The Commodity Futures Risk Premium*

1871 – 2018

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September 18, 2019

Abstract

Using a novel comprehensive database of 230 commodity futures that traded between 1871 and 2018, we document that futures prices have on average been set at a discount to future spot prices by about 5%. The historical risk premium is robust across commodity sectors and varies with the state of the economy, inflation and the level of scarcity. Although the majority of contracts are defunct, most commodities have earned a positive risk premium over their lifespan. We find empirical support for Gray's conjecture that survival of futures contracts is correlated with the returns earned by investors. Finally, we provide out-of-sample evidence that "factor" strategies based on commodity basis and momentum have historically earned positive returns over time but are subject to prolonged drawdowns (crashes) that are not dissimilar to those experienced by the overall market.

* We have benefited from comments and suggestions from Chris Mascarinas, Kurt Nelson, Ashraf Rizvi, and Kevin Sheehan, and participants at the 3rd JPMCC Annual Commodities Symposium at the University of Colorado, Denver. We thank Liyu Cui, Zining Dong, Yuan Gao, Yimin Gong, Jie-Lu Lee, Nan Liao, Ziwei Luo, Ruilu Ma, Arpita Mukherjee, Usharani Nidadavolu, John Petrini, Yingzhi Xiao, Chunqi Xu, Zi Ye, and Guangyu Zhang for their help in collecting the data. Rouwenhorst acknowledges financial support from the Yale School of Management. SummerHaven Investment Management invests, among other things, in commodity futures. The views expressed in this paper are those of the authors and not necessarily those of SummerHaven Investment Management.

1. Introduction.

We estimate the historical risk premium in commodity futures markets using a new, comprehensive database that covers more than 230 different commodity futures contracts traded primarily in the US and the UK since 1871.[1] A central finding of our study is that averaged across commodities, locations, and time, futures prices are set at a 5.3% discount relative to future spot prices. This downward bias implies that the long side of a commodity futures contract has historically earned a positive risk premium. Short hedgers have paid this premium when obtaining insurance against price fluctuations. The long-term average premium is similar in magnitude across commodity sectors, although short-horizon realized premiums exhibit substantial variation across commodities and over time due to the business cycle, the rate of inflation, and sector-specific shocks.

A distinguishing aspect of this study is that our sample of commodity futures contracts is by far the most comprehensive in the literature. It provides broad market coverage during the early years of commodity futures trading for a wide range of physical commodities across different sectors. A second unique feature of our data is the extensive coverage of delisted contracts, whereas most commodity futures research has focused on surviving contracts. This is of interest because Brown, Goetzmann and Ross (1995) have shown that conditioning on survival can lead to biased inference in the empirical measurement of long-term average returns. We explore the link between the survival of contracts and the risk premium earned by long investors. The risk of failure is highest during the first two years following the introduction of a new contract. We document that short-lived contracts on average earn a negative risk premium; by contrast, those that survive for an extended period of time have historically earned on average positive premiums: of the contracts that survived longer than 50 years, 91% earned a positive risk premium. These two findings are consistent with the Keynesian prediction that (the expectation of) a positive premium is an important prerequisite for speculative participation in futures markets; and Gray's (1966) conjecture that persistent (speculative) losses increase the likelihood of contract failure as loss averse traders become more likely to withdraw from the market. Other factors that are shown to be correlated with contract survival are (i) the stage of the business cycle and (ii) the incidence of large absolute returns, and (iii) the availability of "substitute" commodities at the time of a new contract introduction.

Of the 230 commodity contracts in our sample, 58% earn a positive lifetime "buy-and-hold" risk premium when we roll expiring contracts forward over time, and the median geometric average premium across commodities is 1.5%. To put this into a broader perspective, consider a comparison to US equity markets. Despite the positive equity risk premium, Bessembinder (2018)

[1] Exceptions include contracts traded in Argentina, Canada, Egypt. Europe, India, Malaysia, and Singapore.

documents that the majority of common stocks in the US earned lifetime buy-and-hold returns that are below the return on one-month T-bills.[2]

It is not our objective in this paper to test theories of the commodity futures risk premium, such as the Theory of Normal Backwardation or the Theory of Storage. Yet our findings provide a new perspective on the active debate among academics that ensued following the Keynesian hypothesis that futures prices are downward biased predictors of future spot prices. Twenty-five years after the formulation of the theory, the presence of the bias was actively debated[3] despite the fact that, as our study shows, comprehensive data could have been collected to empirically reject the unbiasedness hypothesis.

In addition to documenting the premiums for individual contracts, we study investment returns to a diversified index of commodity futures. The historical risk premium on an equally-weighted index of all 230 commodities between 1871 and 2018 is estimated at 5.2% per annum. In the context of the debate on the existence and magnitude of the commodity risk premium using recent data (Gorton and Rouwenhorst (2006), Erb and Harvey (2006)), the "out-of-sample" (pre-1960) risk premium estimate of 6.2% annualized is not significantly different from the sample average premium reported by Gorton and Rouwenhorst (2006) for the post-1960 period.

We also compare the return of the equally-weighted index to a commercially promoted commodity index that was calculated in real time between 1933 and 1998 by Dow Jones (DJ) but has received relatively little attention from researchers.[4] We find a similar risk premium for the DJ index constituents of and our equally weighted "research index" for the period that they overlap.

Finally, we examine the premium in different economic environments, including the business cycle, inflation cycle and the general level of scarcity in commodity markets. We find that the realized premium is higher during expansions than recessions across all commodity sectors, as well as in periods of high unexpected inflation. Commodity factor strategies based on the fundamental of scarcity (momentum and basis) earn similar premiums in the pre-1960 period and the post 1960 periods.

The remainder of the paper is structured as follows. In the next section, we briefly review the literature on the commodity risk premium and describe our data. Section 3 provides our basic estimates of the historical commodity risk premium broken down by sector and time period. In the fourth section, we explore the influence of survival on estimates of the commodity risk

[2] Between 1926 and 2016 only 42.6% of all stocks earned lifetime buy-and-hold returns in excess of Tbills

[3] See for example Houthakker (1957), Telser (1958), Cootner (1960), Gray (1960, 1961), and Gray and Rutledge (1971) for a comprehensive survey of the early empirical work on the risk premium. Later studies include Bodie and Rosanski (1980), Kolb (1992), Erb and Harvey (2006) and Gorton and Rouwenhorst (2006).

[4] See Bhardwaj and Rouwenhorst (2019) for a summary of the evolution of the Dow Jones Index

premium. The fifth section looks at factors that influence variation of the risk premium over time, and across commodities. In section 6 we consider the returns on commodity indices as well as the time series returns and drawdowns on factor strategies based on futures basis and momentum. Section 7 concludes the paper.

2. Background on the risk premium and overview of data

Contracts that call for the future delivery of commodities date back to Babylonian times and the centralized trading of commodities predates the development of many securities markets in Europe. The founding of the Dojima Rice market in 1752 in Japan marks the first regulated commodity futures exchange (Schaede (1989)), roughly a century before US futures trading commenced in Chicago in 1865. The forward nature of contract settlement raised questions of how futures prices would be set relative to spot prices and whether futures trading would influence spot prices. Keynes (1923) argued that while futures prices would naturally embed expectations about future market conditions, they would be biased estimates of future spot market conditions and embed a risk premium to accommodate the transfer of price risk between hedgers and speculators.

Since the formulation of the Keynesian hypothesis, the presence of risk premiums in commodity futures markets has been actively debated.[5] Early attempts to measure premiums in individual markets were often inconclusive and hampered by the sampling variation induced by the high volatility of commodity prices.[6] More recent studies have examined the returns on portfolios of contracts over periods that span several decades, in the same way that the equity risk premium literature has focused on portfolios of stocks instead of individual securities.

Despite the long history of commodity futures trading, few comprehensive databases of historical price records exist. Among the most widely used resources is a database maintained by the Commodity Research Bureau which reports individual futures price data going back in time to 1959. Papers that collect earlier data samples include Bodie and Rosanski (1980) and Levine, Ooi, Richardson, and Sasseville (2018). The latter studied the longest time series of futures prices in the literature to date, obtained by digitizing the CBOT yearbooks back to 1877. The combination of the data analyzed in these studies is a subset of the data we use in this paper.

[5] See Gray and Rutledge (1971) for a survey of the early literature, and Rouwenhorst and Tang (2012) for a recent update.

[6] Houthakker (1957), Telser (1958), Cootner (1960), and Gray (1960, 1961).

There are several hurdles in assembling a comprehensive database of commodity futures prices. Exchanges did not always create a published record of prices[7] and in some instances when they did the primary archival records were lost.[8] For this reason, we combine data from exchange handbooks, when available, with price data that was hand-collected from newspapers in the US and Europe. By combining multiple sources, we were able to collect prices for 230 commodity futures contracts listed on 28 exchanges going back to 1871. It is to our knowledge the most comprehensive database available to researchers.

Unlike exchange handbooks or exchange archives, newspapers represent a secondary source of data which potentially creates a selection bias. Early newspapers had a regional audience, and US and UK papers are naturally more likely to report prices of commodities that are traded or delivered in their own hemispheres and ignore futures that settle in other parts of the world. In addition, a likely requirement for a contract to be included in a newspaper is that the market has gained enough economic importance to merit coverage. Contracts that failed to attract sufficient trading volume are likely to be underreported, and economically important contracts may not always have data coverage since inception of the contract. For these reasons, our database does not include all contracts ever traded, nor does it necessarily provide a complete time-series record for the commodities that are included.[9] To the extent that the success of a contract is correlated with the risk premium, this would create a bias in our return calculations. We will provide some evidence on the impact of survival in section 4. On the upside, the database otherwise reports prices "in real time" and does not suffer from a survivorship bias. Despite some of these shortcomings, we believe that a new database that covers the economically important commodities of its time provides an important resource to researchers studying the long-term properties of commodity futures markets.

2.1 Data sources and definitions, and the evolution of contract introductions.

The primary source of futures price data are the yearbooks published by the *Chicago Board of Trade* (CBOT), the *Chicago Mercantile Exchange* (CME), and the *Annual Report of the Chamber of Commerce of Minneapolis* (CCM). Newspaper data was collected from *The New York Times*, the *Wall Street Journal* and the *Chicago Tribune* in the United States and *The Guardian* in the United Kingdom. The exchange yearbooks account for 37 contracts, and the newspapers for 184

[7] The CBOT has published yearbooks with futures prices from 1877 until 1968. The Chicago Mercantile Exchange has published futures prices since 1925. First in the *Dairy and Produce Yearbook* from 1925-1951 and subsequently in the *CME yearbooks* from 1952 to 1977, The Minneapolis Chamber of Commerce published Annual Reports since at least 1876, and includes futures data beginning in 1895.

[8] The records of the New York Board of Trade were lost as a result of the events of 9/11/2001.

[9] For the period 1960-1970, Sandor (1973) provides a list of 56 contract introductions on 10 US exchanges. This is roughly double of the number of contracts added to our database over that same period.

commodities.[10] For price data obtained from newspapers, we often used two independent sources to verify the accuracy of prices. Figure 1 depicts the timeline for all contracts in the database chronologically ordered by their date of entry. Appendix Figure 1 groups the contract timelines by sector.

Panel A of Figure 1 provides an overview of the data coverage in the early days of futures trading pre-1900. The figure can be thought of a pictorial representation of the evolution of commodity futures markets: many contracts were introduced, most eventually disappeared, and few survived until today. Of the contracts that initiated coverage pre-1900, eight have survived until today: Chicago Wheat, Corn and Oats; New York Cotton; London Copper and Tin; and the Wheat contracts traded in Minneapolis and Kansas City. The timelines further illustrate how the early expansion of futures markets was concentrated in the agricultural sector, and more narrowly in contracts on Grains and Oilseeds. An important aspect of this evolution is that many new contract introductions were designed to expand the delivery and trading locations of existing commodities (ignoring differences in grades), while relatively few expanded the range of underlying physical commodities. For example. following Chicago (1870)[11], corn contracts were introduced in Toledo (1874), Baltimore (1877), St Louis (1879), Philadelphia (1880), New York (1881), Boston (1883), Buffalo (1884), and Kansas City (1900), Milwaukee (1902), and Minneapolis (1937). These same cities also initiated futures trading in Wheat, as did several others: Cincinnati and Detroit, Duluth, and San Francisco. As a result of this sector expansion, the database covers 12 different Corn contracts and 27 different types of Wheat. The majority of new contract introductions pre-1900s are linked to Wheat, Corn, Oats, Barley. Rye (Chicago), Cloverseed (Toledo, Chicago), Flaxseed (Chicago and Duluth), and Timothy seed (Chicago) round out the set of early agricultural commodity contracts.

Expansion of futures trading on new physical commodities was relatively infrequent pre-1900. Most notable are the introduction of futures on animal products in Chicago (1870-74) and New York (1900), and the inception of Metals trading in London for Copper (1875), Tin (1875), and Pig Iron (1901). The earliest Softs contracts include Cotton in New York (1873), Liverpool (1879), New Orleans (1881), and Alexandria (1893) and Coffee in New York (1882) and Havre (1900). Despite the concentration in Agriculture, by 1900 our futures database encompasses four of the six major commodity sectors recognized today including Grains and Oilseeds, Softs, Industrial Metals, and Livestock. Precious Metals enter the database in 1909 (London Silver). Futures on Energy are the last to emerge: Crude Oil and Gasoline contracts appears to have briefly traded in New York in 1935 but failed shortly after their introduction; no mention of energy contracts can be found until the introduction of Heating Oil in 1978, followed by Crude Oil (WTI, 1983) and Gasoline (1984).

[10] Recent data on nine commodities were obtained from CRB as these were unavailable from primary sources such as European rapeseed, and Chicago Platts Ethanol.

[11] The dates refer to the first year of entry in our database instead of contract introduction

Figures 1b- 1e show the remainder of the evolution of the data sample. Of the contracts that were listed in the first 30 years of the 20th century, only New York Cocoa and New York Copper still exists; of those initiated between 1930 and 1960, only the Chicago Soybean complex and New York Platinum have survived until today. Most of the currently traded commodity futures contracts were introduced after 1960.

Figure 1 illustrates the ebb and flow of contracts entering and leaving our database but also the emergence and decline of settlement locations of commodities trading. The role of Chicago as the center of early commodities trading is well documented (Taylor (1917)) but by the middle of the 20th century New York had all but overtaken Chicago in terms of the number of unique commodity listings. And many of the trading locations that emerged during the early expansion of commodity futures trading have since disappeared as improvements in transportation led to closing or consolidation of futures exchanges over time.

To illustrate the depth of our database at any given point in the sample, we plot the total number of distinct commodities in Figure 2, using three different levels of aggregation. Under the first method, (level 1) all available contracts are counted separately, distinguishing for example between the Hen Turkey and Tom Turkey contracts that were both introduced on the CME in 1962. When we aggregate across commodities by location (level 2) the two Turkey contracts are counted as one: Chicago Turkey. Our final measure of commodity coverage (level 3) aggregates across locations; Chicago Corn, Duluth Corn, and Toledo Corn and are counted as a single underlying (Corn).

The figure shows that aggregation by location (level 1 versus level 2) has little effect on the overall commodity count. With the exception of the first 10 years, the number of distinct contracts in the database at any point in time averages between 25 and 55 (level 1 and 2) up to World War II. The number of unique underlying commodities varies between 10 and 35 for most of the sample (level 3). By comparison Levine et al (2018) who study the CBOT commodities back to 1880 cover 6 contracts (mostly grains) between 1880 and until 1950.

2. Excess return calculation

For the purpose of measuring the risk premium we use end-of-month data to calculate excess returns on the nearest-to-maturity contract that does not mature during that month. Denoting F_t^T as the futures price at time t for a contract that matures at time T, we define the futures return as:

$$R_{t,t+1}^T = \frac{F_{t+1}^T - F_t^T}{F_t^T} \qquad [1]$$

Because the futures return defined in (1) is an excess return, its expectation has the interpretation of a risk premium. Averages of realized excess returns are then used as estimates of realized risk premiums in "front-month" futures contracts. [12]

3. Empirical results on the average risk premium.

For our main estimates of the commodity risk premium, we use three different approaches for averaging return observations across contracts and time. The simplest is to assign all observations in the database equal weight. We compare this to the cross-section of average individual commodity risk premiums, and the average excess return on an equally-weighted index. The latter effectively averages returns cross-sectionally by month, before calculating a time series average. The three estimates of the risk premium are summarized in Panel A of Table 1.

3.1 Average commodity risk premium

Are average futures excess returns positive? Our first estimate of the risk premium takes a simple average across all 67,541 monthly return observations in the database. Treating each monthly excess return as a separate observation on the risk premium results in an average (annualized) excess return of 5.32%, with an annualized volatility of 28.9%. This estimate of a positive premium is the basis for our main conclusion in the introduction, that on average across commodities, locations, and time, futures prices are set at a discount relative to future spot prices.

The second approach is to measure the average risk premium at the commodity level and calculate the individual time-series average premium for each of the 230 commodities. The cross-sectional average of these time-series means is 2.33% annualized (t = 1.52), which is below our first estimate. In section 4, we will show that the difference is explained by low average premiums for short-lived contracts, which results in relative overweighting of these commodities in the cross-sectional mean. A full list of the individual commodity risk premiums is given in Appendix Table A1.

Finally, we estimate the average excess return for a monthly rebalanced equally-weighted commodity index, constructed after aggregating commodities by location (level 2). The historical premium of the equally-weighted index is 5.20% (t = 4.40), which is in line with our first estimate that simply averages across all observations. The premium on an equally-weighted index has

[12] Risk premiums can vary across the curve. See Szymanowska et al (2014)

been used in several recent studies of the risk premium (Gorton and Rouwenhorst (2006), Bhardwaj, Gorton and Rouwenhorst (2016), and Levine et al (2018)).

To put these findings into context, it is of interest to compare the distribution of commodity risk premiums to those reported for US and global equity markets. Bessembinder (2018) reports that the median stock in the CRSP database did not earn a positive return in excess of one-month T-bills. Only for 42.6% of the stocks did the lifetime buy-and-hold return (with dividends reinvested) exceed the risk-free rate between 1926 and 2016. A similar conclusion applies to global stocks, albeit measured over a much shorter time period (Bessembinder et al (2019)). In contrast 58% of the commodities in the database earned a positive risk premium over their lifetime. Using returns to rolling futures as a measure of the "buy-and-hold" returns, we find that the median commodity earned a geometric average premium of 1.5% annualized over its lifetime.

3.2 The premium by sector and over time

Panel B of Table 1 summarizes the average contract premium by sector and by decade. The second row of the table shows that the full sample average premium has been positive in every sector, and remarkably uniform across sectors. The annualized average sector premiums fall within a relatively narrow range of 2 per cent, with the exception of Energy, for which the history and number of contracts is much smaller than for other sectors. An F-test of the hypothesis that full-sample risk premiums are equal across sectors fails to reject at the 5% level (p-value = 0.095).

The uniformity of the long-term premium masks substantial time-series and cross-sectional variation in the premiums as is evident by inspecting the returns by decade. In the 1970s, for example, when inflation fueled high commodity returns in many sectors, the average premium in Animal Products was low. In the decade that followed, the premium in Industrial Metals and Energy was positive when average commodity returns were negative. Panel C of Table 1 summarizes the premiums in sub-samples pre and post 1960, which was the breakpoint provided by the study of Gorton and Rouwenhorst (GR, 2006). Together with Bodie and Rosanski (1980) and Fama and French (1987), these are the first studies to provide evidence of a long-term risk premium in portfolios of commodity futures. The overall premium is 4.3% post 1960 and 6.2% during the period that predates the GR (2006) sample and represents a statistically significant drop in the risk premium in the more recent sample (t=2.55). The lower premium is mostly concentrated in the Agricultural commodities (Softs, Animal Products and Grains & Oilseeds). And while the equality of average sector risk premiums cannot be rejected in the early subsample, the F-test for the post 1960 means rejects equality at the 5% level.

3.3 The premium relative to a public benchmark.

A final approach to evaluate our premium estimates is in a comparison with a public benchmark. Although investable commodity indices are of relatively recent date, Bhardwaj and Rouwenhorst

(2019) analyze the historical returns of a commodity index that was calculated in real time by Dow Jones since 1933, a.k.a. the Dow Jones Commodity Index (DJCI).[13] While this index does not cover the entire history of our database it provides a market-based benchmark for 65 years of our sample. The data on the DJCI is hand-collected from the *Wall Street Journal* and the index earned a statistically significant risk premium of 3.7% (*t*-stat = 2.4). A comparison of the DJCI and the EW index (level 2) is reported in Panel D of Table 1. The DJCI has lower premium than the EW index. The DJCI returns however suffers from various periods of underinvestment due to several trading suspensions, as documented in Bhardwaj and Rouwenhorst (2019). The premium of a fully invested DJCI is not significantly different from our EW index.

In conclusion we find strong out-of-sample evidence of a that commodity futures prices have historically been set below future spot prices on average across sectors and across time. The long-term premium is comparable across sectors, although the premium has deviated from this long-term average varied over time and across sectors.

4. Survival and the risk premium.

Of the 230 contracts in our database, only 49 are actively traded at the end of the sample. The majority of contracts that emerged did not survive until the present. The large number of defunct contracts is a unique aspect of our data. In this section we explore the potential link between survival and the risk premium.

To characterize the likelihood of survival, we estimate the Kaplan-Meier survival distribution function in Figure 3. The probability of contracts leaving the database is highest in the years immediately following entry: 9% in the first year, 15% within the first 2 years and 19% within the first three years. For years 5, 10 and 20 the probabilities are 26%, 37% and 51% respectively. 25% of the contracts have been in the database for more than 50 years.

The literature on the history and development of futures markets suggest that many factors potentially contribute to the success and failure of contracts[14]. In discussing the requirements for success, Gray (1966) emphasizes the importance of an active spot market, well-designed contract terms that do not provide an advantage to either hedgers or speculators, and the presence of hedging demand for the underlying commodity. Speculative capital is essential when the hedging demand for futures is not evenly balanced across both sides of the contract, and there is excess hedging demand on one side of the market.

[13] The Dow Jones index was introduced in 1933, with a backfilled history back to 1924. The index went through several reconstitutions, most recently the Dow Jones AIG commodity index, the Dow-Jones UBS commodity index and the Bloomberg Commodity index. See Bhardwaj and Rouwenhorst (2019) for details.

[14] See for example Gray (1966), Hieronymus (1971), Silber (1981), Carlton (1984), Black (1985), Brorsen and Fonfana (2001) and for a recent survey of the literature Till (2014).

While these may be necessary elements for success, failure can occur for many other reasons. The egg futures contract failed when technological progress dampened the seasonal production cycle of fresh eggs and diminished the need for hedging the price risk of egg inventories kept in cold storage. Onion futures were outlawed by an Act of Congress after growers convinced policy makers that futures speculation amplified fluctuations in onion spot prices. Similar political pressure likely contributed to the demise of Potato futures (Gray (1964)). Yet other contracts failed because of the availability of more liquid close substitutes: this was likely a factor contributing to the quick failure of the Ham contract which was launched three years after a Pork Belly contract was first introduced on the CME in 1961 (Hieronymous (1971)).

4.1 Survivorship bias

For the purpose of our study we ask: do risk premiums differ between defunct and surviving contracts? Or stated differently, do estimates of the commodity risk premium differ when defunct contracts are excluded from the sample and only surviving contracts are included in the estimation?

Accounting for biases induced by survival is a central theme in many areas of finance. For example, Brown et al (1992), Elton Gruber and Blake (1996) and Carhart et al (2002)) demonstrate the importance of accounting for survivorship in evaluating the performance of fund managers. Poor past performance negatively impacts the probability that a fund survives, hence the returns earned in a sample of surviving managers overstates the average return that investors can expect to earn. Brown et al (1995), and Jorion and Goetzmann (1999) apply a similar logic to the average risk premiums of national stock markets, showing that survival can impart an upward bias into realized returns.[15] Few stock markets have survived for as long as the US market and the average return earned by investors in the US market is likely to overstate ex-ante estimates of expected returns in equity markets around the world.

Gray (1966) hypothesizes two channels by which returns can affect the likelihood of survival of a commodity futures contract. The first presumes that futures traders are averse to suffering persistent losses. When sustained high returns are earned on one side of a futures contract, the market is unlikely to survive because the losses incurred by their counterparties will cause those traders to eventually withdraw from the market. This would predict that large realized returns to either the long or short side of the contract increase the likelihood of contract failure. This

[15] Although survival is often associated with an upward bias in returns and failure with poor performance, Brown et al (1995) also discuss the possibility of the failure of a market following high average returns, as might happen in the case of a revolution.

hypothesis links the likelihood of survival to the absolute size, but not the directional sign of the risk premium.

Second, Gray (1966) points to the importance of speculative market participation. Speculators are needed to help offset the general tendency for short hedging to exceed long hedging. This is increasingly important as the excess hedging demand in the market becomes more lopsided. Although all futures traders are loss averse, the net exposure of speculators exceeds that of hedgers by the nature of hedging: futures losses by hedgers are partially offset by a gain in the value of the underlying asset, limiting their net exposure to the basis. Following Gray's line of reasoning then, the willingness of speculative capital to meet the excess short hedging demand on a sustained basis would require that speculators earn on average a positive return; absent a premium the likelihood of withdrawal by long speculative capital and contract failure increases following sustained episodes of negative excess contract returns.

These considerations are likely more salient in the early years following the introduction of a new futures contract where is less familiarity with the contract and concerns may exist whether the contract is well designed and offers fair terms to all market participants.

4.1 A Comparison of the premium on surviving versus non-surviving contracts

In panel A Table 2 we calculate the average premium for surviving and non-surviving contracts in two different ways. If we weight all contract-month observations equally, we find a small difference between the average premiums: 4.70% per annum for surviving and 5.81% for non-surviving contracts. If we take averages of the individual commodity time-series means we find that the spread between the premiums becomes larger: 5.0% for surviving versus 1.6% for the non-surviving commodities.

To better understand the sensitivity of individual commodity risk premiums to survival we provide a scatterplot of the average contract excess return against the length of the price record in our database. In Figure 4, the surviving contracts are plotted in red and the defunct contracts are represented by blue dots. The chart merits several interesting observations about the evolution of futures markets. First, most contracts are relatively short-lived (as shown before in the Kaplan-Meier survival plot) and there is substantial dispersion in the average realized risk premiums at these shorter horizons. This can in large part be attributed to sampling variation. What is masked by sampling variation is that short-lived commodities have earned lower average returns.

This is documented in Panel B of Table 2, where commodities are sorted into four groups based on survival time. About 16% of the commodities appear in the database for a period shorter than two years. Of these none have survived until the present, and the cross-sectional mean of their average excess returns is -8.0% annualized (median = -0.5%). Half of the contracts in this group earned positive average returns prior to disappearing. By contrast, 45 commodities are in the database for more than 50 years, about 40% of which have survived until the present. The average risk premium in this group is 5.1% annualized, and 91% of the commodities in this group record a positive risk premium.

4.2 Factors influencing survival

We estimate a Cox proportional hazard rate regression to formally test for factors influencing the probability of survival: recessions, recent performance, extreme recent performance, and the availability of a substitute contract. Commodity returns have been documented to be procyclical (Gorton and Rouwenhorst (2006)), and, as we will show in the next section, long positions in futures tend to incur losses during recessions. Based on the earlier discussion of short-lived contracts we examine the influence of poor recent returns (recent 12-month return below the median). To capture Gray's (1966) loss aversion hypothesis, we condition on extreme performance (last 12-month return in the top or bottom decile of the cross-sectional distribution). Finally, we ask whether the existence of a substitute contact in the market (Duluth Corn introduction when Chicago Corn already trades) affects the probability of survival.

The results are in Panel C of Table 2, which shows that contracts are more likely to fail during economic recessions. There is little evidence that below median prior 12-month performance affects the likelihood of failure. While our earlier results showed that several short-lived contracts failed following poor recent performance, there are many instances where poor performance of established contracts does not lead to contact failure. By contrast we find some support for Gray's hypothesis that extreme performance increases the probability of failure. Similarly, the presence of a substitute commodity in the market lowers the likelihood of survival of a new contract introduction. This is consistent with a first-mover advantage whereby the original contract attracts liquidity, open interest, and trading volume thereby creating a hurdle for new entrants.

In conclusion, we find that the return realized during the first years following a new contract introduction potentially plays an important role for the likelihood of survival. The impact of these early contract failures for estimates of the long-term commodity risk premium is mitigated by the fact that these contracts contribute relatively few observations to the sample and receive little weight in the calculation of the average risk premium of a commodity index. This is reflected in the marginally higher long-term risk premium estimates for an index that is based on surviving contracts (5.5% in Table 2A) versus an index that includes all contracts (5.2%)

5. Conditional commodity risk premiums

Previous literature has documented that commodity futures returns vary with the level of inventories (Gorton, Hayashi and Rouwenhorst (2013) and with macroeconomic conditions such as the level of inflation (Greer (1978)) and the business cycle (Strongin, Petsch, and Fenton (1997)), Gorton Rouwenhorst (2006) and Levine et al (2018).

We also consider two state variables that predict ex-ante risk premiums, backwardation and prior one-year returns (Pirrong (2005), Erb and Harvey (2006), Gorton and Rouwenhorst (2006), Miffre and Rallis (2007)). Gorton, Hayashi and Rouwenhorst (2013) argue that these state variables predict risk premiums because they reflect the fundamentals of scarcity. Under the basis measure, we assign each individual commodity to one of two portfolios depending on whether the commodity is in backwardation or contango. [16] Under our second measure we assign commodities to portfolios based on prior one-year return. We calculate average contract returns by sector as in Table 1 panel B.

The full sample results are summarized in Panel A of Table 3; the results for subsamples (using again 1960 as a cutoff) are in Panels B and C. Commodities in backwardation on average outperform commodities in contango by a wide margin (11.2% versus 1.2%) over the 150-year period. The spread in risk premiums is present across sectors (with the exception of precious metals), and as well as in both subsamples: 11.3% versus 2% (pre-1960) and 10.8% versus 0.5% (post 1960). Commodities are more likely to be in contango (58%) than in backwardation (42%), and the incidence of backwardation has fallen slightly over the subsample periods from 48% to 37%.

The premiums in the out-of-sample (pre-1960) portion of our data are similar to the in-sample (post-1960) returns. Contrary to the findings in Gorton, Hayashi, and Rouwenhorst (2013), we find that prior returns do not appear to be as informative in spreading premiums as the backwardation signal.

Hayashi, Gorton and Rouwenhorst (2013) show that high commodity spot returns are correlated with the state of inventories (high spot prices indicate low inventories), and hence high average premiums going forward. These findings are corroborated in our broader sample. Spot returns have less power to spread future excess returns than backwardation. The point estimates of the premiums are slightly higher in the post-1960 subsample, that overlaps with the Hayashi, Gorton and Rouwenhorst (2013) sample period.

Next, we examine the premium in economic states that are correlated with ex-post returns. Greer (1978), Strongin, Petsch, and Fenton (1997)), Gorton and Rouwenhorst (2006) and Levine et al (2018) document the cyclical behavior of commodity returns over the business cycle and the

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[16] If F_1 is the futures price of the contract and F_2 is the futures price of the next contract, the annualized basis is calculated as $[(F_1 - F_2)/ F_2] \times 365/(T_2 - T_1)$, where T_1 and T_2 refer to the time (in days) to expiration of the two contracts. A commodity is in backwardation of the basis if non-negative and is in contango if the basis is negative.

inflation cycle. We use the (ex-post) dating of business cycles by the NBER and distinguish between early and late stages of the cycle. For inflation, we distinguish between above average and below average inflation periods. Finally, we use a measure of unexpected inflation used by Fama and Schwert (1977) who suggest subtracting the T-bill return from inflation. We distinguish between periods when this difference is positive and negative.

Panel A of Table 3 shows that commodity returns are strongly procyclical, earning a premium that is more than 14% higher on average in expansions than recessions. This finding is robust in both subsamples. Even sectors such as Softs, Grains, and Animal Products exhibit strong return cyclicality, even though their link to the economic cycle is perhaps less obvious than is the case for Industrial Metals and Energy. Based on the full sample, most sectors tend to peak in the second half of the expansion and trough in the beginning of a recession. These patterns are not always robust in the subsamples. For example, Precious Metals appear countercyclical in the pre-1960 sample, and peak in the late stages of a recession. Energy, for which we have relatively few data, has high returns in the early recession, which is mostly driven by the first Gulf war in 1990's and the energy rally during the first six months of 2008.

The final rows of Table 3 lists commodity premiums across the inflation cycle. Realized commodity premiums are high when inflation is above average or in periods of rising inflation. These stylized facts are robust in both subsamples.

A main conclusion of this section is that commodity backwardation and (spot price) momentum have been important signals that spread commodity risk premiums over the past 150 years. We also find that ex-post returns vary with the business cycle and with inflation. Do the premiums for backwardation and momentum vary the economic and inflation cycle? We show the results of a double sorting procedure in Table 4. Backwardated contracts earn higher returns than commodities in contango over all phases of the business cycle as well as the inflation cycle. A similar conclusion applies to price momentum, albeit that the spread is slightly lower in magnitude. In both instances however, the merit of factor-based investment strategies appears not to be dependent on the economic cycle.

6. Commodity index and factor strategy returns

Up to this point, we have compared the average return across contracts and time, treating all contract-month return observations equally. From the perspective of an investor in commodity futures, we compare the time series returns of the equally weighted index (level 2) to the return to other asset classes, such as stocks and bonds, as well as two monthly rebalanced "factor strategies" that invest in the top half of the commodities (level 2) sorted on backwardation and spot price momentum.

6.1 Commodities, Stocks and Bonds

Panel A of Table 5 summarizes the average excess returns, volatilities and Sharpe Ratios. In comparing the risk premium across asset classes, we find that the risk premium of commodities is slightly lower than equities but substantially above the risk premium of long-term bonds. Full sample Sharpe ratios are remarkably similar across asset classes. Of particular note is that our estimate of the commodity risk premium exceeds the estimate in Levine et al (2018). The reason is that our index return exceeds theirs during the beginning of the sample, when their index of CBOT commodities suffered a larger drawdown than our more broadly diversified index.

Figure 6a shows the cumulative excess returns to stocks, bonds and commodities. The graph shown the upward trend in futures prices, i.e. the commodity risk premium. The graph also shows that the accumulation of premium more closely resembles equities than bonds, both in magnitude as in terms of volatility. A second feature of the data is that stocks, bonds, and commodities all suffer prolonged periods of drawdowns. Table 6b shows that the largest depth of the largest drawdowns in equities and commodities are comparable in magnitude, but drawdowns on average last longer in commodities than in equities, and recoveries tend to be slower. The largest commodities drawdown, both in terms of length and depth occurs in the pre-1900 period of the sample, and exceeds the large drawdown that includes the period of the great depression of the 1930s until World War II.

6.2 Commodity Basis (Carry) and Momentum

Based on the results in the previous section it will come as no surprise that factor portfolios based on basis (carry) and momentum historically outperformed an equally-weighted index over long horizons. In this section we will focus on periods of underperformance of factor strategies as in the most recent years of our sample. Panel A of Table 6 shows the returns to long-short factor strategies formed by dividing commodities into two halves (top-bottom) based on prior one-year spot return (momentum) and the futures basis. Both strategies are equally-weighted and monthly rebalanced. The two factor strategies have similar average returns and volatilities. Average drawdowns in both strategies are shorter than 1 year, and recovery periods last on average 6 months. In contrast to these relatively modest averages, we find occasional very long drawdowns. The maximum drawdown of both factor strategies exceeds 25 years. Figure 7 shows that the longest drawdowns included World War I, the Great depression and World War II.

Daniel and Moskowitz (2016) document momentum crashes in equity markets, and Illmanen et al (2018) report large factor drawdowns across many asset classes during the past century. The nature of these “crashes” of the factors or the asset class premiums for that matter is not well understood and beyond the scope of the current paper, and we will leave this as a question for future research.

7. **Conclusions**

We present an estimate of the long-term commodity risk premium using a new dataset of commodity futures prices that traces the performance of commodity futures back to 1871, shortly after the inception of futures in the United States. Our dataset exceeds the size of existing datasets both in terms of time series coverage as well as in terms of the number of contracts studies tracked, most importantly in its coverage of "dead" contracts that failed to survive. Across contracts and time, the average arithmetic average risk premium was 5.3% annualized. An equally-weighted index of all commodities earned a premium of 5.2% between 1871 and 2018. The long-term premium is present and remarkably uniform across sectors.

There is considerable variation in the sample average risk premium across individual commodities. The average (median) commodity earned a risk premium of 2.3% (4.9%) annualized and 58% of the 230 commodities in the database recorded a positive buy-and-hold premium during their lifetime. We find that short-lived contracts have earned considerably lower premiums than longer lived contracts. Because these short-lived defunct contracts do not contribute many datapoints to the sample, by construction they have little impact on our estimate of the equally-weighted market risk premium. The majority of contracts, and especially long-lived contracts have earned positive average risk premiums, consistent with the Keynesian view that a positive risk premium is required to incentivize speculators to meet the imbalance of short hedgers over long hedgers.

We contribute to the empirical literature on the survival of contracts by showing that contracts are more likely to fail during the early stage of their life, during recessions, when investors experience extreme returns, and when there exists a substitute contract in the market at the time of launch.

Viewed as an out of sample test of the post-1960 literature on the risk premium, we confirm several stylized facts in the literature: (1) the presence of a positive commodity risk premium, (2) that backwardation and past spot returns are "factors" that spread future risk premiums in commodity markets and (3) that commodities perform better in inflationary environments and when the majority of contracts are in backwardation.

Finally, our study documents that factor strategies have on average performed better in all phases of the business cycle and inflation scenarios.

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Table 1: The commodity risk premium 1871-2018

Panel A

	By Contract	By Commodity	Index
Average Premium	5.32%	2.33%	5.20%
Number of Observations	67541	230	1776
t-Stat	13.82	1.52	4.40
Geometric Returns		1.52%*	4.26%
Fraction Non-Negative	51%	58%	53%

* Median geometric returns

Panel B

	All	Softs	Animal Products	Grains & Oilseeds	Energy	Precious Metals	Industrial Metals
Full Sample	5.3%	5.2%	3.9%	5.4%	9.8%	3.7%	5.7%
1870	-1.1%	-3.6%*	-5.5%	0.9%			5.6%*
1880	-1.4%	4.7%	8.8%	-5.0%			2.5%
1890	1.0%	1.4%	-3.7%	1.7%			1.4%
1900	15.4%	12.5%	20.5%	17.1%		25.1%*	6.1%
1910	19.0%	22.4%	15.5%	21.3%		-0.8%	9.5%
1920	-0.2%	-2.1%	1.3%	1.7%		-6.9%	-4.0%
1930	0.9%	0.8%	2.9%	-0.2%	-4.0%*	3.9%	2.2%
1940	14.2%	17.9%	8.5%	14.5%		12.8%	9.5%
1950	5.2%	6.3%	2.0%	3.7%		2.7%	10.3%
1960	3.2%	0.8%	2.5%	0.2%		4.5%	15.2%
1970	14.8%	18.1%	2.0%	17.3%	57.9%*	26.0%	10.2%
1980	-1.8%	-7.8%	-4.9%	-1.9%	22.0%	-12.9%	6.0%
1990	0.9%	2.4%	6.4%	-4.1%	9.0%	0.1%	-3.0%
2000	7.5%	2.6%	-0.3%	5.6%	13.7%	11.5%	14.6%
2010	2.1%	1.3%	7.2%	1.1%	1.5%	3.8%	-0.6%

* Partial Decades

Panel C

	All	Softs	Animal Products	Grains & Oilseeds	Energy	Precious Metals	Industrial Metals
1871-1959	6.2%	6.8%	5.5%	6.7%	-4.0%	3.8%	4.3%
1960-2018	4.3%	3.0%	2.4%	3.0%	9.9%	3.7%	6.8%
t-test	2.55	2.06	1.58	3.03	-0.52	0.02	-1.37

Panel D

	DJ Index	EW Index	Difference	t-stat
Average Premium				
Oct 1933 - Nov 1998	3.7%	6.6%	2.9%	2.68

Note: Panel A presents our estimates of the commodity risk premium, using three different approaches for averaging across contracts and time. Estimate of the risk premium 'by contract' is obtained by taking a simple average across all 67,541 monthly return observations in the database, treating each monthly excess return as a separate observation of the risk premium. 'By commodity' risk premium measures the average risk premium at the commodity level. After calculating the time-series average premium for each commodity in our database, we report the cross-sectional average of these time-series means. 'Index' risk premium is for a monthly rebalanced equally-weighted commodity index, constructed after aggregating commodities by location. Panel B summarizes the average contract by sector and by decade. Panel C summarizes the premiums in sub-samples pre and post 1960, which was the breakpoint provided by the study of Gorton and Rouwenhorst (2006). Panel D analyze the historical returns of a commodity index that was calculated in real time by Dow Jones since 1933, the Dow Jones Commodity Index.

Table 2: Survival and the risk premium

Panel A

	By Contract			By Commodity			By Index	
	All	Surviving	Non-Surviving	All	Surviving	Non-Surviving	All	Surviving
Average Returns	5.3%	4.7%	5.8%	2.3%	5.0%	1.6%	5.2%	5.5%
Volatility	28.9%	28.9%	28.9%	27.1%	28.0%	26.9%	14.4%	17.4%
Median Returns				4.9%	5.1%	4.7%		

Panel B: By commodity

Survival Time	2 Year or less	2-10 Years	10-50 Years	> 50 Years	All
# of Commodities	36	50	99	45	230
Number Surviving	0	1	30	18	49
Average Returns	-8.0%	0.2%	5.9%	5.1%	2.3%
Median Returns	-0.5%	3.5%	5.6%	5.1%	4.9%
Average Returns > 0	50%	60%	76%	91%	71%
Average Returns Outside 95% CI	11%	12%	14%	2%	11%

Panel C: Cox Proportional Hazard Regressions

	(1)	(2)	(3)	(4)	(5)
Recession =1, Else 0	**2.14**				**2.12**
	0.00				0.00
1 (if last 12 month return < median), Else 0		1.02			0.97
		0.92			0.86
1 (if last 12 month return in bottom/top 10th Percentile of cross-section), Else 0			1.36		**1.47**
			0.11		0.05
1 (if a same name commodity is trading), Else 0				**1.74**	**1.53**
				0.00	0.02
Log likelihood	-833	-671	-670	-835	-659

Note: Panel A presents our estimates of the commodity risk premium, and volatility, using three different approaches for averaging across contracts and time, see notes to Table 1. We separate the universe into surviving and no-surviving commodities, surviving commodities are the set of commodities that exist till the end of our sample, Dec 2018. Panel B buckets the commodities by the length of data availability. Panel C reports the estimated hazard ratio and the p-values based on Cox proportional hazard regressions. All the covariates are dummy variables, recession dummy is turned for recessions based on dating of business cycles by the NBER. Two return-based variables look at the previous 12-month average returns and compare it with the cross-section of 12-month average returns. For constructing the 12-month average returns we require that at least 6 months of data is available. Last dummy variable is turned on if a commodity with same name is trading.

Table 3: Conditional commodity risk premiums

Panel A

	All	Softs	Animal Products	Grains & Oilseeds	Energy	Precious Metals	Industrial Metals
Backwardation	11.1%	11.3%	9.1%	10.5%	21.3%	11.6%	10.2%
Contango	1.2%	0.4%	-0.1%	2.0%	0.0%	1.3%	2.0%
% In Backwardation	42%	44%	44%	42%	46%	24%	46%
Positive Spot Returns	9.0%	10.1%	8.7%	8.0%	12.0%	10.6%	9.2%
Negative Spot Returns	1.5%	0.2%	-1.8%	3.5%	7.0%	-3.7%	0.5%
Expansion	9.0%	9.1%	7.6%	8.2%	12.8%	6.1%	11.8%
Recession	-5.4%	-6.6%	-7.7%	-1.3%	-18.7%	-8.9%	-14.2%
Early Expansion	8.3%	11.3%	7.0%	6.8%	18.6%	-0.4%	10.1%
Late Expansion	10.9%	7.8%	8.4%	10.5%	20.0%	12.7%	15.9%
Early Recession	-10.8%	-9.0%	-12.6%	-8.7%	24.2%	-29.6%	-21.0%
Late Recession	-1.5%	-6.4%	-4.8%	4.5%	-61.5%	11.1%	-7.7%
Inflation above Mean	11.4%	9.1%	9.5%	13.7%	21.6%	7.7%	8.1%
Inflation below Mean	-0.6%	1.6%	-2.1%	-1.7%	-5.7%	-3.4%	3.1%
Inflation-Bill >=0	14.5%	11.7%	12.0%	17.2%	22.7%	16.5%	8.8%
Inflation-Bill <0	-0.3%	1.2%	-1.4%	-1.6%	0.0%	-4.0%	3.9%
YoY Change Inflation >=0	9.3%	7.7%	10.8%	9.0%	18.4%	8.7%	7.8%
YoY Change Inflation <0	1.3%	2.7%	-3.3%	1.8%	0.0%	-1.6%	3.4%

Note: Full sample results are summarized in Panel A the results for subsamples (1960 as a cutoff) are in Panels B and C. First two rows group each individual commodity in any given month into one of two sets, depending on whether the commodity is in backwardation or contango at the beginning of the month. Spot returns are estimated by the previous 12-month change in spot price. Expansion and recession are based on (ex-post) dating of business cycles by the NBER. Early and late expansion group the first and second half of all the expansion periods, similarly early and late recession divide the recession periods. Inflation mean is the average of monthly inflation for the entire sample (0.17%). Following Fama and Schwert (1980) unexpected inflation is measured by subtracting the T-bill return from inflation.

Panel B

1871-1959	All	Softs	Animal Products	Grains & Oilseeds	Energy	Precious Metals	Industrial Metals
Backwardation	11.3%	14.1%	14.7%	11.0%		2.1%	5.8%
Contango	2.0%	-0.2%	-0.6%	3.4%		9.1%	2.9%
% In Backwardation	48%	49%	41%	47%		74%	51%
Positive Spot Returns	9.3%	11.6%	9.9%	9.4%		4.4%	4.3%
Negative Spot Returns	3.6%	1.9%	1.2%	5.3%		4.5%	1.2%
Expansion	12.2%	13.5%	12.1%	11.7%		2.9%	13.5%
Recession	-4.4%	-6.9%	-6.4%	-1.7%		5.7%	-11.6%
Early Expansion	13.1%	16.1%	13.2%	11.1%		14.1%	15.2%
Late Expansion	11.1%	10.7%	11.1%	11.9%		-7.9%	11.8%
Early Recession	-11.7%	-10.8%	-12.5%	-10.3%		-11.8%	-19.1%
Late Recession	1.0%	-5.9%	-2.3%	5.1%		21.7%	-4.6%
Inflation above Mean	19.6%	16.6%	23.9%	22.9%		8.7%	7.1%
Inflation below Mean	-1.5%	1.1%	-5.6%	-2.7%		1.1%	2.7%
Inflation-Bill >=0	19.6%	16.6%	23.9%	22.9%		8.7%	7.1%
Inflation-Bill <0	-1.5%	1.1%	-5.6%	-2.7%		1.1%	2.7%
YoY Change Inflation >=0	12.3%	14.0%	17.0%	12.0%		3.7%	6.2%
YoY Change Inflation <0	0.7%	0.2%	-4.6%	1.7%		3.9%	2.5%

Panel C

1960-2018	All	Softs	Animal Products	Grains & Oilseeds	Energy	Precious Metals	Industrial Metals
Backwardation	10.8%	6.4%	4.7%	9.2%	21.4%	20.0%	14.3%
Contango	0.5%	0.9%	0.3%	-0.2%	0.0%	0.8%	1.4%
% In Backwardation	37%	36%	47%	33%	46%	15%	42%
Positive Spot Returns	8.8%	8.3%	7.6%	5.4%	12.0%	11.7%	12.8%
Negative Spot Returns	-0.8%	-2.1%	-4.8%	0.2%	7.0%	-5.0%	-0.1%
Expansion	6.2%	4.4%	4.4%	3.3%	13.0%	6.6%	10.8%
Recession	-8.7%	-5.7%	-11.2%	0.6%	-18.7%	-15.0%	-20.2%
Early Expansion	3.1%	5.0%	1.0%	-0.7%	18.6%	-3.0%	6.2%
Late Expansion	10.7%	4.1%	6.2%	8.2%	20.5%	16.2%	18.7%
Early Recession	-8.2%	-3.5%	-12.9%	-0.2%	24.2%	-36.5%	-25.5%
Late Recession	-9.4%	-7.7%	-11.4%	1.0%	-61.5%	6.5%	-14.5%
Inflation above Mean	6.1%	3.3%	1.6%	3.6%	21.7%	7.6%	8.5%
Inflation below Mean	1.0%	2.6%	3.8%	1.8%	-5.8%	-5.1%	3.7%
Inflation-Bill >=0	9.1%	5.6%	1.7%	6.6%	22.9%	17.9%	10.1%
Inflation-Bill <0	1.2%	1.3%	2.8%	0.7%	0.0%	-4.9%	4.9%
YoY Change Inflation >=0	6.2%	0.0%	5.7%	3.7%	18.5%	9.5%	9.1%
YoY Change Inflation <0	2.1%	6.4%	-1.8%	2.1%	0.0%	-2.8%	4.3%

Table 4: Conditional commodity risk premiums

Panel A

	Backwardation	Contango	Positive Momentum	Negative Momentum
Expansion	14.0%	5.3%	11.8%	5.3%
Recession	2.1%	-10.7%	-2.0%	-7.3%
Early Expansion	12.4%	5.4%	9.6%	7.0%
Late Expansion	16.8%	6.3%	16.0%	4.2%
Early Recession	-0.6%	-18.6%	-4.8%	-15.7%
Late Recession	4.5%	-5.5%	0.6%	-2.2%
Inflation above mean	17.7%	6.4%	14.1%	7.7%
Inflation below mean	4.4%	-4.0%	3.2%	-3.6%
Inflation-Bill >=0	21.0%	9.3%	16.3%	11.6%
Inflation-Bill <0	4.4%	-3.6%	3.7%	-3.4%
YoY Change Inflation >=0	15.0%	4.9%	11.1%	6.7%
YoY Change Inflation <0	6.9%	-2.3%	6.0%	-2.1%

Panel B

1871-1959	Backwardation	Contango	Positive Momentum	Negative Momentum
Expansion	15.8%	9.2%	12.8%	11.6%
Recession	2.1%	-9.3%	0.3%	-6.6%
Early Expansion	16.0%	11.0%	12.3%	15.2%
Late Expansion	15.6%	7.0%	13.4%	7.7%
Early Recession	-3.1%	-18.8%	-4.7%	-16.1%
Late Recession	7.0%	-3.3%	5.1%	-0.6%
Inflation above mean	11.2%	1.3%	9.0%	3.1%
Inflation below mean	11.5%	2.8%	9.7%	4.0%
Inflation-Bill >=0	24.1%	14.8%	19.7%	19.2%
Inflation-Bill <0	11.5%	-4.7%	1.8%	-3.3%
YoY Change Inflation >=0	16.4%	8.8%	11.8%	13.6%
YoY Change Inflation <0	6.6%	-4.1%	5.7%	-2.6%

Panel C

1960-2018	Backwardation	Contango	Positive Momentum	Negative Momentum
Expansion	12.0%	2.8%	10.9%	0.7%
Recession	2.2%	-14.4%	-7.5%	-9.7%
Early Expansion	7.4%	0.6%	6.4%	-0.4%
Late Expansion	18.2%	5.8%	18.5%	0.7%
Early Recession	7.8%	-18.0%	-4.8%	-14.3%
Late Recession	-5.0%	-11.3%	-12.3%	-7.2%
Inflation above mean	11.9%	0.5%	8.6%	0.7%
Inflation below mean	10.0%	0.5%	8.9%	-1.8%
Inflation-Bill >=0	16.7%	5.0%	13.0%	4.2%
Inflation-Bill <0	10.0%	-2.5%	5.6%	-3.6%
YoY Change Inflation >=0	13.3%	1.5%	10.3%	0.0%
YoY Change Inflation <0	7.5%	-0.6%	6.4%	-1.4%

Note: See notes to table 3, momentum is based on 12-month spot price change.

Table 5: Performance of stocks, bonds and commodities Dec 31, 1870 – Dec 31, 2018

Panel A

	Stocks	Bonds	Commodities
Risk Premium	6.7%	1.7%	5.2%
Volatility	17.2%	6.6%	14.4%
Sharpe Ratio	0.39	0.25	0.36

Panel B

	Stocks	Bonds	Commodities
Max Drawdown	-84%	-60%	-77%
Second Biggest Drawdown	-55%	-27%	-75%
Average Length (in months)	12.6	29.2	25.0
Longest Drawdown	198	485	435
Second Longest Drawdown	187	461	285
Average Recovery Period	7.6	10.8	14.2
Longest Recovery Period	154	141	208
Second Longest Recovery Period	129	114	121

Note: Stocks: Shiller, R. J. (2000), "Irrational Exuberance." Princeton University Press; Prior to 1988 and S&P 500 TR for the period 1988-2018. For the period 1926 to 1991 bond returns are based on Ibbotson Associate Long Term Government Total Returns, and Bloomberg/Barclays 7-10 year index subsequent to that. For the period prior to 1926 we use data from Siegel (1992)), "The real rate of interest from 1800-1990 A study of U.S. and U.K." Journal of Monetary Economics 29: 227-252. Commodities: Equally weighted commodity futures returns of all commodity futures using level 2 aggregation, i.e. different grades of coffee contracts traded in New York are counted as one. Commodity futures returns are collateralized by t-bill returns. T-Bill returns are based on data from Federal Reserve Economic Data for the period 1934-2018, 3-Month Treasury Bill: Secondary Market Rate. For the period 1926 to 1934 Bills returns are based on Ibbotson Associate 30 Day Treasury Bills Total Returns. For the period prior to 1926 we use data from Siegel (1992)), "The real rate of interest from 1800-1990 A study of U.S. and U.K." Journal of Monetary Economics 29: 227-252.

Table 6: Commodity factor performance Dec 31, 1871 – Dec 31, 2018

Panel A

	Basis factor	Momentum factor
Risk Premium	7.5%	7.2%
Volatility	12.2%	12.2%
Sharpe Ratio	0.62	0.59

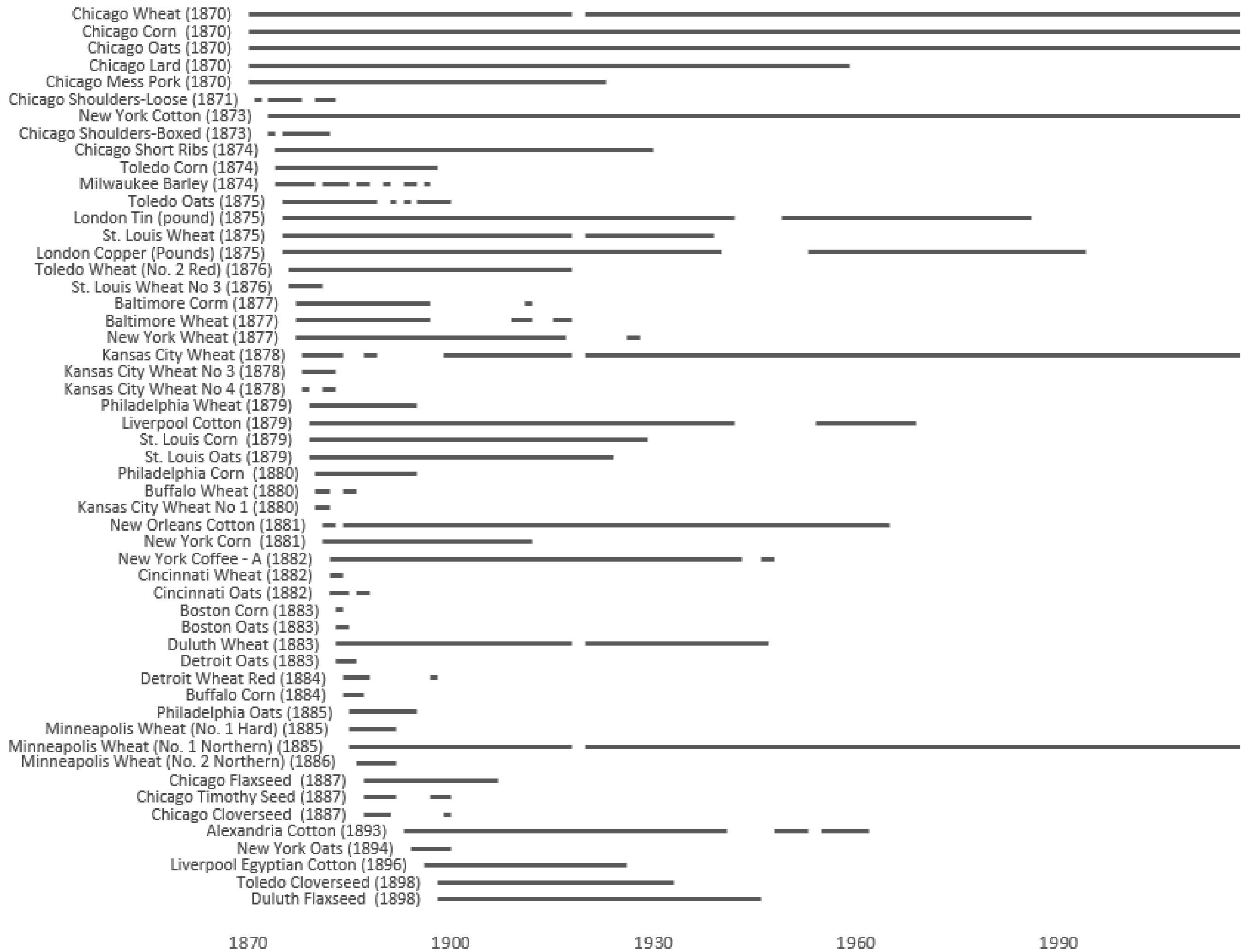
Panel B

	Basis factor	Momentum factor
Max Drawdown	-53%	-58%
Second Biggest Drawdown	-52%	-50%
Average Length (in months)	9.9	11.3
Longest Drawdown	314	329
Second Longest Drawdown	189	211
Average Recovery Period	5.1	6.1
Longest Recovery Period	160	153
Second Longest Recovery Period	44	150

Note: For basis factor we use annualized backwardation, for momentum we use 12-month spot price return, see Gorton, Hayashi and Rouwenhorst (2013). Factor portfolios are based on dividing the commodity universe into two equal halves. Long portfolio is based on next month equal weighted returns of the top half of the sorted commodities, and short portfolio is based on equal weighted returns of the bottom half of the sorted commodities. Figure plots the long short returns.

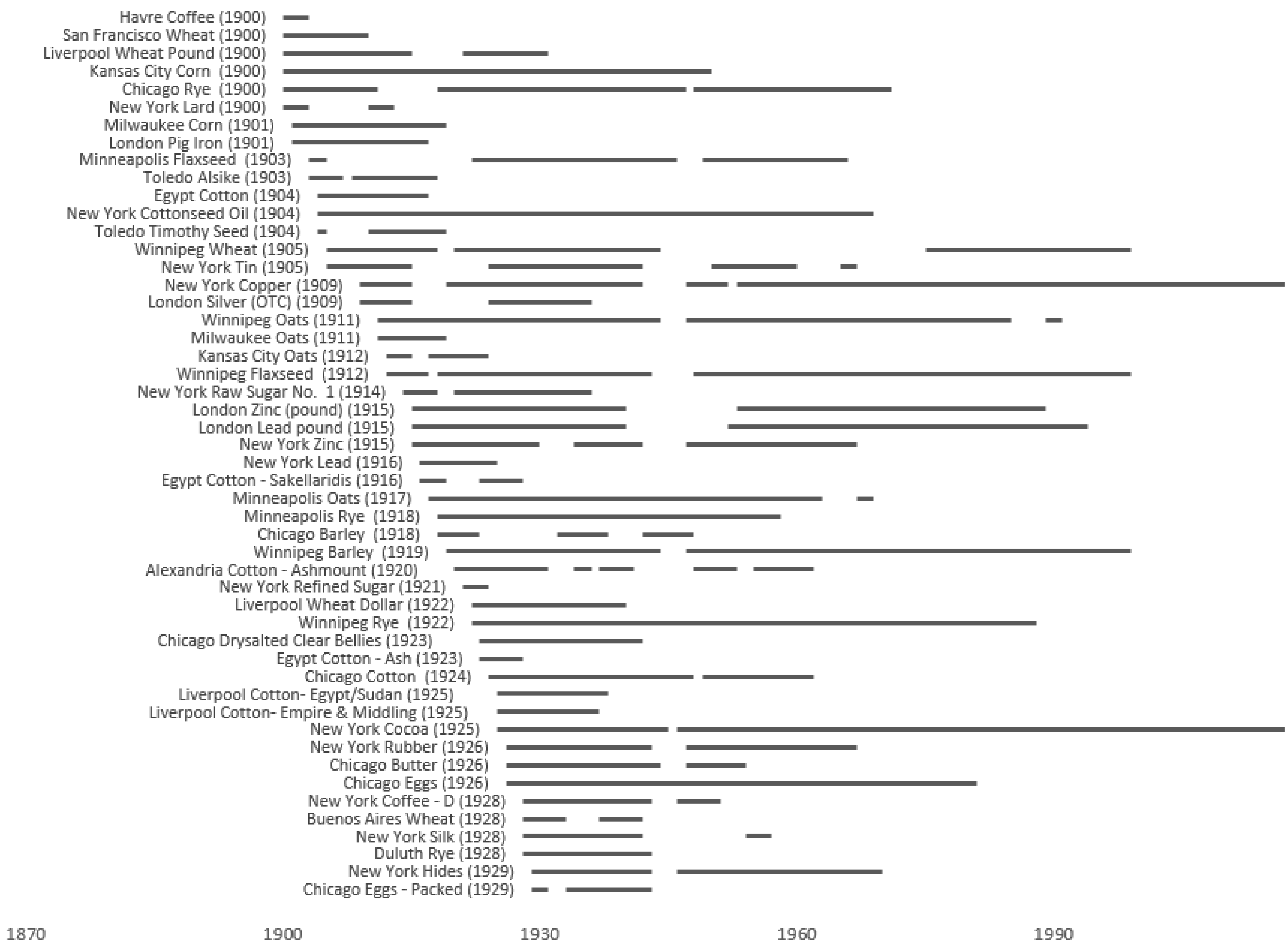
Figure 1: Timeline of commodity futures

Panel A: Commodities that started trading Pre 1900

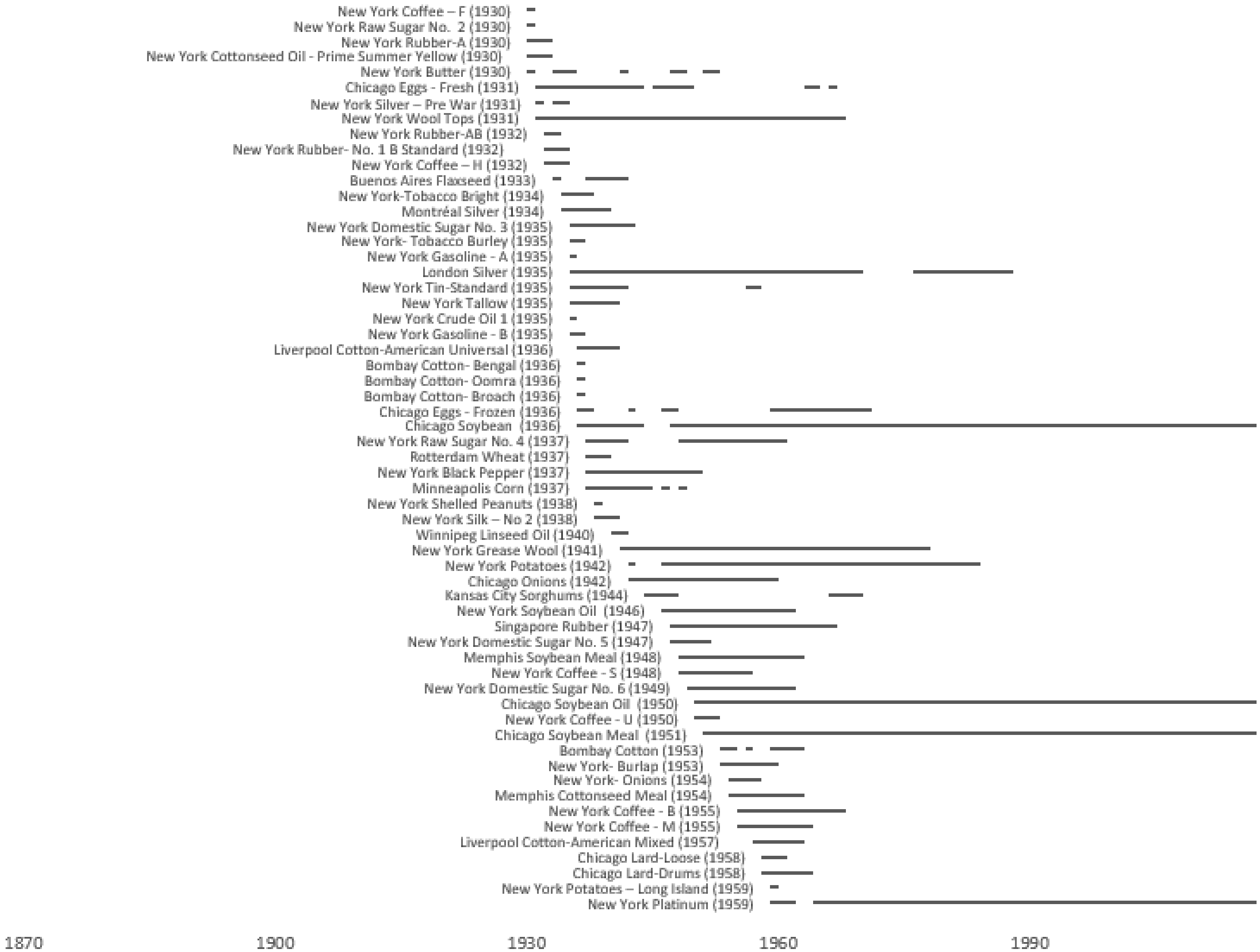


Note: The figure depicts the chronological evolution of commodity futures market. Every commodity is listed as a combination of city and contract name, we also list the first-year data is available. The timeline for each commodity is populated at the annual frequency, i.e. the gaps in the timeline appear only if there is no data available for a full calendar year.

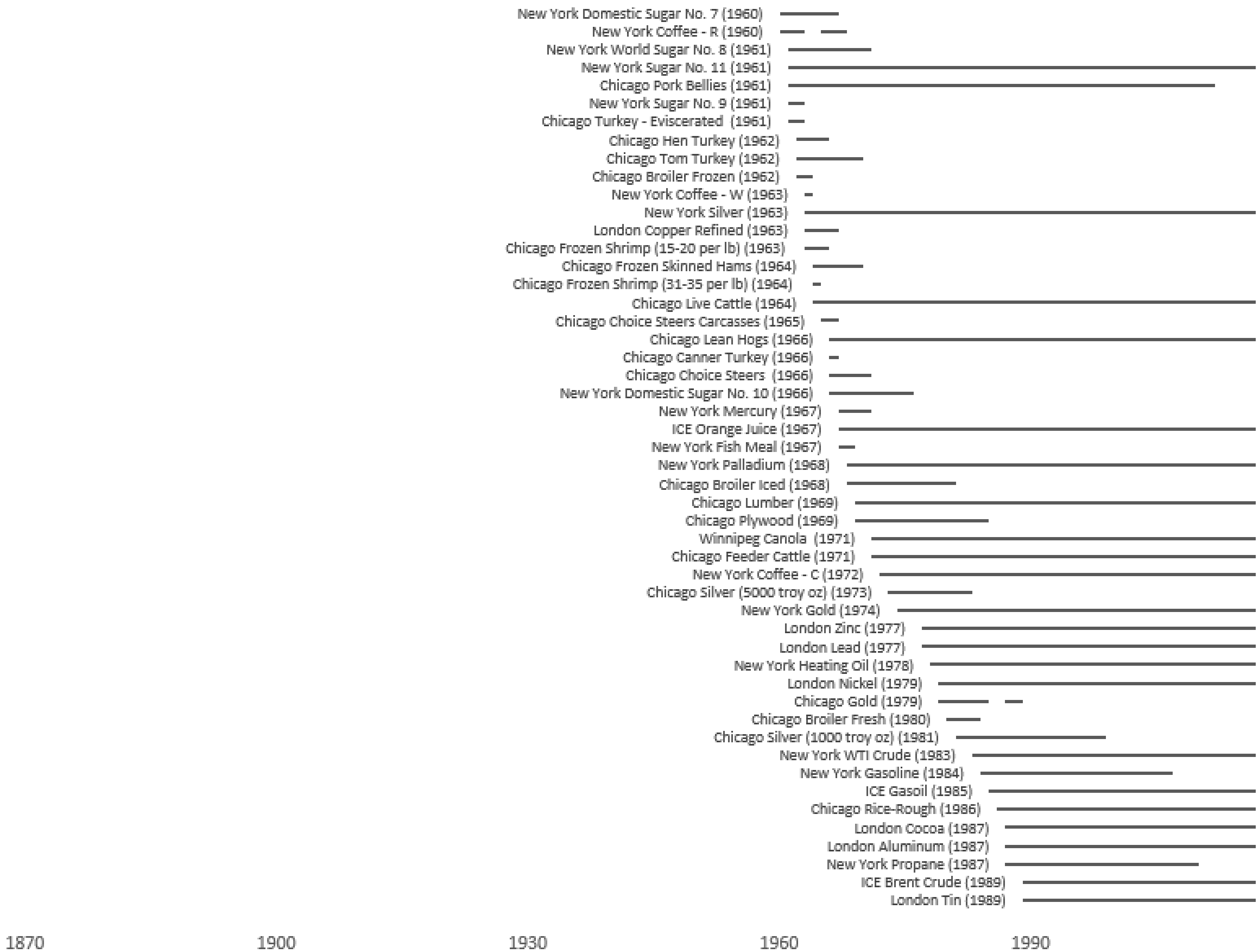
Panel B: Commodities that started trading 1900-1930



Panel C: Commodities that started trading 1930-1960



Panel D: Commodities that started trading 1960-1990



Panel E: Commodities that started trading Post 1990

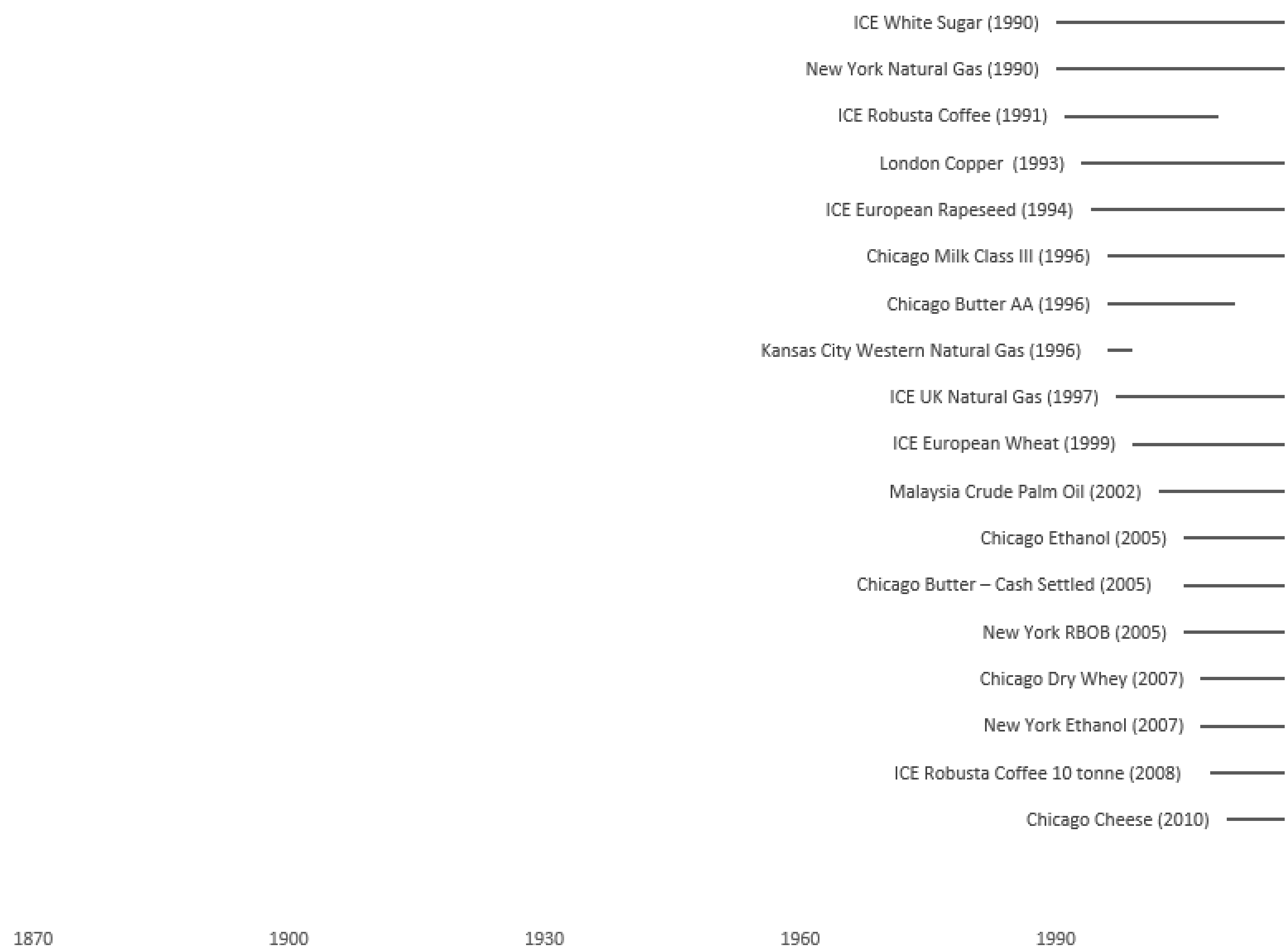
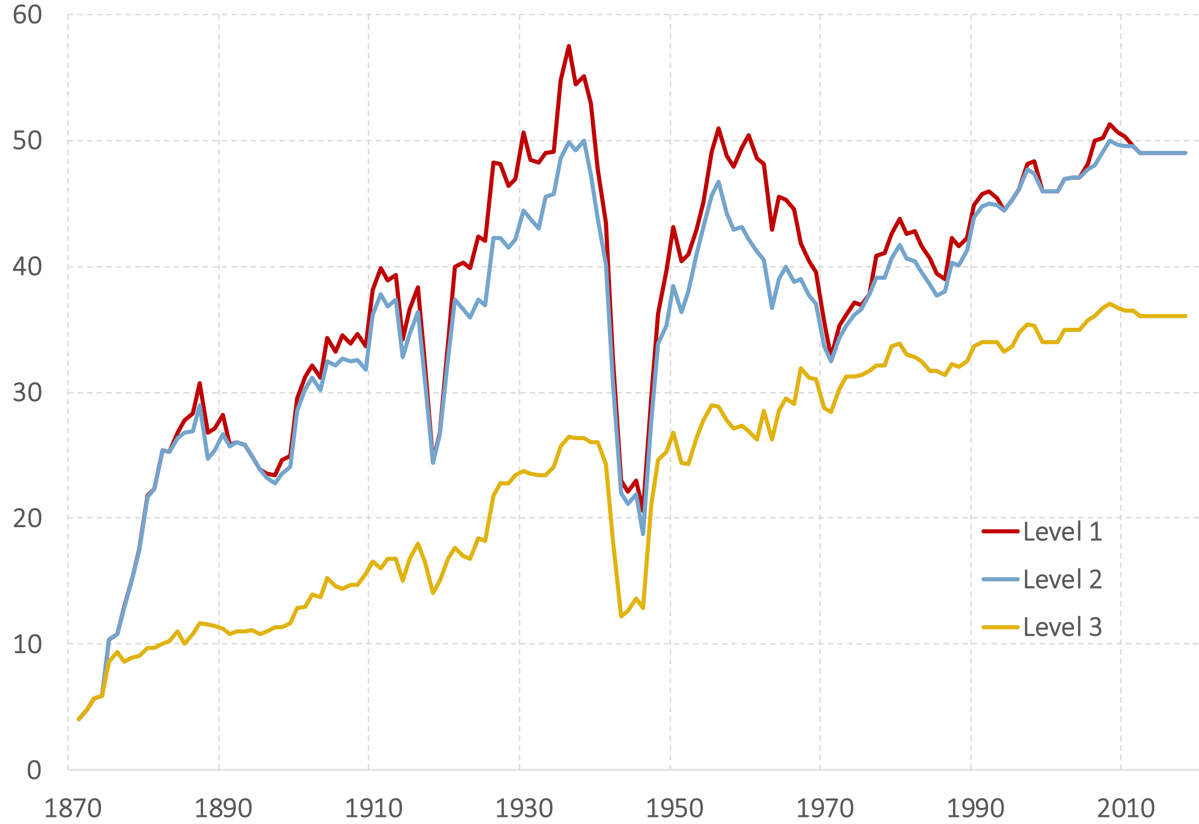
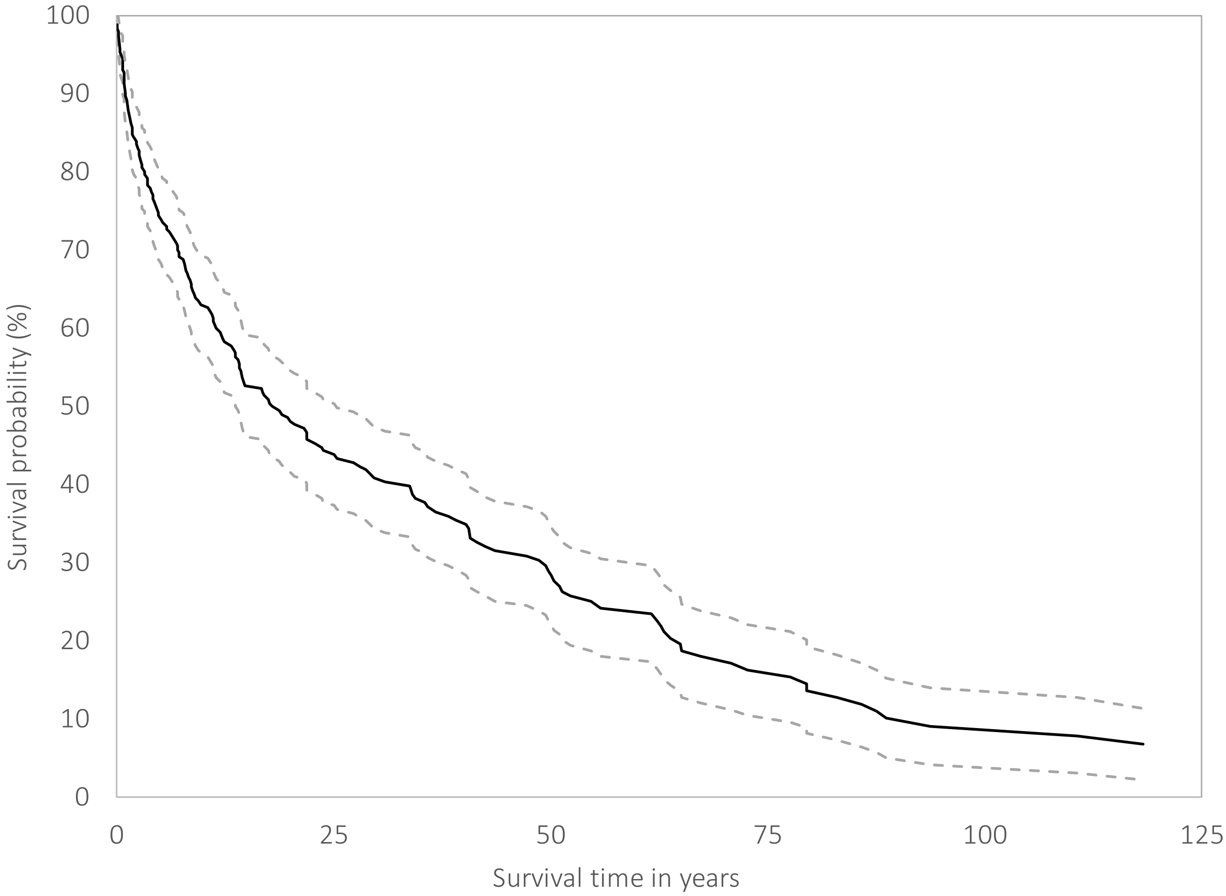


Figure 2: Number of unique commodities over time



Note: The figure depicts annual average number of commodities in the database. Level 1 counts all available commodity contracts separately. Level 2 aggregates across commodities by location, i.e. different grades of coffee contracts traded in New York are counted as one. Level 3 aggregates across location and commodities, i.e. different grades of coffee traded in all locations are counted as one commodity.

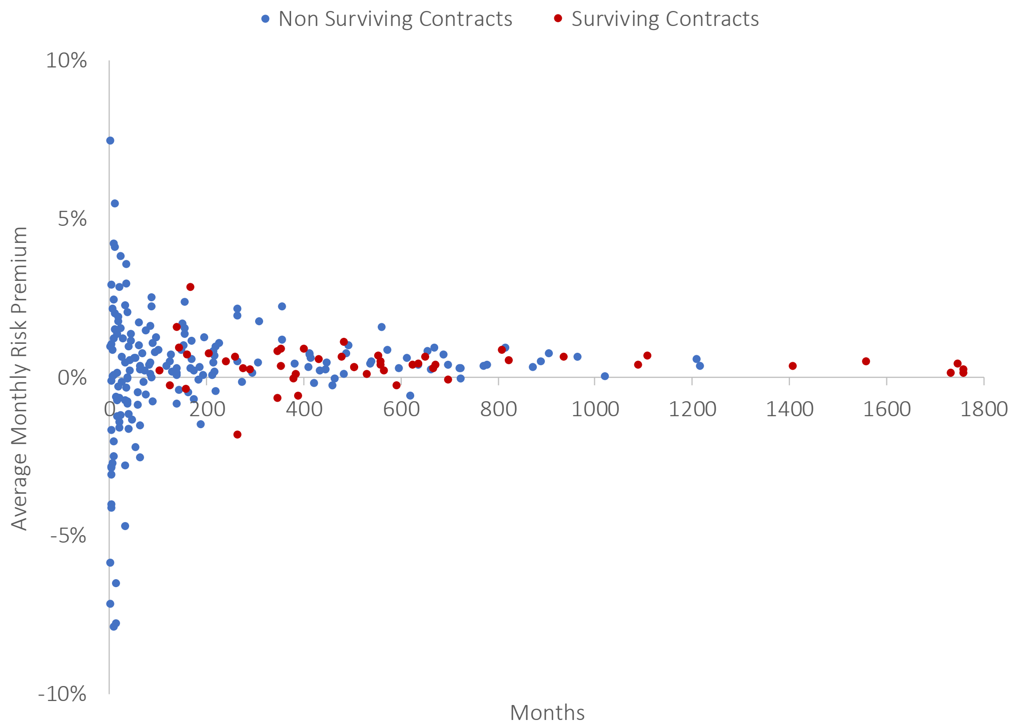
Figure 3: Kaplan-Meier survival distribution function of commodity contracts



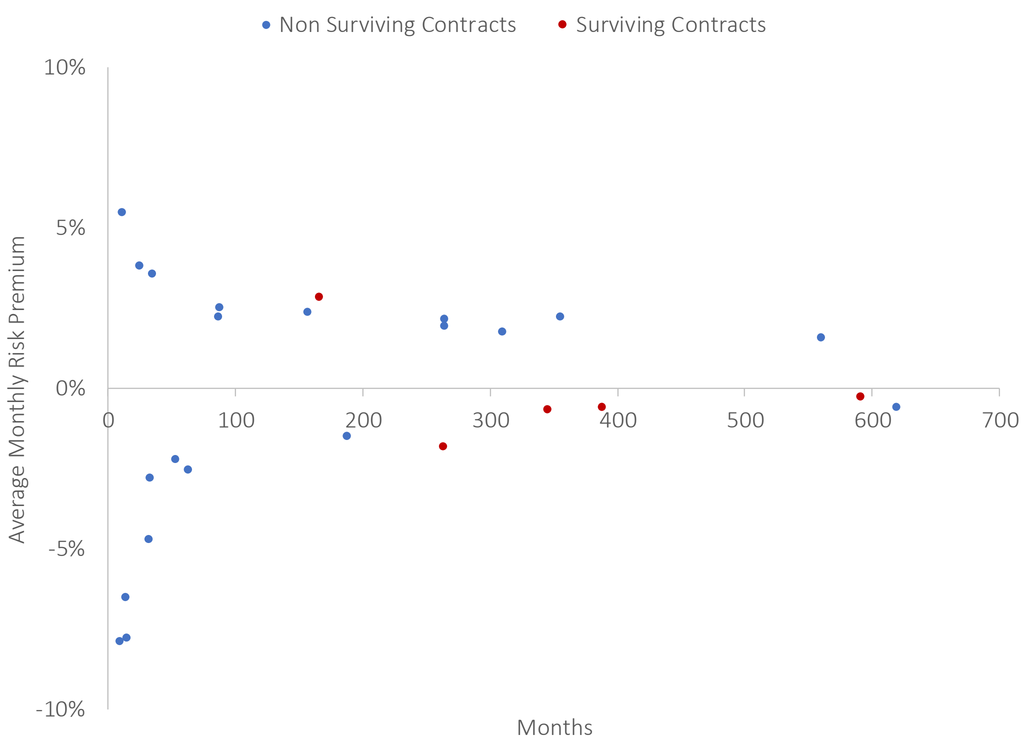
Note: The figure plots Kaplan-Meier survival distribution by contract, and the 95% confidence intervals.

Figure 4: Survival times and risk premiums

Panel A

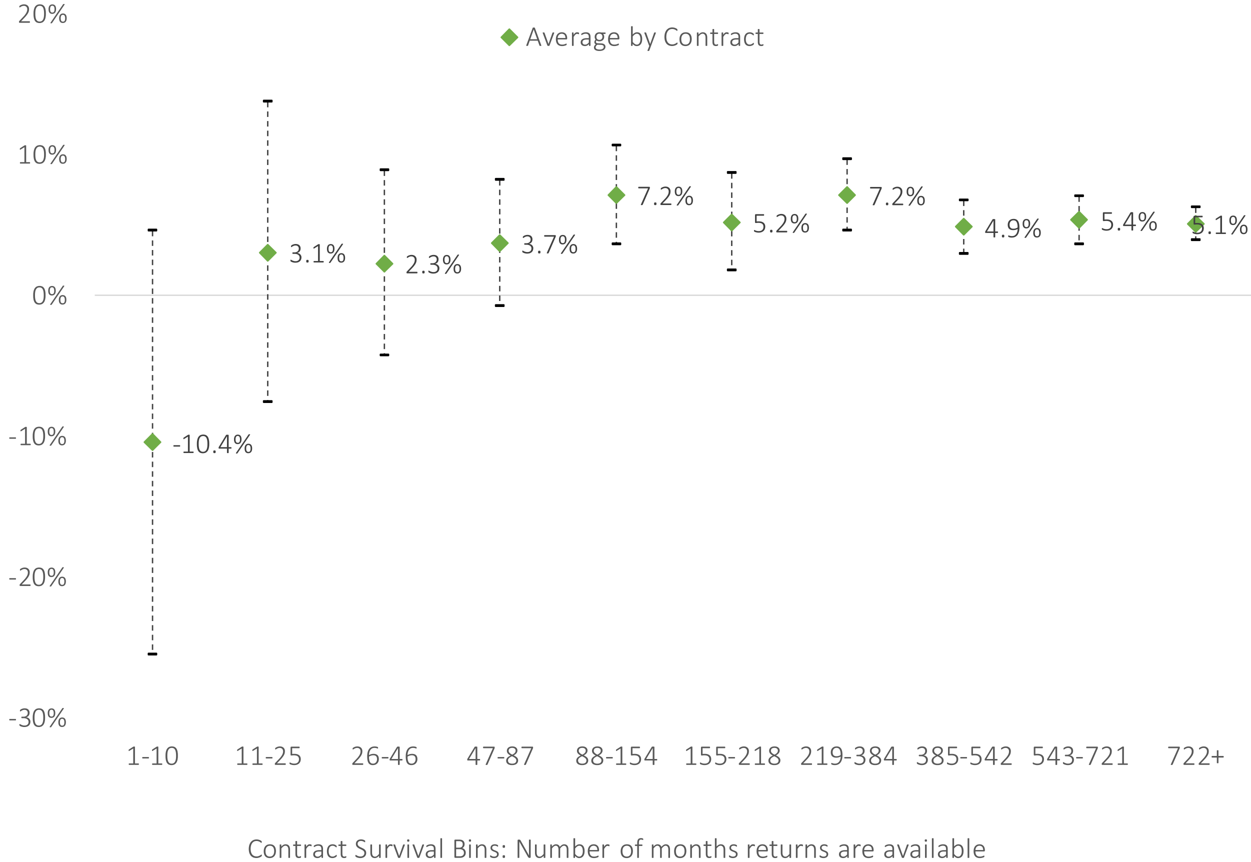


Panel B



Note: Panel A plots average monthly excess return for all the commodities in our sample against the length of monthly returns in the database. Panel B only plots the commodities that fall outside the 95% confidence interval. Currently surviving contracts (as of December 2018) are plotted in red, non-surviving contracts are plotted in blue.

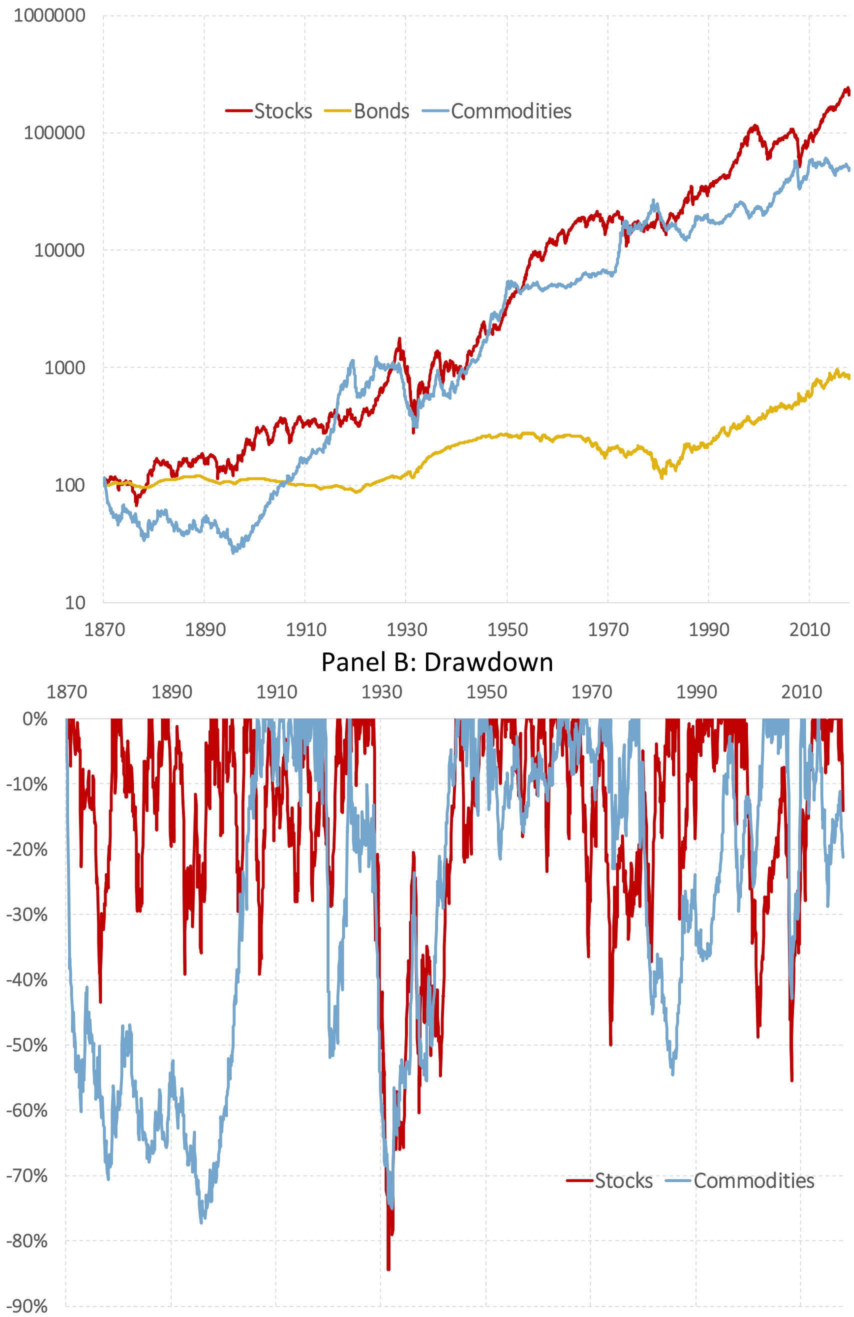
Figure 5: Average contract returns on decile portfolios



Note: We sort all the contracts into deciles by the number observations they contribute to the database. The first decile containing the short-lived contracts and so on. For every decile bin average risk premium is obtained by taking a simple average across all monthly return observations (times 12 to annualize), treating each monthly excess return as a separate observation of the risk premium. We also plot the 95% confidence interval around the means.

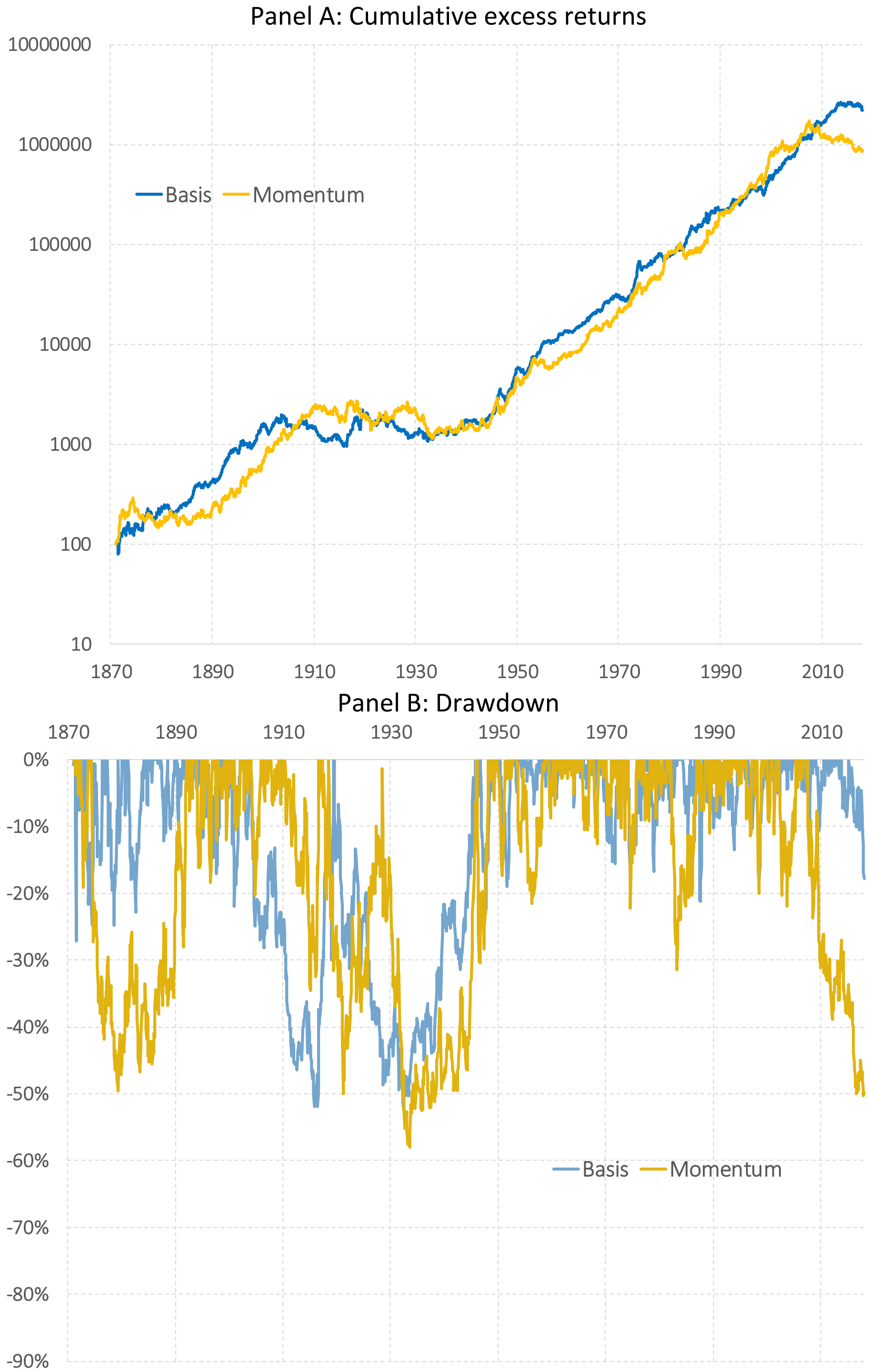
Figure 6: Performance of stocks, bonds and commodities Dec 31, 1870 – Dec 31, 2018

Panel A: Cumulative excess returns



Note: Stocks: Shiller, R. J. (2000), “Irrational Exuberance.” Princeton University Press; Prior to 1988 and S&P 500 TR for the period 1988-2018. For the period 1926 to 1991 bond returns are based on Ibbotson Associate Long Term Government Total Returns, and Bloomberg/Barclays 7-10 year index subsequent to that. For the period prior to 1926 we use data from Siegel (1992)), “The real rate of interest from 1800-1990 A study of U.S. and U.K.” Journal of Monetary Economics 29: 227-252. Commodities: Equally weighted commodity index returns of all commodity futures using level 2 aggregation, i.e. different grades of coffee contracts traded in New York are counted as one. Commodity futures returns are collateralized by t-bill returns. T-Bill returns are based on data from Federal Reserve Economic Data for the period 1934-2018, 3-Month Treasury Bill: Secondary Market Rate. For the period 1926 to 1934 Bills returns are based on Ibbotson Associate 30 Day Treasury Bills Total Returns. For the period prior to 1926 we use data from Siegel (1992)), “The real rate of interest from 1800-1990 A study of U.S. and U.K.” Journal of Monetary Economics 29: 227-252.

Figure 7 Commodity factor performance Dec 31, 1871 – Dec 31, 2018



Note: For basis factor we use annualized backwardation, for momentum we use 12-month spot price return, see Gorton, Hayashi and Rouwenhorst (2013). Factor portfolios are based on dividing the commodity universe into two equal halves. Long portfolio is based on next month equal weighted returns of the top half of the sorted commodities, and short portfolio is based on equal weighted returns of the bottom half of the sorted commodities. Figure plots the long short returns.

Appendix Table A1 Risk premium by commodity

	Monthly Returns					Monthly Returns			
	Average	Geometric Average	Standard Deviation	# Obs		Average	Geometric Average	Standard Deviation	# Obs
New York Cocoa	0.40%	0.01%	9.00%	1087	New York World Sugar No. 8	0.34%	-0.62%	14.29%	117
London Cocoa	0.12%	-0.19%	8.03%	383	New York Sugar No. 9	5.48%	4.82%		11
New York Cotton	0.44%	0.16%	7.49%	1745	New York Domestic Sugar No. 10	1.63%	1.30%	8.55%	85
Liverpool Cotton	0.77%	0.53%	7.04%	904	New York Sugar No. 11	-0.05%	-0.87%	12.91%	695
New Orleans Cotton	0.66%	0.39%	7.38%	963	ICE White Sugar	0.83%	0.62%	6.58%	344
Alexandria Cotton	0.41%	-0.03%	9.42%	635	Chicago Lumber	-0.26%	-0.62%	8.55%	590
Liverpool Egyptian Cotton	1.77%	1.20%	10.93%	309	ICE Orange Juice	0.43%	0.01%	9.49%	622
Egypt Cotton	0.50%	0.20%	7.71%	124	Chicago Eggs	-0.57%	-0.95%	8.64%	619
Egypt Cotton - Sakellaridis	1.73%	1.18%	10.61%	61	Chicago Eggs - Packed	1.92%	1.82%	4.71%	18
Alexandria Cotton - Ashmount	-0.14%	-0.68%	10.30%	273	Chicago Eggs - Fresh	2.06%	1.74%	8.50%	37
Egypt Cotton - Ash	-1.35%	-1.62%	7.44%	47	Chicago Eggs - Frozen	0.73%	0.62%	4.66%	126
Chicago Cotton	0.42%	0.22%	6.41%	381	New York Hides	-0.17%	-0.63%	9.75%	421
Liverpool Cotton- Egypt/Sudan	-0.41%	-0.71%	7.84%	144	New York Lard	0.64%	0.52%	5.00%	25
Liverpool Cotton- Empire & Middling	0.17%	-0.18%	8.59%	129	Chicago Lard	0.03%	-0.26%	7.70%	1020
Liverpool Cotton-American Universal	1.36%	1.04%	8.24%	44	Chicago Lard-Loose	-1.43%	-1.60%	6.09%	20
Bombay Cotton- Bengal	4.22%	4.09%		10	Chicago Lard-Drums	-2.21%	-2.42%	6.50%	53
Bombay Cotton- Oomra	2.00%	1.90%		11	New York Wool Tops	0.77%	0.61%	5.77%	411
Bombay Cotton- Broach	2.45%	2.36%		10	New York Grease Wool	0.31%	0.12%	6.39%	410
Bombay Cotton	0.97%	0.47%	10.55%	40	Chicago Cheese	0.23%	0.17%	3.46%	102
Liverpool Cotton-American Mixed	-0.14%	-0.17%	2.67%	70	Chicago Dry Whey	0.95%	0.82%	5.00%	141
New York Burlap	0.21%	0.17%	2.95%	73	Chicago Milk Class III	0.32%	0.25%	3.84%	274
New YorkTobacco Bright	-1.58%	-1.80%	6.65%	21	Chicago Butter	0.49%	0.29%	6.46%	263
New York Tobacco Burley	-0.63%	-0.86%	7.13%	13	Chicago Butter AA	0.56%	0.14%	9.40%	169
New York Onions	-7.89%	-8.78%		9	Chicago Butter – Cash Settled	-0.34%	-0.42%	4.05%	157
Chicago Onions	-1.47%	-3.65%	21.37%	187	New York Butter	-0.30%	-0.49%	6.16%	18
New York Rubber	0.70%	0.23%	10.16%	413	Chicago Frozen Shrimp (15-20 per lb)	-0.72%	-0.79%	3.64%	16
New York Rubber-A	-4.69%	-5.38%	12.13%	32	Chicago Frozen Shrimp (31-35 per lb)	2.92%	2.78%		5
New York Rubber-AB	2.17%	1.04%		6	Chicago Hen Turkey	-0.72%	-0.73%	1.97%	32
New York Rubber- No. 1 B Standard	4.11%	2.99%		11	Chicago Tom Turkey	-0.48%	-0.54%	3.28%	59
Singapore Rubber	0.98%	0.58%	9.40%	218	Chicago Turkey - Eviscerated	-5.84%	-6.81%		2
New York Potatoes	-0.25%	-0.90%	11.43%	460	Chicago Canner Turkey	1.03%	1.03%		3
New York Potatoes – Long Island	-2.86%	-3.04%		5	Chicago Shoulders-Loose	2.27%	1.90%	8.63%	33
New York Black Pepper	2.38%	1.73%	12.30%	156	Chicago Shoulders-Boxed	0.55%	-0.20%	12.59%	43
New York Silk	0.33%	-0.02%	8.55%	185	New York Fish Meal	-2.50%	-2.59%		10
New York Silk – No 2	3.82%	3.22%	11.14%	24	Chicago Frozen Skinned Hams	1.54%	1.46%	4.05%	24
Chicago Plywood	0.21%	-0.08%	7.75%	175	New York Tallow	-0.86%	-1.29%	9.75%	58
New York Coffee - A	0.29%	-0.06%	8.32%	721	Chicago Meats - Boxed	2.97%	2.61%	8.89%	34
New York Coffee - D	1.06%	0.77%	7.65%	225	Chicago Short Ribs	0.84%	0.47%	8.65%	654
New York Coffee – F	-0.11%	-0.25%		5	Chicago Choice Steers Carcasses	0.13%	0.10%	2.49%	17
New York Coffee - S	2.53%	2.25%	7.76%	87	Chicago Choice Steers	1.16%	1.11%	3.26%	44
New York Coffee - U	1.37%	1.24%	5.37%	17	Chicago Broiler Frozen	0.06%	0.04%		9
New York Coffee - B	0.87%	0.81%	3.44%	147	Chicago Broiler Iced	0.29%	0.07%	6.89%	138
New York Coffee - M	1.27%	1.18%	4.28%	95	Chicago Broiler Fresh	-2.78%	-2.90%	4.87%	33
New York Coffee - R	-0.01%	-0.24%	6.99%	36	Chicago Drysalted Clear Bellies	1.27%	0.76%	10.31%	194
New York Coffee - W	1.23%	1.21%		8	Chicago Pork Bellies	0.29%	-0.24%	10.31%	595
Havre Coffee	-0.16%	-0.40%	7.00%	26	Chicago Feeder Cattle	0.24%	0.12%	4.84%	565
New York Coffee - C	0.42%	-0.11%	10.70%	556	Chicago Live Cattle	0.66%	0.53%	5.07%	649
ICE Robusta Coffee	0.83%	0.23%	11.43%	213	Chicago Lean Hogs	0.44%	0.14%	7.80%	634
ICE Robusta Coffee 10 tonne	-0.25%	-0.57%	7.97%	124	Chicago Mess Pork	0.62%	0.18%	9.60%	613
New York Raw Sugar No. 1	0.19%	-0.57%	12.53%	216	Winnipeg Wheat	0.92%	0.66%	7.31%	669
New York Raw Sugar No. 2	-4.13%	-4.15%		5	Duluth Wheat	0.71%	0.41%	7.85%	687
New York Refined Sugar	1.24%	0.94%	8.05%	28	Baltimore Wheat	-0.44%	-0.64%	6.29%	218
New York Domestic Sugar No. 3	0.45%	0.24%	6.44%	84	Buenos Aires Wheat	-2.52%	-3.16%	11.05%	63
New York Raw Sugar No. 4	0.48%	0.05%	9.56%	214	Buffalo Wheat	0.98%	0.98%		2
New York Domestic Sugar No. 5	0.21%	0.16%	3.20%	41	Cincinnati Wheat	-2.71%	-2.73%		7
New York Domestic Sugar No. 6	0.15%	0.13%	2.17%	138	Detroit Wheat Red	-0.85%	-0.99%	5.48%	36
New York Domestic Sugar No. 7	0.41%	0.19%	6.74%	83	Detroit Wheat White	-0.76%	-0.93%	5.93%	88

Note: Table lists the monthly average commodity front futures returns, monthly geometric returns, and number of monthly return observations. For commodities where at least 12 months of returns are available we also report standard deviation of monthly returns.

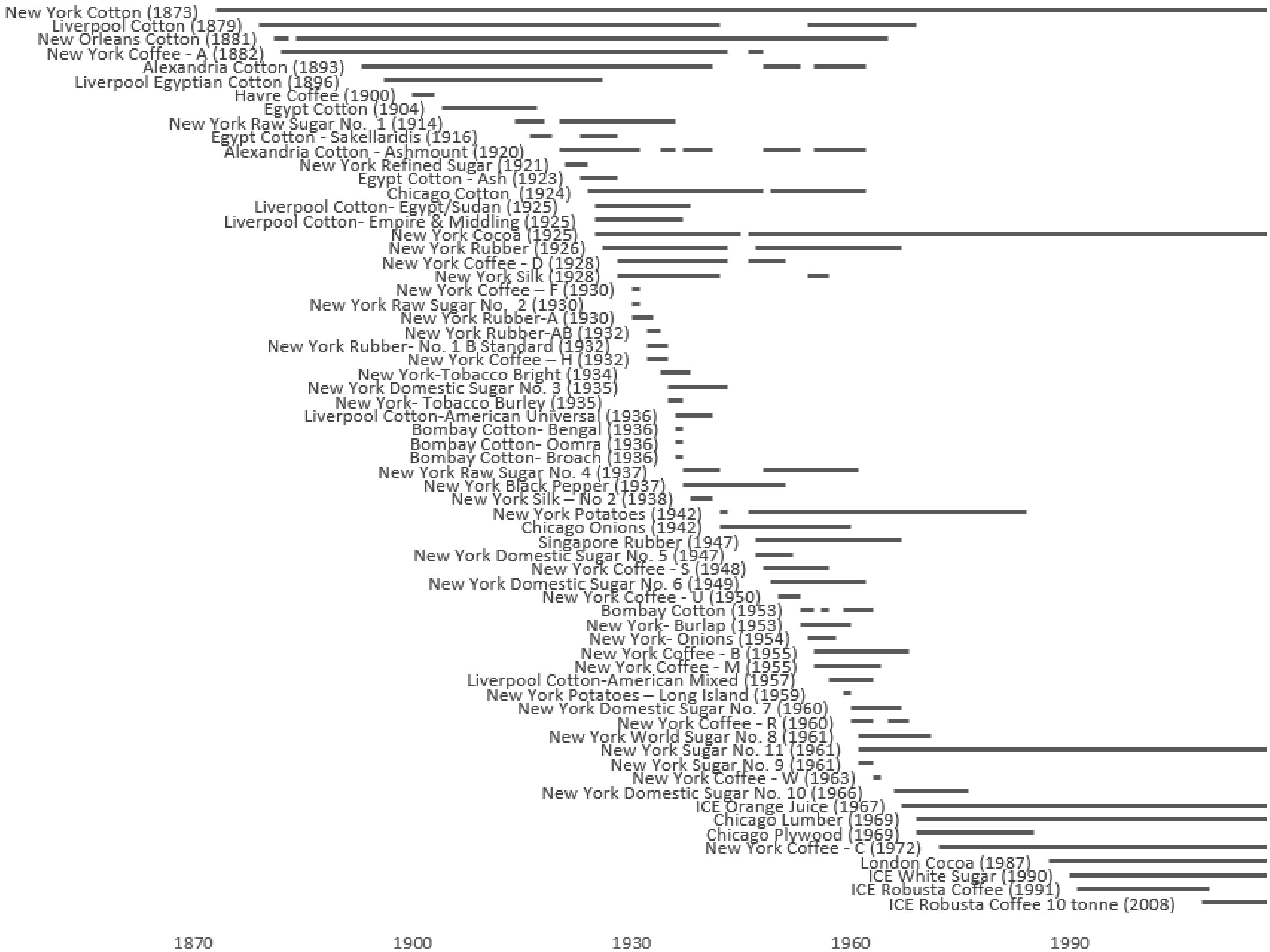
Appendix Table A1 Risk premium by commodity (continued)

	Monthly Returns					Monthly Returns			
	Average	Geometric Average	Standard Deviation	# Obs		Average	Geometric Average	Standard Deviation	# Obs
Rotterdam Wheat	-7.77%	-8.10%	8.12%	14	Cincinnati Oats	7.47%	7.47%		1
San Francisco Wheat	1.07%	0.87%	6.33%	89	Toledo Oats	-1.16%	-1.35%	6.04%	39
Philadelphia Wheat	-0.49%	-0.62%	5.24%	163	Kansas City Oats	-0.55%	-1.09%	10.54%	74
New York Wheat	0.12%	-0.06%	5.99%	482	Chicago Oats	0.26%	-0.12%	9.02%	1758
Liverpool Wheat Pound	0.13%	-0.05%	6.03%	294	Memphis Cottonseed Meal	0.10%	-0.07%	5.81%	85
Liverpool Wheat Dollar	0.06%	-0.28%	8.45%	211	New York Soybean Oil	1.16%	0.77%	9.17%	170
European Wheat	0.51%	0.31%	6.49%	239	Chicago Soybean Oil	0.56%	0.22%	8.48%	821
Kansas City Wheat	0.38%	0.13%	7.24%	1405	Memphis Soybean Meal	1.36%	1.09%	7.43%	154
Kansas City Wheat No 3	-12.17%	-12.17%		1	Chicago Soybean Meal	0.90%	0.54%	8.86%	807
Chicago Wheat	0.16%	-0.12%	7.67%	1730	Chicago Soybean	0.66%	0.35%	8.06%	933
Minneapolis Wheat (No. 1 Northern)	0.51%	0.26%	7.15%	1556	Chicago Rice-Rough	-0.55%	-0.87%	8.21%	387
Minneapolis No.1 Hard Wheat	0.59%	0.39%	6.59%	54	Winnipeg Canola	0.52%	0.15%	10.09%	557
Minneapolis No. 2 Northern Wheat	0.61%	0.30%	8.22%	52	European Rapeseed	0.27%	0.05%	6.08%	288
Milwaukee Wheat	0.47%	0.18%	8.00%	307	Malasian Crude Palm Oil	0.78%	0.46%	8.02%	203
St. Louis Wheat	0.26%	-0.05%	7.97%	661	New York Gasoline - A	-2.02%	-2.37%		8
St. Louis Wheat No 3	-1.23%	-1.93%	12.76%	15	New York Gasoline - B	1.50%	1.25%		11
Toledo Wheat (No. 2 Red)	0.20%	-0.04%	7.16%	433	New York Gasoline	2.16%	1.52%	11.73%	264
New York Corn	1.17%	0.90%	7.71%	356	New York RBOB	0.75%	0.24%	9.95%	158
Chicago Corn	0.17%	-0.12%	7.70%	1756	New York Propane	1.94%	1.07%	14.33%	264
St. Louis Corn	0.86%	0.53%	8.18%	573	New York Crude Oil 1	-1.68%	-1.71%		5
Kansas City Corn	1.60%	1.19%	9.28%	560	New York WTI Crude	0.59%	0.15%	9.42%	429
Philadelphia Corn	1.02%	0.73%	7.82%	153	ICE Brent Crude	0.90%	0.47%	9.30%	353
Baltimore Corm	-0.07%	-0.41%	7.87%	183	New York Natural Gas	-0.65%	-1.59%	13.80%	344
Boston Corn	-4.01%	-4.12%		4	ICE UK Natural Gas	-1.79%	-2.45%	11.56%	262
Buffalo Corn	-7.14%	-7.14%		1	Kansas City Western Natural Gas	-2.83%	-3.07%		4
Duluth Corn	-3.06%	-3.13%		3	New York Heating Oil	1.13%	0.65%	10.16%	481
Milwaukee Corn	1.54%	1.36%	6.17%	154	ICE Gasoil	0.93%	0.48%	9.60%	400
Minneapolis Corn	0.36%	0.20%	5.71%	62	Chicago Ethanol	2.87%	2.33%	10.90%	165
Toledo Corn	0.06%	-0.42%	9.61%	138	New York Ethanol	1.59%	1.34%	7.36%	137
New York Cottonseed Oil	0.28%	-0.02%	7.83%	724	New York Gold	0.11%	-0.04%	5.47%	528
New York Cottonseed Oil - Prime Summer Yellow	-6.49%	-7.28%	12.62%	13	Chicago Gold	-1.53%	-1.86%	8.20%	62
Toledo Cloverseed	2.22%	1.82%	9.01%	355	New York Silver	0.30%	-0.11%	9.17%	666
Chicago Cloverseed	0.03%	-0.31%		7	New York Silver – Pre War	2.84%	2.59%	7.65%	20
Chicago Flaxseed	0.69%	0.48%	6.66%	216	Chicago Silver (5000 troy oz)	0.86%	-0.20%	14.76%	100
Winnipeg Flaxseed	0.32%	0.04%	7.62%	872	Chicago Silver (1000 troy oz)	-0.70%	-1.01%	7.98%	174
Duluth Flaxseed	0.75%	0.48%	7.50%	488	Montréal Silver	-0.77%	-0.99%	6.68%	38
Minneapolis Flaxseed	-0.03%	-0.18%	5.44%	464	London Silver	0.50%	0.20%	7.95%	539
Buenos Ares Flaxseed	0.48%	0.10%	9.04%	33	London Silver (OTC)	0.06%	-0.05%	4.86%	192
Chicago Rye	-0.05%	-0.41%	8.52%	724	New York Platinum	0.41%	0.11%	7.73%	670
Minneapolis Rye	0.26%	-0.20%	9.75%	445	New York Palladium	0.70%	0.19%	10.07%	553
Winnipeg Rye	0.41%	-0.02%	9.40%	777	New York Mercury	-0.06%	-0.14%	4.23%	36
Duluth Rye	-0.83%	-1.38%	10.69%	138	London Aluminum	-0.02%	-0.23%	6.63%	378
Winnipeg Barley	0.50%	0.25%	7.18%	889	New York Copper	0.70%	0.41%	7.60%	1106
Chicago Barley	1.68%	1.08%	11.40%	150	London Copper	0.74%	0.47%	7.27%	305
Milwaukee Barley	1.76%	0.70%	16.41%	18	London Copper (Pounds)	0.36%	0.11%	7.14%	1217
Chicago Timothy Seed	-1.21%	-1.37%	5.68%	22	London Copper Refined	3.58%	3.16%	9.27%	34
Toledo Timothy Seed	-0.01%	-0.65%	10.88%	86	New York Tin	0.48%	0.32%	5.65%	448
Kansas City Sorghums	-0.32%	-0.39%	3.94%	34	New York Tin-Standard	0.76%	0.60%	5.74%	67
Winnipeg Linseed Oil	-0.67%	-1.19%	10.14%	21	London Tin	0.37%	0.16%	6.48%	353
Toledo Alsike	2.25%	2.04%	6.63%	86	London Tin (pound)	0.58%	0.42%	5.66%	1208
New York Oats	-1.63%	-2.03%	9.22%	40	New York Zinc	0.60%	0.38%	6.83%	414
Winnipeg Oats	0.92%	0.65%	7.58%	814	London Zinc	0.32%	0.07%	7.10%	503
Philadelphia Oats	0.79%	0.55%	6.84%	94	London Zinc (pound)	0.40%	0.13%	7.43%	697
St. Louis Oats	1.00%	0.59%	9.21%	492	New York Lead	0.99%	0.63%	8.42%	60
Minneapolis Oats	0.44%	0.01%	9.80%	537	London Lead pound	0.37%	0.11%	7.34%	771
Milwaukee Oats	1.49%	1.08%	9.17%	75	London Lead	0.34%	0.05%	7.58%	502
Boston Oats	0.85%	0.76%		7	London Nickel	0.67%	0.18%	10.42%	476
					London Pig Iron	0.28%	0.14%	5.39%	167

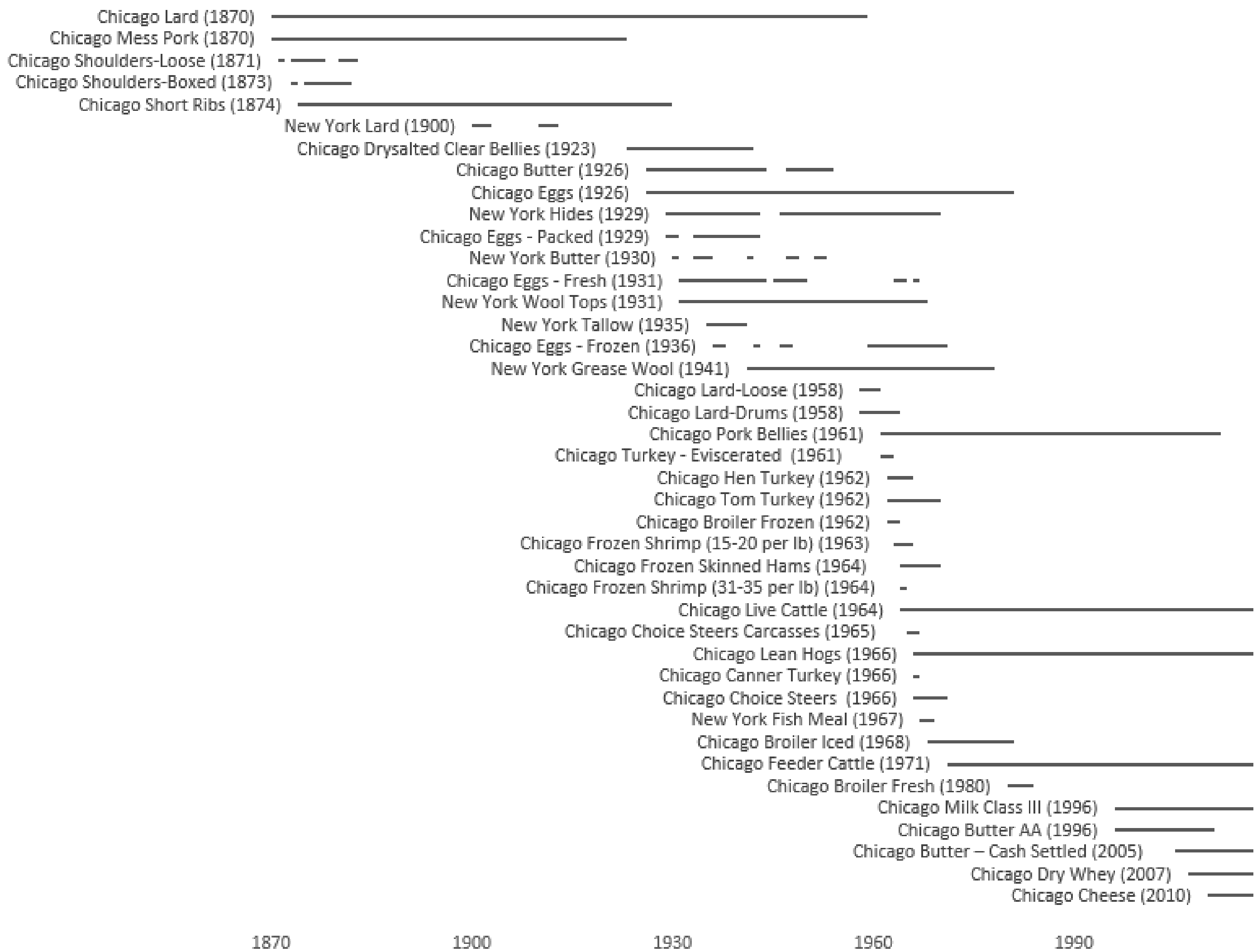
Note: Table lists the monthly average commodity front futures returns, monthly geometric returns, and number of monthly return observations. For commodities where at least 12 months of returns are available we also report standard deviation of monthly returns.

Appendix figure A1: Futures timelines by sector

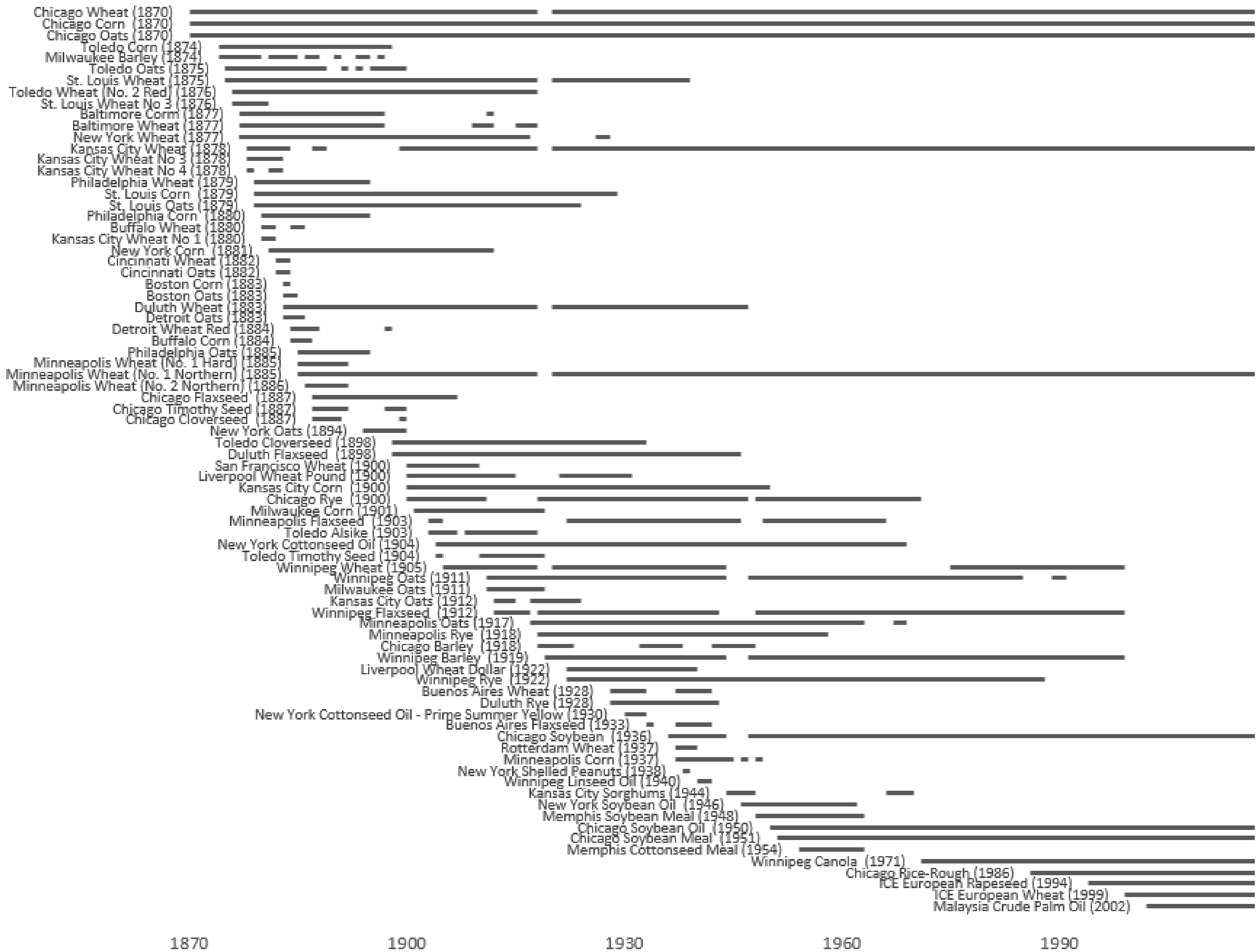
Panel A: Softs



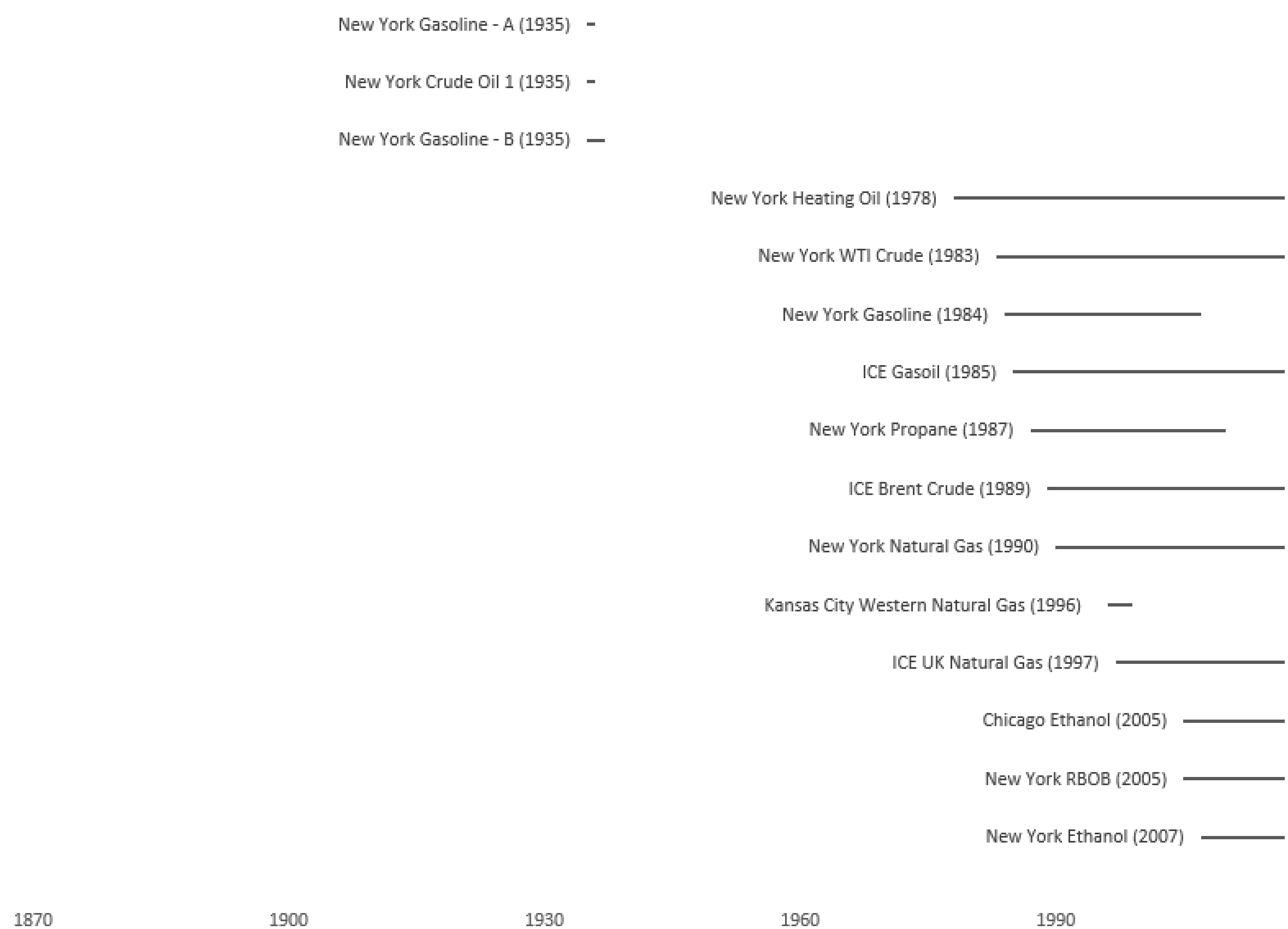
Panel B: Livestock



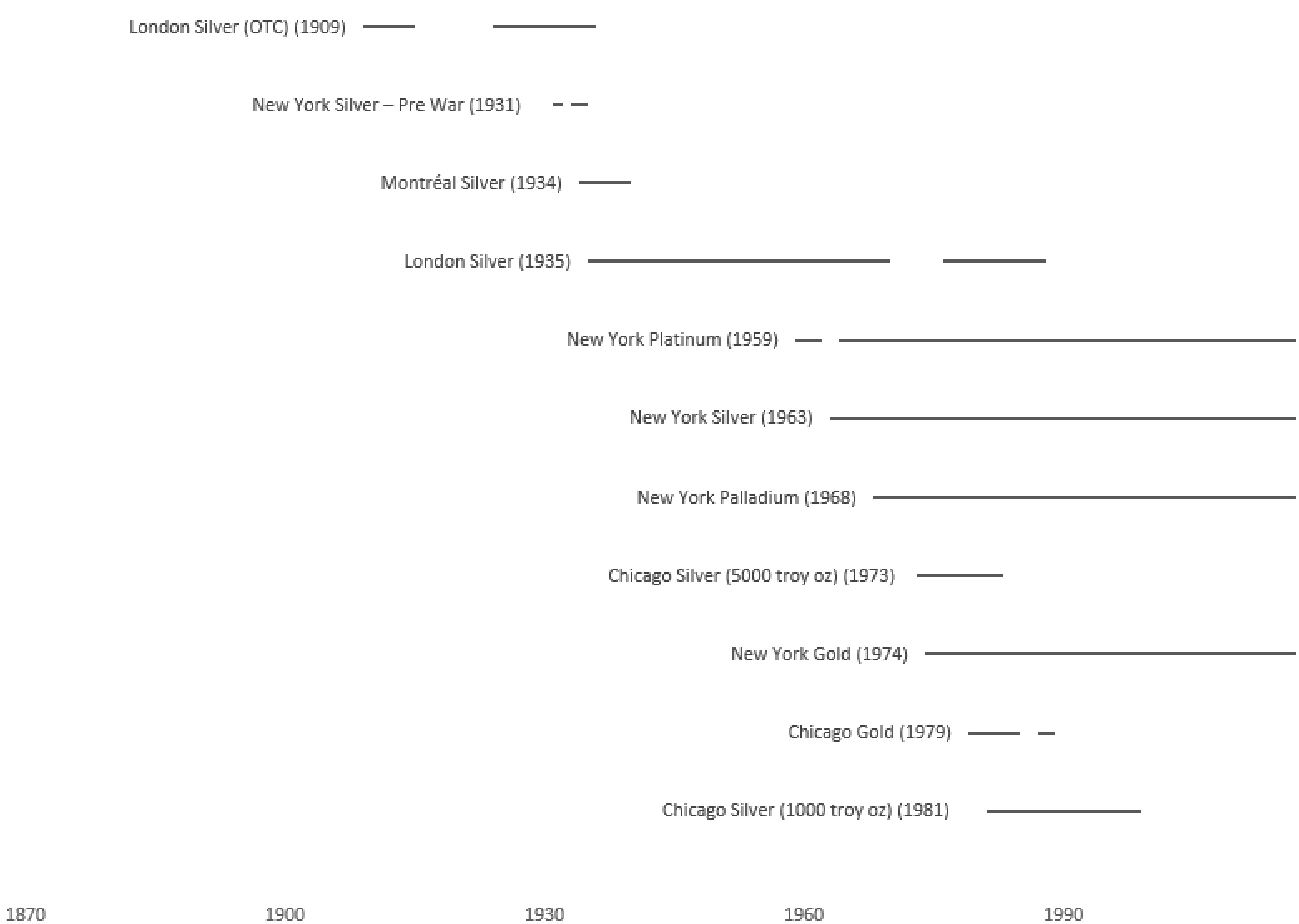
Panel C: Grains and oil seeds



Panel D: Energy



Panel E: Precious metals



Panel F: Industrial metals