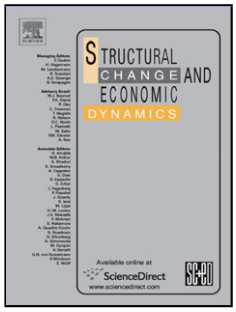

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Can inflation expectations be measured using commodity futures prices?

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Highlights

- Wholesale re-examination of the link between commodities futures prices and inflation from 1929-1932
- Emphasises the importance of rigorous attention to market microstructure when using data from commodities exchanges
- Agricultural commodity markets did adjust to deflationary expectations by late 1930
- Clarifies the appropriate use of futures price in forecasting wider economic trends

This paper reexamines the use of US commodity futures price data to show that the US deflation of 1929 to 1932 was at best no more than partially anticipated by economic actors. By focusing on the expected real interest rate, previous studies provide some empirical support for explanations of the Great Depression that are not exclusively monetary in nature. However, these studies did not consider the

context and the market microstructures from which the data was sourced. Our analysis suggests that it is more likely that agricultural commodity markets adjusted to deflationary expectations by the end of 1930. Evidence from commodities futures markets, such as the Chicago Board of Trade, therefore should not be used to critique the Keynesian challenge to the classical monetarist explanation of the Great Depression.

Keywords:
Commodity futures, inflation expectations, normal backwardation

JEL:E3

I. Introduction

In economics, there remains a significant controversy over the causes of the length and depth of the Great Depression, as well as the role, if any, of the severe deflation from 1930 to 1933. On one side, Milton Friedman and Anna Schwartz (1963) argue for a strictly monetary cause. Other authors, while agreeing partially with the monetarists, point to other important transmission effects, such as the loss of banks as credit information holders (e.g. Bernanke 1983 or Fisher 1933). Finally, there are those, mostly Keynesians, who reject the monetarist explanation, and focus on the role of secular shocks (e.g. Peter Temin 1976). There are significant problems with a strictly monetarist explanation. Specifically, Friedman and Schwartz comment on but cannot fully explain the decline the velocity of money during the period, nor are some convinced that the direction of causality runs from money supply declines to real output declines (Temin 1976). An additional problem with the Friedman-Schwartz hypothesis is that interest

rates during the Great Depression were too low to indicate the severe monetary contraction that the US Federal Reserve is accused of accelerating (Temin 1976). The counter argument, voiced by Brunner (1981) is that, as economic agents expected deflation after 1929, real interest rates *ex ante* were actually quite high. However, at first, economists lacked the tools to measure inflation expectations. By the 1980s, Frederic Mishkin and James Hamilton brought together the concept of 'rational expectations' (RE) with the latest in financial theory, the 'efficient markets hypothesis' (EMH)[1], to address such questions as price expectations and their role in economics.

John Muth (1961) exhorted economists to 'model agents as if they know the model' (Hoover and Young 2011). That is, 'if economic variables are determined by an identifiable on-going process then sooner or later intelligent economic agents will recognize the process and will then model their expectations in the light of that process' (Shaw 1987). Academics studying expected inflation in the 1980s examined interest rate (e.g. Cecchetti 1992) and commodity price (Hamilton 1992) data for potential measures of expected future inflation. Another line of attack for those looking for market expectations of inflation utilized the then new tools of finance that posited that all information was fully discounted into the market price of a stock, bond or commodity contract (Fama 1965). As such market-determined prices would already reflect the expectation of future performance.

[1] Interestingly, though often viewed as identical, the development of RE and the EMH were quite separate. Even Merton Miller, who sat on the PhD committees of both the generally-accepted founders of RE (Muth, at Carnegie Tech) and EMH (Fama, at Chicago), did not connect the two theories at first (Hoover and Young 2013).

James Hamilton (1987) appears to be the first to marry conceptions of the EMH from such adherents as Eugene Fama and Kenneth French (1987), with somewhat stylized understandings of agricultural commodities futures market to examine the broader implication of commodity price movements on expected economy-wide price level changes. In his early study of commodity markets in 1987 Hamilton shows that, for example, the wheat futures market was 'predicting' a 19.9% annualized own inflation rate in May 1930, when, in fact wheat prices fell for the next five months at an annualized rate of 53.8% (See table 3). He finds similar results throughout 1929 to 1932 for corn, cotton and oats as well, therefore asserting that commodity investors did not anticipate the oncoming deflation. As such, he concluded 'I am persuaded that one can convincingly rule out the hypothesis that the mechanism whereby monetary policy led to the depression in agriculture was that large anticipated deflation led to high *ex ante* real interest rates' (Hamilton 1987 p. 166). '[This] seems to [cast] considerable doubt on the Keynesian interpretation' (Hamilton 1987: 166). Hamilton's 1992 article begins with a similar study, observing that six commodity 'markets seemed to repeat the same error [underestimating deflation] throughout 1929-1932' (Hamilton 1992: 160). From this he concludes that such futures markets did not anticipate any deflation from 1929 to 1932, and, in fact, expected commodity prices to rise.

In this paper, we argue that Hamilton in 1987 and in the first part of his 1992 paper misinterpreted his dataset in making such findings, and therefore the conclusions should not stand. In the second part of his 1992 study, Hamilton incorporated a RE approach to make an even more precise claim that deflation of 1930-1933 was at best partially anticipated by examining four and then three of the six commodities he analyzed in part one. Hamilton (1992: 159) states 'during the first year of the Great Depression, people anticipated stable prices, meaning that the initial deflation of the Great Depression was largely unanticipated.' This,

in his view, indicates that, rather than operate through expected deflation, 'highly contractionary monetary policy… operated through unanticipated deflation' (Hamilton 1987: 145).

Thirty years later the debate surrounding unanticipated inflation remains unresolved. Hamilton (1987, 1992) sides with Dominguez, Fair and Shapiro (1988), and Evans and Wachtel (1993), while Cecchetti (1992) and Nelson (1990) oppose Hamilton by claiming that deflation was anticipated. On the other hand, Hamilton (1992) remains unchallenged in the literature, with the author himself continuing to present his evidence in the debate (Hamilton 2013) and with others applying the 1992 methodology to more recent periods of price volatility (e.g. Dotsey and DeVaro 1995). Additionally, both Hamilton's 1987 and 1992 articles appear as chapters in Randall Parker's (2011) *The Seminal Works of The Great Depression*, while top policymakers in key decision-making roles such as the Bank of Japan Governor Haruhiko Kuroda (2013) continue to cite Hamilton's conclusions in public presentations of their monetary theories. If Hamilton is correct, and inflation was not expected, financial or other debt-focused models such as Ben Bernanke's (1983) or Irving Fisher's (1933) appear to better explain the depth and length of the largest contraction in over the last 100 years, while direct transmission such as via a Keynesian IS-LM mechanism are less likely. From a policy perspective, Hamilton's results support governmental attempts to fix the financial system as opposed to those who preach only an expansion of the money supply.

In the context of the Global Financial Crisis of 2007's comparison to the Great Depression, the awarding of the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel to Eugene Fama in 2013, and the recent end to Great Depression academic Ben Bernanke's tenure as Chairman of the Federal Reserve,

we believe it is highly timely to revisit Hamilton's methodology, specifically the justification for using futures markets to determine expectations of real interest rates.

Our paper weighs in on the normative and empirical evidence as presented by the parties while introducing key contextual and theoretical arguments that to us appear ignored or misunderstood in the debate. Specifically, Hamilton (1992) cites as justification for his techniques papers by French (1986), Fama and French (1987) and Holbrook Working (1949), yet we could not find adequate defense of his methodology therein. In fact, we argue that proper application of the empirical evidence and the theoretical framework proposed in these studies would have led to an entirely different framing of the investigation, and would likely have led Hamilton to wholly different conclusions. Our own conclusions, though still preliminary, point to conclusions broadly opposite to those of Hamilton.

More broadly, historical economics can, and does in the papers investigated here, suffer when historical context and the particularities of the markets under investigation are ignored, especially market microstructures. In such instances, we as financial historians can add to the debate on policy issues of the modern day by contributing to the analysis of markets from an earlier era.

This paper first, in section two, explores the history of the study of agricultural commodity futures markets, paying specific attention to the collected works of Holbrook Working, as well specific arguments from the 'efficient markets' school. In section three we show that there is strong reason to believe that Hamilton's argument in the earlier part of his 1992 paper, and a dominant theme of his 1987 paper, is missing a crucial independent variable. Once we correct for the agricultural conditions of 1929-1931, we find it impossible to conclude that

commodity markets forecasted inflation rather than deflation during the early years of the Great Depression. In this section, we also weigh in on the debate between Hamilton (1992) and Cecchetti (1992) on the relevance of government intervention in the futures market.

In section four, we examine Mishkin's critique of Hamilton's methodology and find that, though the paper itself is flawed, we support Mishkin's (1990) argument against Hamilton's (1987) paper. Specifically, Hamilton's literal interpretation of rational expectations provides a theoretical justification for a data mining exercise that concludes that the prices of two minor and two reasonably important (though not the most important) commodities were used by economic agents of the time to forecast changes in the general price level in the US economy. In section five, we reinterpret the contributions of Fama (1965), Fama and French (1987), and Working (1942) to show that futures markets likely did anticipate some deflation ahead of its actual occurrence in the wider US price index. We conclude that a claim could be made that commodity futures markets did anticipate the deflation of the Great Depression. That is, we argue that Hamilton's evidence in his 1987 and 1992 papers relating to commodity futures markets cannot be used as evidence against the unexpected deflation hypothesis, and therefore offers no support for theories of the Great Depression acting through financial channels.

2. The Intellectual History of the Futures Markets: Holbrook Working, Eugene Fama and Kenneth French

A. Futures Markets

Although there are earlier cases of documented exchange-based trading of contracts for delivery of a pre-agreed quantity of a pre-agreed quality of a certain product at a pre-agreed price at a specific location long before "futures" trading began in Chicago in the mid-19th century[2], historical economists often rely heavily on price data from the Chicago Board of Trade because of the high volume and reasonably continuous nature of the trading. Speculation and 'hedging' (in the sense of Marshall's notion of price insurance) in commodities as diverse as wheat, cotton, eggs and butter on organized exchanges such as the Chicago Board of Trade provide excellent data for studies in individual decision-making under uncertainty (Telser 1958; Marshall 1919: 260). Hamilton in his 1987 paper investigates the three most liquid contracts of the time - wheat (traded in Chicago), corn (Chicago) and cotton (New York), as well as the much less important oats contract (Chicago). Hamilton in 1992 adds another two less important commodities –rye and lard (both Chicago). Fama and French in 1987 cover many more commodities such as cattle, hogs and many metals such as copper. Wheat was by far the most traded commodity, of all the grains and overall, as can be seen from table 1, below. Lard future volumes were unobtainable, but it is known that they were lower than grains in terms of dollar volume traded during this period.

[2] For example, see the Baltic grain in 16th century Amsterdam (Tielhof 2003) or rice futures in 18th century Osaka (Wakita 2001).

So, for example, on 1 April of 1927, spot market trades (for immediate delivery) for various qualities and types of wheat were executed at Chicago, but also at regional centers such as Kansas City and Minneapolis. The Chicago Board of Trade, the dominant futures market (see table 1) hosted transactions in wheat for delivery in May (between one month and almost two months in the future), July, and September. Working (1934) reports the closing price for Chicago futures and the relevant deliverable cash variety on 1 April 1927 as:

Cash wheat (No. 2 Red Winter):	132 5/8 cents per bushel
May delivery:	134 1/8
July delivery:	129 3/8
September delivery:	127 ¾

December delivery futures started trading in July, after the May future had long been settled and overlapping for one month with the July future. By September of 1927, wheat for delivery the following May (1928) began trading. Realistically, for wheat, July would be the first opportunity to deliver crops from the new harvest of that year, as very little new crop would be harvested before then. The corn harvest is generally later, as is cotton in the southern States.

B. Holbrook Working and the Working Curve

At a time when 'to some economists the very idea of a mathematical treatment of economic problems [was] not only repugnant, but seem[ed] even absurd' (Fox 1986: 381), a young agricultural economist named Holbrook Working spent thirty-five years (1925-1960) at the Stanford Food Research Institute as a

'methodological statistician', beginning without theory to make empirically-founded (positivist) assertions about the futures markets for agricultural commodities. Working was an American Statistical Association fellow, Econometric Society fellow, consultant to the USDA, Cowles Commission meeting attendee and co-founder of *Econometrica* during the golden age of agricultural economics, when he, along with many others of his profession, 'led the world in the creation and application of what are now known as econometric techniques' (Fox 1986).

By 1935, Working had turned his attention to price differentials between two delivery months and/or the spot or cash price, and his results are relevant to the empirical work done by Hamilton as well as Fama and French and Mishkin in the 1980s and 1990s. Specifically, all four of these later respected economists failed to take into adequate account an important influence on the differential between the spot price for a cash transaction of a commodity and the price of a futures contract to mature sometime in the next two to four months. Working found empirically that, in years of oversupply post-harvest, such as 1907, 1916 and, *importantly, 1929-1932*, spot prices should (and usually do) fall below the futures price so that

$$F(t) - S(t) > 0$$

Where F(t) is the second-closest futures price at time t and S(t) is the futures price for the closest future delivery date at that same time t.

In this theory of storage developed by Working (1942, 1949) and formalized in 1958 by Lester Telser (where 'factors that affect the marginal storage cost and the marginal convenience yield thereby determine the spread [between F(t) and

S(t)]'), the price differential in years of large inventories should be therefore related to the costs of storage. Keynes is often credited with the theory of normal backwardation that predicts futures price will always be less than the expected spot price, so that speculators may earn risk-adjusted returns in taking the other side of producer hedges. Such a theory might at first glance appear to be counter to Working-Telser (see, for example, Cristiano and Paesani (2012)). Importantly, however, Keynes acknowledged that, in years of oversupply, the Working curve must hold: 'indeed the existence of surplus stocks must cause the forward price to rise above the spot price' (Keynes 1930: 129).

In lower carryover years, the 'convenience yield', the marginal value of a stockholding to a holder of a commodity in the spot market, comes into play to the point where there is no upper bound to which the spot price can rise over the futures price in periods of short term excess demand. For example, a miller who is worried about maintaining an adequate supply of wheat to avoid disruptions may hold a higher inventory than normal, and thus it would take a much lower futures price relative to the spot price (often referred to as the basis) to motivate the miller to reduce inventories and 'wager' that supplies may become available at a later date.

'If the effective cost of carrying wheat – that is, the marginal net cost - is thought of as a function of the supply, and if it is recognized that there is always wheat to be carried over into the next crop year… then it appears necessary to think of the price of the May [near] future as always logically under the same expectations that bear on the price of the July [further] future. That is, 'maximum supplies can bring about unusual discounts only to the point where carrying costs of marginal hedgers are fully met. For this reason, futures discounts have a fairly well defined

lower limit in contrast to futures premiums, which have no marginal upper limit when supplies appear inadequate' (Hoffman 1941).

Note that in the above formulation, having a positive price differential does not imply that actors expect the spot price, S(t) to rise to F(t) by the farther delivery date t+1, but only that, once one of F(t) or S(t) incorporates all relevant information, the other is set so that the marginal holder can earn a risk-free profit from storing the historically large inventories. This is a subtle but important difference from Hamilton's interpretation of Working (1949), as we shall see. To restate, according to the theory, the future price, F(t) is set by expectations based on all available information, and then, in years of high carryover, S(t) must take into account all of the influences on F(t) but also allow for storage costs (which can be net positive or negative).[3] The marginal holder will therefore buy and hold grain in storage even if $E[S(t+1)] > S(t)$. On the other hand, the buyer of the grain for future delivery is likely a higher cost storer than the current marginal storer in the example above. As such, this buyer for future delivery may pay above $E[S(t+1)]$ instead of buying the spot market. F(t) greater than S(t) is thus the 'no arbitrage condition', regardless of expectations.

Now, the costs of carry are different for each actor, and (likely) increase as more and more storage is required (increasing marginal costs). In contemporary studies (Working and Hobe 1929; Working 1934), storage costs were estimated at

[3] As Phillips (1966: 43) argues, 'futures markets have developed to facilitate coordination [of buyers and sellers] through time.' In his now classic framing, Phillips explains that future expectations about storage and production costs involve high degrees of uncertainty, which create different business risks for those involved in agricultural marketing, whteher storage, processing, or cultivation (Phillips 1966: 55). Hedgers will insofar as possible engage in risk transfer. Speculators, in turn, offer to bear those risks. The distinctions that Phillips makes between routine hedging, selective hedging, operational hedging, and finance hedging are no longer used, but his essay is useful in elaborating the many and varied factors that influence expectations about futures prices, which are by no means limited to the commercial factors driving crop sizes and quality.

between zero and two cents per bushel for wheat.[4] As such, we should, and often do, see wheat futures prices one to two cents higher per bushel per month than spot. We should further see, and do see in table 2, reasonably stable bases (F – S) during periods when grain carryover is known and high. As Working (1942: 50) wrote; 'relations between futures prices… indicate merely the market appraisal of price changes that are likely to occur in consequence of anticipated marginal net costs of carrying the commodity.' Interestingly, in 1907, the futures price (July) rose 25% while in 1930 prices fell 6% over these nine weeks. In both cases, the spread was remarkably stable. Also, crop carryover in 1930 was 50% higher than in 1907. Therefore, applying the theory of storage one would expect the spread in 1930 to be higher than in 1907.

This cost of carry in years of high carryover causes the shape of F(t) – S(t) in interwar years to follow what is now known as the 'Working Curve' as in figure 1.[5] Work done by the Commodities Exchange Administration (1938) found the same shape for corn markets as well, while Brennan (1958) identified the same phenomenon in the oats market. It must be noted that if the old crop/new crop relationship can be shown to be a function of the crop carryover, the relationship must also be true of 'intra-crop' spreads, or those that do not bridge a new harvest.

Importantly, when examining the demand and supply for storage (and therefore its costs for each commodity) it is important to note that wheat, corn, rye and oats compete for the same storage facilities. As such, high crop carryover for wheat

[4] In practice, storage costs were highly variable but Working (1934, p. 119, Table III) gives storage charges on grain in "regular" elevators at Chicago as 1.25 cents for the first 10 days and 1/20th cent per day after.

[5] The first formal explication of this can be found in Working (1933), where he considers wheat. Subsequent studies conirm the phenomenon for other commodities.

would impact the cost of storage for other commodities if they, too, were in oversupply.

[Insert Figure 1]

Source – Working (1933)

C. Efficient Futures Markets

We now ask 'to what extent are futures prices forecasts?' given 'futures prices are not independently established forecasts for various maturity months, but are linked to each other and to cash prices'? (Tomek 1997). Quite early on in his studies, and certainly before the emergence of Fama (1965), Working found that futures prices could be unpredictable, and additionally provided theoretical evidence that Cowles and Jones's (1937) findings in the equity market could be explained by a random walk (Working 1960) if the model were properly specified and there were theoretical reasons to expect it. What is often forgotten today, however, is that Working thought it was possible to observe structure in apparently random fluctuations (McKenzie 2006, p. 95; Working 1958, Coffman 2015, p. 61) In any case, there are a significant number of students of the history of agricultural economics and finance who would argue that Holbrook Working should get credit rather than, say, Eugene Fama for the EMH (MacKenzie, 2006, pp. 94-96).

It is almost gospel that the futures price is an unbiased estimator of the future spot price, but it has to be remembered that the current spot price may be even more efficient. Tomek and Gray (1970) conclude the futures markets do not incorporate any 'prophecy that is not reflected in the cash price.' Tomek (1997) adds that

'[t]he two price levels are dependent on precisely the same set of explanatory variables. They differ by the basis, which reflects the temporally difference in delivery time, but their changes depend on the same factors.' As Working stated in 1942 (p. 49) 'Broadly it seems that futures prices afford forecasts of changes that will probably occur in response to some classes of influences, and that they give within themselves no anticipatory indication of price changes that may develop from certain other classes of influences.'

Importantly, while some, including Hamilton (1992), interpret French (1986) and Fama and French (1987) to conclude that the futures price less the spot price is the market's view of own commodity price deflation, French actually concurs with Working's more sophisticated characterization. That is, French (1986) agrees that there is a convenience yield, and that the cost of storage needs to be considered as per the Working Curve: 'Futures prices cannot provide reliably better forecasts [than spot prices] unless the variance of the expected spot price is large relative to the variance of the actual spot price changes. This relative variance is related to a number of factors, including… the cost of storage' (French 1986: S39). This cost of storage 'equals the physical storage cost…minus the marginal convenience yield' (French 1986: S41). That is, for commodities with low physical carry costs, when stocks are high, the convenience yield is zero, and the variance of the spot price and the futures price will be quite similar. With the spot and futures prices therefore under the same influences, it is highly unlikely that the basis (F –S) tells us anything at all in cases of high crop carryover. Fama and French (1985) agree that that 'positive values of the basis can be explained in terms of storage costs that outweigh marginal convenience yields when inventories are high', as per Working's theory of storage. As Fama and French could not easily access inventory levels to test the theory of storage, they looked

at seasonal variation in the basis against seasonal variation in inventories. Where storage is easy, basis volatility should be low. Where storage is impossible or at least very expensive, such as for eggs and live hogs, the basis should be quite volatile.

Fama and French test a model that breaks the basis between two futures contracts into an expected premium and a forecast of the future spot prices. Modeling this by measuring seasonality in prices, Fama and French find that, of the commodities also examined by Hamilton in 1992, only the oats futures market may have some predictive value. Corn and wheat markets exhibit time varying expected premiums (that is, there are changes in the cost of storage), while cotton futures appear to have no predictive ability. It is further interesting that, of the four (and then three) commodities in the body of his 1992 paper Hamilton (1992) chooses to examine, French (1986) found that only one had "good" (and none have 'strong') forecasting power. Separately, Fama and French (1987) also find that only one of Hamilton's commodities should have 'strong' forecasting power.

To summarize this section, we can conclude that the futures and the spot price will have some relationship to each other in commodities with low storage costs and/or in times of high inventory carryover.

3. Futures Data in the Context of the Great Depression

Hamilton examined the difference between F(t) and S(t) in select agricultural commodity markets[6] of the 1920s and 1930s every four months (Hamilton 1992)

[6] Hamilton actually uses the future maturing in the observation month as a proxy for the spot price S(t).

or once a year for a five-month period (Hamilton 1987) and used the log difference to calculate the implied expectations of own price deflation or inflation of each commodity. Hamilton then compared this expected price change to the actual commodity's own price change, or S(t+1) – S(t). His results are reproduced in table I of Hamilton (1992) (reproduced here as table 3) and table 4 of Hamilton (1987) (reproduced here as table 4). Hamilton concludes that, as expected own price inflation was positive by his measure even while commodity prices were falling, people did not appear to have anticipated the deflation in the general economy.

Source - Hamilton (1992)
Note to table – 'Figures for cotton and wheat represent the average values for 1930-1932 reported in Hamilton (1987 tables 3, 4). For the other four commodities, the raw data are reported in Table Al; actual inflation figures represent the change in the log of the spot price between September 1929 and September 1932 divided by three, while expected inflation figures represent three times the average log difference between the four-month future price at t and the spot price at t, where t is indexed triannually from September 1929 to May 1932' (Hamilton 1992).
Note to table - 'The entry for the first column for May 1930 is based on the difference between the natural logarithms of (a) the futures price of May wheat quoted at the beginning of December 1929 and (b) the futures price of December wheat quoted at the beginning of December 1929. The entry for the second column for May 1930 is based on the difference between the natural logarithms of (a) the futures price of May wheat quoted at the beginning of May 1930 and (b) the futures price of December wheat quoted at the beginning of December 1929' (Hamilton 1987).

Working, ironically cited by Hamilton in defense of his methodology, assumed in 1949 what he already believed he had showed empirically without any doubt: that the cost of carry on a storable commodity has the biggest influence on the futures markets, causing the futures price to be higher than the current spot price, when crop inventories are much higher than in a 'normal' year. The crucial depression years where he observed F (t) – S (t) was much higher than S (t+1) –S (t) were also years of high carryover (Working 1949). As such, the first column in Hamilton's table I (our table 3), at least for wheat, corn and oats, will be positive

from 1929 to 1931, regardless of any deflationary expectations. As such, it is impossible to conclude, as Hamilton (1992: 157) does that '[f]utures prices were well above spot prices for most commodities during most of the Great Depression; [implying that] evidently the spectacular declines in agricultural prices caught many by surprise.' We thus conclude that Hamilton mischaracterized the fundamentals of the wheat market during the Great Depression. However, Fama and French (1997) and Fama (1986) showed that all storable commodities should exhibit similar behaviour to Working's wheat market (that is, in times of high carryover). Additionally, as oats, rye and corn compete for storage space for wheat, wheat being in general oversupply during the early years of the Great Depression, we would expect the economics of storage to apply in these other grains as well. Note that this can be true even in falling markets (see table 3 and figure 2). In Working's own words; 'the price difference between two futures has widely been interpreted as indicating the market's appraisal of expected price change. A principal result of our investigations of price relations in both the Chicago and the Liverpool futures markets has been to show that this assumption is a mistaken one' (Hoos and Working 1940).

It is of course also possible that the market was particularly inefficient during the period in question. In fact, there is a very interesting debate in the literature between Cecchetti (1992) and Hamilton (1991) concerning the involvement of the US government in the wheat and cotton markets during the Great Depression. Cecchetti (1992) claims that rationality and efficiency should not be possible to identify due the significant influence of the Federal Farm Board's Grain Stabilization Corporation purchases from 1929 to 1933 as documented by Anne Peck in 1976 and even earlier yet less eloquently by G. Wright Hoffman in 1941. Hamilton (1992: 162) claims that '[t]here is room to be skeptical about the U.S.

government's ability to control the price of something so openly traded on world markets.' However, it is very difficult to explain the behaviour of Chicago futures versus the world price as measured by Liverpool futures or Winnipeg futures (Peck 1976). It appears to be too much of a coincidence that a premium of Kansas City wheat to Liverpool and Canada wheat is uniquely associated with an overwhelming dominance of the open interest in 1930 wheat futures markets by the US government, when the Federal Farm Board 'proceeded to corner the wheat market' in 1930, primarily through the May 1930 future (Moser 1990). By early 1931, the government held approximately half the open interest in Chicago and Kansas City wheat futures, as well as most of the open interest in Minneapolis. Given this evidence, we have a hard time understanding why Hamilton dismisses the effects of US government intervention so easily.

[Insert Figure 2]

Source – Various Chicago Board of Trade Statistical Annuals

It would seem that Hamilton (1987, 1992) made what Working (1942 p. 50) called 'the error of common theory' by 'supposing that the prices of futures, or some particular futures, tend to be more strongly influenced by [these] anticipations than are spot prices.' That is, theoretically and empirically for storable commodities, during the high carryover years of 1929-1931, we would expect to see, and indeed do see, that F and S move together as per figure 2 for wheat.[7] As fundamentals unrelated to the carryover change, both F and S should move almost in parallel, with the difference saying nothing about future expectations.

[7] Following Keynes (1930) and Hamilton (1987, 1992), S is proxied by the nearest future.

4. Irrational rational expectations

Besides the methodological problems and issues with the data as stated above, there are several other problems with using futures prices as predictions of the overall price level in an economy. One of the first problems is reverse causality, which is worth a mention but will not be dealt with in depth here. It is not entirely out of the question that a fall in farm incomes due to lower agricultural prices could have exacerbated the downturn after 1929 by reducing consumption. However, this suggestion has been dismissed by a recent study Federico (2005: 949), which found the relationship between the rural banking crisis (caused by over-indebtedness of farmers after the boom of 1918-1921), the banking panic of 1930 and the Great Depression was 'tenuous at best.'

A larger problem rests on Hamilton's (and others') reliance on rational expectations theory to model economic agents predictions of economy wide price level changes. 'The theory of rational expectations, initially developed by John Muth, asserts that both firms and individuals, as rational agents, have expectations that are optimal forecasts using all available information' (Mishkin 1981). In its most basic form, rational expectations seems more reasonable than its predecessor, adaptive expectations, by suggesting that economic agents are able to identify and utilize easily discernable patterns in economic data (Mishkin 1981). As Hamilton (1987) writes: 'if the historical path of money and prices does not surprise a naïve statistical forecasting equation, it should not have surprised rational economic agents either.' So, Hamilton therefore assumes in part II of his 1992 paper that '[m]ovements in aggregate prices that are correlated with commodity futures prices are assumed to have been anticipated by people at the time.' Armed with this assumption he concludes that the expected and unexpected components of general price level changes are identifiable. However,

Hamilton goes much further than proposing that rational agents can easily forecast to the extent that a simple model could have predicted price movements. He assumes that actors knew to limit their analysis to four commodities, two extremely obscure and none of them in the top two of traded futures. Specifically, it is not obvious that agents have the ability to identify complex interactions within an economy, and Hamilton's simplest model incorporates 52 parameters.

Hamilton effectively states that actors could legitimately forecast inflation by looking at four rather idiosyncratically chosen commodity futures prices as well as a two-period serial correlation in the price index itself. This can be criticized on several fronts. Firstly, Mishkin (1990) shows that it does not seem at all plausible from the evidence that even the larger commodities should be able to 'predict' movements in the general price level. Mishkin points to the fact that commodities prices are much more volatile than the economy-wide price index. In fact, because commodities are often far too volatile to be of any use in predicting the price level in the economy, practitioners often use "core" consumer prices that exclude *food* and energy (Motley 1997). Mishkin evaluated Hamilton's methodology by using 'futures market data for contracts on individual commodities to examine real interest rate behaviour.' He finds that the real rate of return implied by individual futures markets is highly volatile, and therefore unlikely to be useful to estimate market participant's predictions of future changes in aggregate price indices. Hamilton (1992) counters that this is not an insurmountable problem, as his regression coefficients can account for the higher volatility of the individual futures markets relative to the aggregate price levels in the economy. The problem with Hamilton's defense, however, is that the predictive ability of futures is both a theoretical and empirical question.

Mishkin's 1990 conclusions are flawed, however, as he follows Cornell and French (1986) in identifying and then calculating a commodity's own rate of interest. In such a calculation, there is an implicit assumption that traders can short the commodity in the spot market or the nearest future and go long (buy) the future while depositing the cash from the (short) sale in a risk free account. However, this 'no arbitrage' equation is incorrect in that agents cannot perform this set of transactions without assuming terrible risks (Liu and Tang 2010). Being short the near month commodity future will require delivery of the actual commodity, and therefore no trader would take such a position unless they were able to secure stocks on short notice. But this then requires a long position to be taken in the commodity, which is no longer an arbitrage.[8] As such, a commodity's own rate of interest is unbounded in this direction, and it is therefore no surprise that Mishkin found highly volatile and at times very large interest rates using the flawed arbitrage condition.[9] Mishkin's results are also consistent with the Working Curve in that storable commodity-rate of interests are bounded on the downside (presumably during periods of high carryover).

It is possible that Cornell and French's understanding of an own rate of interest of a commodity is based on a reading of Keynes (1936), who cited Sraffa (1932) as the first mention on the subject.[10] Sraffa, in a review of Hayek's 1931 work *Prices and production*, identifies a rate at which a commodity can be purchased in

[8] Put another way, if one holds an amount of a commodity, it is either for immediate use (in which case there is 'convenience' to having it today, or it can be sold in either the forward or the spot market. If it is sold forward, then the seller earns the difference in the forward price less carry costs. This is what many holdiers would do in times of oversupply. The other alternative is to sell the commodity spot and buy it forward while investing the cash proceeds of the sale. But this is not an arbitrage, in that the purchaser of the forward now has price risk.

[9] A trade the other direction, of course, assuming one owns the deliverable commodity, is the 'cash and carry arbitrage' Telser uses to place a bound on the F – S basis.

[10] However, Cornell and French (1986) do not cite either Keynes or Sraffa in their paper.

the spot market and sold in the forward market. This Keynes, in his *General Theory*, calls the commodity-rate of interest.[11] Sraffa (1932: 49-50), however, acknowledged that, out of equilibrium, the commodity-rates of interests would not converge and would therefore not be useful in calculating the 'natural' rate of interest. To some extent, Sraffa was correct when he observed that commodity rates of interest would be higher (or in the terminology of Cornell and French or Mishkin, more negative) in times of overproduction, and, indeed, his concept of purchasing a commodity to deliver it forward is a much better way of thinking of a commodity's ability to generate a return that the opposite conception as per Mishkin.

The second problem with the rational expectations assumption is that there is no theory which supports Hamilton's choice of four, narrowed down to three commodities, used by economic agents to predict economy-wide changes in the price level. Hamilton appears to have taken the available price data and data-mined for the optimal model. What would make any economic agent focus on three commodity prices to estimate inflation and deflation in uncertain times? Hamilton gives us no reason for choosing the original six commodities of his 1992 paper, and his reduction to four and then three using data mining is theory-free. This is where the crude application of RE becomes problematic. Hamilton chooses four commodities - rye, lard, corn and oats - that are far from obviously the prime drivers of an economy and are, further, not as liquid (and therefore

[11] There is an interesting paper by Naldi (2012) addresing the difference between Keynes' and Sraffa's calculation of the own rate of interest, but for our purposes this distinction is not important. For completeness, however, we are in a money economy, so the amount borrowed must be equal to the spot price times the quantity, while the amount earned wil be the forward pirce times that same quantity less net carry costs. This is equivalent to Mishkin's calculation in the one direction. Remember that there is no possibility of effecting such a trade in the opposite direction (shorting a commodity, lending money and buying in the forward market -- see footnote 6).

likely less efficient) than other alternatives (e.g. wheat and cotton). It seems highly unlikely that investors and other economic agents constantly updated their forecasts for price level changes in the US economy as a whole based mostly on the price of two important (yet not the most important) and two unimportant agricultural products. Again, wheat and cotton are ignored in the important analyses in the bulk of Hamilton's 1992 paper. Tellingly, from 1923 to 1938 trading volumes for wheat futures, ignored in the study, were more than 30 times those of rye and more than 10 times those of oats (see table 1).

The third problem with RE, related to the second, is that mathematically it is hard to argue that the prices of oats, corn rye and lard determine the price level in the economy, as less than 10% of the price index consisted of all agricultural commodities combined. Work by Joel Popkin (1974) and others shows the complexity involved in such an exercise for a larger number of very important commodities. However, of course, lard, oats, corn and rye, being only small components of the agricultural economy, would have even less of an effect on the CPI than wheat or cotton. Corn, specifically, is even more problematic as it is predominantly used for animal feed and it is not proven that price increases in such commodities cause the price level of animals to rise or fall. That is, the corn/hog cycle predicts that falling net food prices may result if the slaughter of animals fed on corn rises due to the increasing cost of feed (Davenant 1696).

Telser (1958) examines the extent to which futures prices incorporate expectations on the future general price level. He concludes that the general price level must be only one of many factors to be incorporated into commodity futures price expectations and, importantly, that the futures markets could not anticipate most movements in the general price level. This fits in well with the earliest studies of, for example, wheat futures prices, which show clearly a reasonably

linear relationship between visible supply of wheat as seen by contemporary traders and the realized futures price level (Hoffman 1941) (see figure 3). Certainly, it does not seem unreasonable to believe that idiosyncratic influences for single commodities will be at least as strong as the influence of general price level expectations. In order to have any hope of diversifying away the idiosyncratic effects of each commodity and maximize the possibility that somehow the futures prices he examines could be reflective of expectations of the price level of the entire economy, Hamilton should consider all of the major commodities markets. Yet he does not do so.

[Insert Figure 3]

Source – Hoffman (1941)

The final problem in assuming RE is determining when economic agents change their model to account for structural changes in the economy (see Zulaf *et al* (1999). Even if agents can divine and take advantage of the relationships between price levels while they are occurring in the economy, it is not at all clear how agents deal with unexpected changes, which include, of course, regime changes (where the underlying economic relationships change structurally). That is, when (and how?) would agents know to stop using a now obsolete complex model and then adopt the new "correct" one? Of course, correlations between commodities and between all commodities and the general price level are all highly volatile (see figure 5). For example, in 1923 and 1924, CPI was almost unchanged. However, in 1923 wheat prices fell 16% while in 1924 wheat prices rose by 62%.

[Insert Figure 4]

Source – Federal Reserve Bank of Minneapolis; Working (1934)

Hamilton's assumptions imply that economic actors were predicting inflation based on previous inflation (trend is your friend – which in itself does not seem outrageous), the 'season' as defined imperfectly by arbitrary trimesters, and the current spot prices of two liquid and two illiquid and obscure (and correlated) commodities (without taking into account idiosyncratic influences on each individual commodity's price from factors such as crop size and crop inventories). This involves agents estimating as many as 126 parameters in the biggest model. To what extent and according to what theory can price dynamics in a very small section of the economy be reliable manifestations of general price expectations?

The difficulties in assessing what agents could have 'known' and when without resorting to anachronistic theories and models led many otherwise orthodox economists to question rational expectations almost from its inception (Hoover and Young 2013). Importantly, even Muth in his later years was far from convinced that such an approach was legitimate (Hoover and Young 2013). Yet Hamilton assumes that actors could ascertain a complex relationship between the prices of three reasonably unimportant commodities, adjusted for seasonality and combine this with a short term trend following system to deduce the potential for changes in the economy-wide price index. The only logic for this model is that it maximizes the chosen likelihood function. However, it cannot at all be surprising that some model might fit the data without being a true representation of the relationships underlying the price action.

5. Extending the EMH

We have already shown above that F – S can not, at least in the context of crop carryovers during the Great Depression, tell us much about the expectations of economic agents. However, that does not mean we can not use the EMH to understand market expectations during prior to the Great Depression. Hamilton in his attempts to build on French's (1986) and Fama and French's (1987) work on the efficiency of commodities markets misinterpreted their conclusions as to the use of futures as predictors of future spot prices. The efficient markets hypothesis (Fama 1965) actually asserts that the futures price (and not the difference between the futures and spot price) will adjust immediately to the expectations of the market participants. As per Working's theory of storage, if we think of both S(t) and F(t) as, together (and not as a difference), providing information as to expectations of future prices, it is trivial to examine the spot and/or futures markets to identify rapid adjustments to new conditions. In figure 5 we show that the wheat futures market, for example, reacted quickly to changing economic expectations while the price level itself took longer to adjust. Our main point is that futures markets fell fast and hard in 1929-1930, reaching what would become a medium-term trading range by late 1930, and this was certainly faster than the overall price level as measured by the Consumer Price Index (CPI), which hit a similar range only in early 1933. While the CPI continued down its deflationary path throughout 1931 and 1932, wheat prices remained in a trading range averaging around 60 cents per bushel until, once again, possibly in anticipation of a slower adjustment by the economy-wide price index itself, wheat prices rose.

[Insert Figure 5]

Source – U.S. Department of Labor: Bureau of Labor Statistics; Working 1934

Hamilton claims that 'during the first year of the Great Depression, people anticipated stable prices, meaning the initial deflation of the Great Depression was largely unanticipated' (1992: 159). Yet wheat prices, for example fell spectacularly from July 1929 to March 1930, ahead of the deflation of 1930 and following, and Fama's EMH might interpret this as evidence that economic agents of the time actually reacted reasonably quickly to new deflationary expectations. There followed a further fall in prices from March until December 1930. After this adjustment, a few months of very low volume trading took place in the wheat pits, followed by almost two years of remarkably stable prices. Once again, the EMH would predict just such a price formation if agents reacted quickly to new information and a new equilibrium established soon after the fundamentals of the 'new normal' were accepted. Additionally, these commodity price movements slightly anticipated similar decreases in the general price level beginning in late 1930. That is, while commodity prices were falling, the general price level had not yet reacted. This is the opposite of what Hamilton (1992) claims. To be clear, we are not implying that the above proves that the markets were anticipating their 'own' price dynamics, let alone the general price deflation that occurred between 1930 and 1932. However, we believe it is very good evidence against Hamilton's (1987 and 1992) assertion that commodity markets were forecasting inflation during this period, either in the wider economy or in the individual commodities themselves.

6. Conclusions

In conclusion, economists in the 1980s and early 1990s experimented with the combination of rational expectations with their own interpretation of the simple yet important concepts from Nobel laureate Eugene Fama as well as one of the founding fathers of econometrics, Holbrook Working. However, it turns out some of their most important conclusions cannot stand up to scrutiny once we understand the historical context of the Great Depression as well as the theory of storage developed before, during and slightly after these volatile economic times. The simple application of the theory of storage applied to the high carryover years of 1929-1932 reveals that the futures basis (F – S) cannot be seen as a proxy for the market's expectation of commodity price deflation. Market interventions by the Federal government around this time make the waters even murkier (Cecchetti 1992). Additionally, a realistic view of rational expectations does not support the modeling of general price expectations based on the dynamics of a few commodity prices traded on the Chicago Board of Trade handpicked for their availability.

We showed that futures prices fell considerably well ahead of the severe declines in the general price level. They remained at lower levels while the general price level caught up, before the idiosyncratic risk of dust bowl economics dominated the grain complex. This appears to show that deflation was anticipated by the futures markets. However, it is not at all clear that economic agents would have respected such a signal, given the false alarms that occurred before in the complex (e.g. 1923 – see table 5). Mishkin was right, if perhaps for the wrong reasons. That is, futures market retreats were quite common during the interwar period,

and many of these did not precede a deep depression, or even a mild recession. [12] Even so, major falls in wheat prices do appear to be associated with future deflation. EMH did hold, and commodity markets did, in fact, anticipate deflation. Again, though not proof positive that some might view wheat price declines as indicators of coming deflation, a simple linear regression regressing inflation of wheat price changes annually from 1920 to 1932 on one year future CPI, or even a simple nonlinear regression from 1920 to 1928, hints at a significant fit at the 95% confidence interval (see figure 6 for 1920-1928 data). For simple linear regression of CPI change on wheat price change lagged one period for the 13 data points from 1920 to 1932 generates an R squared of 56% and a 95% confidence interval of the x intercept of between 0.053 and 0.206. Adding in a squared term to the independent variable, the R squared rises to 75% and both Wheat and Wheat squared have coefficients that are significant at the 95% level. Of course, we remain somewhat skeptical of the usefulness of these conclusions given the small sample size (13).

Our reading of the evidence differs from earlier accounts. Using the same tools as those available to earlier authors, we cannot conclude that futures market participants did not anticipate the deflation of the early years of the Great Depression. Certainly, the data does not indicate that futures markets were pricing in inflation, even in their own markets, and there is some hint that markets did anticipate some deflation. The monetarist critique of the Temin's Keynsian rejection of the Friedman & Schwartz hypothesis requires deflation to not have been anticipated. As it is possible that markets did anticipate the upcoming deflation of the Great Depression, one cannot reject a wholly Keynesian

[12] This pattern in contract grain markets is similar to the finding in White et al (2002) with respect to the magnitude of price deflation that anticipated by railroad shippers in the summer of 1929.

explanation of a Great Depression caused by monetary contraction on this basis alone.

[Insert Figure 6 about here]

Source – Federal Reserve Bank of Minneapolis; Working (1934)

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Figures

Figure 1

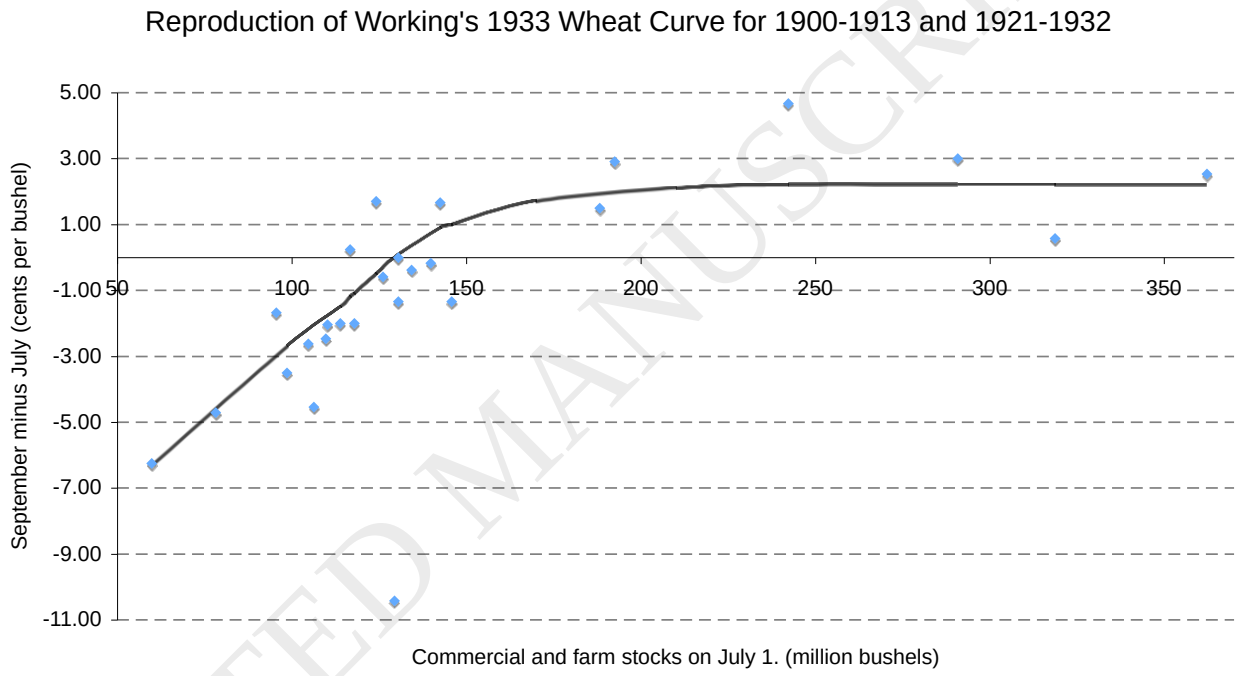

Figure 2

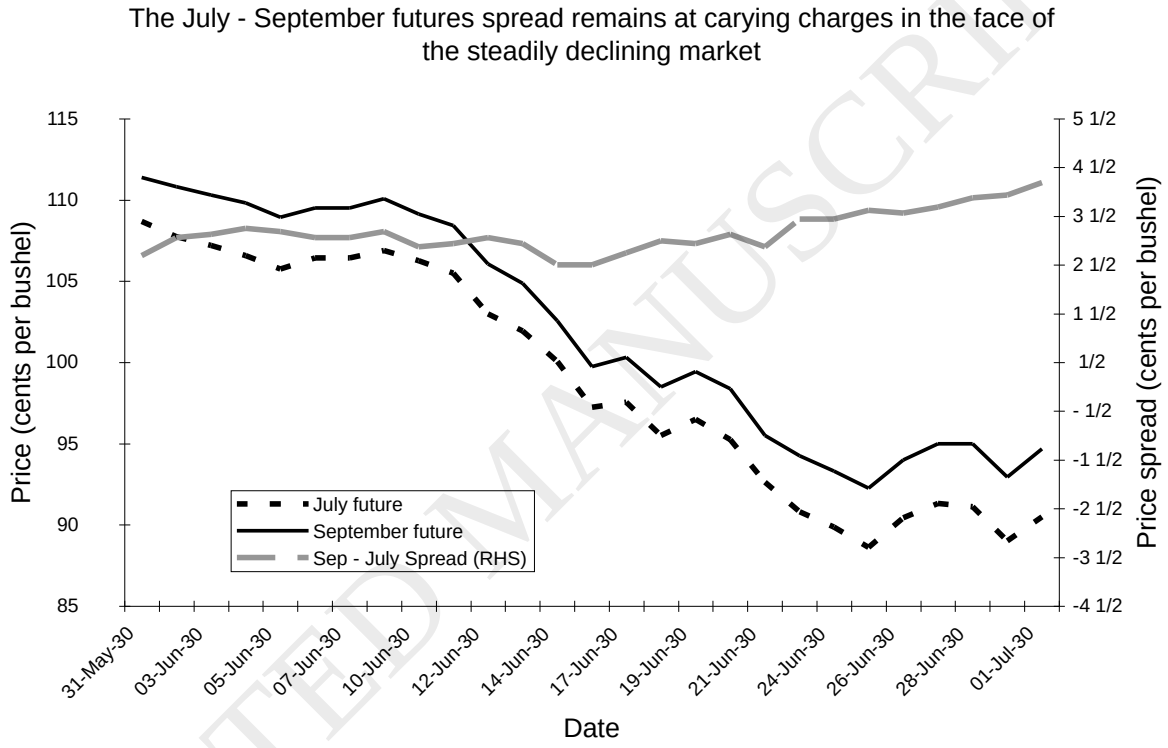

Figure 3

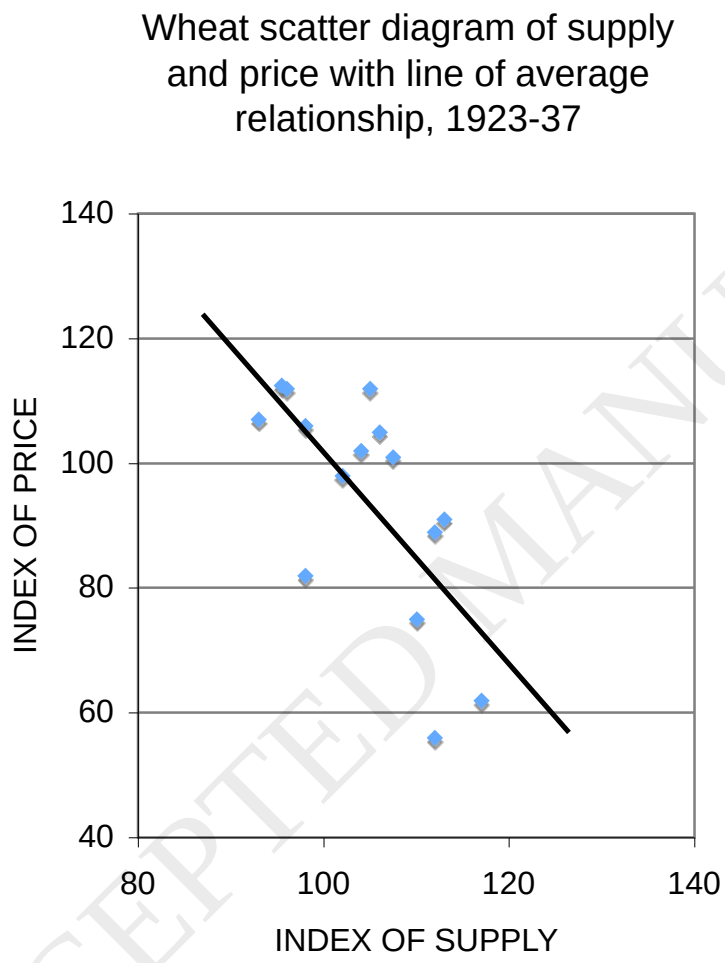

Figure 4

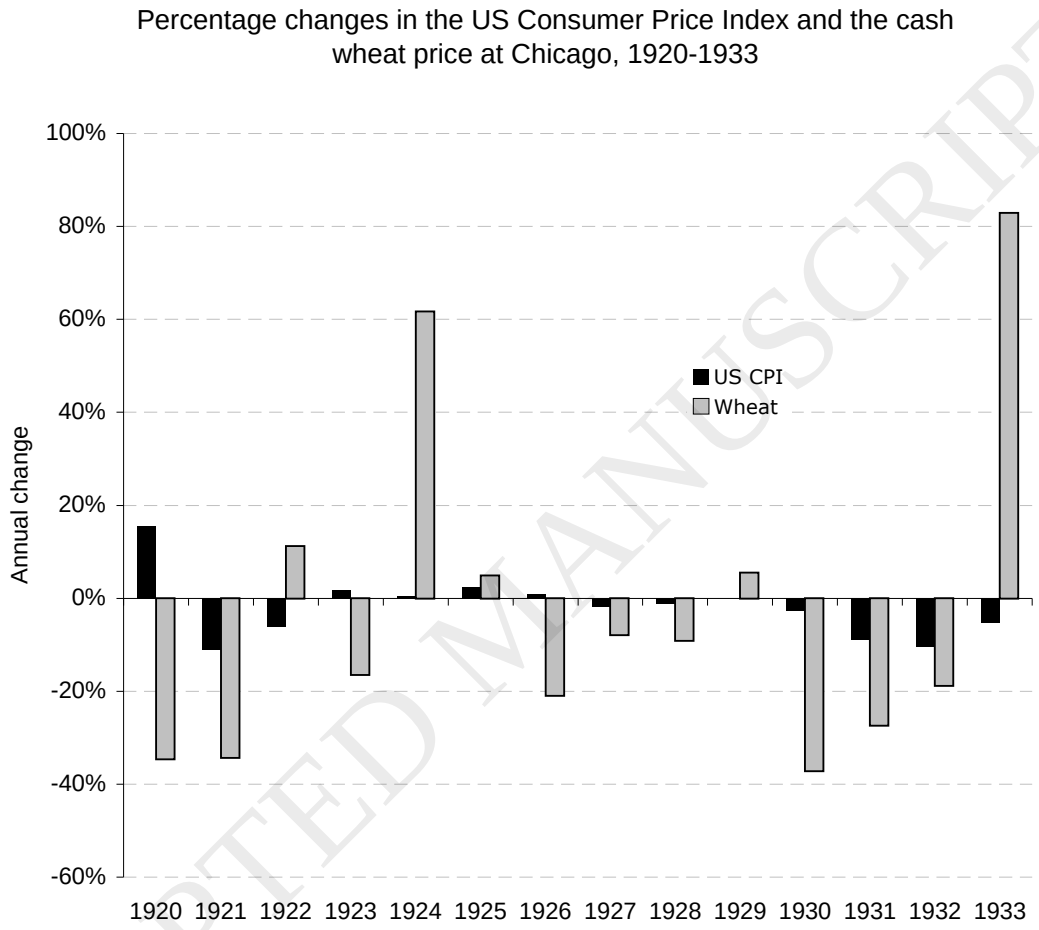

Figure 5

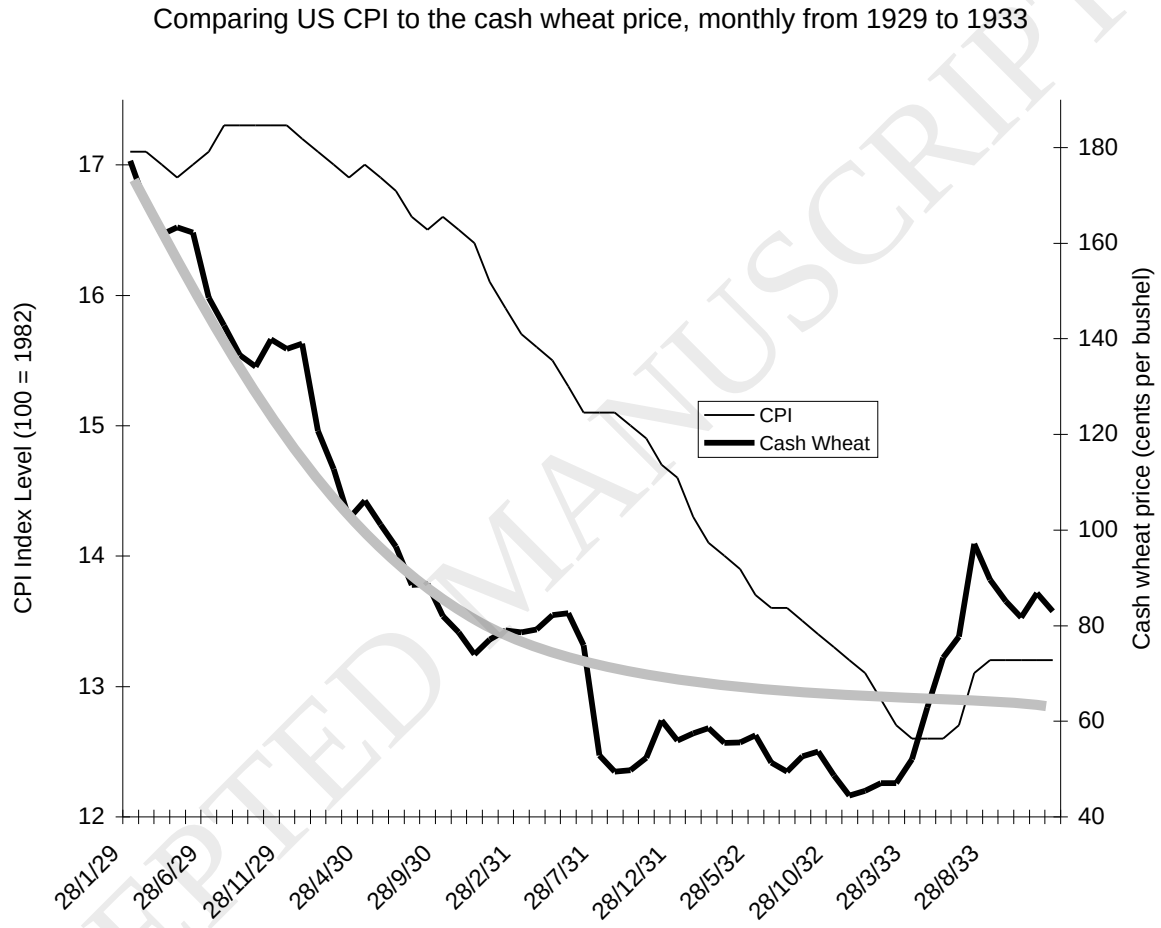

Figure 6

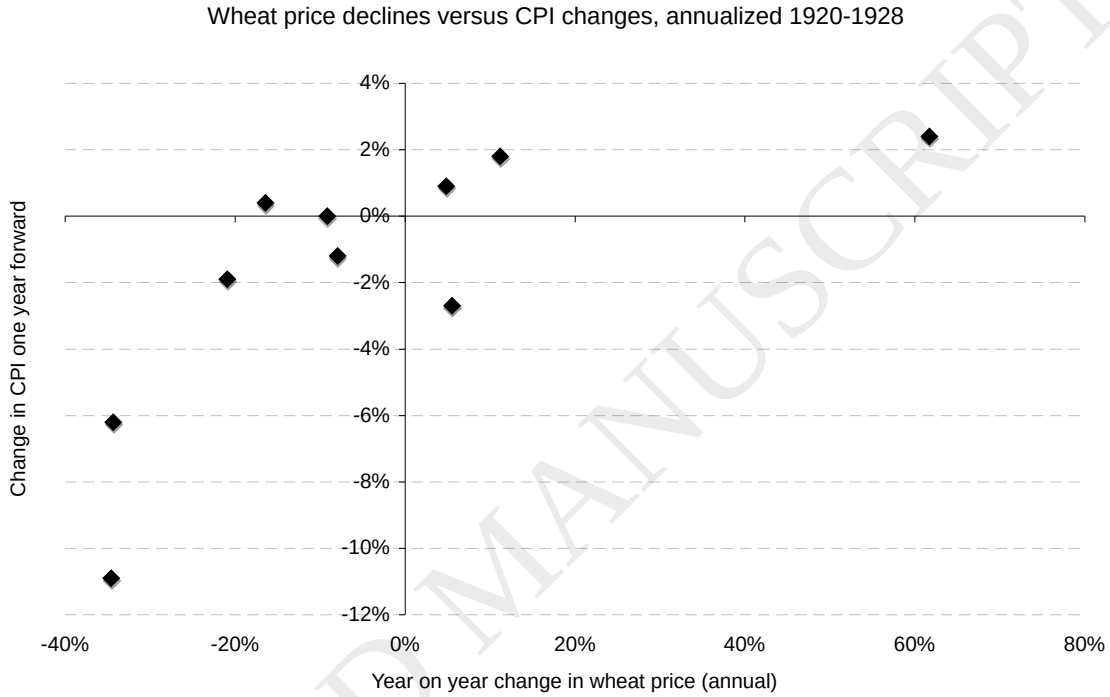

Table 1 - Average volume of trading and open contracts, all futures combined, for the 15-year period, July 1923 to June 1938 (millions of bushels)

Grain	Futures Volume			
	Chicago Board of Trade	Minneapolis Chamber of Commerce	Kansas City Board of Trade	Total
Wheat	33.8	2.2	2.1	38.1
Corn	13.0	<.1	0.6	13.6
Oats	3.2	0.4	<.1	3.6
Rye	1.0	0.2	0.0	1.2
Barley	<.1	0.2	0.0	0.2

Source – Hoffman (1941)

Table 2 - September – July Chicago wheat futures spread for April and May 1907 and 1930 (cents per bushel)

	Year	
Week	1907	1930
1	0.875	2.500
2	1.500	2.625
3	1.750	3.000
4	1.750	3.125
5	1.750	3.875
6	2.000	2.625
7	1.125	2.750
8	1.250	2.500
9	1.500	2.750

Source – Working (1934)

Table 3 - Hamilton's (1989) expected and actual inflation rates for six commodities during the Great Depression

	Inflation (% per year)	
Commodity	Expected	Actual
Corn	+14.2	-41.3
Oats	+20.1	-35.0
Rye	+29.4	-39.9
Lard	+5.8	-27.9
Wheat	+16.3	-8.0
Cotton	+9.4	-39.0

Table 4 – Hamilton's (1987) expected and actual rates of inflation over five-month intervals (annualized rates) in wheat, corn and oats prices from futures market

	Wheat		Corn		Oats	
	Expected inflation	Actual inflation	Expected inflation	Actual inflation	Expected inflation	Actual inflation
May 1930	+19.9	-53.8	+20.5	-24.6	+21.5	-28.6
May 1931	+15.2	+21.5	+12.8	-72.8	+20.1	-65.9
May 1932	+15.2	+8.4	+29.0	-65.9	+20.3	-26.3
Average, 1930-1932	+16.3	-8.0	+20.8	-54.4	+20.6	-40.3

Source – Hamilton (1987)

Table 5 - Wheat deflation versus one year forward inflation

Year(s)	Major wheat moves	Wheat price change	Total inflation one year later
1920-1921	From 259.6 to 111.5	-57.0%	-16.0%
1923	From 124 to 103.6	-16.5%	0.4%
1926	From 175.9 to 138.9	-20.9%	-1.9%
1927-1928	From 138.9 to 116.2	-16.3%	-1.1%
1929-1930	From 116.2 to 77	-33.7%	-11.6%
1929-1931	From 116.2 to 55.9	-51.9%	-20.9%

Source – Federal Reserve Bank of Minneapolis; Working (1934)
Note to table – All figures unannualised