EXTRACTING PRICE SIGNALS FROM THE TERM STRUCTURE OF COMMODITY AND CREDIT MARKETS USING AUSTRIAN BUSINESS CYCLE THEORY

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P. DEUSSEN* AND M. RANGELEY**

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1. **Introduction**

Austrian School economists first explained the significance of interest rates for the structure of production in time. Furthermore, they showed how manipulating the level of interest and the credit supply causes the business cycle (v.Böhm-Bawerk, 1891; v.Hayek, 1938; v.Hayek, 1941 and v.Mises, 1949). More recently, Austrian School economists have elaborated the relationship between the term structure of interest rates and the business cycle (Barnett and Block, 2009; Bagus and Howden, 2010; Bagus et al., 2018; Potuzak and Nemec, 2020; Alonso-Neira and Sanchez-Bayon, 2023). At the same time, market practitioners understand the potency of yield curve inversions as a predictor of future recessions as a result of experience and observation unrelated to Austrian Business Cycle

* Department of Chemical Engineering, University College London, Torrington Place, London WC1E 7JE, United Kingdom. philipp.deussen.15@ucl.ac.uk
** The Cobden Centre, University of Buckingham, Vinson Building, Hunter Street, Buckingham, MK18 1EG, United Kingdom

Theory (ABCT). Reference textbooks (Stigum and Crescensi, 2007) explain that capital allocators are pricing in future cuts to the central bank discount rate, thus inverting the yield curve. This ignores the role of free-market price signals in credit, which result from supply and demand fundamentals, and are the link connecting ABCT to term structures.

The term structure of commodities markets is also affected by actual or anticipated shortfalls in production over different time horizons. This is widely understood, perhaps because settlement by physical delivery is commonplace and tangible (Hull, 2022). Even though credit and derivatives may at first glance seem more abstract, the same underlying market principles are at work there. The theoretical foundations of and recent work on ABCT provide the necessary tools to analyse both markets through the same lens.

The scope of this paper comprises an Austrian lens to analyse the term structure of commodities and credit markets, demonstrating common principles and drivers in theory and several case studies. The term structure of the yield curve will be shown to be a price signal that is not solely dependent on expectations on future central bank discount rates, but rather arising from supply and demand of capital in the context of changing credit supply, entirely consistent with ABCT. The scope will not include the impact of (lowered) interest rates on investments into the heavy, commodities producing industries, such as mining. Past studies cover this in theory (v.Hayek, 1941) and practice (Ewing et al., 2017). The detail of instruments and procedures in futures and credit markets will only be covered in so far as they are relevant to the thesis of the paper.

This paper begins by outlining relevant theory and then be analyses these principles in four practical case studies. The first theoretical section presents an overview of ABCT. The importance of interest rates and price signals in the structuring of production to meet demand and makes investments over the appropriate time horizons is highlighted. Two further sections outline the fundamentals of commodity futures and bond markets, as well as analysing the driving principles through the lens of ABCT. The four individual case studies span two commodities markets, one financial derivatives and a bond markets case study. By moving from very tangible to more financialised and abstract markets, the theory can be observed in practice at gradually increasing levels of abstraction and general applicability.

2. **Theoretical Foundations**

2.1. *Austrian Business Cycle Theory (ABCT)*

To understand the price of money, the mechanism of saving and investment of capital goods is central (v.Böhm-Bawerk, 1891; v.Hayek, 1938). In an economy at equilibrium, all capital goods are being utilised at every moment in time. That is, when conducting analysis in terms of real capital goods, rather than credit, there is no degree of freedom that would allow for an investment to occur in one part of the economy without an economic actor elsewhere having to forgo the utilisation of that capital in his own aims. Colloquially speaking, there is no free lunch. Hence, the lender of capital must be compensated for forgoing his own aims at the present time and delaying the (anticipated) use of his capital into the future —the price for this is known as the interest rate.

Furthermore, to maintain the current structure of production, constant reinvestment is necessary to replace capital lost, for instance to wear and tear and accidents. Therefore, for any loan to be profitable, it must have an interest rate higher than the profits that can be obtained by the capital good if it continues to be used in its current function. Ceteris paribus, the longer the capital is used by the lender, the higher the generated profit must be in order to compensate the lender for his forgone utilisation of said capital. This includes forgoing the optionality that comes with increased liquidity of shorter-term loans. This explains why long-term loans usually have higher interest rates than short-term loans. Therefore, in a free, unhampered market, entrepreneurs will attempt to allocate their capital to the least roundabout processes with the highest profits first, or alternatively to more roundabout processes that are also more profitable than any alternative shorter-term process. Processes that are equally profitable but more roundabout, or less profitable but equally roundabout will see capital allocated to them only once the former investment opportunities have been taken advantage of. However, if over time more capital is saved and becomes available for investment purposes, more roundabout process will begin to become profitable investments at the margin, thus elongating the structure of production (v.Hayek, 1938). Thus, in a free, unhampered market, a market interest rate for capital will result for the duration over which it is invested. This price will vary depending on the information available about investment opportunities (entrepreneurial ventures), the overall amount of capital as well as the willingness of investors to part with their capital over different durations to obtain a delated gratification that is anticipated to be greater than that which could be obtained at present. This willingness is known as time preference (v.Mises, 1996).

Unfortunately, not all assumptions that hold true in free, unhampered markets where all analyses are carried out in terms of real capital hold true in practice. One example is the artificial expansion of the credit supply by commercial or central banks which lowers the interest rate. This leads to investment in sub-marginal projects, which now initially seem profitable, but which must end by lenders somewhere in the economy taking a loss and having to write off their investments, provided there are no further changes to the credit supply. This can either occur when the input prices for current projects rise faster and further than anticipated, squeezing margins from the cost side, or when anticipated demand does not materialise to the same extent as projected, squeezing margins from the revenues side. The former may be captured by producer price inflation metrics, while the forced saving (v.Hayek, 1938) dynamic of the latter may go unnoticed in statistical metrics. Alternatively, if legislation unduly protects insolvent ventures or banks that engage in lending over the long-term but having short-term liabilities, thus creating a term structure mismatch, the same business cycle may arise (Bagus and Howden, 2010).

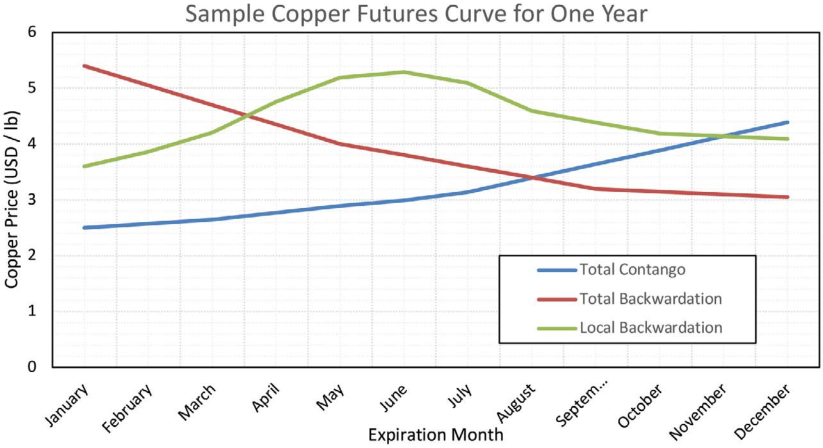
The problem is that artificial expansions and contractions in the credit supply prevent the correct pricing of capital by the market. Von Hayek (1945) outlined the role of prices in aggregating local information in the economy, while von Mises (1949) pointed to why the absence of market prices makes economic calculation impossible. Therefore, a price of capital that does not derive from a free and unhampered market will not incorporate all the existent information and send incorrect scarcity signals. As a result, even if the existent information is used to price all assets efficiently, it does not *«fully reflect»* (Fama, 1970) the information about an overall capital shortage that is suppressed through artificial changes of the credit supply. It is not a question of how market participants use available information or how quickly it travels, rather, the suppression of price signals is a suppression of available information in and of itself. However, the capital markets can be analysed more closely in order to understand where and how the remnants of this free market price of capital emerge and can be used as useful scarcity signals.

2.2. *Term Structure in Commodities Markets*

The basic premise of forwards (over-the-counter) and futures (exchange traded) is simple: to lock in the price today for a transaction that will occur at some point in the future. The commodities in question can be physical commodities such as iron ore, lumber, live cattle or wheat, but may also include financial derivatives or baskets thereof. When the contractually specified transaction date occurs, the contracts can either be settled physically or in cash in lieu of the commodity (Hull, 2022).

The main participants in futures markets are hedgers, speculators and arbitrageurs. All are entrepreneurs in the Austrian School sense of the word with some important distinctions. Hedgers are physical producers or consumers of a commodity that use the futures markets to reduce risk and uncertainty, for instance by locking in a sales price for their anticipated future production. Similarly, producers can protect themselves against rising inputs costs by buying futures on raw materials to be delivered when the production scheduling estimates they will be needed. Clearly, changes in the futures prices will directly affect production decisions made by hedgers. Speculators anticipate movement of certain economic variables and position themselves to attempt to profit from these. This also affects the structure of production by sending price signals to hedgers. Finally, arbitrageurs attempt to lock in profits by buying and selling commodities that are mis-priced for reasons such as geography, political events or possible substitute goods. The coordinating function here includes dissipating rapid price movements in one market to markets of possible substitute goods and thus spreading it throughout the entire economy. It is abundantly clear that in futures marketplaces, production is coordinated in time and the future demands of industry and end consumers are being estimated by the market participants. This estimation process, of course, results in changing prices and subsequent capital allocation. Therefore, the commodities term structure sends producers price signals which convey where and when to produce how much of a given commodity (Hull, 2022).

FIGURE 1. A FICTIONAL EXAMPLE OF A FUTURES CURVE FOR COPPER WITH THREE POSSIBLE SCENARIOS. THE TOTAL CONTANGO SCENARIO INDICATES A MARKET WITH NO TIGHTNESS, THE TOTAL BACKWARDATION SCENARIO INDICATES A TIGHT MARKET AND THE LOCAL BACKWARDATION SCENARIO ANTICIPATES A TIGHT MARKET IN THE SUMMER MONTHS BUT NOT BEFORE OR AFTER THAT



When two parties agree on a future transaction, new contract volume (open interest) is created. That is, if one party decides to sell a future to another and then buy it back, the delivery obligation disappears. The controlling mechanism is that each transaction leads to a real future (cash or physical) delivery obligation for someone if the contract is not bought back by the seller. Thus, each transaction forcibly leads to the adaptation of the structure of production. Also, as the last trading day of a contract approaches, that price must converge with the spot market price, otherwise free arbitrage profits would emerge (Hull, 2022). This is the latest point at which consequences of a deal with future execution fully arrive in the present. While estimating the future spot prices, speculative demand can affect pricing. However, speculators who are incorrect about the future situation will lose capital to more effective allocators, thus anchoring futures markets to supply and demand fundaments.

The term structure of the futures curve (Hull, 2022) can be described using two terms: contango and backwardation. In contango, the futures curve slope upwards with delivery times, i.e., futures prices are higher than the spot price. In backwardation, futures prices are lower than the spot price. When there is an acute shortage of a commodity in the present, the curves tend to go into backwardation, while if the market is not as tight, the curve tends to go into contango. The reasons behind this may seem counterintuitive at first but are logical upon closer inspection. If there is a shortage in the present, the most profitable time frame over which to produce is the shortest possible time frame, as this is the most urgently needed. To facilitate this, prices in the spot market must be higher than for future delivery. Conversely, when there is no tightness in the market at a given time, the biggest shortage of a commodity will occur at the furthest possible date in the future, as stockpiles are used up over time. Without production being directed towards the distant future, these would eventually run out, causing a shortage of the commodity in question then. Of course, if a shortage is anticipated at some specific time in the future, the curve may be in contango for delivery until that point in time and in backwardation for delivery after it (figure 1). In this way, the futures curve directly sends price signals that elongate or shorten the process of production. Finally, whether the price signal was correct or not is determined when the futures contract is settled, as at this point the futures price that is closest to the current date must converge with the spot price. Price expectations can thus be created and affect the structure of production; however, their correctness is checked against market reality at the very latest when delivery is due. If priced-in expectations did not materialise, the speculator (or hedger or arbitrageur) will pay for his mistake with his own capital. The analogy of this coordinating function in time and space of commodity futures price curves with interest rate term structures shall be seen in due course.

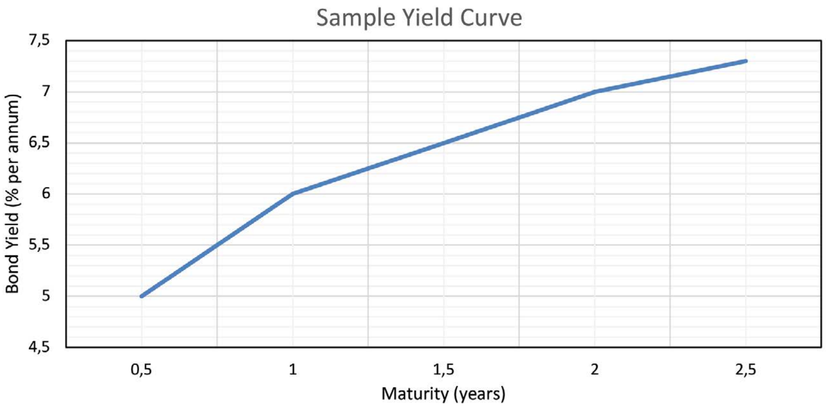
In practice, the supply and demand fundamentals that shape the term structure of commodity prices are themselves subject to changes in the credit volume. Also, the lag from initial investments to first production of minerals projects is 5-30 years (Buchanan, 2016). Therefore, analysing the entire commodities industry and price term structure using ABCT is not a straightforward exercise. For example, rate cuts following the global financial crisis (GFC) caused a shale oil boom in the US through an influx of cheap capital into the sector (Ewing et al., 2017). The bulk of production from these investments came online around 2014, however, the anticipated demand never materialised and oil prices fell massively. The consequence was capital destruction in the shale oil sector, which in aggregate returned negative value to shareholders. This demonstrates the complex relationship between central bank monetary policy, bond purchases, capital (mis)allocation, ensuing technological developments and commodity futures pricing. As a result, this paper is limited to assessing term structure of the futures curve, leaving other complexities of this relationship for future work.

2.3. *Term Structure in Credit Markets*

The term structure of interest rates in credit markets depend on how bond prices and interest rates form, the markets in question and the decision-making criteria of capital allocators. The yield on a bond can be determined from its par value (principal sum), coupon payments, time to maturity and market price. If the price of a bond moves, inevitably, so does the interest (yield) the bondholder receives (v.Mises, 1949). Therefore, bond prices cannot move without affecting interest rates. Bonds are traded in various markets, including commercial paper aggregated into brackets of creditworthiness, municipal and government bonds. Other financial instruments are designed to have no coupon payments or isolate the interest portion of a bond only. Price discovery results from constant arbitrage between markets, such that price discrepancies should result only from bond- or market-specific parameters and not random inefficiencies in liquid markets. A term structure arises in each market, reflecting the yields that can be obtained if money is lent over different periods of time.

In any credit market, the capital allocator faces a choice of which bonds he should buy, illustrated by an example along the lines of Stigum and Crescensi (2007). The capital allocator could buy a one-year bond now with a yield of 6% p.a., and then buy another in a year's time. Instead, he could also buy one two-year bond at a 7% p.a. yield that matures at the same time as the second one-year bond would have matured. The difference is that only in the first case there is uncertainty associated with the yield over the two-year time horizon. The one-year bond in a year's time would need to yield more than 8% p.a. to break even with the 7% p.a. two-year bond. Therefore, the decision of how to allocate capital depends both on the estimated situation of the market in the future as well as the information that is priced in about credit at different maturities today. The term structure arises from the aggregate of such decisions.

FIGURE 2. A FICTIONAL EXAMPLE
OF A YIELD CURVE IN A BOND MARKET



In practice, the yields on publicly traded credit instruments vary widely, therefore, there is debate on which best represents the term structure in the whole economy. A widely used proxy, which merits its own case study in this paper due to its transparency, liquidity and size, is the yield curve of US government debt (Stigum and Crescensi, 2007). It is interwoven with the global financial system as many financial products are priced in relation to and valued in comparison to similar maturity US government bonds. The bonds themselves underpin much of the financial system as collateral.

The commonly stated expectations hypothesis (Stigum and Crescensi, 2007) contents that the shape of this yield curve depends on the market expectations of the future interest rates set by the central bank, e.g. as a reaction to anticipated future inflation. In the US, the monetary policy tool in question in the Federal Reserve's discount rate. It is, of course, true, that expectations of future central bank rates (price of short-term capital) would influence investment decisions and by extension the shape of the yield curve (example in figure 2). However, market expectations of the future interest rates, which are the price of capital, would only depend on central bank policy fully if central banks were the only agents of credit creation in an economy (i.e. in a fully centrally planned economy). In reality, commercial banks are also agents of credit creation in most economies today (Deutsche Bundesbank, 2017; McLeay et al., 2014 and Ryan-Collins et al., 2012) and their loans are based on estimations of future profitability. Of course, due to the constant arbitrage between different credit markets, estimates of default probabilities in private sector loans will find their way into the government yield curve and constitute a pricing factor distinct from central bank action.

An analogy to the futures market may be useful at this point. A bond can be viewed as a futures contract on the delivery of a fixed amount of money in the future, subject to some cost of carry (interest rate). This is not to be confused with bond futures, which add a second time dimension to this structure, and will not be further elaborated here. Market participants considering future expectations of interest rates are analogous to speculative commodities traders, while those that are looking at the fundamental default probability of and availability of capital for different types of loans with different maturities are analogous to fundamental participants of a commodities futures exchange. This is because, at the time when a bond needs to be paid back, the debtor repays the creditor fully, partly or not at all. For this repayment, the fundamentals of the debtor's business ventures are more immediately consequential than central bank action. At the time of repayment, it will be determined whether the price of the bond was adequate or whether there will be a shortfall in capital versus what was priced in. This is similar to an expiring futures contract, in which the spot and futures price must converge. Thus, the final determinant of the yield curve is the demand and supply of capital that can be supplied over different durations to borrowers.

Consistent with this analogy, economic crises can be understood as shortages of capital. Like in commodities markets, localised shortages of capital may occur naturally due to random individual errors of entrepreneurial calculation. The price of capital over that timescale will rise, attracting more investment such that these shortages are arbitraged away by the corresponding random localised surpluses of capital. It is either allocated to failing ventures by purchasing them after bankruptcy or simply through further lending. The time when this arbitrage occurs will, at the latest, be the time at which the failing venture must repay its credit (in the analogy: when the futures contract is set for delivery), or earlier if entrepreneurs see the opportunity in advance.

This explains local fluctuations in the term structure of credit, but not the system-wide default waves that occur during economic crises like the GFC. Such shortages of capital resulting from systemic miscalculation have been described in literature, although without emphasising the term structure of credit. Von Mises (1949) points out that it is unlikely that all entrepreneurs (capital allocators), whose sole task is to correctly anticipate future demand, are all suddenly wrong all at once in their anticipations without the effects of an exogenous force. This force is the distortion in the supply of credit (or conversely, height of the interest rate), which creates an illusion of abundant capital goods.

As ABCT outlines, an expanding credit supply without an accompanying increase in productive capital will affect the price structure of the economy. The information about the new money cannot immediately be priced in by the market equally, rather, it takes time to travel amongst market participants. This may occur by way of unexpectedly high demands for certain goods or services, which will raise their price after the fact —the non-neutrality of money (v.Mises, 1949). Thus, stress must emerge through margin compressions in some economic ventures planned before the new information reached all entrepreneurs. Either price inflation makes projects unviable from the cost side or defaults make other projects unviable when expected demand for their outputs does not materialise. Both scenarios result in increased credit stress.

Initially, this credit stress will be perceived in certain maturities only. However, as the information about the expanded money supply travels to more capital allocators, inflation and/or credit defaults rise across the entire economy. Not all loans outstanding (after the expansion of credit) can be repaid as planned by the borrowers (without further credit expansion). At the margins, where borrowers have no capital left to consume, the only options are default or refinancing at less favourable conditions. For each borrower that could not meet prior loan obligations and/or used up more of his capital base than he could afford at the time the last loan was given, this refinancing must either be shorter in duration or higher in price than the previous loans, ceteris paribus, as the now reduced creditworthiness reflects on these borrowers' price of capital. However, to capital allocators that are not yet aware of the shortage of capital, underperformance of the failing ventures may still seem like a random, not a systemic problem. Thus, refinancing and waiting for the random factors to mean revert may seem sensible to them. The problem, of course, cannot mean-revert in aggregate, as it results from systemic miscalculation. Thus, the shorter durations and higher prices will, over time, simply shift forward to the shortest possible duration, diffusing information to the present in the process.

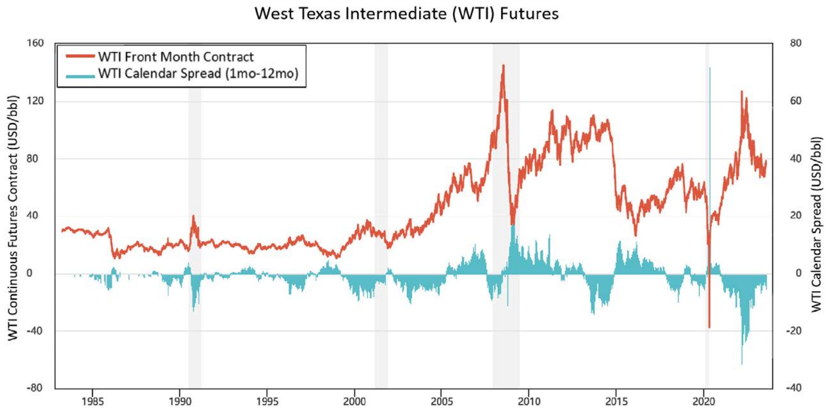
Therefore, according to ABCT, the following phenomenon should be observable in liquid markets if changes to the credit supply result in mispriced interest rates. Initially, the interest rate curve slopes upwards — long term loans are more expensive than short term loans. Lenders do not anticipate specific instances of shortages. The term structure arises from the limited nature of capital in the long run and the liquidity preference of lenders. However, loans made at cheaper interest rates mature and will inevitably need to be refinanced. Due to underperforming loans, prices begin reflecting the smaller than expected capital stock and interest rates rise locally in the term structure. The spike in the interest rate at some maturity cannot be arbitraged away, as the capital necessary for the arbitrage was only a mirage resulting from the expansion of credit. The problem is systemic, not random, and the spike in the term structure represents a wall of bad credit of some maturity in the economy. These bad credits cannot be refinanced at equal or more favourable conditions and thus begin travelling towards the present with each refinancing. If, for instance, the price of credit was artificially lowered particularly on loans that mature in ten years, it will be these loans that will be flagged up in the term structure afterwards. After eight years banks might forecast lower repayments than anticipated in these loans and the price of loans with a two-year maturity would rise compared to adjacent maturities. Interestingly, the forecaster may be oblivious of the root-cause, the business cycle, and simply attribute the phenomenon to peculiarities of a specific economic sector or financial product. This refinancing cycle repeats itself as the maturation of the new loans, and thus the wall of bad credit, approaches the present moment. At last, previously viable projects must be marked down as unviable – seemingly suddenly and without warning. The credit stress becomes acute and the price incentivises immediate-term investments, as the capital shortage cannot be deferred any longer. Like in the futures markets, the spot and the front month can no longer diverge at delivery. Of course, the term structure of credit anticipated this ever since the wall of bad credit started travelling towards the present, but the capital to avert the bust simply does not exist. In practice, one can assess the predictive power of the term structure of government bonds or other credit markets on recessions or stock market crashes.

3. **Case Studies**

3.1. *Oil Market*

The oil market in early 2020 strikingly illustrates how relative abundance in the present versus the future results in steep contango. The West Texas Intermediate (WTI) Crude Oil futures front month contract in April 2020 (figure 3) settled at a negative price of ca. -37 US dollars per barrel, while longer-dated contracts (May, June, July, etc.) traded significantly higher. The calendar spread (figure 3) is in steep contango, which rises sharpy to ca. 70 US dollars per barrel during the negative pricing incident.

FIGURE 3. WTI OIL FUTURES CONTRACTS (SOURCE: CME GROUP VIA MACROMICRO, 2023). RED LINE SHOWS FRONT MONTH CONTRACT WHILE TURQUOISE AREA SHOWS CALENDAR SPREAD (PRICE DIFFERENCE BETWEEN THE 12TH AND FRONT MONTH FUTURE). POSITIVE NUMBERS INDICATE CONTANGO IN THE 1-12 SPREAD. SHADED AREAS INDICATE US RECESSIONS



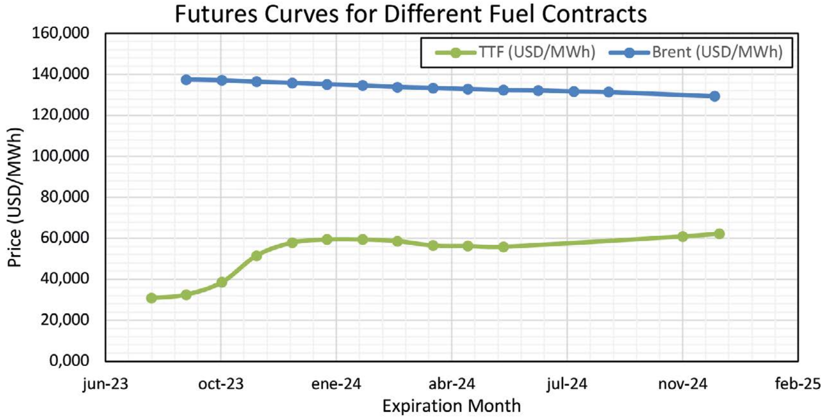
The specifications of the WTI futures contract (CME Group, 2023) cause these unusual price dynamics. It is physically settled at Kushing in Oklahoma, i.e., all holders of futures contracts at the last trading date must take physical delivery of the underlying oil on the delivery date. However, the storage capacity at Kushing is limited and in April 2020 the total amount of oil leaving to be used elsewhere in the economy was curtailed by lockdowns (Knight, 2021). Since the delivered oil cannot easily be disposed of, the transport costs of removing it affected the pricing of that month's contract. As transport costs exceeded the value of the oil, taking delivery became unprofitable, resulting in negative prices. The further out oil contracts were still cheap due to low demand, but never had negative prices as the market anticipated the immediate-term logistical problems to be resolved by their delivery dates. While this example is admittedly extreme, the main takeaway is that higher abundance of goods leads to contango in the term structure and thus extends the time horizon of the production structure into the future.

Another pertinent explanation is the Mengerian concept of marginal utility (Menger, 1871). As prices are made at the margins, the marginal unit of the commodity contract prices the whole. Despite the general usefulness of oil, logistical constraints made the productive use of the marginal barrel of the WTI front month in April 2020 unprofitable. This reflected on the price of all April 2020 barrels of WTI. This can be extrapolated to the entire futures curve: as today's reserves of a commodity would get used up in the distant future without extra production, the marginal utility of a future barrel rises relative to the marginal utility of a barrel today. Therefore, in a market with no immediate-term shortages, production is directed into the future, which stops reserve depletion in the long run. Conversely, during an immediate-term shortage, the marginal utility of a unit of that commodity today would rise above that of the future unit. If sufficient commodity supplies cannot be secured for today, the enterprise requiring them may no longer exist in the future due to bankruptcy. This enterprise can derive little utility from hypothetical future units of the commodity if its existence up to that point in the future cannot reasonably be assumed.

3.2. *Natural Gas Market*

Two particular examples of natural gas shortages in the European natural gas market will be analysed: regular seasonality and the disruption caused by the Russia-Ukraine war. The benchmark Dutch TTF (Title Transfer Facility) contract, settled in Rotterdam, is usually used as proxy for Europe. Even in normal times, Dutch TTF winter months are priced at a premium to the adjacent autumn and spring contracts (figure 4) due to the combined heating and industrial demand coupled with storage and logistical constraints (Fleiter and Jung, 2022). Given these limitations, even a full storage (figure 5) does not eliminate the risk of gas shortages in cold winters. TTF is priced to reflect this and production is directed towards the highly-priced winter contracts. As Europe goes through the winter, the uncertainty in the gas futures must resolve by the front month futures meeting spot or vice versa.

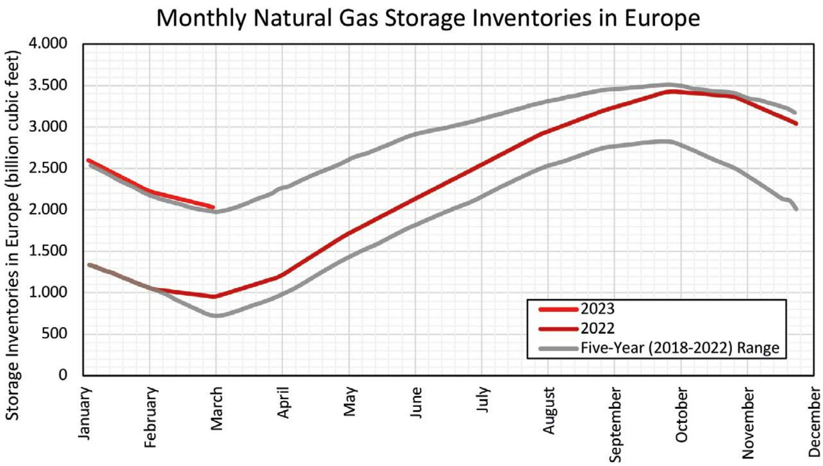
FIGURE 4. DUTCH TITLE TRANSFER FACILITY (TTF) NATURAL GAS FUTURES VS. BRENT OIL FUTURES. CONTRACTS ARE SHOWN IN USD PER UNIT OF ENERGY (MWH) TO BE DIRECTLY COMPARABLE. ALL LISTED FUTURES CONTRACTS IN THIS TIME PERIOD ARE DENOTED BY THE DOTS AND CONNECTED BY A LINE FOR SAKE OF CLARITY



Source: Intercontinental Exchange, 2023.

The logistical constraints for gas cause its seasonality. In less constrained markets, such Brent Oil, there is no winter premium. Brent Oil is delivered in the North Sea (CME Group, 2023) and no low temperatures, high pressures or specialised vessels are needed for transport. The Brent curve (figure 4) is in backwardation, indicating a tight global oil market, while TTF contracts are generally in contango, except for the winter periods. Despite the well-publicised energy crisis in Europe in the summer of 2023, the demand for TTF, per unit of energy, is significantly lower than for Brent. The constraining capital costs associated with natural gas transport inhibit easy substitution and reduce arbitrage opportunities. On the contrary, oil is less constrained and global energy demand affects Brent through arbitrage. Clearly, the futures curve prices in all available information and sends holistic scarcity signals, which include the effects of long-term, external constraints such as capital investments. Similar infrastructural challenges fragmentate the US natural gas market. Texas, replete with fracking operations and pipelines, enjoys cheap gas compared to New England and California, further supporting this point of view (Natural Gas Overview, US EIA, 2023).

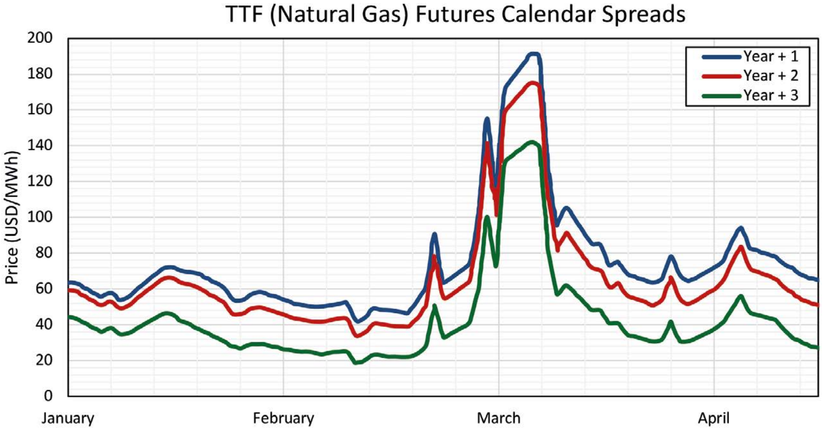
FIGURE 5. EUROPEAN NATURAL GAS STORAGE LEVELS



Source: Today in Energy, US EIA, 2023.

The outbreak of the Russia-Ukraine war in February 2022 is an example of prices moving to reflect and abate anticipated imminent scarcity. The futures curve went into backwardation, with the 1–12 month calendar spread more than doubling (figure 6), as the EU or Russia could have decided to curtail the gas flow for geopolitical reasons at any time. This was priced in by the market, which immediately re-directed delivery from other parts of the world towards the port of Rotterdam, thereby shortening the global structure of production. However, initial EU sanctions excluded Russian natural gas (Official Journal of the European Union, 2022) which kept flowing through the North Stream pipeline until May of 2022 (Commodities – Gas via MacroMicro, 2023). As no shortage materialised, the calendar spread quickly collapsed towards pre-war levels. The structure of production was elongated and the market price directed production towards filling the storage in a more optimal manner (just in time) for peak winter demand (figure 5). Had the term structure not reverted to its pre-war shape, price signals would have directed gas into storage prematurely during the summer months at suboptimal prices, thus destroying value.

FIGURE 6. EUROPEAN NATURAL GAS CALENDAR SPREADS. N.B. IN THIS FIGURE THE CALENDAR SPREAD IS CALCULATED WITH THE OPPOSITE SIGN TO THOSE IN FIGURE 3, I.E. A MORE POSITIVE VALUE INDICATES A MARKET IN BACKWARDATION RATHER THAN IN CONTANGO



Source: Intercontinental Exchange via European Natural Gas Hub, 2022

These examples demonstrate how anticipated shortages of a commodity lead to curve backwardation around the date in question.

This translates into incentivising production and delivery to bear fruit whenever it is most needed. The same principles causing contango in oil markets example cause backwardation in the gas case study, both locally in the winter season and across the curve following the Russia-Ukraine war. This is consistent with the theory laid in this paper previously.

3.3. *Volatility Futures (VIX) Market*

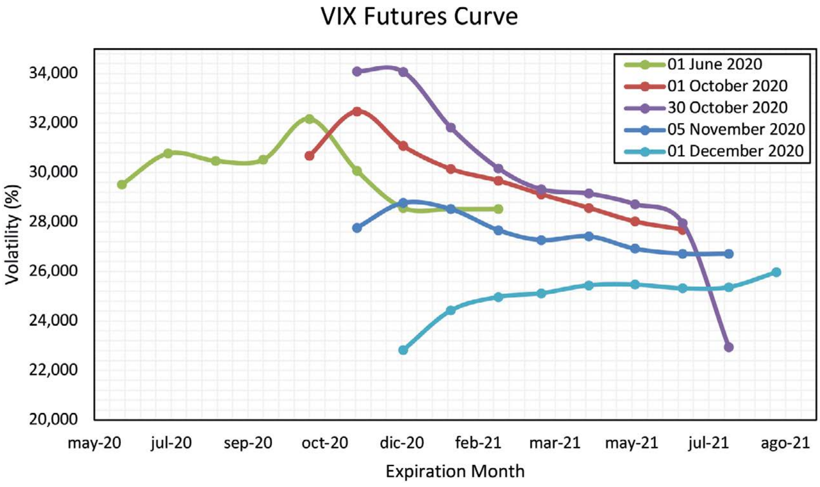
The previously described phenomena are not limited to physical commodities. The Volatility Index, or VIX, (Chicago Board Options Exchange, 2023) is an index calculated based on a basket of options with strike (exercise) prices specified distances away from the current price of the S&P 500 index. A spot VIX index is always calculated, but there is no tradeable spot product. Instead, cash-settled futures with monthly expiries are traded. The VIX price calculation depends on the options constituting the VIX basket for the relevant dates. As these heavily depend on the implied volatility of the options, the VIX is often used as a measure of expected (implied) market moves.

Options are usually priced using the Black-Scholes model (Black and Scholes, 1973) or stochastic variations thereof. A normal distribution of outcomes is assumed and then the impacts of several components on the price of that option are isolated. These include the derivatives of the options price with respect to a price change in the underlying (1st and 2nd derivatives), the interest rate, the passage of time and volatility of the underlying security (Passarelli and Brodsky, 2012). Conversely, market participants can back-calculate the implied volatility (anticipated move in the underlying) from the current market price of the option and the other factors. In addition, these factors can be isolated and trading arrangements made to hedge against particular events, including rising borrowing costs, large directional price moves or increasing volatility of the underlying. However, such hedging may itself move the price of the underlying, for instance, if a market maker buys the underlying to hedge directional exposure from a large call options position. In the 1987

Black Monday crash, the hedging dynamics of portfolio insurance were instrumental (McMillan, 2004).

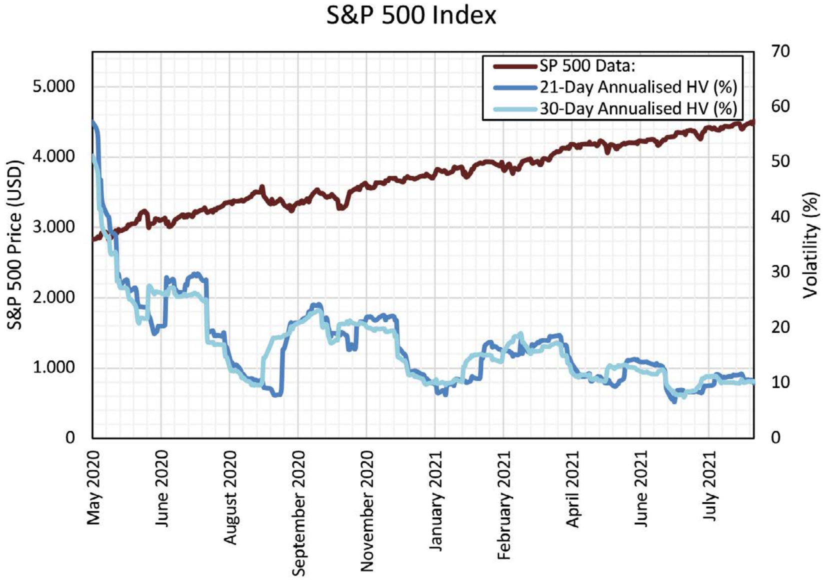
The VIX futures term structure around the November 2020 US presidential election (figure 7) is an interesting case study. The curve was in contango until the October or November contracts and in backwardation after that. Possible reasons include expectations of political turmoil, which would result in capital destruction and consequently a suddenly lower valuation of the S&P 500 index (figure 8). Alternatively, an unwind of hedged positioning that existed due to the fear of an undesirable political outcome may have been expected. This would reflexively propel the S&P 500 higher after the election, just like it moved reflexively down on Black Monday. Either way, as the VIX insures against market volatility, the price of insurance rightly increased because of such concerns of allocators.

FIGURE 7. VIX FUTURES CURVES DEPICTED AS SEEN FROM VARIOUS DATES (SEE LEGEND). THE 2020 US PRESIDENTIAL ELECTIONS ON THE 2ND OF NOVEMBER AFFECT THE IMPLIED VOLATILITY OF THE OCTOBER AND NOVEMBER FUTURES CONTRACTS AS VIX FUTURES CONTAIN OPTIONS EXPIRING THIRTY DAYS AFTER THE CONTRACT SETTLEMENT



Source: VIX Central, 2020

FIGURE 8. S&P 500 PRICE AND HISTORICAL (REALISED) VOLATILITY (HV) WITH A 21- AND 30-DAY LOOKBACK PERIOD. NOTE THE HIGH HISTORICAL VOLATILITY IN EARLY 2020. THIS RESULTS FROM THE STEEP MARKET SELLOFF COMMONLY ATTRIBUTED TO COVID AND THE ENSUING MARKET VOLATILITY BEING CAPTURED BY THE LOOKBACK PERIOD



Source: Yahoo Finance, 2021

Market expectations of volatility around the election drove certain VIX futures up, resulting in higher prices and implied volatilities of the corresponding options. This, in turn, increased hedging activity around that date, which directly involves buying and selling of the underlying. Prices in the VIX term structure directly impact the stock prices of and capital allocation to the underlying S&P 500 companies in this manner, thereby altering the length of the structure of production. This is evident in the brief increased realised volatility of the S&P 500 (figure 8) around the same time that the implied volatility of the VIX begins oscillating in the September-November timeframe.

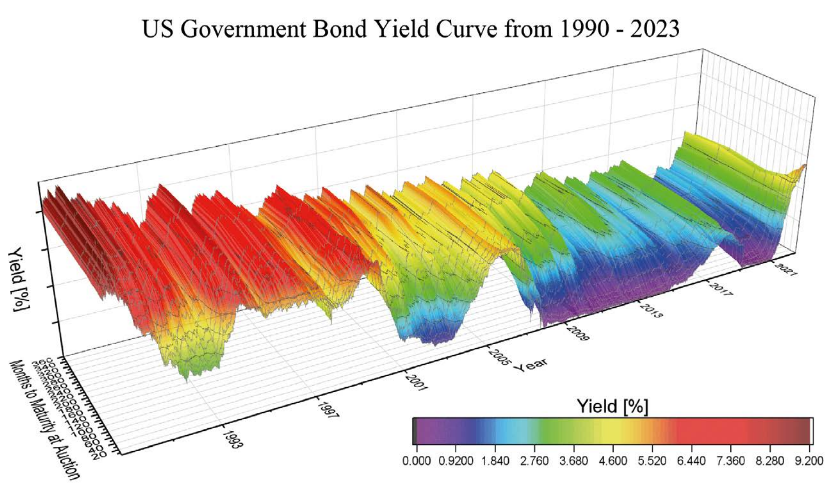
Factors other than the election driving local backwardation in October/November VIX futures, e.g., interest rate changes or volatility associated with earnings reports, is unlikely. The Fed Open Markets Committee did not make or announce any changes to interest rate policy from June until December (Monetary Policy Report, 2020; Summary of Economic Projections, 2020). The yield curve (figure 9, to be elaborated on in the next section) is not inverted either, suggesting no expected interest rate changes or other economic dislocations. Furthermore, normal quarterly earnings reporting cycles do not create implied volatility of similar magnitude, as is evident from the futures curves (figure 7) around the end of each quarter. Furthermore, the financial press reported a link between the volatility spike and election uncertainty (Peterseil, 2020) and this type of event-driven volatility is well-known among investment professionals in the volatility space.

In keeping with the theoretical framework and the previous case studies, once the anticipated event occurs, the futures price meets the (calculated) spot price. However, the realised market moves were finally smaller than what was priced in, as shown by comparing implied volatility (VIX futures price, figure 7) to realised volatility (figure 8). First, the anticipation of the post-election volatility moved into the future along the term structure as it failed to materialise in the initially expected timeframe (compare the green, red and purple lines in figure 7). However, when it finally becomes clear that there will be no capital shortage and no ensuing elevated realised volatility, implied volatility collapses and VIX futures quickly fall into contango. Due to the reflexive dynamics of hedging, capital is once again allocated in a way that is conducive to higher stock prices of listed companies and thus more investment in these ventures. This case study shows how the price mechanism in futures markets successfully allocated capital to insurance against the impacts of a foreseeable event affecting the real economy, as opposed to a policy or central bank decision. This demonstrates that financial derivatives futures are subject to the same forces of supply and demand of capital as physical commodity markets. Importantly, the theoretical foundations remain applicable even as the form of capital analysed becomes more amorphous (v.Mises, 1949).

3.4. *US Government Bond Market*

Thus far, the term structure of markets has been shown to contain information about the present and anticipated future. Arbitrage, linking all markets in space and time, becomes easier as the capital being traded becomes more amorphous, e.g., VIX and S&P 500 arbitrage is easier than oil and gas arbitrage (figure 4). The most amorphous capital constitutes credit and stock markets, as can be seen from their close empirical relationship (Baker and Rangeley, 2023). Indeed, the ability of the US Treasury yield curve (figure 9) to act as a proxy for the credit structure of the US and global economies reflects such arbitrage processes. Large market participants, e.g. pension funds, with exposure to other sectors of the economy, e.g. labour markets, allocate significant capital to government bonds. Additionally, many financial products are priced relative to similar maturity US government debt. Hence, it is one of the deepest and most liquid credit markets globally.

FIGURE 9. DAILY US TREAASURY YIELD CURVE SINCE 1990



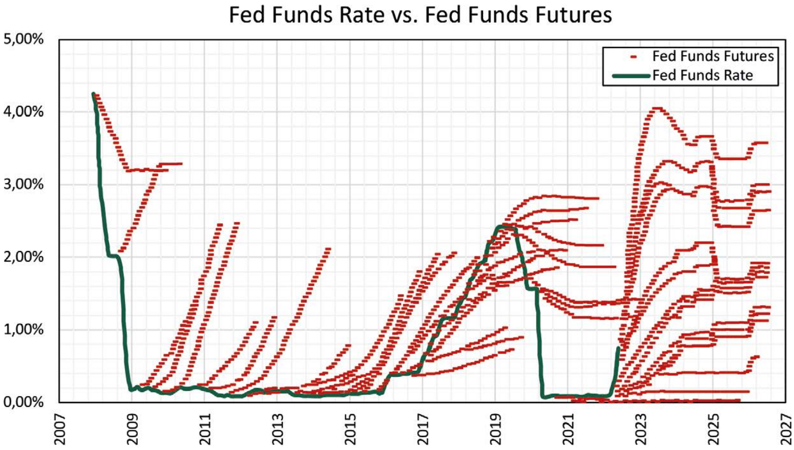
Source: US Dept. of the Treasury, 2023). N.b No data were available for the 20-year treasury auction from 02.01.90 to 30.09.93 and the 30-year treasury auction from 19.02.02 to 08.02.06; data points have thus been extrapolated from adjacent values.

In keeping with its function as a proxy for credit structure in the economy, all recessions since 1978 (US Dept. of the Treasury, 2023; NBER, 2023) have been preceded by an inversion of the US Treasury yield curve (figure 9). Usually, the following cycle occurs. The central bank lowers discount rates, followed by higher valuations of assets (Baker and Rangeley, 2023). Then, the yield curve inverts as the pace of discount rate cuts slows or discount rates are lifted higher, followed by a fall in asset valuations. Examples include inversions in 2000 before the dot-com bubble bust, in 2007 before the GFC and in 2020 preceding the Coronavirus crash. It is noteworthy that interest rates to-date have never sustainably risen back to the pre-crisis levels, which indicate a systemic problem, rather than random fluctuations resulting from the entrepreneurial process. Whether the current rate hiking cycle will be the first to structurally raise rates without additional financial repressions or expansions of credit volume elsewhere remains to be seen, but is unlikely given prior evidence.

The central question is what drives this cycle in interest and its term structure. The expectations hypothesis may explain inversions to the extent to which changes in the discount rate affect the overall availability and structure of credit. However, market expectations of interest, such as forward rates, are in fact unreliable. Reputable practitioners have pointed out (Bassman, 2024) that forward rates are only the mathematical the break-even rate, calculated from two bonds of different maturities. For example, if one-year bonds yield 3% and two-year bonds yield 4%, buying one-year bonds would only make sense if in one year one-year bonds would yield 5%, thus averaging 4% over two years just like two-year bonds at the time of the initial decision. This hypothetical 5% rate on one-year bonds in a year is the mathematical break-even rate reflected in forward rates market. It is not an expectation of actual rates in a year and therefore contains no additional information over the yield curve. The Fed Funds futures market and the Fed Open Markets Committee (FOMC) dot plots themselves (figures 10 & 11) can also be construed as estimates of future rates.

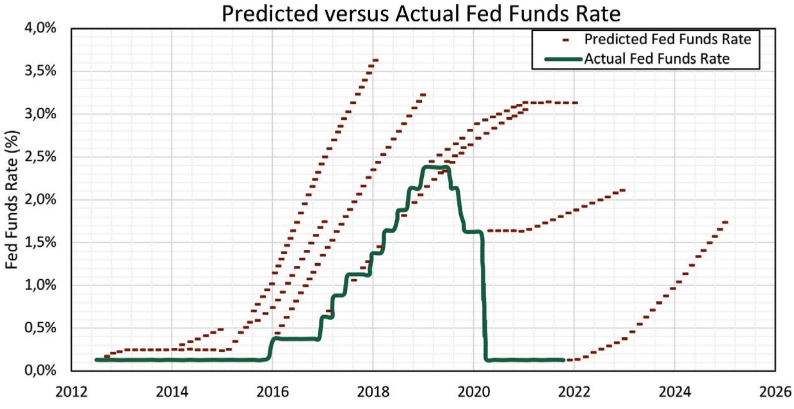
Clearly, Fed Funds futures and have little predictive power with respect to the actual future course of the Fed Funds rate. In contrast, the track record of the yield curve predicting recessions is excellent and not prone to false alarms. This divergence suggests that, after all, the yield curve is not inverted primarily by market expectations of future discount rates.

FIGURE 10. ACTUAL FED FUNDS RATE COMPARED TO FED FUNDS FUTURES



Source: Slok, 2022.

FIGURE 11. ACTUAL FED FUNDS RATE COMPARED TO THE AVERAGE PREDICTIONS OF THE FOMC MEMBERS



Source: Summary of Economic Projections, 2012-2021

The FOMC, which sets discount rates, publicly releases the future interest rates predictions of its members in the dot plots (figure 11). Judging by their predictive power, it seems that even the (public) predictions of the committee centrally planning the discount rate cannot predict near-term future rates! Thus far, empirical support for the expectations hypothesis is rather weak because of the divergence in signal strength of the inversion and the expectations that are hypothesised to cause it.

More importantly than expectations and discount rates, the yield curve reflects information about supply and demand fundamentals of credit. This depends on global liquidity flows and the quality of credit maturing at certain points in the term structure, as well as market interventions and special credit facilities. These include quantitative easing or tightening, direct bank bailouts as well as the Bank Term Funding Program (BTFP) or Reverse Repurchase Agreement Operations (RRP). The aggregate supply and demand picture regulates the absolute level of interest and their relative level at the short and long end. This is confirmed by the Treasury Borrowing Advisory Committee (TBAC) in statements such as from 31.10.2023:

> "The Committee expressed continued comfort with the bill share of total marketable debt outstanding remaining temporarily above its recommended range given continued robust demand for bills…"

That is, the issuance of debt is shifted to the short-term due to the demand for debt that exists there, while the yield curve is steeply inverted. Implicitly, this admits that there is less demand at the longer end. A TBAC statement from 30.01.2024 confirmed this:

> "… asset managers' preference for Treasury futures may result from regulatory considerations in addition to the embedded leverage and operational flexibility that futures afford. These features […] enable asset managers to enhance returns in fixed income funds that track broad market indices by facilitating additional exposure to credit products."

That is, much demand from funds for long-term US Treasuries comes from levered exposure through futures positions and the ensuing hedging dynamics of all market participants involved. Since the purchase of a futures contract requires only a fraction of the notional value to be paid (the margin), the debt market becomes more volatile and more prone to outsize reactions to small disturbances. This means the market is less deep and liquid than the low interest rates suggest. To avoid volatility, more issuance is shifted into short-term Bills. Indeed, a BIS study (Avalos and Sushko, 2023) confirms that margin spirals caused several unexpected US Treasury selloffs in 2019 and 2020. During both selloffs, the yield curve was inverted, lending further credence to the fundamental, ABCT-based argument.

This approach, unlike the expectations hypothesis, can explain the 2019 bond market inversion preceding Coronavirus. Had the 2020 recession been induced solely by Covid and lockdowns, how did the market already know about lockdowns or the subsequent Fed rate cuts? Given the virus probably did not yet exist in 2019, it could not have been priced in. Instead, the market in late 2019 was pricing endogenous credit stress with a two-year time horizon (2y-10y inversion). The accelerated arrival of the credit crunch in six months resulted from lockdowns and reduced economic activity. Credit became tight and refinancing difficult in early 2020, especially for the US government. Increased fiscal outlays and lower tax receipts coupled with less global demand for US Treasuries expanded deficits caused high interest rates and a margin spiral (Avalos and Sushko, 2023). Well-capitalised governments and corporates without credit stress could have used savings to survive temporarily lower cash flows. Valuations would have been more stable since markets discount future cash flows and not only present ones. Recall the US Treasury yield curve suggested no capital shortage during the 2020 presidential election. Under these circumstances, the VIX futures markets succeeded at structuring production in time in such a way that adapted to real economic constraints without disruption or volatile drops in asset valuations. It follows that the fundamental driver of crises, reflected in the yield curve, are shortages of real capital.

One may object that the price of credit is not an unhampered free market, but heavily regulated and manipulated. This is, of course, true. In an unhampered free market, the overall level of interest rates might have been higher in recent decades. However, just like in oil markets, the marginal unit of credit determines the price of the whole. A price signal survives in the relative movement of rates at a lower absolute level as long as if there remains a significant proportion of free market action in credit markets. That is, the inversion of the yield curve will fail to acknowledge the magnitude of the shortage of capital, but it will succeed at timing crises. This is consistent with the insight (Hayek, 1941) that to maintain an asset bubble by outpacing price discovery, an ever-increasing growth rate of the money supply is necessary. If the growth is only linear (constant rate of change), the price discovery process will eventually catch up to the credit manipulation and price it in. In future work, a credit impulse metric measuring the rate of change of the term structure of important bond markets could be developed for forecasting and quantification purposes. A similar impulse metric (Alonso-Neira and Sanchez-Bayon, 2023) has been developed linking the rate of change of the money supply and the term structure of credit with high predictive power, further supporting the strong link between ABCT and the term structure of rates.

To illustrate the validity of the futures analogy in unfree markets, imagine the hypothetical example of a central bank expanding the credit volume through QE. It purchases a fixed amount of five-year bonds for one month, lowering interest rates, after which manipulations of the credit supply cease. Eventually, the divergence between perceived and real capital stocks in five-year bonds must manifest itself. Arbitrage and re-financing over shorter time horizons will transmit signals of shortages of investable capital to ever shorter time horizons until they reach the present. In the commodities analogy: the very latest when front-month futures and the spot market must converge is at delivery. As capital allocators are forward-looking, this is only an upper bound. A less hypothetical example is in credit the 2y-10y Treasury yield inversion, which signals scarcity over a two-year time window. Indeed, no recession since 1978 arrived with a lag longer than 22 months after an inversion. The average lag was 12.8 months, with the pre-Coronavirus lag of 6 months being shortest (US Dept. of the Treasury, 2023; NBER, 2023). Now, what if scarcity signals are obfuscated by further intervention into the credit market, e.g. QE? This may delay the arrival of credit stress in the present and the yield curve may become a weaker predictor of future recessions. Since the current inversion in April 2022, many regulatory changes, special credit facilities (e.g., BTFP, RRP), interventions in Bank bankruptcies (e.g., Silicon Valley Bank and Signature Bank) have likely done just this. Centrally planned rates, such as the discount rate set by the Fed, contain no price signal. The extreme case, a fully centrally planned yield curve, would eliminate all traces of price information.

A practical deliberation is the predictive power of the current yield curve inversion regarding the economy and the equity markets. It is the steepest inversion since 1990 (figure 9), indicating that capital allocators should act cautiously in the coming months and quarters. Nevertheless, further interventions, such as bank bailouts and regulatory changes may attenuate the inversion signal. This applies especially to listed stocks and bonds as the credit market appears to, once again, be pricing an imminent shortage of capital. It should also be analysed how an inversion of the US government debt yield curve may interact with other credit markets, such as municipal bonds or corporate bonds with all peculiarities of those markets, their structures and regulations. There are likely practical, actionable insights in these relationships that remain to be explored in the future.

4. Conclusions

It can be concluded that price signals in the term structure of credit and commodity markets elongate or contract the structure of production. A shortage in the present leads to higher present prices while an anticipated shortage in the future leads to higher future prices. The entrepreneurial process translates expectations of the future into efficient and optimal adjustments that direct production towards the time and place with highest demand. Commodities markets behave analogously to credit markets in this respect, as is evident from the localised and global inversions in the case studies. This is entirely consistent with ABCT as laid out by the great thinkers of Austrian School.

Unfortunately, the entrepreneurial process does not drive markets alone and the term structure, especially of credit markets, is subject to intervention. For instance, central banks may lower or raise long- or short-term rates and the structure of production will initially elongate or shorten according to this manipulated price signal rather than the now hidden free-market signals. The consequences include overproduction for which there is no demand given the stock of savings or idle capital goods that cannot be put to economic use. Either way, underperforming business ventures may result in bankruptcies and defaults on obligations. Obviously, the loss of decentralised information arising from the entrepreneurial process results in a suboptimal allocation of resources. With the price signals that can be isolated from the credit markets stunted, increasing intervention results in an ever-more vigorous business cycle.

Practically, however, useful price signals survive in credit markets as long as the entrepreneurial process in that market partially persists. Prices are made at the margins and it is rates of change, not absolute levels, that are particularly informative. Despite the manipulated absolute level of interest rates, the rates of change in their term structure carries information on where and when underperformance will occur in the economy. A rate of interest that is rising more quickly over one maturity than over another is an indication of the market re-discovering a capital shortage over that maturity. The entrepreneurial process re-asserts itself absent further intervention. This means that the inversion of the yield curve is a quantitative indicator of ABCT in practice. It reflects whether the entrepreneurial process identifies credit stress approaching the present from the future. An inversion of the term structure of any market, free or manipulated, indicates a shortage and is to be taken most seriously. In commodity markets, this is very well understood. However, in credit markets the origin and significance is not sufficiently understood, even though inverted yield curves (e.g., 2y-10y spread) are routinely used as predictors. It is in fact nothing but a shortage indicator of the present in the capital structure of the whole economy, as explained by this ABCT framework and thus one of the most invaluable price and timing signals for the capital allocator. As a practical consequence, the rate of change (impulse) of credit should be quantified and studied further by practitioners and academics.

Conflict of interest

The author declares that it has no conflict of interests.

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