

Can We Forecast Cocoa Butter Prices?

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Vlad Peksa is a director of Mintec Ltd, a leading company in the field of providing pricing and fundamental information to the food industry as well as in analysis and consultancy. The company motto is: “Data and information are not knowledge; they are like any raw materials, requiring some intervention and processing to make them useful”.

Introduction

I am a statistician by profession, so I am frequently asked for assistance with problems related to data analysis. Of course, everyone expects an answer to an innocent question: What is going to happen to the price?

If somebody asks me whether or not I can forecast cocoa (or soyabeans, crude oil, butter, beef etc.) prices, I answer without hesitation: “Of course I can, no problem - prices will either go up, down or, exceptionally, may stay steady”. That somebody (if they listen to my answer) becomes uneasy about it and expects a serious answer from me. Then comes my second answer: “If I could, I would be a millionaire now and would be drinking gin and tonic under the sun in the Bahamas”.

The really serious answer is - categorically NO; if somebody tells you a different story do not believe them. Nobody has a crystal ball. However the situation is not as bad as I have painted it. We can employ all sorts of wizardry to at least partly achieve our objectives.

In this article I investigate various approaches to price extrapolation. I will illustrate how analysis might proceed in the cocoa bean and cocoa product markets.

There are a number of elements to look at:

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1 The Product

Cocoa products are made from cocoa beans, which are the kernels of the cocoa fruit. These fruit are shaped like a miniature rugby ball, with each containing approximately forty seeds. These seeds are the actual cocoa beans and each weighs about one gram. The beans are white at the time of harvesting, when they are collected along with fruit pulp. They are then covered. The preparation of the beans is important in developing the flavour of the cocoa products. During fermentation the distinctive aroma is created, while the bean turns dark brown. After fermentation the beans are dried, preferably in the sun.

Drying reduces the moisture content from about 60% to about 7.5%. This must be performed slowly to allow oxidation and to prevent the development of bitter or off-flavours and mould. Where possible, sun drying is used. However if the weather is not dry and sunny, artificial drying methods may be employed, such as drying beans over fires or using heat exchangers. This can sometimes lead to poor quality beans because of smoke contamination or if the beans have been dried too quickly. The dried beans are then put into sacks and taken to a port for shipping.

The dried beans are cleaned and shelled and the nib is roasted. The roasted nibs are ground to produce cocoa liquor (cocoa particles suspended in cocoa butter), which at that stage is liquid due to the high temperatures arising from friction during grinding. The grinding process yields approximately 80kg cocoa liquor for every 100kg cocoa beans. Cocoa liquor is pressed to extract the cocoa butter leaving behind the solid material called cocoa cake, which is broken up and pulverised to form cocoa powder. 80kg of liquor will yield approximately 40kg of butter and 40kg of powder.

Cocoa butter is combined with additional cocoa liquor to be processed into chocolate. Other ingredients are combined with the cocoa products to make different types of chocolate:

Dark chocolate = cocoa liquor + cocoa butter + sugar + flavourings, e.g. vanilla
Milk chocolate = cocoa liquor + cocoa butter + dried milk + sugar + flavourings
White chocolate = cocoa butter + dried milk + sugar + flavourings

Note that white chocolate does not contain any cocoa liquor.

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2. The Marketplace

Cocoa beans are traded as spots (or 'Cash' – i.e. trading goods which are immediately available) or on the two futures markets: London and New York. Cocoa beans bought in the EU are almost entirely West African and the Indonesian crop is mainly sold in the US. Cocoa is a very sensitive market because of highly speculative elements in the futures markets. Due to the different sources and customer bases, the two futures markets are often unrelated.

The ICCO daily indicator price for cocoa beans is calculated using the average of quotations of the nearest three active future trading months on the London Euronext Market and on the New York Board of Trade Futures Exchange at the time of the London close.

Cocoa butter and cocoa powder are traded priced as a ratio of the cocoa bean price. This mechanism allows the sharing of risk between the buyer and seller, as the actual price will vary in line with the variation in cocoa bean prices. These ratios usually remain stable while market factors affecting the cocoa market remain stable. These include supply and demand for cocoa beans, and also for cocoa butter and cocoa powder, as 'twin' products. Processors must sell the same amount of cocoa powder by-product as cocoa butter and the profitability of the operation depends on the prices of both products. In theory, if demand for cocoa butter is high, and prices are high, manufacturers may be prepared to lower the price ratio for cocoa powder, and vice versa. Similarly, if supply of cocoa beans is high, ratios are likely to be lower. In the case of cocoa butter, different ratios may be fixed for each standard quality of cocoa butter by bargaining between parties on the terminal markets.

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3. The Basic Overview

Since cocoa butter is produced from cocoa beans, it would be reasonable to expect that when bean prices move, cocoa butter prices would follow. From Figure 1 it would appear so for the most of the time (note the different direction of movement in 2002!). However, if we index prices and compare, most of the time they move at different rates.

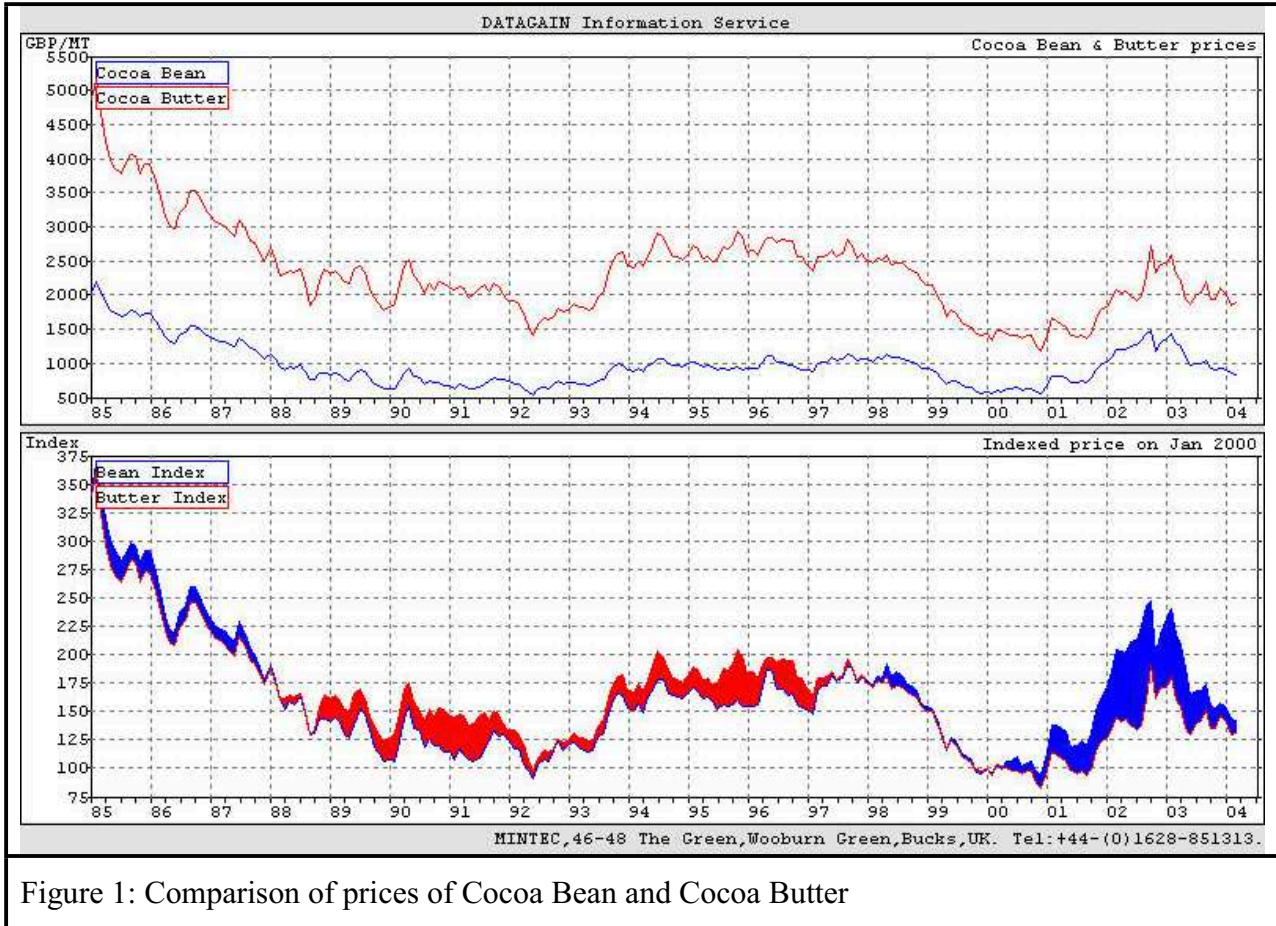


Figure 1: Comparison of prices of Cocoa Bean and Cocoa Butter

In summary: Some relationship is observable, but nothing firm can be concluded from a quick inspection.

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4. Investigate Price Relationships in the Product Market

The results of a visual approach can be confirmed by a statistical method. I would like to calculate a correlation coefficient evaluating a similarity between two series. The correlation coefficient varies from +1 to -1: A coefficient of 0.0 shows complete independence of the series; +1.0 shows a perfect positive relationship between two series (if one goes up, the other goes up too); -1.0 shows a perfect negative relationship (if one goes up, the other goes down). Anywhere in between the extreme values shows a degree of relationship. A close positive relationship is indicated by values of 0.85 and above¹.

In the matrix below, the numbers to the right, above the diagonal, are correlations of long-term data (1990-2003) while to the left, below the diagonal, are correlations of data over an 18 month

¹ Technical Note: Standard correlation cannot be used as a priori statistical conditions are not satisfied, but it is feasible to use Spearman correlation based on a rank non-parametric method.

period (mid 2002 to end 2003).

Long Term Data

	Cocoa Butter	Cocoa Powder	Cocoa Beans	White Sugar	Hardened Palm Kernel Oil	Crude Soyabean Oil	Crude Palm Oil	Whole Milk Powder
Cocoa Butter	n/a	-0.42	0.71	0.56	0.53	0.80	0.67	-0.56
Cocoa Powder	0.90	n/a	0.18	-0.49	-0.46	-0.23	-0.26	-0.56
Cocoa Beans	0.86	0.75	n/a	0.11	0.34	0.69	0.65	-0.07
White Sugar	0.69	0.71	0.84	n/a	0.22	0.43	0.25	0.72
Hard. Palm Kernel Oil	0.27	0.05	0.09	-0.20	n/a	0.60	0.83	0.37
Crude Soyabean Oil	-0.09	-0.29	-0.32	-0.55	0.53	n/a	0.84	0.35
Crude Palm Oil	0.28	0.05	0.10	-0.18	0.95	0.62	n/a	0.39
Whole Milk Powder	-0.69	-0.60	-0.76	-0.82	-0.32	0.27	-0.37	n/a

Short Term Data

Note: Hardened Palm Kernel Oil is a fat used in many confectionery and compound chocolate applications.

It can be deduced that:

- Long term data is usually correlated at different levels as compared to correlation of short-term data.
- If the series are TRULY related, long-term correlation is usually higher than short term correlation. An example is the mutual dependence of Soyabean Oil and Palm Oil, where price movements of one tend to affect the other.
- The best correlations are in the vegetable oils area. A close relationship between Palm Oil and Soyabean Oil prices is not surprising (see (b) above). Somewhat surprising is long term 0.83 between Crude Palm oil and Hardened Palm Kernel oil and even more the table highest in the short term 0.95. Further analysis shown that this relationship is strong in the steadily rising markets but falls apart in the fast falling market.
- The best correlation (not shown in the matrix) was found between lauric oils (Palm Kernel and Coconut): Long-term correlation is 0.98 and short term 0.96.
- Some spurious relationships came to light - the higher the price of sugar, the cheaper the price of milk powder (and vice versa)!
- The relationship between cocoa, cocoa butter and cocoa powder is somewhat variable. One would expect a high positive correlation between cocoa bean and butter prices and high negative correlation between cocoa powder and cocoa butter/bean (as the market prices are ratio based - see Section 2 above). Note especially the very low long-term correlation (0.17) between cocoa bean and powder. The implications of this unsatisfactory relationship is that some other market forces are breaking the expected dependence.

In summary: Cocoa butter prices are related (in the statistical sense) to cocoa bean but not to cocoa powder. The relationship to cocoa bean is reasonably reliable in the short term but in the longer term this relationship breaks down on a number of occasions. This suggests that the butter/bean ratio is not stable and warrants a further analysis.

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5. Analyse Feedstock Commodities

This is a very important analysis when there is a clear progression of the raw material in the chain. For example, typically production of ethylene is based on crude oil and subsequently polyethylene’s major input material is ethylene. This progression does not apply to cocoa.

However, there is a clear material relationship and a tentative price relationship between cocoa bean and cocoa butter and powder as its products (See Section 4 above). This relationship requires a detailed analysis.

5a. Analysis of Cocoa Butter and Powder Ratios

For decades, the combined ratio of cocoa butter and powder was around 3.0 (Butter was around 2.4 and powder around 0.6). These were derived from the relative values attributed to butter and powder products. In another words cocoa butter was usually four times as expensive as cocoa powder. If butter ratio went down in price, the powder ratio went up and vice versa. A brief look at the ratios in Figure 2 seems to support this view. A more detailed look suggests that from about 1998 this pattern might have broken.

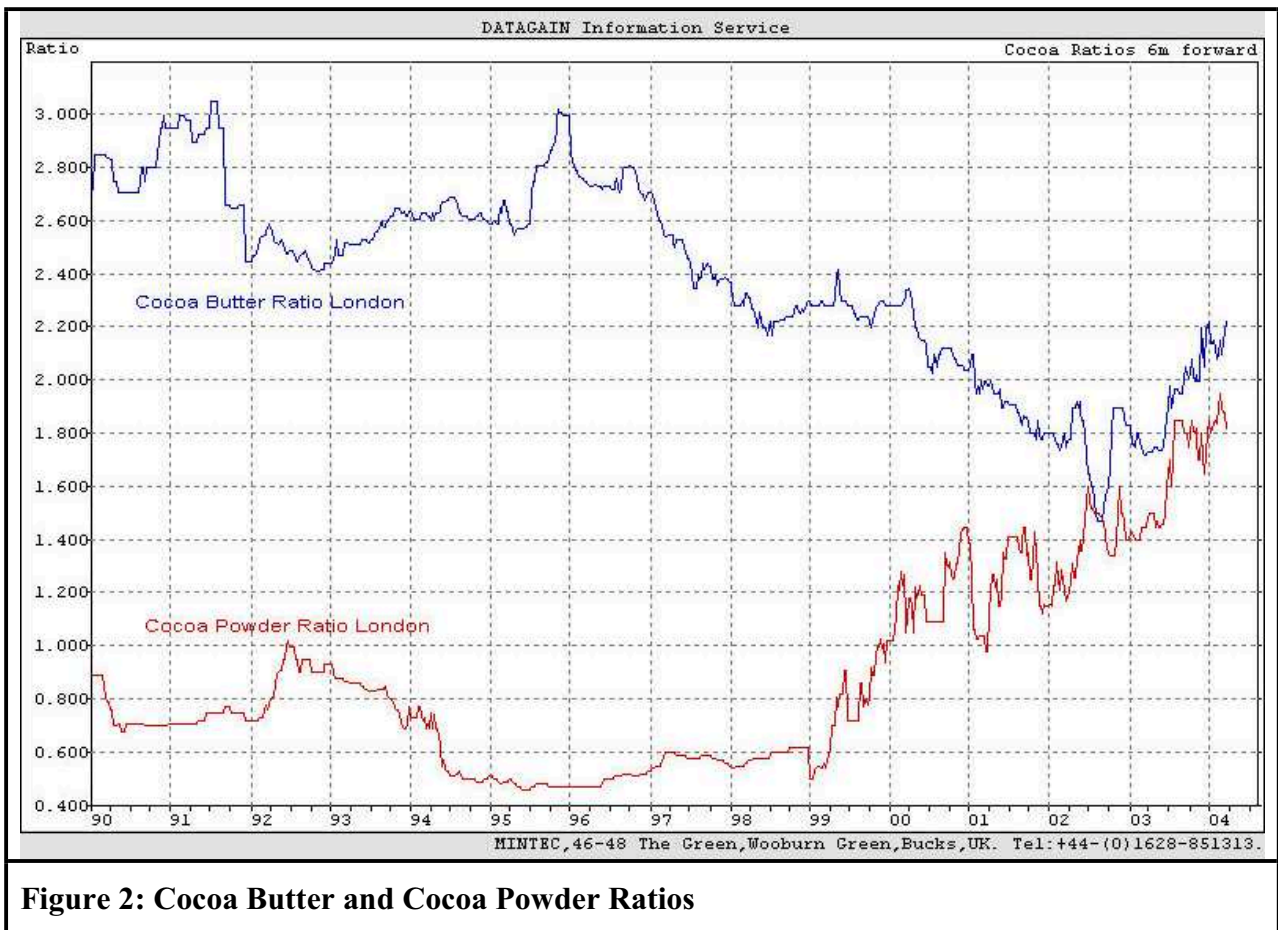


Figure 2: Cocoa Butter and Cocoa Powder Ratios

I have decided to investigate this pattern change using an alternative approach. Butter and powder ratios are set (in principle) by product manufacturers (the grinding industry). The grinders will not grind unless they can maintain profit margins. In Section 1 we noted that each tonne of beans yields 400kg of butter, 400kg of powder while 200kg is disposed of or lost. Figure 3 shows the processing margin based on this simplified calculation:

$$\text{Margin} = \text{Bean Value} - \text{Bean}$$

where Bean is Cocoa Euronext London and Bean Value is calculated from the product prices based on ratio values: $\text{Bean Value} = 0.4 \times (\text{Butter Ratio} \times \text{Bean} + \text{Powder Ratio} \times \text{Bean})$.

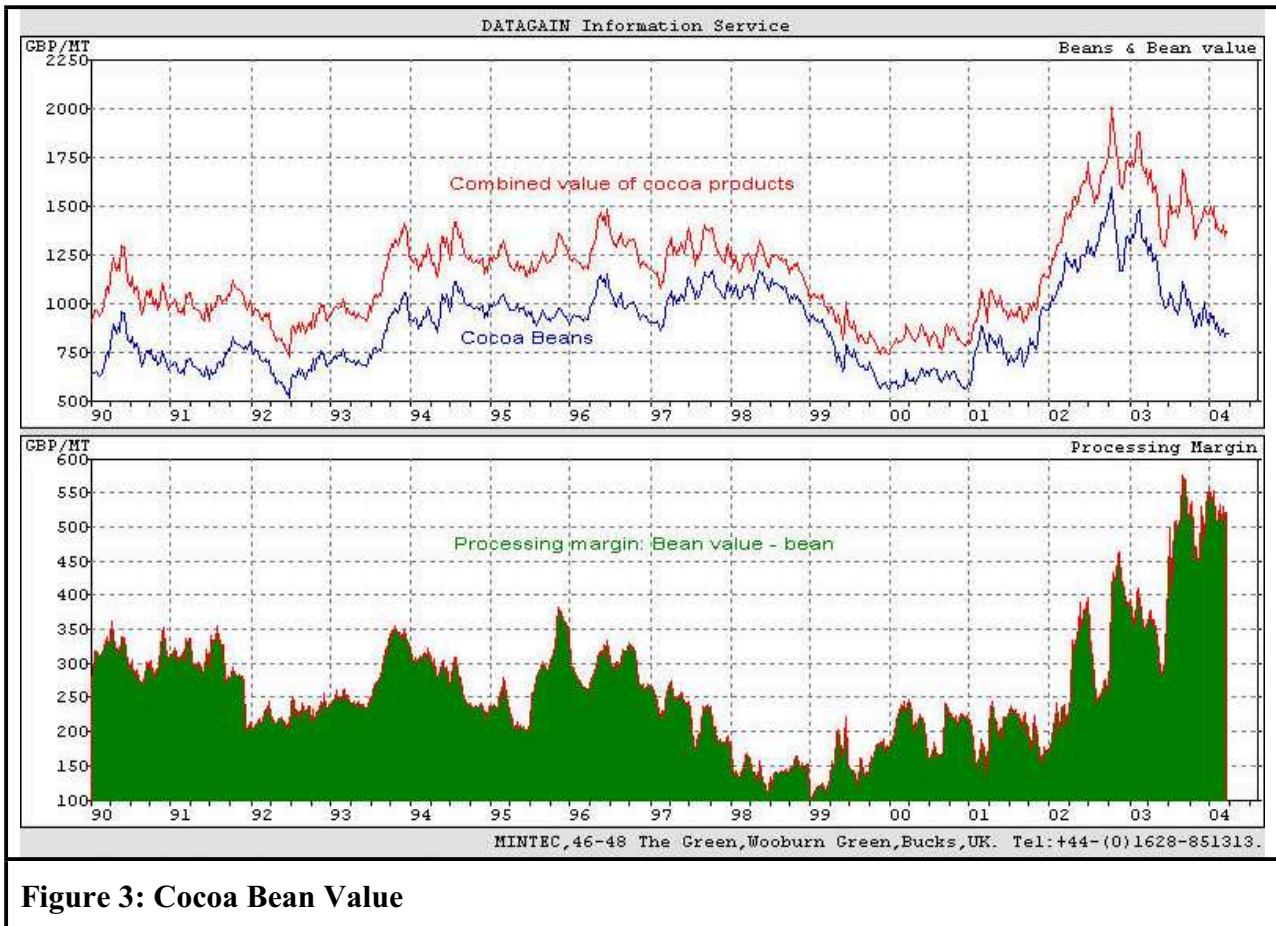


Figure 3: Cocoa Bean Value

The analysis suggests that the margin was steadily decreasing until the beginning of 1999 when it started to increase. The margin in January 1999 was GBP100 which was an inadequate reward for processing. That discouraged grinders from grinding and stocks were gradually depleted. That in turn led to price increases which in turn provided a higher margin. The 2004 margin of about GBP500 seems excessive. While calculating processing margin we decided to look at the combined ratio as shown in Figure 4.

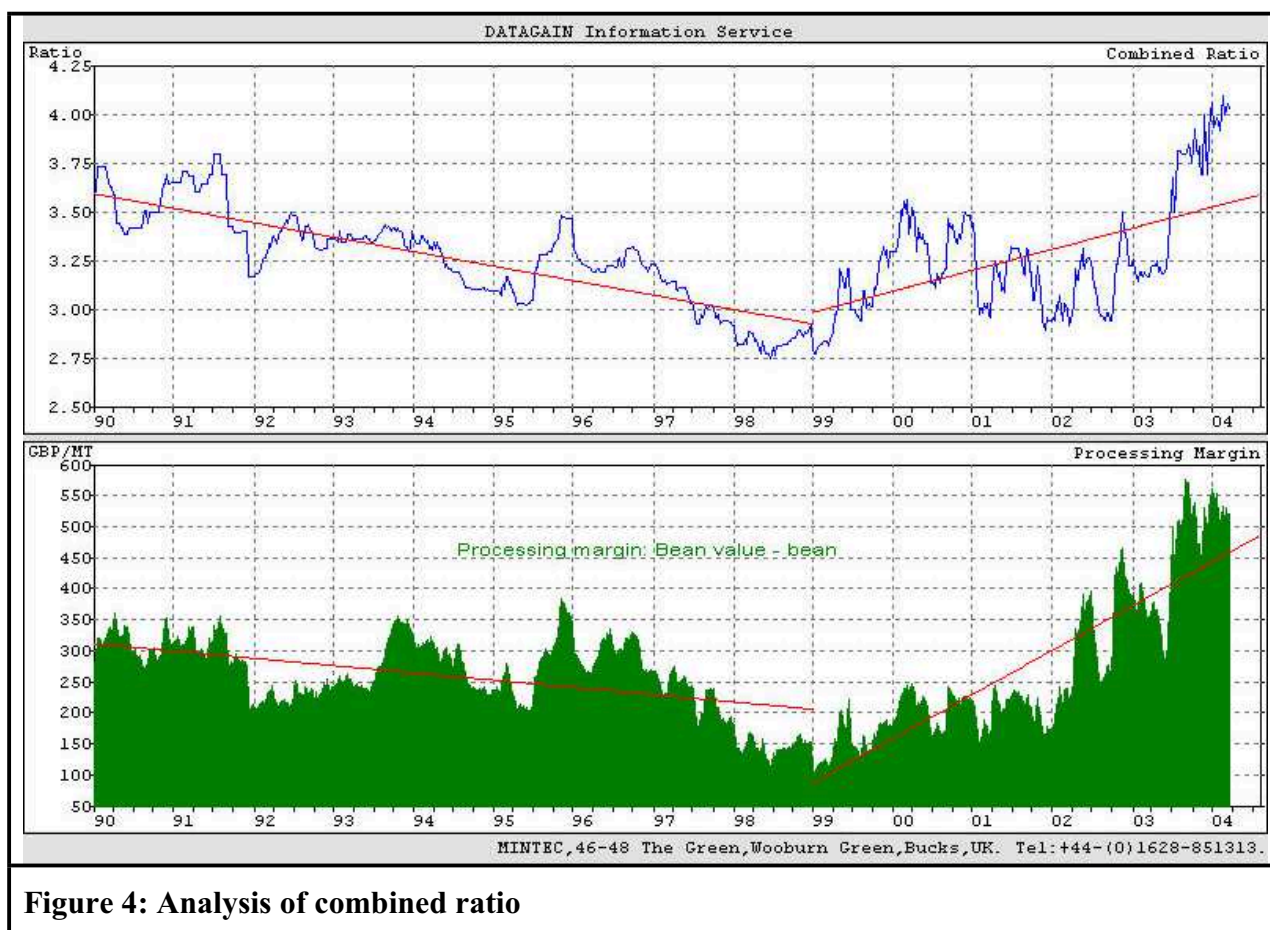


Figure 4: Analysis of combined ratio

The picture speaks for itself. The two entirely different periods of time show different trends in both panels (Combined ratio at top; Processing margin at bottom). However while on the surface the trends look very similar, there are differences.

6. Analyse the Situation in Related and Competing Products

This approach is fruitful when two or more commodities are competing for the same application – e.g. soyabean oil vs. rapeseed oil vs. palm oil.

With regard to cocoa very little analysis can be done in this area, as there are no similar products to cocoa bean. As far as cocoa butter is concerned a few quality substitutes (Cocoa Butter Equivalents based on palm oil, shea butter, illipe butter, kokum butter, mango kernel and sal fats) are relatively rare and are not freely quoted in the market place and therefore no objective comparison can be made. A possible influence on the structure of the cocoa products market is an increased usage of lauric-based fats in Cocoa Butter Substitutes (primarily used in compound chocolates). However this influence cannot easily be quantified.

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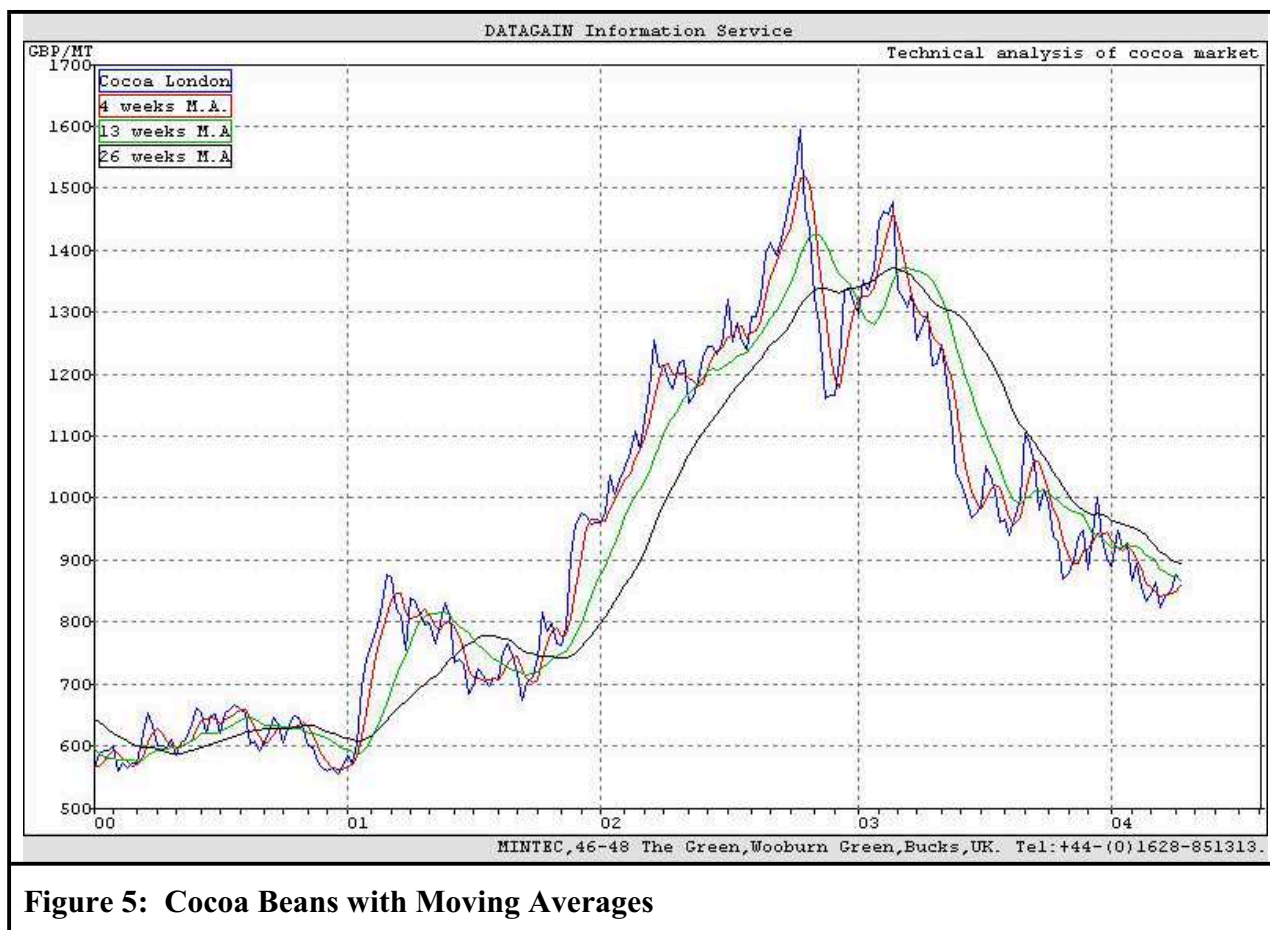
7. Technical Analysis

This is often incorrectly referred to as ‘charting’. These techniques have been applied with some success in futures and financial markets, but little success was derived from their application in the physical commodity markets. Therefore the examples in this section show the behaviour of the Cocoa Beans LIFFE market.

In principle the objective of technical analysis is to identify trend changes at an early stage when a trading decision is made and maintained until there are indications that the trend has reversed.

The data are looked at primarily in two different ways (various techniques are discussed in specialist books, such as [1]):

- (a) Subjective - through graph patterns and comparing with similar movements in the history. The longer the history the more reliable is the result. This approach ignores any reasoning for the price movements and is based on pure sentiment.
- (b) Analytical – based on imperfections in the market place. The various indicators are calculated and their evaluation suggests whether the market is overbought or oversold in a short, medium or long term. An example of this is given below.



General interpretation of a few buzz-words and hints on how to use this information:

TRENDS: Watch for price crossing the trend line.

MOVING AVERAGES: A change from a rising to a declining market is signalled when a price crosses its moving average and falls below it.

MOVING AVERAGES: Market is selling when a short term MA (on the way down) is crossing

a long term MA (on the way up). Market is buying when a short term MA (on the way up) is crossing a long term MA (on the way down).

And some other words, not illustrated in Figure 5:

MOMENTUM: Market is selling when momentum is above the overbought¹ line and crossing it on the way down. Market is buying when momentum is below the oversold² line and crossing it on the way up.

RELATIVE STRENGTH INDEX: Generally an overbought line is at 70%, an oversold line is at 30%. Watch for the proximity to these lines.

VOLATILITY: Define from history medium and high volatility levels. 15 and 30 work generally quite well. Watch your buying (or selling) activity when market is highly volatile.

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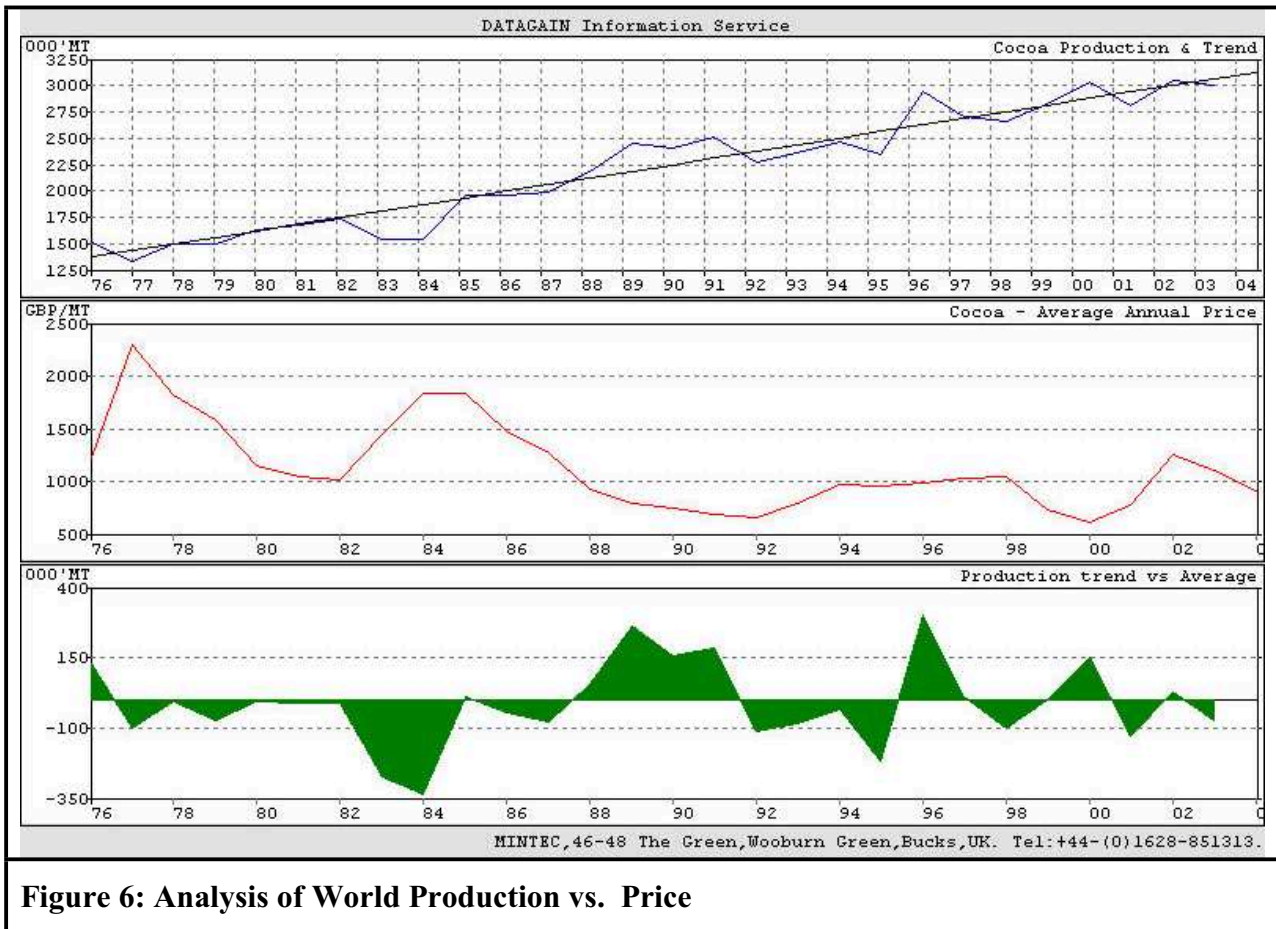
¹ 'Overbought' is a technical condition that occurs when prices are considered too high and susceptible to a decline.

² 'Oversold' is a technical condition that occurs when prices are considered too low and prices are expected to rally.

8. Analysis of Fundamental (Supply/Demand) Parameters

8a. Supply/Demand Situation in the Primary Market

The analysis of cocoa production shows a fairly steady trend since 1977 when Ivory Coast embarked on a new ambitious planting programme. In the 80's the demand started to lag behind the supply (despite two poor harvests in 1983-84 and 1984-85). In the 90's the demand caught up. From Figure 6 it becomes apparent that in years when the crop is below the trend the price of cocoa beans moves down and vice versa in years of poorer crop the price goes up. Compare poor harvests in 1983-84 and 1984-85 resulting in a near doubling of the price in that period. Also an above average crop in the new millennium resulted in a price drop followed by price increases in the following year when crop was below average.



In the new millennium the increase in demand has slowed down and the supply/demand scenario remains more or less in balance. The outlook will change only if there is a huge crop failure.

In many markets extra information can be gained via the analysis of basic fundamental factors (Production, Yield, Stocks, Trade Statistics, and Consumption) and relating them to price. In the cocoa market some factors are not available, but a useful relationship can be found by comparing stocks and prices.

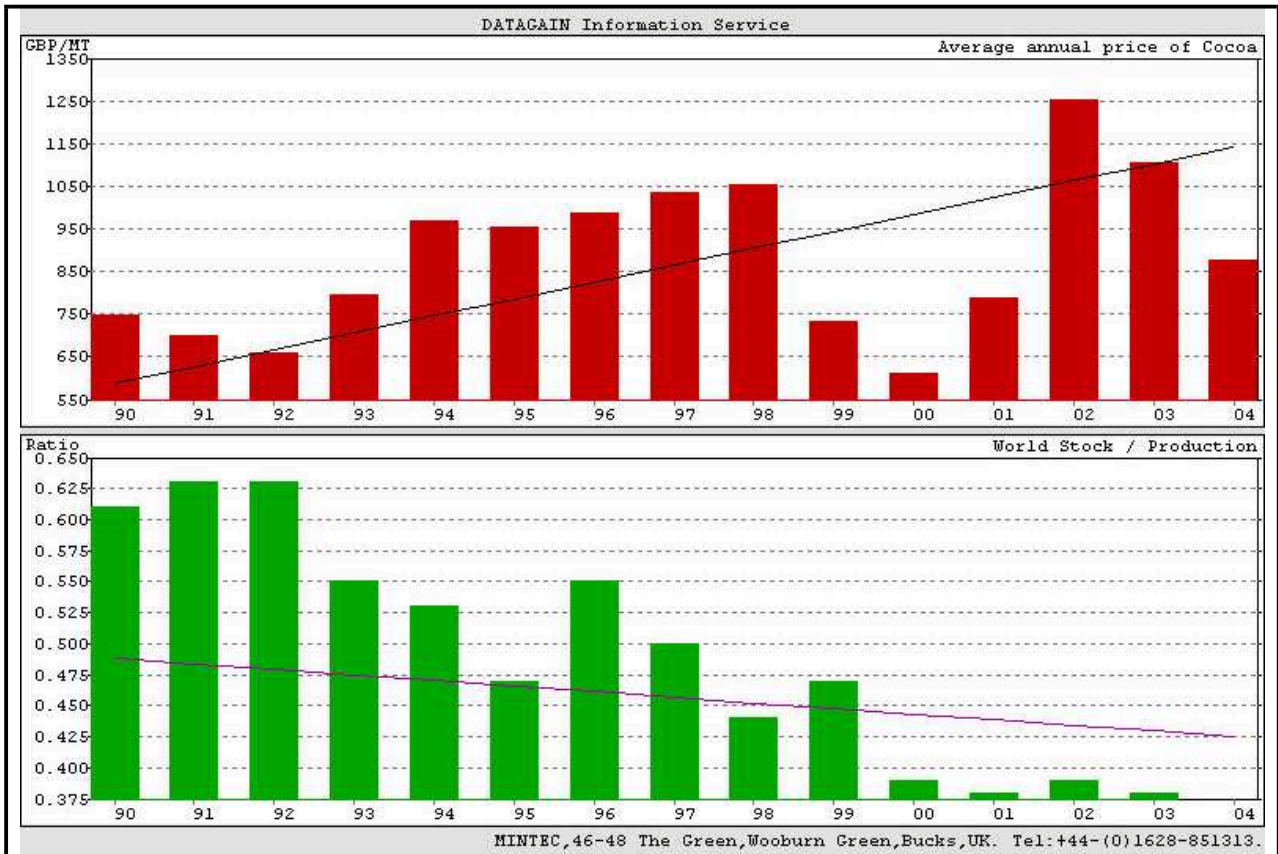
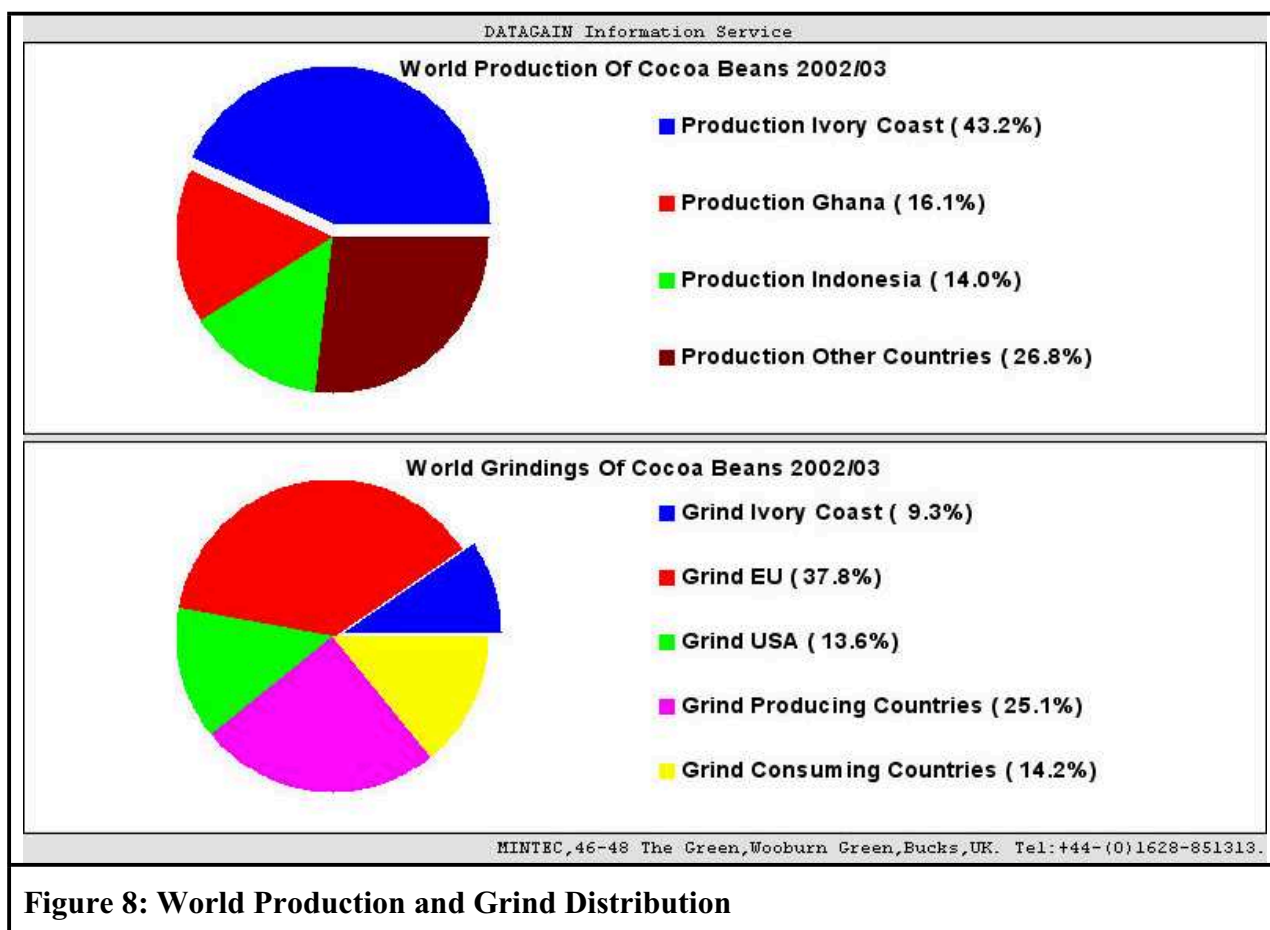


Figure 7: Relationship between annual price of cocoa beans and stocks held

It is apparent that a higher stock ratio (= world stocks/world production, Figure 7, lower chart) usually means a lower price. In the last few years deficit crops have resulted in a slow price increase. In other words, any exceptional crop year would result in significant price changes.

8b. Supply/Demand Situation in the Product Market

The only demand-type fundamental statistic available is cocoa grind (those beans that are ground to produce cocoa liquor). Since cocoa bean in its primary form has no other use we find that any difference between production and consumption is wholly reflected in stock i.e.: world production + old stock = grind + new stock. Consumption figures are primarily driven by demand from the chocolate and chocolate-using industries.



These two pie charts show the production and grindings of cocoa by its largest producers and consumers. Nearly half the world’s supply of cocoa beans is grown in Ivory Coast with another 30% in two other countries. The danger of such dependency is obvious: Variation in crop growing and harvesting conditions (usually caused by changing weather patterns) may cause large crop fluctuations. Further, many producing countries in the tropical growing belt are susceptible to political and industrial unrest as well as inefficient economic decisions.

Figure 9 shows the growth of both production and grind over the last thirty years. In the late 60’s and early 70’s, increased demand brought the introduction of a new fast-yielding hybrid variety in Ivory Coast shortly followed by a growing boom in South East Asia. Ever increasing production was followed by ever increasing demand (or maybe vice versa!).

The grind (representing demand) is driven by chocolate (requiring cocoa butter) consumption in consuming countries. Thirty years ago nearly all the crop was processed in Europe, USA and a few other advanced economies. The increased production required more processing capacity. While grinders in Europe and USA significantly expanded their factories, this was not enough and many new facilities have been developed in producing countries (which wanted to cash in on the value added to the raw cocoa beans). In 2002-03 over one third of cocoa beans were ground in producing countries. As discussed earlier, this fact may have been the most significant factor contributing to combined ratio growth.

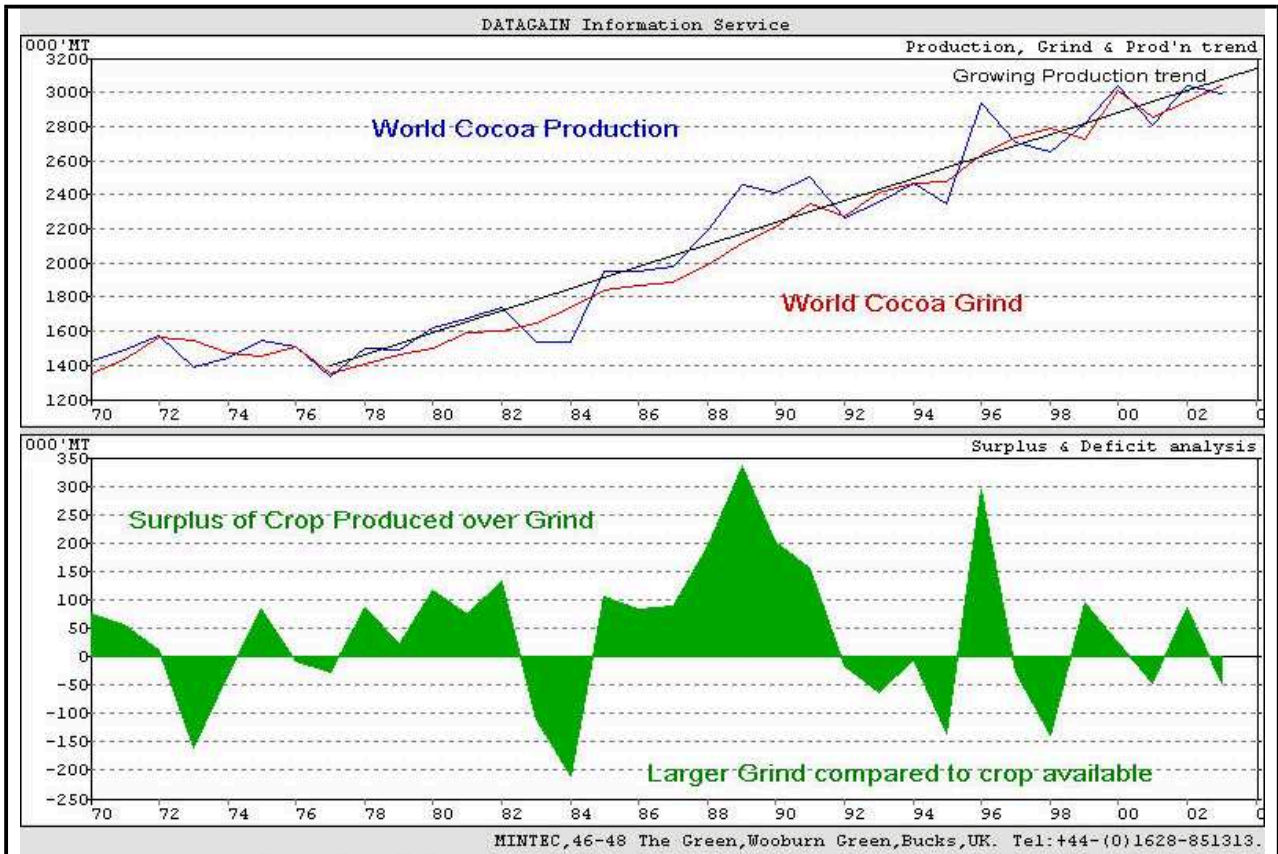


Figure 9: World Production & Grind Trend

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9. Weather/Crop Relationships

In 8a above we have noted that crop production plays a very important role in the primary market price movements. Maybe the question of forecasting a price can be re-formulated as ‘Can we forecast the crop?’. A completely different approach to forecasting and analysis is required, encompassing diverse subjects such as plant physiology and meteorology together with building complex statistical and simulation models.

In principle, soil relationship to water is similar to the function of one’s bank account. The bank account balance is created by debits and credits and the total affects one’s livelihood. Similarly, the water credits (rainfall) and debits (evaporation) affect tree or tree products survival/growth. While we have a reasonable chance to forecast a crop on one tree with some degree of confidence, the task becomes virtually impossible if we need to take into account all the variables across the crop region (lack of uniformity of weather parameters, soil type, tree variety and age, farm maintenance and other cropping practices, etc).

To illustrate the global complexity I have chosen to show a relationship between crop and rainfall deviations from the trend against an annual average. We would expect that above average rainfall should result in an above average crop. I have deliberately chosen Abidjan station (see paragraph about market rumours below) as it is most frequently reported and it is most reliable in providing information. It would be natural to assume that there is a relationship between crop and rainfall.

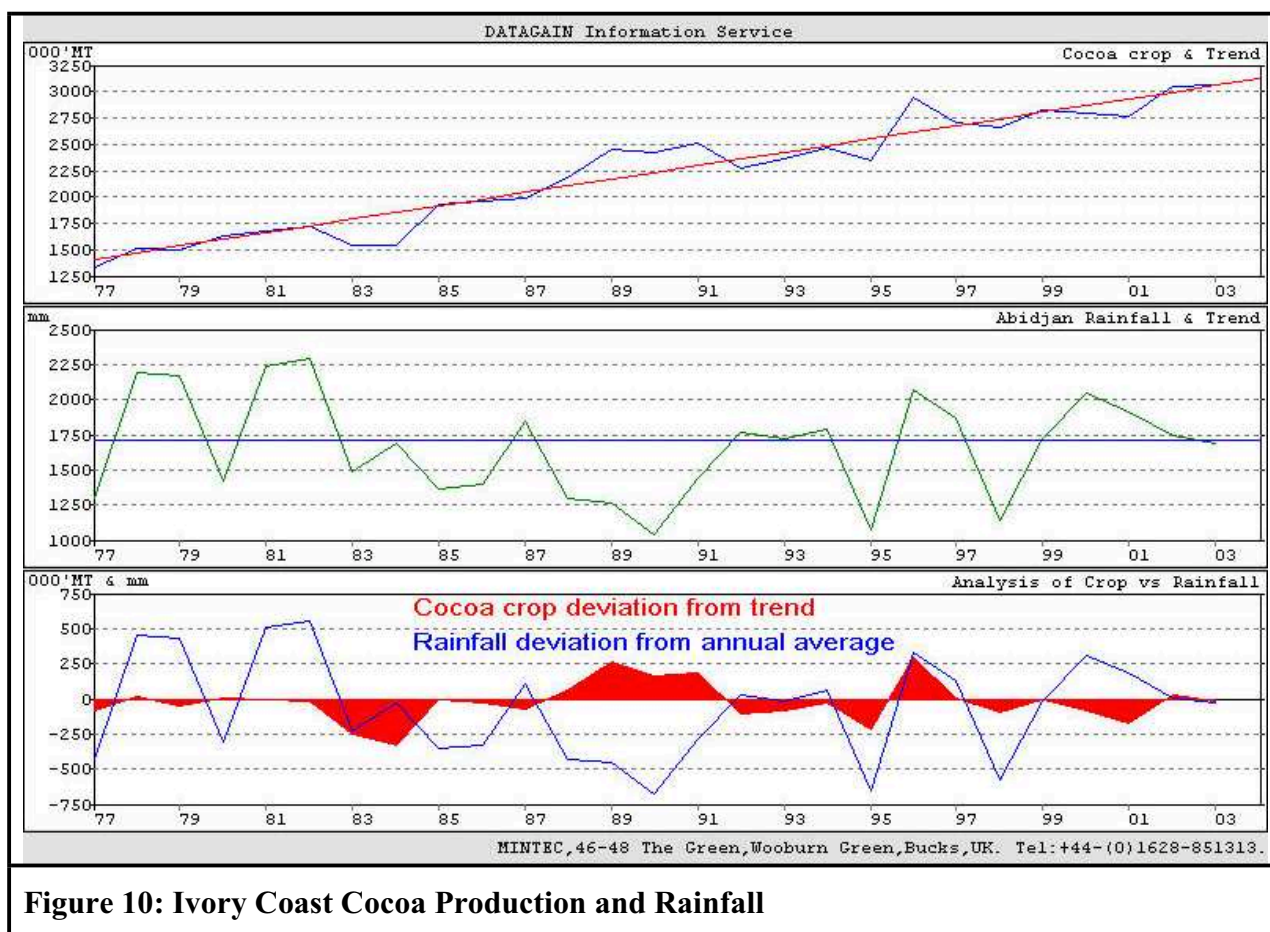


Figure 10: Ivory Coast Cocoa Production and Rainfall

The result is disappointing. In only one season do we see a good – good (above average rainfall – above average crop) relationship (1996-97) or a bad – bad relationship (1983-84 & 1995-96). In fact we can see good – bad or bad – good relationships in most seasons! Conclusion? Take the weather/crop predictions with a pinch of salt and examine the facts!

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10. Dealing with Market Rumours

The initial question (‘What is going to happen to the price’) is often prompted by a rumour or market sentiment. Before starting a potentially expensive analysis it is usually worthwhile to analyse the rumour.

Typically the cocoa market might react to news that it is/is not raining in Abidjan and that this is/is not good for crop prospects. Look at the map and you will find that Abidjan lies on the sea front. The dense cocoa area is some 200km inland. It is guaranteed that the rainfall pattern will be quite different in the two areas – it is like comparing rainfall quantity and patterns between Brighton (on the coast in South East England) and Coventry (in the English Midlands).

The other favourite cocoa market ‘news’ items are: smuggling between Ivory Coast and Ghana; crop devastation caused by a disease like black pod; frost/cold weather in the flowering season; change in the government; dock strike; etc. Evaluating these pieces of market news is another story...

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11. Conclusions and Surprise at the End

I hope I have provided the reader with a few ideas on how to analyse price data to help with the assessment of potential future price progression. I still maintain that I cannot forecast with confidence the price of cocoa butter. Actually, I can ...

Some of you may have noticed that I did not use the most obvious set of techniques – statistical forecasting. A number of purely mathematical extrapolation and statistical forecasting techniques is available to us. I will not go into the detailed methodology (I want to get paid for that) – several of them are described in [2] and [4]. Computers make it easy to do number crunching and spit out predictions. I have flippantly suggested at the beginning that if you give me a set of numbers I can forecast that price will go up or down simply by selecting the right (or wrong!) method. Here is the illustration:

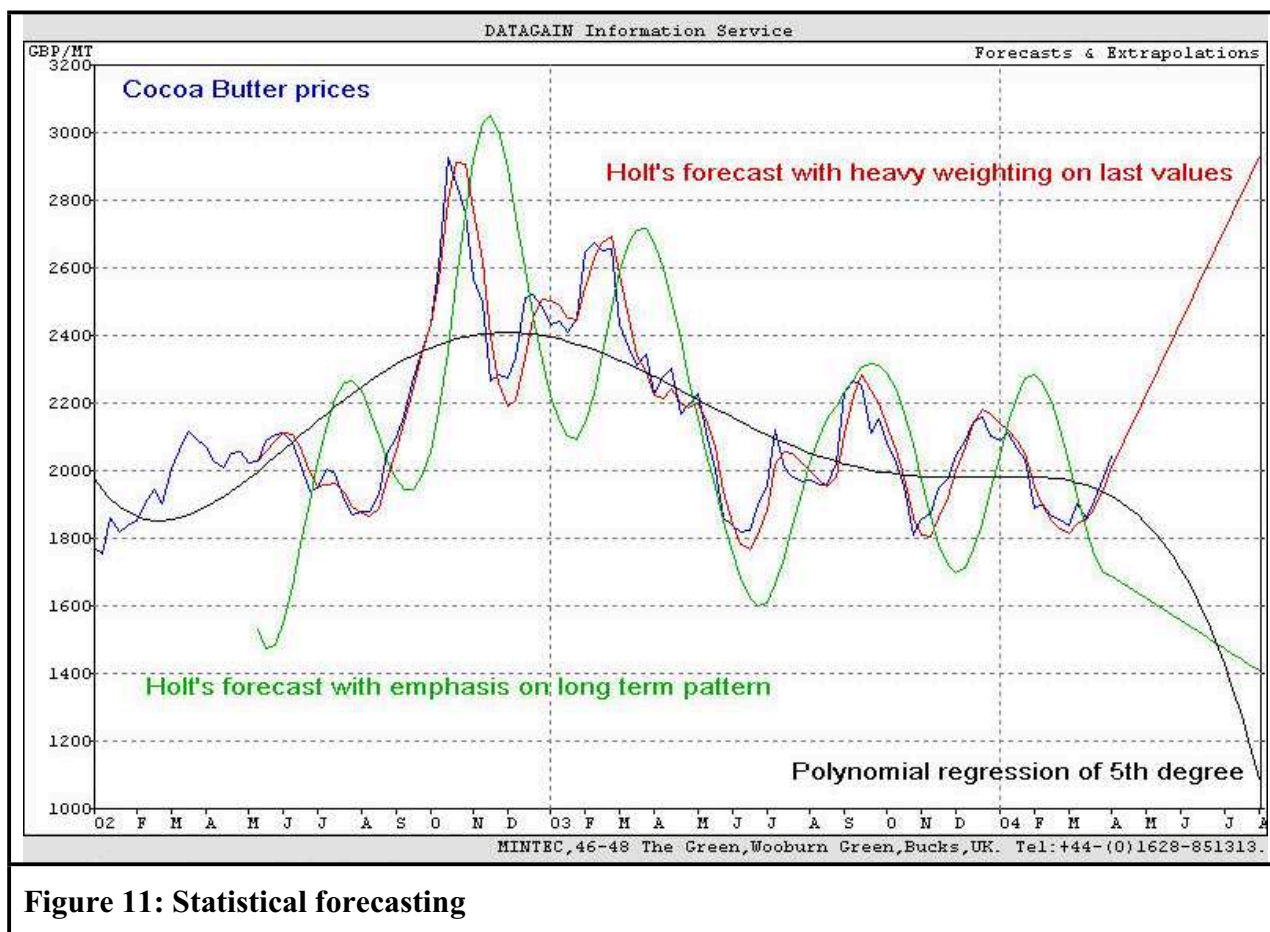


Figure 11: Statistical forecasting

Now we know that cocoa butter prices within three months will be in the range of GBP1000 - GBP3000!

On this stunning result I had better finish or as a statistician I might talk myself out of a job.

References:

1. Martin J. Pring: Technical Analysis Explained; McGraw-Hill 1991; ISBN 0-07-051042-3.
2. John C. Nash & Mary M. Nash: Practical Forecasting For Managers; Arnold Publishers & Oxford University Press Inc.; ISBN 0-340-76238-1.
3. Cocoa Products; International Trade Centre UNCTAD; Geneva 1975.
4. STATLIB – Time Series Analysis & Forecasting Library; John Wiley, 1987.

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