

Henry L. Moore and the application of institutional economics to the cotton market in the early twentieth century

by Éric Chancellier

Abstract

In this paper, our aim is to analyse the work of Henry L. Moore on the cotton commodity market in the 1910s in the United States. Moore put into practice the institutional approach to economics on two aspects of the cotton economy. The first section of the paper presents Moore's development of better methods for the prediction of yields. He used the hypothesis of a causal relationship between meteorological phenomena and crop yields to overcome the limitations of the census methods employed by the United States Department of Agriculture. The second section considers Moore's approaches to fair pricing-related research. In the context of the farmers' suspicions of speculators and in an effort to stabilize cotton futures markets, the United States Federal Government passed the Cotton Futures Act in 1914, implemented the following year. Its purpose was to standardize the quality of cotton offered in the futures markets. Using the correlation coefficient, Moore validated the effectiveness of this legislation.

One task of modern agricultural meteorology is to study the relation between the climatic variations and those of agricultural production.¹

An examination of the historical record suggests that the U.S. cotton exchanges were [...] vulnerable to manipulation.²

In critical times of crop development, prices have typically been found to be more volatile because of the uncertainty about crop conditions. Market participants likely become acutely sensitive to new information during these times.³

At the beginning of the twentieth century, the United States experienced a complete restructuring of the agricultural sector. The Federal government, through the United States Department of Agriculture (USDA) became increasingly involved in the agricultural sector to facilitate

¹ A. Wallén, 'Notiser. Production and Climate in Australia', *Geografiska Annaler* 1 (1919), p. 395.

² S. C. Pirrong, 'The self-regulation of commodity exchanges: the case of market manipulation', *J. Law and*

Economics, 38 (1) (1995), p. 184.

³ D. Hudson and K. Coble, 'Harvest contract price volatility for cotton', *J. Futures Markets* 19 (1999), p. 719.

its mechanization and regulate its operations.⁴ Specifically, with the development of futures markets for farming products at the end of the nineteenth century, farmers, in a corporate movement, accused the financial markets of destabilizing commodity prices, thereby negatively impacting on their income.⁵ On the other hand, economic agents doubted the effectiveness of the price of commodities to incorporate all the information available to the market, but there were also doubts about the accuracy of the available agricultural statistics.⁶

One author, the economist Henry L. Moore (1869–1958), whose contribution to agricultural economics is now largely overlooked, perfectly illustrates this environment. Moore is considered an atypical author in the field of economic thought, particularly in regard to his representations of economic mechanisms where he placed weight on natural phenomena.⁷ Stigler and Mirowski have outlined Moore's professional path.⁸ His academic training began in Europe.⁹ Later, in 1906, as a political economy professor at Columbia University, Moore began research to link economic statistics through the use of correlation coefficients. It was at Columbia where he participated in the development of a new academic project: institutional economics.¹⁰ As shown by Rutherford, Columbia was the major academic centre for economics and the social sciences between the two World Wars. Moreover, Columbia is where the combined use of quantitative methods – statistics – and multidisciplinary approaches developed. Additionally, as J. B. Clark's student, Moore developed his competence in technical mathematics and statistics, and particularly in cyclical analysis, evidenced in his work of 1914, *Economic cycles: Their law and cause*. As such, the institutional context of Columbia University was a major influence on Moore's work.¹¹

More specifically, Moore's 1917 book – *Forecasting the yield and the price of cotton* – clearly reveals the importance of this environment to Moore. His book focuses exclusively on cotton because the cotton market had been the subject of a number of scandals related to speculations in cotton futures markets.¹² In 1915, the United States Federal Government legislated to

⁴ A. D. Sheingate, *The rise of the agricultural welfare state: Institutions and interest group power in the United States, France, and Japan* (2001).

⁵ Y. Simon and D. Lautier, *Marchés dérivés de matières premières* (2006); C. B. Cowing, *Populists, plungers, and progressives: A social history of stock and commodity speculation, 1890–1936* (1965).

⁶ F. H. Sanderson, *Methods of crop forecasting* (1954).

⁷ See P. Le Gall, 'A world ruled by Venus: on Henry L. Moore's Transfer of Periodogram analysis from physics to economics', *Hist. Political Economy* 31 (1999), pp. 723–52. Moore published a succession of papers which used statistical data related to commodities but employed the periodogram tool – the ancestor of spectral analysis – to define cyclic periodicities. See T. F. Cargill, 'Early applications of spectral methods to economic time series', *Hist. Political Economy* 6 (1974), pp. 1–16.

⁸ G. J. Stigler, 'Henry L. Moore and statistical economics', *Econometrica* 30 (1962), pp. 1–21; P. Mirowski,

'Problems in the paternity of Econometrics: Henry Ludwell Moore', *Hist. Political Economy* 22 (1990), pp. 587–609.

⁹ Moore took mathematical statistics courses with Karl Pearson in London before obtaining a Ph.D. at John Hopkins University in 1896. Furthermore, his travels also led him to meet Pareto, Edgeworth, Walras, and Cournot.

¹⁰ In particular, in 1918 Walton Hamilton first used the term institutional economics in his article 'The institutional approach to economic theory'. M. Rutherford, 'Institutional economics at Columbia University', *Hist. Political Economy* 36 (2004), pp. 31–78.

¹¹ As stated by Rutherford, 'Institutional economics', p. 36, 'at this point, particularly with J. B. Clark and Moore, the department probably possessed more strength in neoclassical theory than any other leading department in America'.

¹² Pirrong, 'Self-regulation of commodity exchanges.

regulate the cotton market – The Cotton Futures Act – in order to restore some confidence in the markets' operations. As Garside and Hubbard show, the analysis of the cotton market in the very early twentieth century was based on two quite distinct fields: an increasing interest in meteorological impacts on the crop; and the developments in financial markets, particularly strategies of hedging on futures markets.¹³ Moore's work announced what would be the institutional approach insofar as it focused on a multidisciplinary approach – Agricultural Meteorology – as well as on the role of the institutions – The Cotton Futures Act – to regulate the market.¹⁴ Also, Moore used the statistical methods of correlation and regression in order to validate the different methodological approaches. Therefore, his work belongs to the emerging field of institutional economics. As Rutherford has explained, 'the institutional approach 'was to be focused on institutions and their role in affecting economic behavior and outcomes ... to be relevant to issues of "social control", and to utilize proper "scientific" methods, including quantitative and statistical research'.¹⁵

As we will show in the first part of this paper, agricultural meteorology was made possible by the pioneering work of the Norwegian physicist Vilhelm Bjerknes, who outlined the importance of better weather forecasting for agricultural purposes as well as aviation. As Friedman notes, as early as 1917, Bjerknes developed a statistical-climatological approach to weather forecasting. He then developed a new cyclone analysis model to allow better forecasts. The key variables in Bjerknes' work are temperature and rainfall.¹⁶ Thus, Moore puts into practice the methodological orientation of the institutional approach in regard to two issues of the agricultural economy.

This paper is organized as follows. The first section will present Moore's method of analysis, which allows for a better prediction of yields. The agricultural meteorology on which Moore drew was a new method of analysis gaining considerable momentum at the very end of the nineteenth century. Monteith describes this period as the golden age of agricultural meteorology because its foundations are clearly delimited to exogenous explanations of crops – climate, rainfall, and temperature – and to the statistical tool of correlation.¹⁷ Moore is part of this approach: he uses the hypothesis of a causal relationship between meteorological phenomena and crop yields to overcome the limitations of the census methods employed by the USDA. Our second section will be devoted to Moore's different approaches to fair pricing-related research. In the context of the farmers' suspicion of speculators and to stabilize cotton's futures markets, the Federal government passed the Cotton Futures Act in 1914. Its purpose

¹³ A. H. Garside, *Cotton goes to market: A graphic description of a great industry* (1935); W. H. Hubbard, *Cotton and the cotton market* (1923).

¹⁴ In 1922, the USDA launched a vast institutional reform project when it developed agricultural cooperatives as a means of regulating the market and supporting farmers' purchasing power. E. Chancellier, 'Les coopératives agricoles comme bien commun: un projet multiforme. Le cas du marché du coton aux Etats-Unis dans les années 20. *Transversalités*, Supplément 4 (2016), pp. 93–110.

¹⁵ Rutherford, 'Institutional economics'.

¹⁶ R. M. Friedman, *Appropriating the weather: Vilhelm Bjerknes and the construction of a modern meteorology* (1989), pp. 110–13, 163. Bjerknes (1862–1951) was a Norwegian geophysicist, mathematician and physicist. Described by Friedman as the 'father of modern meteorology', he showed that weather forecasts based on isobaric surfaces are more reliable (p. 6).

¹⁷ J. L. Monteith, 'Agricultural Meteorology: evolution and application', *Agricultural and Forest Meteorology* 103 (2000), pp. 5–9.

was to standardize the quality of cotton offered in the futures markets. Using the correlation coefficient, Moore validated the effectiveness of this regulation as he noticed that futures prices evolved in parallel with spot prices. In addition, to legitimize the role of economic theory in explaining fluctuations in the price of cotton, Moore used Marshall's work – the law of demand – to show its effectiveness in predicting cotton prices, thus favouring the real sector – supply and demand – to determine the price of cotton.

I

In his comparative history of the development of agricultural institutions in the United States, France, and Japan from the beginning of the twentieth century to the present, Sheingate noted that the first agricultural institutions in the United States appeared in the late nineteenth century with the establishment of the USDA in 1862.¹⁸ Since its foundation, the USDA posited a close relationship between farmers and meteorological phenomena. The Weather Bureau prepared weather maps and made weather predictions for farmers, as illustrated by Ward who presented the geographic distribution of different crops in the United States based on the type of farming (Map 1). So:

the country is conveniently divided into two major divisions, separated by ... the 'dry farming-line'. The half of the country east of this line has sufficient rain in normal years and produces annual summer crops cultivated by ordinary farming methods. ... The West is a region of irrigation, of dry farming or grazing.¹⁹

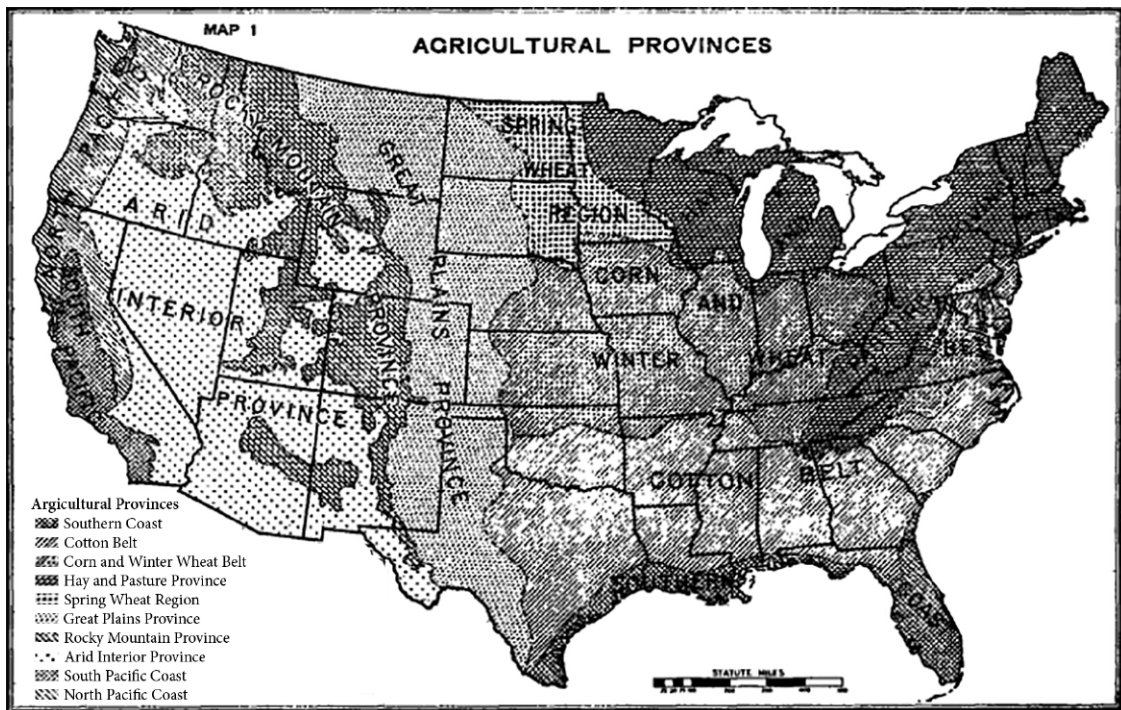
As seen in Map 1 and as explained by Sheingate, from the end of the 1870s to the 1920s, the authorities implemented aid policies for farmers to specialize in crops appropriate to the climates of the different regions in the country. Consequently, 'by the end of the century, regional product specializations were clear: the Corn Belt stretched from western Ohio through Indiana, Illinois, and Iowa; wheat dominated from the Canadian border to the Texas Panhandle; the Upper Midwest specialized in dairy; and the South specialized in cotton, tobacco, and rice'.²⁰ Mapping therefore became an important element for the farmer and for the authorities, allowing them to control the development of agricultural acreage, especially as

¹⁸ Sheingate, *Agricultural welfare state*, p. 5; V. Wiser, 'Weather, USDA, and the Farmer', *Agricultural Hist.* 63 (1989), pp. 51–61. The USDA replaced the Smithsonian Institution, created in 1849, and intended to provide forecasts based on telegraphic reports to the military and farmers: 'An agreement for cooperation was adopted with the Patent Office using its franking privilege for the return of the meteorological reports. This gave the work an agricultural emphasis and farmers had access to weather data in Patent Office publications' (V. Wiser, 'Weather, USDA, and the Farmer', *Agricultural Hist.* 63 (1989), p. 52). Other institutions or governmental decisions relating to the agricultural sector appear at the end of the nineteenth century. In 1862, the

United States Congress passed the Homestead Act to accelerate the migration of people to the West and the Pacific Railway Act intended to release credits to link by railway areas of agricultural productions located in the center and south of the country with the urban areas in the east. The Morrill Act (1862) started agricultural education in American universities. In 1887, the Hatch Act sought to develop scientific research organizations in the field of agriculture.

¹⁹ R. De C. Ward, 'The larger relations of climate and crops in the United States', *Monthly Weather Rev.* 47 (1919), pp. 238–40.

²⁰ Sheingate, *Agricultural welfare state*, p. 15.



MAP 1. The dry-farming line lay on the east side of the Great Plains Province.

Source: Adapted from R. De C. Ward, 'The larger relations of climate and crops in the United States', *Monthly Weather Rev.* 47 (1919), p. 238.

these acreages increased dramatically between 1870 and 1914.²¹ Hence, it became necessary to create effective statistical tools to estimate crop yields.

Thus, weather data and the factors determining agricultural yields were of great interest to the USDA. As such, the Weather Bureau, through its journal, *The Monthly Weather Review*, offered advice and provided meteorological information that would help optimize harvests. This information was practical, and it concerned the organization of farm work, as Kincer indicates in his monthly note 'Effect of weather on crops', for June, 1919:

Farm work: the continuation of frequent rains from Missouri and eastern Kansas northward were unfavorable for farm work during much of the month and planting and cultivation were delayed in that area. ... Much of the month was fairly favorable for cotton in the eastern portion for the belt, but it was too cool and rainy as a rule for this crop, particularly in the western cotton growing districts.²²

As Azzi wrote in 1918, 'the problem of agricultural meteorology is of high importance for crop yield'.²³ Therefore, international authorities established meetings to homogenize

²¹ The corn acreage increased by 157%, that of wheat by 161%, and that of cotton by 290% (Sheingate, *Agricultural welfare state*, p. 15).

²² J. B. Kincer, 'Effect on weather on crops, June, 1919', *Monthly Weather Rev.* 47 (1919), p. 433.

²³ G. Azzi, 'Le problème de la météorologie agricole',

analysis procedures for defining the best yields according to weather conditions. In 1911, the International Institute of Agriculture in Rome assumed control of the International Meteorological Committee and appointed a commission in 1912 to develop an international organization for agricultural meteorology. The link between weather and crop yields was among the themes addressed. Weather conditions were thus factored into economic forecasts for crops from the beginning of the twentieth century.²⁴ A multidisciplinary field was established that connected meteorological aspects such as weather cartograms, weather bulletins, and agricultural meteorology stations; the phenological aspects such as plant growth and the optimal period of plant flowering; and purely agricultural aspects such as crop yields per hectare, production, and available arable land. State administrations signed partnerships to develop a true network of informational analysis. In 1905 Cleveland Abbe (1838–1916), from the Weather Bureau in the USDA, published the *First Report on the relations between climates and crops*.²⁵ This report was ‘a rapid compilation from a wide range of sources, and presents a preliminary view of the condition of our knowledge at that time as to the effect of climate upon the growth and distribution of our staple crops’.²⁶ As Kaigorodoff noted in 1929, the goal of bringing meteorology and agriculture together was to allow for an increase in agricultural productivity.²⁷ It is in this context that Moore would publish his investigating the prediction of cotton yields based on the available weather data. Thus, Moore’s work coincides with the birth of agricultural meteorology. We note in the first subsection that agricultural meteorology was developed to resolve the problems of crop censuses based exclusively on the farmers’ returns. We show in the second subsection how the work of Moore is based on methods of correlation used in the development of agricultural meteorology.

(i) *The shortcomings of the crop reporting service and the alternative crop weather service*

Between 1914 and 1929, the USDA attempted to forge ties with farmers from different regions. To accomplish this, it deployed a multitude of agents in different American states to provide farmers with technical advice intended to increase crop productivity.²⁸ During this period, the USDA’s interests and responsibilities also broadened from an initial concentration on

Note 24 continued

Revue Générale des Sciences Pures et Appliquées 29 (1918), pp. 307–11 (Author’s translation).

²⁴ In a broader context, Le Gall shows that some French economists in the nineteenth century used a paradigm based on a natural order where the weather partly explains agricultural prices. P. Le Gall, *A history of econometrics in France: from nature to models* (2006), pp. 86–126.

²⁵ Cleveland Abbe (1838–1916) was a meteorologist. He developed a system of telegraphic weather reports, daily weather maps, and weather forecasts. Congress in 1870 established the U.S. Weather Bureau and inaugurated the use of daily weather forecasts. He founded the scientific journal, *Monthly Weather Review*, in 1872, initially as a government publication under the United States Army Signal Corps. In 1891, the Signal Office’s

meteorological responsibilities were transferred to the under the United States Department of Agriculture J. W. Smith, ‘Agricultural Meteorology’, *Monthly Weather Rev.* 48 (1920), p. 281.

²⁶ Smith, ‘Agricultural meteorology’, p. 282 explains that by 1920 the connection between weather and agriculture was established in most industrialized countries: Russia (1896), Canada (1915), England (1875), Brazil (1910), Germany (1911), France (1912). All these countries developed a system to collect weather data – in different weather stations located throughout the country – and to collect crops statistics.

²⁷ A. Kaigorodoff, ‘Agricultural Meteorology and raising agricultural productivity’, *Monthly Weather Rev.* 57 (1929), pp. 374–5.

²⁸ Sheingate, *Agricultural welfare states*, pp. 99–102.

biology and chemistry to include a focus on economic and sociological issues. As such, 'the Office of Markets and the Rural Organization Service, both created in 1913, studies marketing, production, and trade. The creation of the Bureau of Crop Estimates in 1914 increased department resources for the collection and analysis of statistics'.²⁹

The problem of the estimation of yield is not new, and has interested many international organizations, as discussed by Clark as early as 1910.³⁰ Specifically, as Irwin explained, Western countries had difficulty accurately estimating crop yields as the estimates were based solely on the statements of the farmers.³¹ In addition, as Godfrey explained in a review of national practices in 1910, if each country had singularities in their technique of crop forecasting, they all relied on the census technique. With respect to the United States, 'they possess what is probably the oldest and most highly organized system of monthly crop reporting in existence' and which was based on the system of harvest census.³²

Forecasts of acreage are made partly subjectively by asking reporters to express the acreage as a percentage of the usual acreage, partly by a sampling process of securing reports from individual farmers who report the acreages on their farms under each crop in the current and previous years, and partly by 'field count methods', such as counting by means of a special speedometer the number of feet along the road under each kind of crop. Forecasts of yield are made by asking reporters for estimates of the condition of the crop in term of the normal as 100.³³

The census technique was the subject of considerable criticism because of its low level of accuracy. For instance, Sanderson in 1954 conceded that the crop reporting service '[had] in general, yielded fairly satisfactory results' but he admitted that the weak point was the unwillingness of farmers to provide the necessary statistics to the United States government. Indeed, 'questionnaires are sent to about 320,000 farmers; on the average about 25 per cent of these are returned'.³⁴ This shortcoming had the capacity, as indicated by Murray when he outlined the historical development of agricultural statistics between 1900 and 1920, to impart errors into the estimation of agricultural areas and yields.³⁵ Therefore, the USDA attempted to secure new

²⁹ Ibid., p. 100.

³⁰ C. C. Clark, 'Annual Report of the Bureau of Statistics for Fiscal Year 1906-7', *The Crop Reporter* 9 (1907), 95-9.

³¹ J. O. Irwin, 'Crop estimation and its relation to agricultural meteorology', *Supplement to J. Royal Statistical Soc.* 5 (1938), pp. 1-45.

³² Godfrey analyses the systems of crop forecasting for the United Kingdom, France, Germany, Austria, Hungary, Russia, Sweden, the United States, Canada, of Argentina, Australia, South Africa and India. He notes that 'in all countries that have established any sort of system for recording the progress of growing crops and of estimating areas and yields, dependence has to be placed largely upon the services of correspondents'. E. H. Godfrey, 'Methods of crop reporting in different countries', *J. Royal Statistical Soc.* 73 (1910), pp. 257-83;

also L. M. Estabrook, 'The use of crop reports by farmers', *J. Farm Economics* 5, (1923), pp. 28-34 and N. C. Murray, 'The crop reporting system', *Annals of the American Academy of Political and Social Science* 38, pp. 91-103 for a detailed explanations of the techniques of the crop reporting systems.

³³ Irwin, 'Crop estimation', p. 4.

³⁴ F. H. Sanderson, *Methods of crop forecasting* (1954), pp. 138-46.

³⁵ N. C. Murray, 'A close-up of the development of agricultural statistics from 1900 to 1920', *J. Farm Economics* 21 (1939), pp. 707-17. To illustrate, here is what we read in *The Crop Reporter* (1906, p. 9): 'The Department is convinced that the estimated planted acreage in cotton of about 28,686,000, issued June 4, is near the truth; but the increase of 1,686,000, or 6.2 per cent, it should be understood, is not all of this year.'

sources of information in order to reduce 'the bias of farmer crop reporters' and to diversify its crop forecasting techniques by incorporating the impact of weather on crop yields.³⁶

The shortcomings of the crop reporting service were the starting point for Moore's 1917 book. First, he noted the consequences for the price of cotton for failing to estimate accurately the cotton yield and, ultimately, the consequences for the income of the farmers. 'An error in an official crop report which should lead to an ultimate depression of one cent a pound in the price of cotton lint would cost the farmers \$80,000,000, or more'.³⁷ The consequences of an unsound yield estimate on cotton prices was acknowledged by the *Census Bureau*. To minimize fluctuations in the market price of cotton on the stock exchange, a rigorous protocol to control the disclosure of cotton production statistics was implemented. Every year, a synthesis of the state of the supply of cotton was published in *The Crop Reporter*.³⁸ It is important to note that *The Crop Reporter* was aware of the economic dimension of its publications, as one of its responsibilities was to make the most reliable statistics possible available to stakeholders. *The Crop Reporter* was aware of possible errors in forecasts and strived to modernize its estimation methods to improve the accuracy of its reports. For example, in 1907 Clark questioned the accuracy of the methods used by *The Crop Reporter* concerning the estimation of crop acreages: 'should there be a tendency to underestimate or overestimate under this percentage system it may result at the end of a term of years in a deviation from the true situation'.³⁹ Moore adopted the same criticisms toward *The Crop Reporter* publications and devoted an entire chapter to them in his book. One of his major criticisms of the forecasting methods implemented by *The Crop Reporter* was the lack of homogeneity and reliability in forecasting techniques:

Without a measure of the degree of accuracy and reliability of the forecasts the Crop-Reporting Board has no proper ground of choice between methods of forecasting; farmers, brokers, and consumers are without adequate guidance in the planning of their enterprises; and scientific economists have no empirical tests of the degree of error in their analyses of the interrelation of phenomena.⁴⁰

In particular, Moore presented the sources of cumulative errors in the methodology employed by The Crop Reporting Board method, which based its forecasts on the 'full normal crop' concept.⁴¹ Moore criticized this approach.

Note 36 continued

The Census Bureau's final report of the crop of 1905 was about 400,000 bales more than was estimated by the Bureau of Statistics on the 4th of December last'.

³⁶ Murray, 'Close-up view', p. 709.

³⁷ Moore, *Forecasting the yield and price of cotton* (1917), p. 3.

³⁸ 'The *Crop Reporter* is a publication of the Bureau of Statistics, under the authority of the Secretary of Agriculture, and all communications in relation to it should be addressed to the Chief of the Bureau of Statistics, Department of Agriculture' (*Crop Reporter*, 1906, p. 1).

³⁹ C. C. Clark, 'International Crop Reporting Service',

Publications of the American Statistical Assoc. 12 (1910), pp. 181-98.

⁴⁰ Moore, *Forecasting*, pp. 66-7.

⁴¹ *Crop Reporter* (1908, p. 97) gives a precise definition of the concept of full normal condition: 'a full normal condition is *not* an *average* condition, but a condition *above* the average, giving promise of *more than an average crop*. Furthermore, a full normal condition does *not* indicate a *perfect crop* ... The full normal indicates something *less* than this, and thus comes between the average and the possible maximum, being greater than the former and less than the latter. The full normal may be described as a condition of perfect healthfulness'.

The method of the Crop Reporting Board in making the forecast of the yield per acre of cotton is ... to assume that the ratio of the yield per acre for any given year to the mean yield per acre for the preceding five years is equal to the ratio of the condition of any given month to the mean condition for the given month during the preceding five years. ... Is there any relation between the two series, and if so, how closely are they related, and what is the error made in using the condition-series to forecast the yield-series?⁴²

Moore then proposed to overcome the limitations of these techniques by using new sources of information from meteorological data obtained from the Weather Bureau.

We shall consider ... the possibility of forecasting the yield per acre of cotton simply from the current reports of the Weather Bureau as to rainfall and temperature in the several cotton states.⁴³

Moore drew extensively on the work of J. W. Smith,⁴⁴ a forerunner in the field of agricultural meteorology, to present an alternative methodology for the forecasting of crop yields. While Smith published many articles in *The Monthly Weather Review*,⁴⁵ in an article published in 1914, he analysed the effects of weather on the yield of corn, showing that rainfall was the most significant variable: 'In places where the temperature and sunshine are generally sufficient the development of the plant and more especially the crop yield depends most largely upon the rainfall'.⁴⁶

Thus, it is evident that between the end of the nineteenth century and the 1920s, agricultural meteorology witnessed an important development. Moore called on recent developments in this new field of analysis to predict the yield of cotton, drawing his inspiration from the works of Smith and using the variables of rainfall and temperature to establish possible connections between these two meteorological phenomena and cotton yields. All of Moore's views incorporated the concepts used by the agricultural meteorology analysts, especially those of the Climate and Crop Service.

Throughout the period from the first of May until the end of September, the growth of the cotton plant is watched with anxious solicitude. The change of the weather may convert a crop that is flourishing at the first of June into a comparative failure at the time of harvest, or the damage of excessive heat in July may be off-set by a beneficial rainfall in August. The effects of temperature and rainfall upon the crop vary from state to state, but in all cases the effects are cumulative, and the probable consequences of a rain or drought at any point in the growth season are dependent upon the quantity and distribution of rainfall and temperature preceding the time in question. ... The economist who ... seeks to forecast the yield of cotton at harvest must be able to measure the effects upon the crop of the accumulated variations in temperature and rainfall up to the time in question.⁴⁷

⁴² Moore, *Forecasting*, pp. 66–7.

⁴³ *Ibid.*, p. 93.

⁴⁴ J. W. Smith was a professor of Meteorology at the United States Weather Bureau. The Division of Agricultural Meteorology was created in 1916. Smith published numerous articles on the relationship between weather and crop yields of grain and cotton. Sanderson,

Methods of crop forecasting, pp. 214–15.

⁴⁵ Attached to the Department of Agriculture, *The Monthly Weather Review* was founded in 1872. Weather reports are given to farmers – *Climate and Crop Service*.

⁴⁶ J. W. Smith, 'The effect of weather upon the yield of corn', *Monthly Weather Rev.* 42 (1914), pp. 78–92.

⁴⁷ Moore, *Forecasting*, pp. 100–1.

The contribution of the Weather Service became all the more necessary because weather conditions influenced the quality of cotton. Accordingly, it became necessary for the American authorities to set up a system to reference the quality of cotton – the system of US Government Standards – which became effective on 30 June 1909 and was amended in 1914 and 1916 by the Cotton Futures Act. The objective was to establish universal standards criteria for the cotton market in the United States. Thus, the authorities set nine reference grades: middling fair, strict good middling, good middling, strict middling, middling, strict low middling, low middling, strict good ordinary, and good ordinary.⁴⁸ These grades were then referenced in measurement and comparison standard boxes. As Miller noted in his book of 1915, there are no mechanical means to determine the grade of cotton. The cotton must therefore be visually examined by qualified technicians in order to determine the correct grade. Certain rules must be respected, and the technician must refer to universal standards in order to classify the quality of cotton. The Cotton Classifier differentiates broken leaf, large leaf, small leaf; stems; broken seed; immature seed; dirt, gin cuts; naps, and discolourations. The less these elements are found in the cotton, the better its quality. It should also be noted that the length of the cotton staple does not play a major role in the quality of the cotton.⁴⁹ As Miller also noted, the quality of middling cotton was the benchmark in all markets. It is from this grade that all other cotton qualities are referenced. This middling quality is white or nearly white cotton and contains only a small amount of foreign matter.⁵⁰ Miller clearly showed that moisture can alter the quality of cotton, and this is all the more true because farmers might not allow cotton to dry enough if they are trying to save time between harvesting and packaging into cotton bales.⁵¹ Thus, to validate the hypothesis that weather affected crops, Moore employed correlation techniques already exploited in the field of agricultural meteorology.

(ii) *The validation of the hypothesis of the influence of weather on crops through the use of correlation*

If the first attempts to establish a causal connection between weather conditions and crop yields occurred in the mid-nineteenth century, it was with Hooker's article of 1907 that the use of correlation coefficients applied to the relationship between meteorology and crop yields was first employed.⁵² Thereafter, many authors would use correlations to calculate the importance

⁴⁸ The Cotton Exchange recognizes 23 grades of cotton including the Tinges and Stains and Half and Quarter subdivisions.

⁴⁹ T. S. Miller, *Cotton Trade Guide and Student's Manual* (1915), pp. 12–16.

⁵⁰ T. S. Miller, *The American cotton system historically treated: Showing operations of the cotton exchanges: also cotton classification with numerous practical domestic and foreign commercial calculations* (1909), pp. 37–9.

⁵¹ Miller, *Cotton Trade Guide*, pp. 13–16. Cotton is packed, stored and transported in units called bales. A cotton bale consists of cotton fibers removed from the seed during ginning and packaged to facilitate

handling, storage and transportation. The bales are formed after ginning, drying and cleaning by accumulation of cotton fibers in a baling press. A cotton bale weighs approximately 200 kg.

⁵² Sanderson, *Methods of crop forecasting*, pp. 212–13. R. H. Hooker, 'Correlation of weather and crops', *J. Royal Statistical Soc.* 70 (1907), pp. 1–51. Hooker wished to put an end to the debate between Shaw and Thomas concerning the influence of fall precipitation on wheat crops in England. So, 'the method of correlation might quite possibly enable us to determine whether the meteorological conditions during autumn were or were not the predominant factor in our wheat supply' (p. 1).

of weather in explaining agricultural yields. Many articles appeared in *The Monthly Weather Review* in which the correlation coefficient was extensively used to predict crop yields based on weather data.⁵³ It was in this context that the work of Moore appeared in 1917. He claimed to be able to predict cotton yields for the months of May, June, and July based on climate data by employing the correlation coefficient.⁵⁴ Moore was inspired by the work of J. B. Kincer of the Weather Bureau who had proposed in an article of 1915 to apply the emerging approach of agricultural meteorology by using the correlation technique to define the possible links between atmospheric phenomena – rainfall and temperature – and the production of cotton.⁵⁵ In a paper of 1911, J. Warren Smith, the father of agricultural meteorology, had applied the correlation technique to potato yields. He clarified the difficulty of calculating the influence of rainfall and temperature, respectively, on the level of the yield: ‘In a study of the effect of weather conditions upon the growth of crops it is often necessary to combine the influence of two different factors, as rainfall and temperature’. Smith then advocated the use of a partial correlation.⁵⁶ Thus, Moore drew on both Kincer’s work, in the sense that he used the two weather variables namely, temperature and rainfall, and Smith’s work, which incorporated the correlation technique. So:

the cotton crop is affected not only by the weather of May and June but also by that of July and of August. The coefficients for both temperature and rainfall in August have significant values. If at the end of August we should wish to forecast the yield of cotton from accumulated effects of past weather – for example, of the May rainfall, the June temperature, and the August temperature – we have only to extend the principles of multiple correlation to cover four variables.⁵⁷

The results showed negative correlations between gaps in cotton yields as compared with normal yields and between gaps in temperature as compared with normal levels, except for the months of June and September, whereas correlations between gaps in cotton yields as compared with normal yields and gaps in rainfall as compared with normal levels are negative, except for the month of August. Thus, the most significant values of the correlations included the months of June and August for temperature and the month of May for rainfall. At first, if the use of the correlation allowed Moore to select weather phenomena to retain rainfall and temperature, in a second attempt, Moore retained only the most significant periods – the months – to predict cotton yields. For that, Moore drew on the work of Smith, which showed how to determine critical growth periods, an approach belonging to the domain of agricultural meteorological analysis.⁵⁸ Smith held that ‘we believe it will show the methods used [multiple

⁵³ C. N. Moore, ‘On the coefficient of correlation as a measure of relationship’, *Monthly Weather Rev.* 48 (1916), pp. 274–6.

⁵⁴ Moore, *Forecasting*, pp. 103, 105.

⁵⁵ Joseph Kincer (1874–1954) was the principal meteorologist of the Weather Bureau. His work was critical in determining the influence of meteorological factors on cotton production. See his ‘A correlation of weather conditions and production of cotton in Texas’, *Monthly*

Weather Rev. 43 (1915), pp. 61–5; ‘Relation of weather to the amount of cotton ginned during certain periods’, *Monthly Weather Rev.* 45 (1917), pp. 6–11.

⁵⁶ For Smith, see his ‘Correlation’, *Monthly Weather Rev.* 39 (1911), pp. 792–5.

⁵⁷ Moore, *Forecasting*, pp. 108–9.

⁵⁸ In his *Agricultural meteorology: the effect of weather on crops* (1920), Smith set the foundations that came to characterize agricultural meteorology. The concept of

	Values of the Coefficient of Correlation				
	May	June	July	August	September
Temperature-Ratio	— .097	.551	— .032	— .499	.082
Rainfall-Ratio	— .410	— .411	— .254	.426	— .188

FIGURE 1. Georgia. Correlation between the yield-ratio of cotton and the temperature-ratio and rainfall-ratio

Source: H. L. Moore, *Forecasting the yield and the price of cotton* (1917), p. 109.

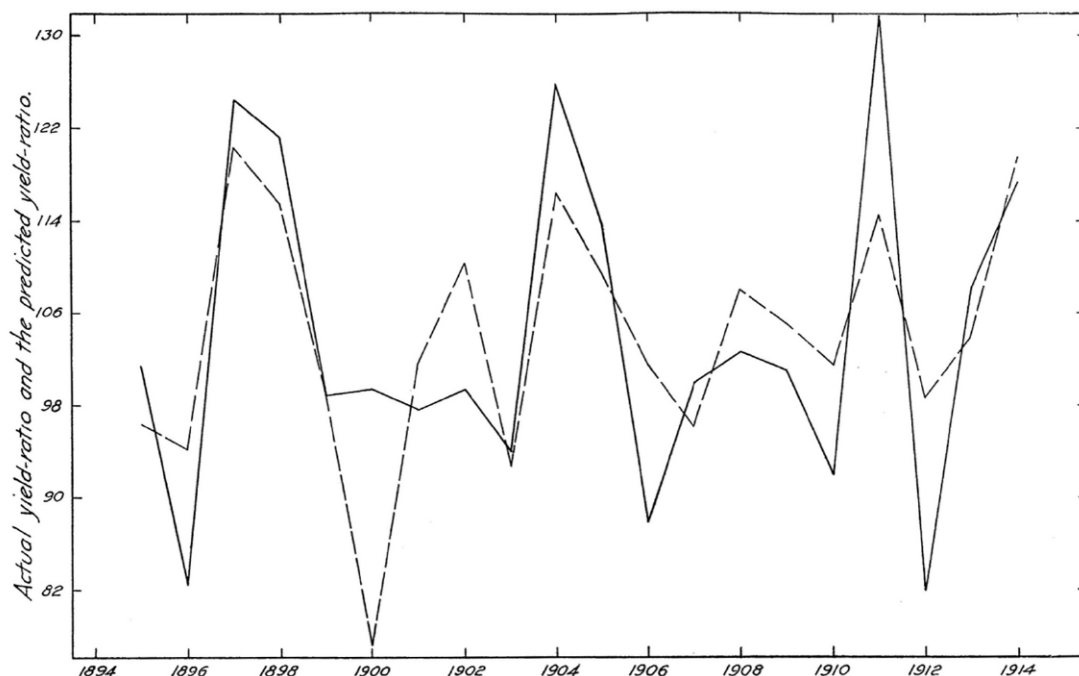


FIGURE 2. Georgia. The actual yield-ratio of cotton, —, and the yield-ratios as predicted, at the end of August, from the accumulated effects of the weather, — —

Source: H. L. Moore, *Forecasting the yield and the price of cotton* (1917), p. 112.

correlation], however, and help to point out the most critical period in the growth of this important crop and the kind of weather that most affects the final yield.⁵⁹ He then used a multiple correlation coefficient to determine the variables that were significant in explaining corn yields.⁶⁰ As for Moore, he kept three significant variables — x_1 = ratio of May rainfall, x_2 =

Note 59 *continued*

a critical period of growth and how to determine it were part of the field of agricultural meteorology.

⁵⁹ Smith, 'Effect of weather upon the yield of corn', p. 79.

⁶⁰ Smith, 'Effect of weather upon the yield of corn',

tested numerous hypotheses of correlation: July rainfall and corn yield, correlation for shorter periods than months, weather effects during different periods of development, thermal and rainfall correlation and corn yield, rainfall and rate of growth of corn.

		Months				
		May	June	July	August	September
Error of the Forecasts	S'	17.28	15.20	12.17	11.92	11.08
	S''	12.67	11.28	9.94	9.46	9.46

FIGURE 3. Relative accuracy of the forecasts of the yield per acre of cotton (1) from the condition of the crop, by the official method, and (2) from the weather reports, by the method of correlation. Georgia.

Source: H. L. Moore, *Forecasting the yield and the price of cotton* (1917), p. 114.

ratio of the temperature in June, and x_3 = ratio of the temperature in August – which, when combined with the multiple correlation coefficients, provided a prediction for the yield of cotton (Figure 2).⁶¹

Finally, to compare the value of the adjustment of the linear regression performed with weather data with the method of the USDA census, Moore calculated forecast errors (Figure 3).⁶² Thus, we notice that forecasting errors S'' were lower for whatever month was chosen when meteorological data were used to compare data coming from the calculations performed with the help of the official census method S' . Therefore Moore noticed that:

as far as the state of Georgia is concerned we have proved our thesis: That it is possible, by means of the weather reports and mathematical methods, to forecast the yield per acre of cotton with a greater degree of precision than the reports of the official Bureau with its vast organization for the collection and reduction of data referring to the condition of the growing crop.⁶³

We have shown in this first section that Moore was inspired by developments in agricultural meteorology to overcome the limitations of the census technique used by the USDA and to identify a better method for predicting crop yields. We argue in the second section that Moore's approach to better predict harvests was linked to the stability of commodity markets, in particular, that of cotton. Specifically, an improved methodology for the prediction of cotton crops would allow for better information in financial markets, which should stabilize cotton's market price, especially given the severe criticisms of the role of futures markets which had emerged. Moore would favour a pricing method based on the economic theory of the law of demand developed by Marshall.

II

Between the end of the nineteenth century and the end of the 1920s, the United States experienced a revolution in the organization of its financial markets. The development of futures markets gave rise to the fear that these markets could, through speculation, be

⁶¹ Moore, *Forecasting*, p. 111:

correlation.

⁶² With σ standard deviation and r_2 coefficient

⁶³ Moore, *Forecasting*, 115.

transmitted to the spot market and induce distortions in the price of products underlying futures contracts.⁶⁴ The social consequences linked to such pricing distortions were also part of the problems addressed at Columbia University.⁶⁵ Nourse has explained how price-making is intimately linked to the approach taken in institutional economics and that

the great expansion and refinement of price behavior studies in the United States during the two decades traces largely to two workers, Wesley C. Mitchell and Henry L. Moore ... [Moore's] work on the law of demand and his monograph on *Forecasting the Yield and Price of Cotton* became the stimulus to a large amount of activity in price behavior and statistical price analysis in the United States Department of Agriculture and in the experimental Stations.⁶⁶

More specifically, Banzhaf and Chancellor have placed emphasis precisely on the preoccupations of the USDA between 1910 and 1930 when priority was given to studies linked to price-making and to identifying functions of supply and demand.⁶⁷ Moore had very close connections with H. A. Wallace,⁶⁸ who wrote in 1915 to Moore indicating his keen interest in Moore's work on the law of demand and asking him to continue his research in order to establish policies to support farmers.⁶⁹ Thus, Moore's work also takes into consideration the issue of commodity pricing as he tested the effectiveness of the 1915 Cotton Futures Act to stabilize the relationship between the spot price and the futures price of cotton. This issue will be the subject of our first subsection. This period also questioned the fundamentals of the market according to which supply and demand determined the prices of commodities.⁷⁰ In a second subsection, we will analyse the works that address the importance of taking into account cotton production to determine the price of cotton. Moore rehabilitated the elements of supply and demand in determining the price of cotton.

⁶⁴ C. B. Cowing, *Populists, plungers and progressives: A social history of stock and commodity speculation, 1890–1936* (1965) and B. E. Baker and B. Hahn, *The cotton kings: Capital and corruption in turn of the century, New York and New Orleans* (2016).

⁶⁵ Rutherford, 'Institutional Economics', p. 24.

⁶⁶ E. G. Nourse, 'The meaning of "price policy"', *Q. J. Economics* 55 (2) (1941), pp. 175–7. Mitchell and Moore knew each other and corresponded.

⁶⁷ H. S. Banzhaf, 'The Other Economics Department: Demand and Value Theory in early Agricultural Economics', *Hist. Political Economy* 38 (suppl., 2006), pp. 9–31. E. Chancellor, 'Les premières années du Bureau of Agricultural Economics. La modélisation des récoltes, 1922–1930', *Histoire et Sociétés Rurales*, 42 (2) (2014), pp. 113–147 recounts the first years of the BAE – Bureau of Agricultural Economics – concerning

econometric techniques applied to harvest modeling.

⁶⁸ Before becoming vice president of the United States under Roosevelt (1941–1944), Henry Agard Wallace had a career in journalism and agribusiness. He was the son of a wealthy farmer – Henry Cantwell Wallace, Secretary of State for Agriculture in 1920 (see Chancellor, 'Les premières années' for the role of H. C. Wallace in the creation of the Bureau of Agricultural Economics in 1922) – and was the editor of *Wallace's Farmer* magazine and *Farm Progress*.

⁶⁹ K. A. Fox, 'Agricultural economists as world leaders in applied econometrics, 1917–33', *American J. Agricultural Economics* 68 (2) (1986), pp. 381–6. H. A. Wallace, *Agricultural Prices* (1920) referred to Moore's work on crop yield estimates (p. 77).

⁷⁰ Sheingate, *Agricultural welfare state*.

(i) Moore and the 1915 Cotton Futures Act: the hypothesis of the relationship between the futures price and the spot price

The history of cotton is linked to American industrial and financial history. Cotton cultivation began in Virginia at the very beginning of the seventeenth century. In the middle of the eighteenth, it had spread to Louisiana and the eastern Mississippi. The major difficulty in cotton production is separating the cotton from its seed, which is a difficult and labour-intensive job. Moreover, a mechanical process was developed to gin cotton.⁷¹ By the beginning of the nineteenth century, cotton was attracting more and more investors and speculators. Banks were created in the region to finance planters' projects. The annexation of Texas in 1845 allowed the United States to benefit from the cotton cultivation on its immense plains and the United States soon achieved cotton supremacy in the world. The Civil War (1861–65) put an end to the cotton prosperity of the United States insofar as the North imposed a maritime blockade on the South, preventing cotton exports. During the fifty years following the Civil War, American reconstruction took place partly with the rebirth of cotton cultivation, which was accompanied by the development of commodity exchanges and the use of futures markets.⁷² The use of futures markets was far from habitual among US cotton producers, as most were small farmers with limited knowledge of financial markets. On the other hand, the big producers had understood the interest of the futures markets: they could guarantee themselves a selling price before planting. Nevertheless, financial markets attracted speculators who, by taking positions on futures markets, have been able to destabilize prices and thus instil a feeling of suspicion amongst producers.⁷³ Protest movements began at the end of the nineteenth century in what was called 'the Agrarian Crusade' and lasted into the 1920s.⁷⁴ The Agrarians explained the erratic movements of the prices of commodities through the behaviour of speculators, specifically by artificially creating excesses in a commodity's supply by exchanging the same contract several times, thereby lowering market prices.

To them [the anti-futures forces] the fact that many times as much grain or cotton was sold in New York, Chicago, and New Orleans as was produced in the nation annually was *prima facie* evidence of perversion of the market system. To agrarians it seemed as if this tremendous activity, this passing of the same bushel or bale through so many hands, meant less money for the farmer and more money for the brokers and traders. If professional traders in Chicago having no wheat could, for example, offer to sell 10,000 bushels, did not this artificially bear the market by creating an apparently excess supply? The offering of nonexistent quantities of wheat by professionals – at harvest time when the farmer was trying to sell crop – was, to farm spokesmen, no coincidence; it was a deliberate effort by

⁷¹ It was a French farmer – Mr. Dubreuil – from New Orleans who invented the first ginning machine in 1742.

⁷² The New York Stock Exchange created a cotton futures contract in 1870, the Liverpool Stock Exchange in 1872 and the New Orleans Stock Exchange in 1880.

⁷³ In 1881, Ranger held the entire stock of Liverpool

Cotton and set his brokers a high daily selling price to dry up the Lancashire cotton spinners market. In 1903 in New Orleans, Brown and Hayne used futures markets to destabilize markets.

⁷⁴ S. Buck, *The Agrarian Crusade: A chronicle of the farmer in politics* (1920).

big speculators to depress the market temporarily in order to buy cheap from the farmer and later sell dear to the miller.⁷⁵

Pirrong distinguishes three types of manipulation in commodity markets: market power manipulation (corners and squeezes), trade-based manipulation, and information-based manipulation.⁷⁶ The first – market power manipulation – is the most important form of manipulation used in raw materials markets. It consists of forcing market participants to liquidate their open positions – and therefore to close out their positions – on the futures markets at any price.⁷⁷ This form of manipulation causes dry losses that result from the imbalance between the futures market and the physical market. However, and even more important, this leads to instability in the base,⁷⁸ which further reduces the effectiveness of the cover and thus the attractiveness of this type of contract to hedgers. Agricultural futures markets are primarily intended to hedge farmers against the risk of falling crop prices by adopting a short hedge strategy.⁷⁹ Price manipulation consists of adopting a long hedge or buying hedge strategy in order to destabilize forward prices. This can be disastrous for farmers, who then lose confidence in the financial markets to help cover their risks of falling crop prices. These dry losses provide a justification for regulation or legislation to deter or prevent manipulation, particularly with the obligation that any futures contracts result in delivery to the physical market, assuming a well-determined and stable product quality. The second type of manipulation – trade-based manipulation – consists of manipulating commodity prices via trade. Specifically, requests to buy or sell products require market intermediaries – market-makers – to take positions in futures markets that they must then liquidate. Each market intermediary has its own private information. Market-maker decisions then influence market prices. Thus, market-makers infer that an order from their clients to buy – or sell – might reflect the fact that the issuer of the order has favourable – or unfavourable – private information. Thus, information leads to rapid price changes resulting from constant changes in supply and demand. Price manipulation results not only from the purchase or sale of the product in large quantities but also from the asymmetry of prices in relation to the quantities requested and offered.⁸⁰ The third strategy – information-based

⁷⁵ Cowing, *Populists, plungers and progressives*, pp. 8–9.

⁷⁶ S. C. Pirrong, ‘The economics of commodity market manipulation: A survey’, *J. Commodity Markets* 5 (2017), pp. 1–17.

⁷⁷ For example, if the farmer fears a drop in prices, he forward-sells his crop at a price fixed in advance. He will then have to settle its position by buying back its contracts. The forward market result is the difference between the sale price and the repurchase price of the contracts. In order to make a profit, he must buy back his position cheaper than he sold it, otherwise he suffers a loss. Some market operators may be tempted to manipulate futures prices by buying contracts on a massive scale in order to drive up prices and thus cause a loss for farmers. As the maturity date approaches, farmers have no choice but to close out their positions

at a loss, i.e., buy back their contracts at a higher price than they sold them.

⁷⁸ The basis represents the difference between a forward price and a physical price (a spot price).

⁷⁹ Farmers who fear a drop in crop prices will therefore adopt a short hedge strategy, which consists of forward selling at the outset. Then, when the deadline approaches – when the harvest begins – the farmer closes out his futures position by buying back his contracts and sells his harvest on the physical market at the spot price. This whole hedging strategy works correctly as long as the basis remains stable at maturity.

⁸⁰ Chancellerie, ‘Les premières années’ shows to what extent the price elasticities of demand and supply prices applied to agricultural commodities are effective analytical tools to account for the stability of an agricultural market.

manipulation – is based on the disclosure of false information. Rumours concern the state of stocks and the quality of products. If the information is wrong, then economic actors make sub-optimal decisions, disrupting the market.

So, between the end of the nineteenth century and the 1920s, there were suspicions regarding the role of speculators in determining the market price of agricultural products. The major problem of the time concerned the possible manipulation of agricultural prices. The protests of farmers against apparent profiteering at their expense had a political impact in the United States that resulted in the regulation of financial markets.⁸¹

As Pirrong has explained, cotton, which was traded primarily on the New York Cotton Exchange and the New Orleans Cotton Exchange, experienced a significant stock crisis due to financial actors manipulating market prices:

corners and squeezes were a regular event, with some especially spectacular manipulations of the New Orleans Cotton Exchange and New York Cotton Exchange (NYCE) contracts occurring in 1870 (4 different months), 1871, 1874, 1875, 1879 (2 months), 1881 (5 months), 1882, 1883, 1885, 1887, 1888, 1889, 1895, 1896, 1901, 1903, 1904, 1906, and 1910.⁸²

For example, in 1904, Daniel Sully speculated on cotton by purchasing all of the cotton available on the New York Stock Exchange. By drying the market, he hoped to increase the futures market prices and obtain a sale profit.⁸³ The farmers' loss of confidence in financial markets was obvious given that market prices, both spot and futures, were based on the information available to the market, in particular, the statistics of crop yields issued by the USDA. In addition, the market authorities were also accused of playing the market in the early twentieth century. The law allowed all of the personnel of the Crop Reporting Board to speculate on futures even though the information asymmetry was obvious.⁸⁴

The distrust towards financial markets led to a decrease in traded volumes on the spot market in the New York Cotton Exchange. '[T]he troubles of the New York Cotton Exchange originated in a decline in 'spot' dealings in cotton at New York. From sales of over 430,000 bales annually in the '70s, the annual average in the '90s fell to less than 160,000 bales'.⁸⁵ As Lipartito explained, the futures markets faced the problem that they no longer reflected the underlying price:

The trouble arose after the Exchange adopted a system of fixed differentials or fixed differences. Essentially, the fixed differences system meant that the Exchange chose to set the ratios of value between different grades of cotton in the futures market, rather than

⁸¹ Sheingate, *Agricultural welfare state*, pp. 110–13. Between 1880 and 1920, nearly 200 bills were passed by the U.S. Congress to regulate the commodities futures markets. R. E. Pirrong, 'Commodity market regulation after financial crisis: a comparative approach', *Economic Affairs* 31 (2010), p. 45.

⁸² Pirrong, 'Self-regulation of commodity exchanges', pp. 184–6.

⁸³ K. J. Lipartito, 'The New York Cotton Exchange

and the Development of the Cotton Futures Market', *Business Hist. Rev.* 57 (1983), pp. 50–72.

⁸⁴ Murray, 'Close-up view', pp. 709–11; A. Hobson, 'A foreign agricultural information service', *J. Farm Economics* 12 (1930), pp. 57–68 and Sanderson, *Methods of Crop forecasting*, pp. 142–3.

⁸⁵ L. Conant Jun., 'The United States Cotton Futures Act', *American Economic Rev.* 5 (1915), pp. 1–11.

letting them fluctuate with economic conditions as they would from the price of spot market cotton.⁸⁶

This structural problem, related to the intrinsic characteristics of cotton, tended to destabilize the market price. The cotton market had the opportunity to offer multiple qualities or grades of its product in quantities which varied from one year to the next. Therefore, it was impossible to open a futures market for each quality: 'one grade ("Middling Uplands") is selected as a basis to which the prices of cotton futures refer'. Thus, if the seller offered a cotton lower in quality than *middling uplands*, he had to pay a penalty to complete the transaction; whereas if he offered a quality superior to *middling uplands*, he would receive a bonus.⁸⁷ The problem was to estimate correctly the amount of bonuses or taxes based on all the qualities offered on the market. The complexity of the system was that 'it became increasingly easy to manipulate the prices of the various grades, and hence the differences between grades'.⁸⁸

To regulate cotton futures markets, the authorities passed the Cotton Futures Act on 18 August 1914 and this came into effect on 18 February 1915. The objective was to limit the number of grades being exchanged on the cotton market and to take into consideration the physical market, that is, the spot market price, to calculate accurately the bonuses and taxes for the development of futures markets:

In 1914 the New York Exchange therefore adopted a plan of monthly revision of grade differences, and instructed its revision committee to take into account as nearly as practicable the quotations which they obtained from the southern spot cotton markets. ... Grades differences at New Orleans as well as at New York are now based upon the 'average actual commercial differences in value' prevailing in not less than five spot markets designated by the Secretary of Agriculture.⁸⁹

This reform highlighted the importance of determined cotton prices on the physical market, as spot prices were the basis for calculating and determining futures prices. Thus, as Markham states in his book on the history of financial speculation in commodities, 'The Cotton Futures Act did not broadly regulate cotton futures trading, but established a commercial difference system for pricing and the use of federal standards for the grading of cotton'.⁹⁰ More generally, as described by Simon and Lautier in their book on the functioning of commodity markets, futures markets allowed operators to reveal their expectations concerning the future state of the spot market. Thus, 'thanks to the futures markets, the spot price was a true balanced price'.⁹¹ It was in this context that the Cotton Futures Act was enacted to ensure that cotton

⁸⁶ Lipartito, 'New York Cotton Exchange', p. 64.

⁸⁷ The cotton futures contract differs from other agricultural futures contracts in that it does not specify the exact quality that the seller undertakes to deliver. This is called a basis contract, which simply specifies the price of a certain quality of cotton – Middling Uplands – which will serve as a basis for comparison with the actual quality the buyer will receive. This means that the seller – the farmer or the cooperative – has the right to deliver the quality that is available at

the moment.

⁸⁸ L. D. H. Weld, *The marketing of farm products* (1916), pp. 330–3.

⁸⁹ G. G. Huebner, *Agricultural commerce, the organization of American commerce in agricultural commodities* (1915), pp. 146 and 148.

⁹⁰ J. W. Markham, *The history of commodity futures trading and regulation* (1987), p. 11.

⁹¹ Simon and Lautier, *Marchés dérivés de matières premières*, pp. 306–8 (author's translation).

futures prices did not destabilize spot prices. Financial theories assumed a link between spot price and futures price from the beginning of the use of the futures markets. Killough and Killough (1926) analysed the links between the different financial locations where the cotton was exchanged. They showed that markets specializing in futures contracts were in constant contact with the physical market: 'Monthly prices of American middling cotton at New Orleans, New York, and Liverpool, and monthly prices of cotton on farms in the United States bore a close relation to each other'. Thus, the cotton spot price and the futures price were linked: 'spot prices have a strong influence in determining bids and offers for future deliveries or that the set of immediate causes which make spot prices has a dominating influence in the making of futures prices also'.⁹² Numerous significant variables could explain the causality between spot prices and futures prices such as the speculators' expectations on the future state of the market and the estimation of crop demand. If the cotton market had the characteristic to be structurally in contango, that is, if the futures price is superior to the spot price, it would justify the storage theory's explanation of the price of a futures contract: 'New Orleans and New York prices are to be expected to range above farm prices because of marketing costs ... The uniformity of month to month movements of American cotton prices in different markets gives universal application to a study based on one series of monthly average prices'.⁹³ Nevertheless, relationships between the spot prices and futures prices were not always constant, as Huebner indicated:

Futures and spot cotton prices, however, have not in the past borne the definite relationship to each other – they have not maintained the substantially exact parity which is maintained in the grain trade ... The failure to maintain a parity between the prices of spot cotton at the large cotton markets and the price of futures has obliged such cotton buyers to base the country price primarily upon the price of futures contracts.⁹⁴

This instability between futures prices and spot prices can be explained by the lack of standardization of exchanged products: 'The failure to establish the "differences" between the various deliverable grades with exactness, cotton futures have frequently sold at an abnormal discount as compared with the prices paid for spot cotton at the large spot markets'.⁹⁵ To address these uncertainties, the Cotton Futures Act should have brought spot prices closer to futures prices by reducing the number of qualities of cotton likely to be exchanged on the markets.

The financial stakes lie in the stability of the basis – the spread between the futures price and the spot price must remain stable – as a necessary condition for the proper functioning of

⁹² H. B. Killough and L. W. Killough, 'Price making forces in cotton markets', *J. American Statistical Assoc.* 21 (153) (1926), pp. 47–54.

⁹³ Killough and Killough, 'Price making forces in cotton markets', p. 47. In the early twentieth century, the term 'marketing costs' had a somewhat broader definition than today. As an illustration, we use the definition of Weld in 1916: 'Marketing costs include those of handlings at local points, transportation,

handling by the various classes of wholesalers, including storage in many instances, drayage and delivering to retailers, and handling through retail stores, including delivery to consumers.', Weld, *Marketing of farm products*, p. 175.

⁹⁴ G. G. Huebner, *Agricultural commerce: The organization of American commerce in agricultural commodities* (1915), p. 111.

⁹⁵ *Ibid.*

agricultural financial markets.⁹⁶ Garside explains very well the dilemma in which the actors of the agricultural world find themselves: futures markets make it possible to hedge against a price risk but not against a basic risk. So:

a merchant who hedges a fixed price forward shipment sale of spot cotton by a purchase of futures cotton, that is, by a purchase of cotton for future delivery on a futures exchange, thereby eliminates the risk of loss through a rise in the full price of spot cotton but by his hedging he bases his operations on the basis price, and he has to assume the risk of a rise in the basis price before he buys the spot cotton which he needs to fill the forward sale. A hedging merchant thus takes positions on the basis price, instead of taking positions on the full price. ... The basis cannot be hedged.

Therefore, the 1910s and 1920s gave way to questions relating to the ability of financial markets to balance the exchange of primary materials in general and particularly that of cotton. This rises from the questions of institutional economics which, according to Nourse, 'presses on past the effort to learn the fundamental nature of the economic forces involved in price-making to examine also the organic mechanisms through which these forces perform their work and how these institutional agencies impress their character on the product'.⁹⁷ In this context, Moore became interested in the matches between the cotton spot price and the futures price using the correlation coefficient:

How can one measure the degree of association between futures and spot values? Or, to put the question in another form, suppose one knew the probable spot values in the South, how could one forecast the price of futures on the cotton exchanges at New York and New Orleans?⁹⁸

Moore used a chart to represent futures prices, as fixed by the New York Stock Exchange and spot prices⁹⁹ from daily data between 11 September 1915 and 30 October 1915.¹⁰⁰ (Figure 4). It is evident that the cotton market was in contango inasmuch as futures prices were higher than spot prices. This situation appeared to be the situation of reference as indicated by Weld: 'During a single crop year the future price should be higher than the cash price at any one time by approximately the cost of carrying until the month of delivery'.¹⁰¹ The standard theory of the time was based on the cost of storage until the expiry date of the futures contract to determine the futures price. Moore also noted a clear visual correlation between spot and futures prices.¹⁰² 'It is clear that, as the fluctuations of average spots increase or decrease, the fluctuations of New York futures increase or decrease'. Moore wanted to validate the effectiveness of the Cotton Futures Act, whose objective was to limit speculation on futures markets so that spot prices reflected a good approximation in the development of futures

⁹⁶ For the following, Garside, *Cotton goes to market*, pp. 247–88.

⁹⁷ Nourse, 'The meaning of "price policy"', p. 176.

⁹⁸ Moore, *Forecasting*, p. 13.

⁹⁹ The spot price is an average price – quality cotton Middling – calculated from the listing of several physical markets: Norfolk, Augusta, Savannah, Montgomery,

New Orleans, Memphis, Little Rock, Dallas, Houston, Galveston (Moore, *Forecasting*, p. 12).

¹⁰⁰ The period used by Moore matched with the period when the Cotton Futures Act was enacted.

¹⁰¹ Weld, *Marketing of farm products*, p. 318.

¹⁰² For the following, Moore, *Forecasting*, p. 29.

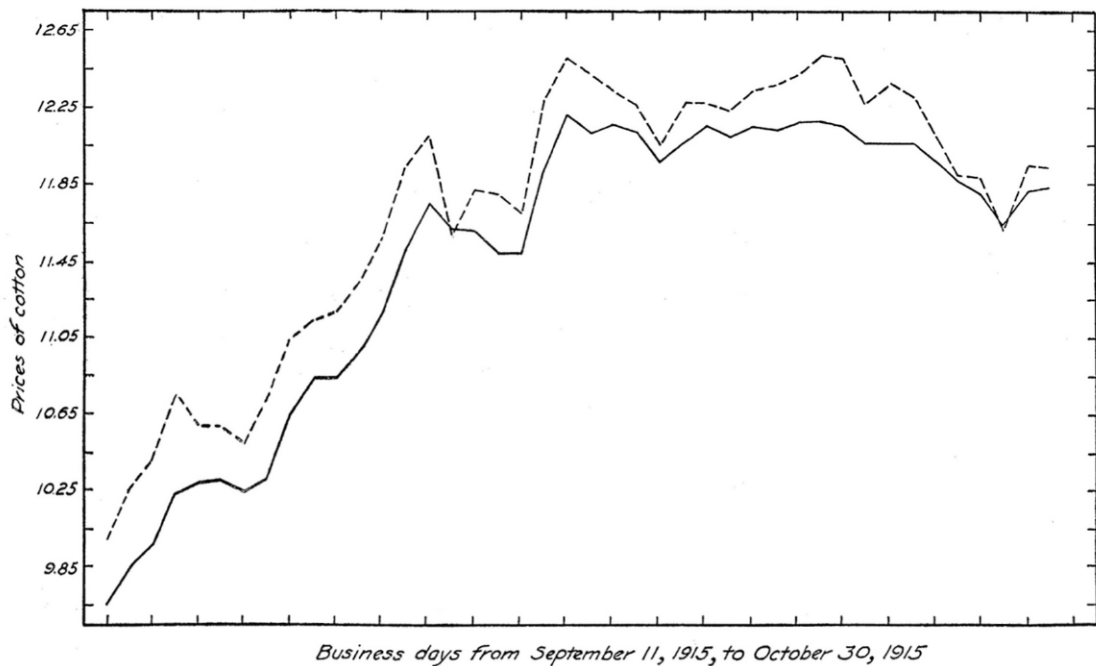


FIGURE 4. The prices of spot cotton in the South, —, and the prices of cotton futures in New York, - - -

Source: H. L. Moore, *Forecasting the yield and the price of cotton* (1917), p. 14.

prices. Therefore, Moore considered that spot prices had to determine futures prices. To test this hypothesis, he used the correlation coefficient:

There is obvious association between the two variables [spot cotton price and futures cotton price], and the substance of our problem is to measure the degree of the correlation and to find the statistical law description of the manner in which the one variable is connected with the other.

Thus, by using linear regression, Moore could calculate the variations of futures prices from the variations of spot prices.¹⁰³ To determine the correct adjustment of the linear regression, Moore calculated the level of forecast errors at 6 per cent.¹⁰⁴ The parameters of the linear regression were positive, which meant that an increase in spot prices led to an increase in futures prices and vice versa. Thus, the underlying theory was that it was the physical determinants – offer and demand – of spot prices that influenced futures price. Furthermore, Moore demonstrated the effectiveness of the Cotton Futures Act in establishing a constant relationship between futures prices and spot prices. Indeed, a near parallelism between the two market prices indicated that arbitration operations worked properly. In other words, the decisions of professionals were based on product qualities and thus conformed to what professionals in the sector expected. Even though the work of Moore showed that the Cotton Futures Act appeared to be

¹⁰³ With x = the variations of spot prices and y = the variations of futures prices in New York (Moore, *Forecasting*, p. 50).

¹⁰⁴ With $\sigma_y = 0.085$ and $r^2 = 0.06$.

effective, cotton producers remained suspicious of futures markets. Therefore, Moore decided to develop a new pricing method for cotton by calculating the possible correlations between the number of crops and the cotton prices.

(ii) *'King Cotton': The hypothesis of the link between cotton harvests and the price of cotton with the challenge of identifying the law of demand*

As we showed, the financial markets dealing in commodities were subject to fraud, resulting in the loss of confidence of economic actors and in problems concerning the methods of rating. As Weld explained, errors in determining the prices of commodities also come from 'the impossibility of measuring either demand and supply accurately'. This difficulty is partly explained by the fact that the world of cotton underwent major technological changes that destabilized the old methods of forecasting supply and demand.¹⁰⁵ It was in 1890 that T. J. King of Louisburg, North Carolina, discovered a new variety of early-maturing cotton, Early or King Cotton. By the 1920s, this strain of cotton had become very commonly grown. With the development of intensive mechanization, this variety also offered increased productivity. Agriculture also adopted a business model of a rational production process, the view being that 'farmers needed to be brought in line with other modern industries, and that would entail mechanization, rationalizing farm operations, and routinizing agricultural practices'.¹⁰⁶ We have already seen how farmers believed that commodity prices could be manipulated by speculators on futures markets, which led to the idea that the prices of commodities would be manipulated as well:

The commodities prices are being manipulated without any reference to demand and supply. ... The Minnesota Union of the Equity at its annual convention in December, 1913, passed a resolution declaring that 'the doctrine of supply and demand is false' and that prices are made 'artificially by the modern business combinations', and that 'hence the only true basis upon which food products may be priced is on their cost at their source on the farm'.¹⁰⁷

Thus, the debates at the time were directed towards new methods of price determination using the source price, that is, the price that the farmers received following the sale of their product from the farm and not the final sale price. The purpose of these debates was to ensure a satisfactory income for farmers: in the end they gave birth to the concept of parity price.¹⁰⁸ Suspicion about the functioning of the markets forced the Federal Government to intervene so as to ensure a certain level of prices for the farmers.¹⁰⁹ More specifically, the Price Committee created in 1917,¹¹⁰ though only for wheat, had the objective of defining a fair price in order

¹⁰⁵ Weld, *Marketing of farm products*, p. 246.

¹⁰⁶ D. Fitzgerald, *Every farm a factory: The industrial ideal in American agriculture* (2003), pp. 21–2, 45.

¹⁰⁷ Weld, *The marketing of farm products*, p. 247.

¹⁰⁸ J. H. Shideler, 'The development of Parity Price Formula for agriculture, 1919–1923', *Agricultural Hist.* 27 (1953), pp. 77–84. The Agricultural Adjustment Act of 1933 establishes the law for parity. The law should allow 'the right of farmers to a fair purchasing power,

measurement of purchasing power by a relationship between prices of farm produce and prices of other goods, comparisons made with a base period in the past when a supposed equilibrium and stability existed, and such government intervention as was necessary to bring about a condition of "parity"'.
¹⁰⁹ Sheingate, *Agricultural welfare state*.

¹¹⁰ Note that the United States entered the World War I in 1916.

to guarantee the income of farmers. Additionally, despite the massive industrialization of cotton harvesting techniques at the end of the nineteenth century – which led to productivity increases – the fact remains that the US domestic market stagnated while supply continued to increase. The United States entered a period of overproduction. The essential challenge of the moment was therefore to return to economic fundamentals from the real sphere – the analysis of demand and supply – in order to better understand the conditions for the emergence of a ‘correctly’ determined price.

Some economic and institutional actors of the early twentieth century doubted the ability of the market to set a price representative of the economic situation. The fact remains that from a theoretical point of view, ‘primary market prices are determined largely by conditions of supply and demand’.¹¹¹ More precisely, the role of supply and demand in the analysis of the price of commodities was part of the essential characteristics of the agricultural economy. As a result, calculations of elasticity were decisive in capturing the responsiveness of the commodities market based on Marshall’s contribution on the elasticity of demand. If Moore pays tribute to a number of neoclassical economists such as Cournot and Walras, he nevertheless sees his work as directly inspired by Marshall in order to differentiate himself from the neoclassical approach, described as deductive and abstract.¹¹²

First, Moore, therefore, drew on concepts discussed in agricultural economics and applied them to the cotton market. He questioned the ability of the law of demand as developed by Marshall to predict the price of cotton.¹¹³ As such, he subscribes to the questions raised at the beginning of the 1910s that address the econometric issue of identification. As a number of authors have explained, the first treatments of the problem of identification were the works of Lenoir in 1913 and Lehfeldt in 1914.¹¹⁴ The objective of Lehfeldt’s research was to model a demand curve econometrically while removing the effects of supply on the price. Indeed, the difficulty lies in the fact that price, supply, and demand are closely intertwined. As such, Moore first calculated the correlation coefficient between the ratio of the production of cotton and the ratio of the price of cotton. The coefficient was high and negative, $r = -0.706$, indicating that an increase in cotton production lowers the price.¹¹⁵ Furthermore, Moore also analysed market dynamics by calculating the correlation coefficient, $r = -0.819$, between the

¹¹¹ Heuber, *Agricultural commerce*, pp. 89–90.

¹¹² Moore, *Forecasting*, pp. 172–3.

¹¹³ Moore’s first tests on the connection between crops and prices of commodities date back to his 1914 book in which, in a cyclic environment based on the periodogram, he calculated the correlation coefficients between the production of different commodities – hay, oats, and potato – and their associated prices. He noticed negative correlations between prices and the produced quantities. He then calculated the correlation coefficients between the rates of price growth and rates of production growth. Here, again, the correlations were negative.

¹¹⁴ M. S. Morgan, *The history of econometric ideas* (1990), pp. 136–42, also D. F. Hendry and M. S. Morgan (eds), *The foundations of econometric analysis* (1995)

pp. 18–22 and D. A. Bessler *et al.*, ‘Econometric developments in agricultural and resource economics: the last 100 years’, *American J. Agricultural Economics* 92 (2010), pp. 573–4. Lehfeldt proposed to measure the elasticity of demand for wheat and believed that if he could find the quantity supplied under conditions in which demand is constant, then the movement of the supply curve should trace the constant demand curve.

¹¹⁵ As evidenced, Moore determined the line of linear regression in the following manner: $y = -0.975x + 206.03$ with x = the production ratio as the ratio between the production of a year and the total production of three years and y = the ratio of the price of cotton as the ratio between the price of cotton in a year and the average price of cotton over a period of three years (Moore, *Forecasting*, p. 143).

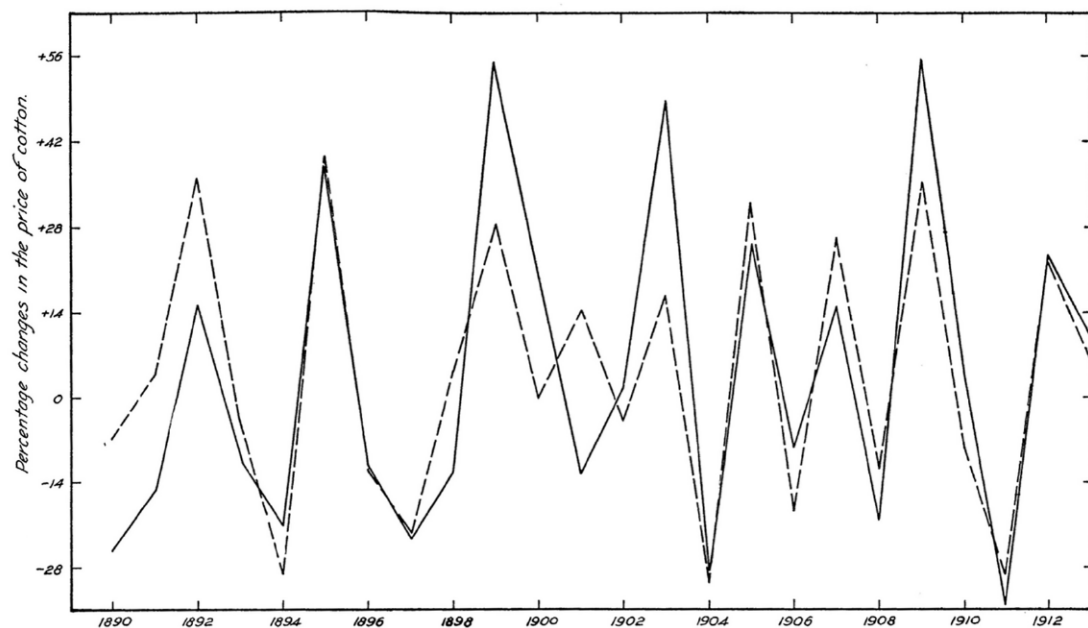


FIGURE 5. The actual percentage changes in the prices of cotton, —, and the percentage changes as they are predicted, - - -, by means of the dynamic law of demand for cotton, $y = -1.08x + 8.81$

Source: H. L. Moore, *Forecasting the yield and the price of cotton* (1917), p. 146.

rate of growth of cotton production and the rate of growth of the cotton price. Here again, the correlation coefficient was high and negative. This result indicated that an increase in the rate of the growth of cotton production was related to a decrease in the rate of growth of the cotton price. Moore then performed the calculation using a linear regression between the rate of growth of cotton production (x) – and the rate of growth of the cotton price (y). The result of the regression, $y = -1.08 + 8.81x$, is illustrated in Figure 5.

The results suggest the market dynamics and their sensitivity towards fluctuations in cotton production. Indeed, an increase of 1 per cent in the growth rate of cotton production caused a decrease of 1.08 per cent in the price of cotton. That is, the rate of growth of the price of cotton was sensitive to the rate of growth of cotton production inasmuch as the growth rate of the price overreacted more so than that of the unit. 'Our law of demand is a dynamic law; it is a summary description of a routine in concrete affairs'.¹¹⁶ Moore thus used the dynamic law to determine the movements of the general level of prices between two different dates.

Nonetheless, Moore wished to convert this dynamic law into a Marshall-like static law. As such, he takes up again the law of demand formulated by Marshall, which consists in establishing a link between the decrease in price and the increase of demand, and conversely between the increase in price and the decrease of demand. In addition, Marshall's theory holds true only given a certain number of conditions, particularly that the prices of all other goods must remain constant, and it assumes that consumer tastes and habits remain unchanged.

¹¹⁶ Moore, *Forecasting*, p. 147.

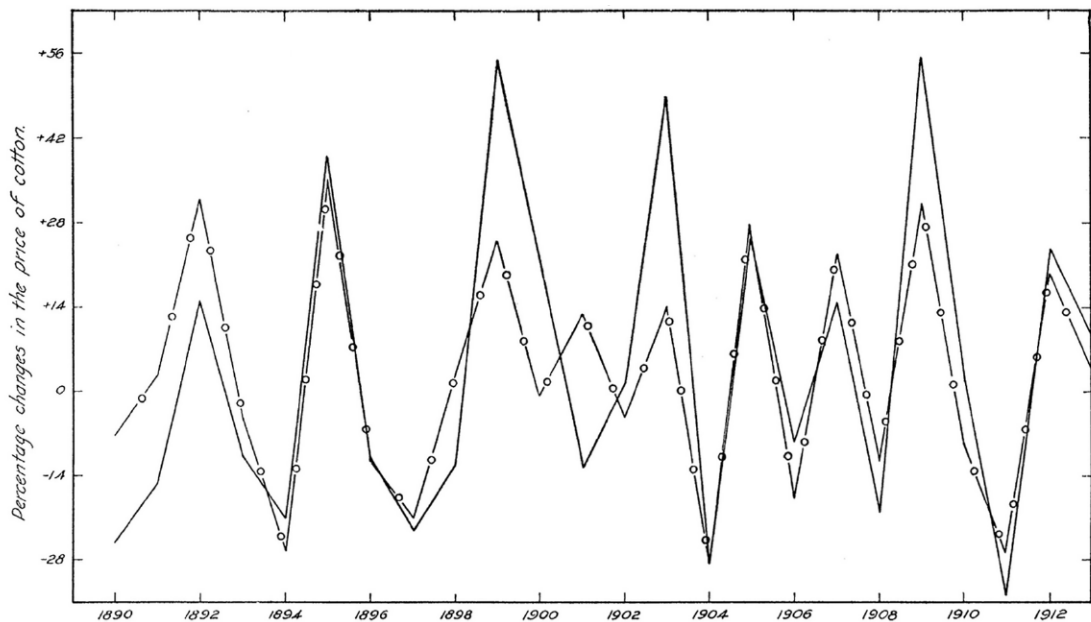


FIGURE 6. The actual percentage changes in the prices of cotton, —, and the percentage changes as they are predicted, —o—, by means of the static law of demand for cotton, $x_2 = -0.97x_1 + 7.11$, where the purchasing power of money is supposed to remain constant

Source: H. L. Moore, *Forecasting the yield and the price of cotton* (1917), p. 160.

Finally, this is a supposed static theory in that Marshall does not take into account the purchasing power of money. Specifically, if we spend more for one good, there is less money to spend on other goods, and consequently the value of money increases for all other purchases. Moore's chosen strategy is therefore to employ the statistical approach of multiple correlation. Specifically, in cancelling out the general movement of prices by using multiple correlation techniques and in disassociating general price movement from the particular movement of cotton, he formulated the static law of cotton: namely, the relationship between quantities of cotton and the price of cotton while assuming the general movement of prices is constant:

We have now a solution of the first part of our problem. We know how to forecast the changes in the price of cotton when account is taken of the changes in the amount demanded and of variations in the purchasing power of money. ... We next enter upon the second part of our problem: What is the relation between the changes in the prices of cotton and the changes in the amount demanded when there are no changes in the purchasing power of money?¹¹⁷

Moore estimated an equation explaining the variation of price according to two variables: the variation of the production of cotton and the variation of the general price index.¹¹⁸ In

¹¹⁷ Moore, *Forecasting*, p. 158.

¹¹⁸ $x_0 = -0.97x_1 + 1.60x_2 + 7.11$ with x_0 = percentage change in the price of cotton; x_1 = percentage change in

the amount of cotton produced; x_2 = percentage change in the index number of general prices.

assuming that the variations in the price index remain unchanged, Moore determines the static law of Marshall-like demand.

So Moore says 'it is possible not only to deal with the dynamic law of demand in all of its natural complexity, but also to ascertain the static law of demand giving the relation between x_0 and x_1 when all the other variables are equal to zero'.¹¹⁹ Moore showed that it was possible to determine the price of cotton from elements related to the real sphere such as the size of the crops, and as a result, in the context of the suspicion towards financial markets, it was possible to obtain an estimate of the cotton price that would be the reference price on the market.

III

Throughout this article, we have placed the work of Moore in the context of his time. We showed how Moore built on the work of agricultural meteorology to produce better predictions of cotton yields. Using the correlation coefficient method to relate weather and yields of cotton, he demonstrated that this technique was more reliable than the census technique used by the USDA. In the second section, we elaborated on the financial and economic aspects of the cotton market. Moore demonstrated the effectiveness of the Cotton Futures Act in stabilizing the correspondence between the futures price and the spot price. He also rehabilitated the economic theory based on supply and demand in its role in determining the price of cotton. Moreover, we have situated Moore's work within an economic, financial and institutional environment that proves the complexity of the functioning of an agricultural market insofar as it depends on exogenous variables derived from meteorological data while maintaining its effectiveness at providing a fair price. The goal is to give economic actors the possibility of hedging themselves against this price risk. This period shows the extent to which the public authorities were still seeking legitimacy in the agricultural world of cotton. It was not until 1922 with the creation of the Bureau of Agricultural Economics (BAE) that the discipline of the agricultural economy came under the spotlight in agricultural policy in order to help agricultural sectors – cotton in particular – to develop.

¹¹⁹ Moore, *Forecasting*, p. 162.