.0003]
LM-RNLT	1.4887 [0.1802]	2.1422 [0.0476]	2.4326 [0.0252]
LRT(c_1=γ_1 =c_2=γ_2=0)	9.6776[0.0462]	9.4001[0.0497]	7.4756[0.1127]

Notes. t-ratios in parentheses and probability values in square brackets; LLF: Log Likelihood value; Skew: Skewness; E.Kurt: Excess Kurtosis; JB: Jarque-Bera normality test; Auto(n): Ljung-Box test statistic for n-th order serial correlation; ARCH(n): Ljung-Box tests statistic for n-th order serial correlation of the squared time series; JTA: Joint Wald test of the null hypothesis of no asymmetry; LM-NLT: LM non-linearity test; LM-RNLT: residual non-linearity test; LRT(x=0): likelihood ratio test of the null hypothesis x=0. The data have a weekly frequency over the sample period 7 January 1921 – 31 December 1929. The sample includes 469 observations.

serially uncorrelated). The estimates of equation (6′) reflect the autocorrelation of the cotton spot and futures return time series; the tenets of the efficient markets theory do not apply to the cotton market of the 1920s. The JTA sign bias tests of Engle and Ng (1993) support the choice of a symmetric conditional variance parameterization since the strong asymmetry of the original return time series detected in Table 1 is filtered out by the specification of the conditional means. The conditional normality of the standardized residuals, however, is rejected by the Jarque Bera test statistics. The t-ratios reported in Table 2 are therefore based on the quasi-maximum likelihood estimation procedure of Bollerslev and Wooldridge (1992). Finally, the F-test for no remaining nonlinearity, set out in the LM-RNLT row (see Eitrheim and Teräsvirta, 1996, pages 63-65), suggest that the model accounts for the nonlinearities of the data, especially those of the spot/cash return time series.

The conditional mean estimates support the nonlinear parameterization of the noise trader/fundamentalist behavior, especially in the case of the spot/cash and one month to maturity futures contracts. The coefficients, as shall be shown below, identify a complex dynamic reaction to price deviations from their normal value.[15] The coefficients of the three month to maturity contracts are smaller in absolute value and detect a systematic reduction in the speed of market reaction to price movements. Trading seems to become less frequent and the relevance of both noise traders and fundamentalists decreases with the maturity of the futures contracts. Indeed, the GARCH parameters detect a progressive decline in informational efficiency since volatility seems to be more affected by past innovations and less sensitive to own lagged values as contract maturity rises.

[15] The LR tests set out in table 2 show that, with the exception of the three month to maturity contract, the joint hypothesis that the noise trading and fundamentalist parameters are nil is rejected at the 5 percent level of significance.

4. Fundamentalist and noise traders' pricing dynamics

The value of the speed of adjustment coefficients, differs according both to the nature of the speculator and to the type of contract. The value of γ_1 is always larger than that of γ_2, denoting a striking difference in the reaction to the same amount of information, i.e. to deviations of past period's prices from their normal value $(N - p_{t-1})$. As shown in Table 3, The value of the means, median and standard deviations relative to noise traders exceed those of fundamentalists, over the three contracts. As the maturity of the contract rises the fraction of noise traders entering the market tends to decline, whilst the fraction of fundamentalists tends to rise; destabilizing speculation tends to focus on the spot and on the one month to maturity futures sections of the cotton market.[16]

Table 3. Descriptive statistics of the S_{10t-1} and S_{20t-1} time series

	Spot/cash prices		One month to expiration futures price		Three months to expiration futures price	
	S_{10t-1}	S_{20t-1}	S_{10t-1}	S_{20t-1}	S_{10t-1}	S_{20t-1}
Mean	0.9013	0.5677	0.8647	0.5755	0.8192	0.5857
Median	0.9768	0.5596	0.9258	0.5630	0.8377	0.5686
St.dev.	0.1384	0.0491	0.1489	0.0562	0.1475	0.0612
AR(1)	0.2940	0.5870	0.3830	0.5930	0.4710	0.5730
$\rho_{S_{10t-1},S_{20t-1}}$	0.7346 [0.0000]		0.8085 [0.0000]		0.9043 [0.0000]	
$\rho_{S_{h0t-1},(N-p_{t-1})^+}$ $h=1,2$	0.6983 [0.0000]	0.6874 [0.0000]	0.7179 [0.0000]	0.6925 [0.0000]	0.7593 [0.0000]	0.7211 [0.0000]
$\rho_{S_{h0t-1},(N-p_{t-1})^-}$ $h=1,2$	-0.6317 [0.0000]	-0.6370 [0.0000]	-0.6572 [0.0000]	-0.6530 [0.0000]	-0.6925 [0.0000]	-0.6675 [0.0000]

Notes. Probability values in square brackets; St.dev. Standard deviation; AR(1): first order autocorrelation coefficient.

[16] This finding is consistent with Hubbard when he observes that "The volume of speculative dealings in spots is certainly not less than the percentage given for futures after examination; it is probably more" (Hubbard 1923, p. 434).

The first order autocorrelation of the S_{10t-1} time series (noise traders entering the market) is smaller than the corresponding autocorrelation of S_{20t-1} (the fraction of fundamentalists that enter the market). Indeed, noise traders tend to enter and exit the market frequently, even if, as the time to maturity of the contract rises, regime persistence rises.[17] As a consequence the correlation $\rho_{S_{10t-1},S_{20t-1}}$ between chartist and fundamentalist reaction to price deviations from their fundamental value too rises with time to maturity.

As shown in the last two rows of Table 3, there is a relevant asymmetric correlation between S_{10t-1} and positive and negative values of $(N-p_{t-1})$, $(N-p_{t-1})^{+}$ and $(N-p_{t-1})^{-}$. Noise traders do not react to both negative and positive price shifts in a similar way. They are more prone to enter the market when $(N-p_{t-1})$ is positive than when it is negative, i.e. they react more to price downswings (in a panic) than to price upswings (in a period of price euphoria). In the same way the correlation with S_{20t-1} is significantly larger when $(N-p_{t-1})$ is positive than when it is negative, as fundamentalists seem to react more to under-pricing (going long) than to overpricing of the cotton contracts (going short).

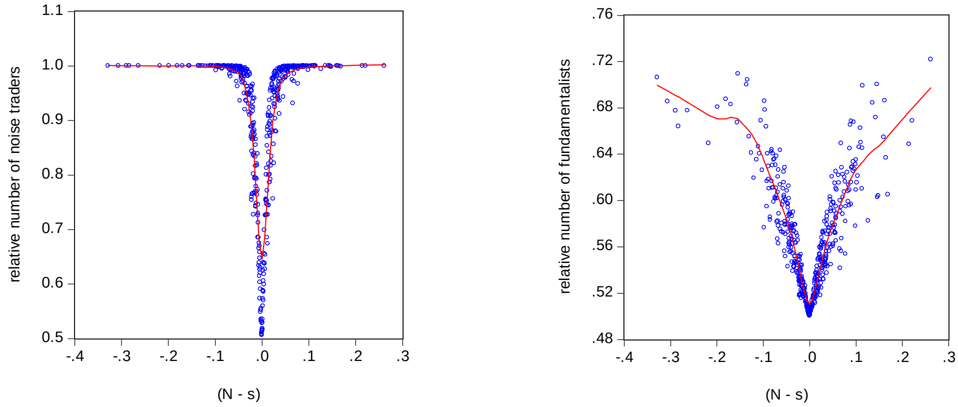
In Figure 2 are set forth scatter plots of the transition functions of noise trader and fundamentalist speculators against deviations of cotton spot/cash and futures prices from their fundamental value. We have interpolated the scatter plots using local first order polynomial regressions with bandwidth based on the nearest neighbor approach.[18]

[17] Ellen ter and Zwinkels (2010) follow De Jong et al (2009)) and attribute strategy persistence to a relevant status quo bias.

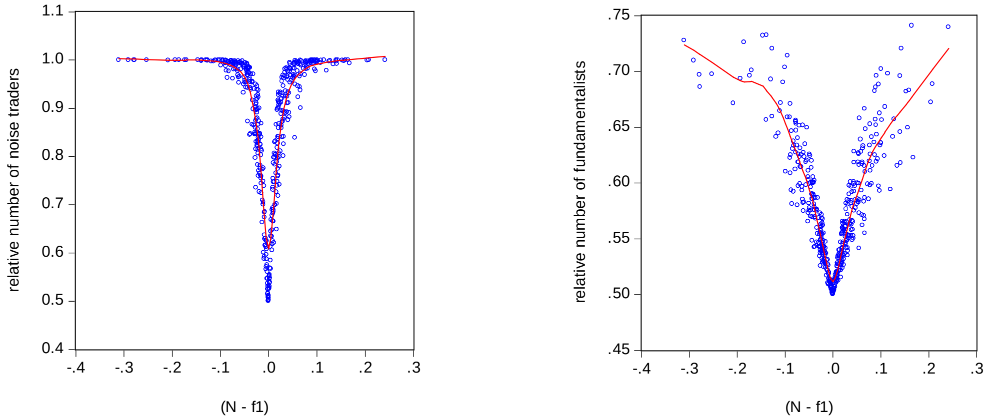
[18] The local regressions are performed on a sub sample selected according to the Cleveland (1993) procedure and involves about 100 evaluation points. Tricube weights are used in the weighted regressions used to minimize the weighted sum of squared residuals. The bandwidth span of each local regression is set to 0.3.

Figure 2. Nearest neighbor interpolations of the scatter plots of S_{10t-1}, S_{20t-1}, and price disequilibrium

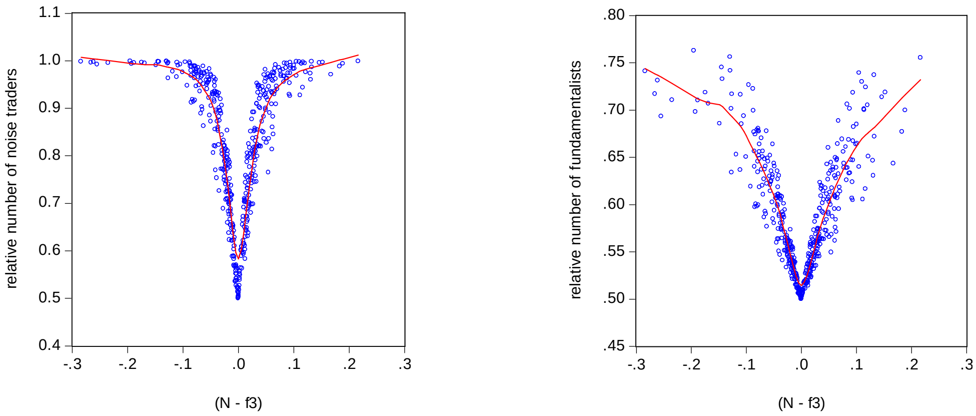
Spot/cash contracts



One month to maturity futures contracts



Three months to maturity futures contracts



The shape of the nearest neighbor fit is highly informative and reflects the differing values of the transition parameters γ_1 and γ_2. Noise traders seem to herd in their reaction to price misalignments; small positive/negative price deviations from their normal (equilibrium) values bring about a large simultaneous increase in their relative number, with a destabilizing impact on pricing. As expected simultaneity decreases with the time of expiration of the contracts, since the absolute value of the transition parameter γ_1 declines.

The scatter plot of fundamentalist speculation reflects a different reaction to price deviations from their three-month moving average. Whereas the value of S_{10t-1} is close to 1 for values of $(N - p_{t-1})$ that lie in the +/-.1 rate of change band, the corresponding value of S_{20t-1} is much smaller, and varies from 0.64 to 0.70 according to the maturity of the contracts. The relative number of fundamentalists grows but slowly as their stabilizing reaction seems to be affected by a growing degree of risk aversion. Increases in the number of speculative positions are brought about by price deviations from equilibrium that are progressively larger in absolute value and the slope of the nearest neighbor fit of the scatter plot declines as the absolute value of the misalignments rises. Risk aversion is larger in absolute value for negative than for positive values of $(N - p_{t-1})$, as fundamentalists seem to be more wary to enter the market when the cotton contracts are overpriced than when they are underpriced, a finding that is corroborated by the relative values of the correlation coefficients $\rho_{S_{20t-1},(N-p_{t-1})^{+}}$ and $\rho_{S_{20t-1},(N-p_{t-1})^{-}}$, set out in Table 3.

As expected, fundamentalist speculation stabilizes market prices. In order to quantify this effect we perform a dynamic ex post (historical) simulation exercise. First, we simulate the non-linear chartist contribution to the price determination process i.e. $C_X = c_1 \left[1 + \exp\{-\gamma_1(|N - p_{t-1}|/h_{t-1})\}\right]^{-1} \Delta p_{t-1}$. Second, we repeat the exercise calculating the combined contribution of both noise traders and fundamentalists i.e.

$$C_X + C_F = c_1 \left[1+\exp\{-\gamma_1(|N-p_{t-1}|/h_{t-1})\}\right]^{-1} \Delta p_{t-1}$$
$$+ c_2 \left[1+\exp\{-\gamma_2(|N-p_{t-1}|/h_{t-1})\}\right]^{-1} (N-p_{t-1})$$

We then compute the standard errors of the two simulated time series and find that the relative decrease in speculative price variability, due to the market entry of fundamentalists $[STD(C_X) - STD(C_X + C_F)]/STD(C_X)$, takes the following values: 0.156 in the case of spot prices, 0.161 in the case of one month to maturity futures prices and 0.181 in the case of three months to maturity futures prices. These findings corroborate the hypothesis that fundamentalist speculators bring about stabilizing price adjustment, dampening the short term impact of noise trading in the context of a model that accommodates for a time varying entry of economic agents into the market that is led by disequilibrium perceptions. Here too the impact of fundamentalists grows with the time to maturity of the contracts.

5. Conclusions

Building on preliminary historical and institutional reconstruction, our analysis of speculation in the Liverpool cotton futures market validates the choice of applying a behavioural finance approach to historical data. This assertion is justified both by the quality of the empirical findings and by the their coherence with the main conclusions of qualitative analyses performed in the 1920s and 1930s. In particular, we find a strong analogy between Hubbard's distinction between competent and incompetent speculators and our own noise traders and fundamentalist speculators.

Based on these considerations, our main findings may be summarized as follows. First, the entry into the market of speculators varies over time and is affected by different reactions to a common perception of market disequilibrium. Second, whereas noise traders tend to herd, fundamentalists are more affected by risk aversion and react asymmetrically more to underpricing than to overpricing of the cotton contracts. Third, the presence of fundamentalists stabilizes the market.

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