What could amplify the dynamics of the oil price decline?

Implementation of hydraulic fracturing dramatically altered the fundamentals in the oil and gas markets. A new technology first got implemented in the natural gas market, but by 2012 unprecedentedly low gas prices forced most exploration firms to switch to shale oil exploration.\(^1\) Large capital expenditure on drilling activity resulted in the growth of oil production in the US, and likely triggered the decline in oil prices. Oil prices collapsed to $50/bbl by the end of December, 2014. However, as Figure 1 shows, oil prices continued to fall and crossed the level of $30/bbl in 2016. At such low prices most shale oil plays cannot remain economical, many shale oil firms were forced to file bankruptcy.\(^2\) The prolonged period of extremely low oil prices raises concerns on whether some additional factors could have contributed to the oil price decline or have delayed the rebounding. This paper provides evidence in favor of non-fundamental amplification mechanism: trading activity in the oil futures market led to a build-up in oil inventories, which was misinterpreted by the market as a sign of oversupply and, thus, put a significant downward pressure on oil prices.

Shale boom in the US  Crude oil production from US shale plays has increased dramatically and has been accelerating since 2011. Figure 2 shows that at the peak, production in 7 most prolific shale plays reached almost 5.5 mln barrels per day. US crude imports declined by 25% between 2007 and 2014, light crude oil imports to the Gulf Coast declined to zero. Despite a notable oil production growth since 2011, oil prices remained at a high level, oscillating in between $80 to $110/bbl. Only in August, 2014 rapid decline of oil prices began. Perhaps, initial information about extra production were not fully reflected in oil prices, and a period of adjustments was necessary to bring the spot price closer to new fundamentals. However, it seems hard to reconcile the observed rapid collapse of oil prices with shifts in oil production and consumption due to shale developments. Rather, the movements in oil prices are reminiscent of non-fundamental movements observed in asset markets. Next we first examine the hypothesis of oversupply in the oil market.

\(^1\)Chesapeake Energy announced a redirect from shale gas to shale oil activity on January 23, 2012 in response to low natural gas prices.
\(^2\)By January 2016, 36 shale oil firms were forced to file bankruptcy according to Chapter 11.
Oversupply  Both, rapid collapse of oil prices in 2014 and prolonged period of low prices, tend to be attributed to global oversupply of oil. Figure 3 shows global supply and demand for oil as estimated by the International Energy Agency. The figure suggests that since second quarter of 2014, supply of oil has exceeded demand, as shale producers have been drilling too much. Persistent oversupply has contributed to a large surge in US crude oil inventories, oil stock reached record highs(see top panel in figure 4). Excessiv growth of oil production finally has put significant downward pressure on oil prices. Thus, oil prices collapsed to restrain shale production and restore equilibrium in the oil market. Oil production is expected to decline in the near future and oil prices should soon rebound. Attractive in its simplicity, the hypothesis of oversupply cannot fully account for a number of empirical facts.

First, consistent oversupply story has to admit that overproduction occurred already in 2014, because the IEA reported excess supply already in second quarter of 2014, while production has not changed much since then. But oil inventories were flat or declining in 2014, not showing any sign of redundant oil. Figure 4 shows that total US commercial inventories in 2014 oscillated around the three-year average. Moreover, inventories in Cushing, Oklahoma, major delivery point of oil futures contracts, declined considerably and reached a minimal level last observed in 2008. Forward curve showed backwared, when current oil is more expensive that oil in the future, thus discouraging stockpiling and contradicting oversupply beliefs pattern. Refineries in 2014

\[\text{Figure 2: Shale production in the US (mln barrels per day). Source: EIA, drilling productivity report, focus on seven most prolific areas, which are located in the Lower 48 states. Seven regions include Bakken, Eagle Ford, Haynesville, Marcellus, Niobrara, Permian, and Utica.}\]
Figure 3: Demand/Supply Balance, IEA. Signs of oversupply since second quarter of 2014.

Figure 4: Oil inventories in the US and in Cushing, Oklahoma. Black lines depict the three-year averages between 2011 and 2013. No build up in inventories before January, 2015.
were showing capacity utilization levels comparable to previous years, as shown in Figure 5, and significantly below the level reached in 2015. So no signs of oversupply could have been noticed in 2014. In fact, even in October 2014 when oil prices already reached $80/bbl, analysts were still reluctant to admit oversupply. Only when total inventories started to increase in January of 2015, oversupply story finally "got confirmed" and became widespread.

Second, despite significant cuts in capital expenditure, oil production remains remarkably "resilient" and does not feature transition dynamics. Although the number of drilling rigs in the US fell by more than 60%, the number of wells fracked is actually rising. Rystad Energy argues that fracking activity has increased by 25% from May to October, 2015. The inventory of drilled but uncompleted wells declined from a peak of 5,000 to 3,500 by year-end, that level of shale wells inventory was last observed in the summer of 2013. Moreover, Rystad Energy’s oil production outlook displayed in Figure 6 shows flat month by month US production since mid 2015, thus contradicting EIA short-term outlook,8.

Third, at the current level of oil prices of 30 $/bbl, shale oil companies struggle to survive. Figure 7 displays an assessment of breakeven prices for the main shale plays in the US done by Rystad Energy. Most shale plays lie in the range of $50/bbl to $60/bbl. Eagle Ford enjoys lowest price of about $40/bbl. At oil prices below $50/bbl only areas in Eagle Ford and Niobrara will remain economical, whereas at prices below $40/bbl there will be none. Not surprisingly, by the end of January, 2016 36 shale firms filed bankruptcy according to Chapter 11, with total indebtedness of $17 bln. The surviving companies report significant write downs of assets and balance at the edge of bankruptcy as well. In 9 months from January to September, 2015, Apache wrote down $12.2 bln after taxes, Chesapeake - $15.4 bln, Devon, Southwestern, Encana, and Newfield Exploration month and second month contracts reached $1.5/bbl.

Bloomberg, October 17, 2014. “Goldman Sachs Says Oil Rout Excessive on Oversupply Doubt": “The ‘supply glut’ is not yet here today, it exists in expectations,” the Goldman analysts wrote. “Prices have likely overshot to the downside. ... Given the high level of volatility and uncertainty, we believe commodity markets will calm at least temporarily until evidence of oversupply is seen in rising inventories,” the report said.


Resiliency of US shale production is in the focus of a recent study by BIS by Domanski et al. (2015). High indebtedness of shale oil firms and necessity to service debt delays a pullback in production. However, the usage of aggregated CFTC data on short-term positions by merchants to confirm downward slopping supply, raises some concerns.
together wrote down $40 bln. Cash flow even cannot cover operation expenses, operating cash flow shortage among 10 largest shale firms reached $32 bln. Major banks lending to shale oil sector increased provisions by $2.5 bln. Thus, the oversupply has to be extremely severe to explain a decline of oil price much below the breakeven prices.

Global oversupply of oil may also be partially due to lower economic activity, for example, lower demand from China. Thus, redundant oil has to go in storage. Indeed, Figure 8 shows that oil inventories in the US experienced a dramatic change during 2014-2015, namely an increase by 45 mln bbl. However it also displays absence of any significant build-up in oil inventories in Europe, in three major ports, Amsterdam, Rotterdam, and Antwerp. Therefore, local oversupply seems to be more reasonable, especially given a long-lived ban on oil export from the US, relaxed only recently. But in response to local oversupply, and given inherent resilience and inertia of production, import should be first to react. But as Figure 9 displays, oil import has not changed in the last two years.

But more importantly, the transition of the oil futures market from backwardation to contango can hardly be explained in oversupply paradigm. Figure 10 shows that since November 2014, forward curve has had a steep upward slope, the situation called contango in oil futures market. By February 2015 second month futures price exceeded the spot price by $2.3/bbl, with contango being even steeper for more distant futures. Typically, forward curve is considered to reflect market expectations of future prices. Thus, consistent with oversupply story, a steep contango curve signals huge but short-term oversupply. Indeed, spot prices may rapidly fall to accommodate redundant oil, but as production is expected to adjust, futures prices don’t have to fall as much and reflect a fundamental price of oil on the market without oversupply in the future. That could explain a large price difference between a year ahead futures contract and spot price. However, the forward curve is particularly steep on the front end, the price difference between second and short term contract is large, and has been large for a long time. So, first, it would be myopic to believe that oil production can considerably change over a very short period of time to justify such a price spread. Second, given prolonged contango, it is unlikely that market systematically overestimated the pace of transition towards equilibrium. So oversupply hypothesis seems to fall short of a fully satisfactory explanation of the contango in the oil futures market.

Finally, oversupply cannot explain unique trading activity observed in the oil futures market. However, we think that it is crucial in understanding the dynamics of oil prices, in particular in explaining a prolonged period of low oil prices since the beginning of 2015.

**Trading activity of ETFs in the oil futures market**  In the last decade, financial innovations provided a broad class of investors with an access to commodities markets. New financial instru-
Figure 7: Average WTI Breakeven Oil Price Per Shale Play (USD/bbl). At oil prices below $40/bbl no shale plays will remain economical. Source: NASReport Q4 2014 by Rystad Energy.

Figure 8: Build-up in inventories in Cushing, Oklahoma (on the right) and in Europe, in Amsterdam, Rotterdam, and Antwerp(on the left). No build-up of inventories in Europe in 2014-2015.
Figure 9: U.S. Imports of Crude Oil (Million Barrels). No decline in 2013-2015. Source: EIA

Figure 10: Price spread, second month futures price minus first month futures price on WTI. Transition from backwardation to contango.
ment, such as exchange traded funds (ETFs) and exchange traded notes (ETNs) were created. In the oil futures market the first and largest ETF is the United States Oil Fund (USO). The fund invests in short-term futures contracts and issues shares that can be traded on a liquid secondary market. Shares of oil funds are convenient to supplement or diversify equity portfolio. Oil prices historically negatively correlate with equity, almost don’t correlate with bonds, and positively correlate with inflation. Thus, liquid and low-cost oil ETFs may significantly extend investment opportunities of the agents.

Oil ETFs and ETNs experienced a rapid growth of assets in the fall of 2014. Figure 11 shows an increase of trading volume and open interest of USO. The Fund grew from holding less then 5 thousand contracts in June, 2014, to holding more than 60 thousand contracts in March, 2015. Substantial growth in holdings should be reflected in the underlying market. Figure 12 traces extra investment in oil ETFs to the front month oil futures market and shows a spike in open interest that coincides with the growth of USO.10

Why would USO increase when oil prices collapse? First, the fund could grow to accommodate extra short interest. In order to lend a share, the broker has to own it, thus it must have been created. From October 2014 to March 2015 short interest, indeed, grew from 13 mln to 43 mln shares. However, similar in magnitude increase in short interest from 18 mln to 42 mln in 2013, did not cause any significant growth of fund’s assets. Second, the fund may increase if agents consider current price of oil to be below some mid-term level defined by oil fundamentals, and thus expect oil prices to rebound in the near future. Investment in the fund is thus investment in oil that is expected to grow in value.11 That explanation goes in line with oversupply story. But in that case one would expect a flow of investment not only in ETFs, but in futures contracts as well. For long-term investment transaction costs do not matter much, thus, USO and futures contracts should represent equally attractive assets. However, Figure 12 shows that open interest disproportionately

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9 Besides USO, oil ETFs and ETNs include OIL, DBO, USL, BNO, UCO, U/DWTI and others. Vast majority invests in short term futures contracts on WTI oil traded at NYMEX (CL1). As of February 1, 2016 USO holds $3.62 bln in AUM, OIL - $832 mln, DBO - $413 mln, all invest in CL1. Leveraged funds that also predominantly invest in CL1: 3x fund UWTI - $815 mln, 2x fund UCO - $765 mln. Other funds are much smaller - USL that invests in 12 nearest-month futures contracts holds only $80 mln, BNO that invests in BRENT holds only $76 mln. When assets of the funds are translated into units of front-month contracts, that gives more than 280 thousand of March 16 contracts. Thus given total open interest of 600 thousand contracts, the funds taken together hold almost half of the market.

10 Other ETFs also experienced similar growth of assets.

11 Such strategies are often called as “an attempt to catch a falling knife”.

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increases in USO market. Open interest in WTI futures markets increases only to reflect extra investment in oil ETFs and ETNs, whereas Brent market does not show any increase at all.

In contrast, for short-term investment with high turnover rate, transaction costs are essential. When frequent trading is required, advantages of liquid, low cost, and efficient exchange traded products become pronounced. Falling oil prices and high volatility may activate trading of the fund’s shares. Large trading volume in turn triggers an increase in shares outstanding to service or facilitate higher turnover, and the fund grows. Figure 13 shows that USO trading volume indeed comoves with volatility in oil futures market, while Figure 11 documents an increase in fund’s position that follows an increase in trading volume. What is the mechanism?

Sophisticated traders, including high-frequency traders, seek a way to get intraday exposure to oil prices for both portfolio protection and for new positioning. High volatility usually leads to more active trading due to intensified price discovery, speculative trading, and statistical arbitrage transactions. Recent reports by Goldman Sachs and BlackRock document that ETFs trading volume spikes when volatility increases. A market maker in ETFs market, LaBranche & Co, reports a favorable role that market volatility plays in providing them trading and arbitrage opportunities (annual 10-K 2009 report). A snapshot of positions as revealed by SEC 13F forms filed by institutional investors, documents a number of high-frequency firms, such as Susquehanna, Virtu Financial, and HBK Investments, among holders of USO shares. Thus, high volatility may intensify trading of USO shares. But, increased trading activity may require constant issuance of new shares. Liquidity providers usually hold some inventory on their own balance to facilitate the trading, and if trading intensifies, a larger inventory may be required.

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12 Academic research has long been building micro foundations for volatility-volume relationship. Andersen (1996) develops a volatility-trading volume model in which trade is motivated by information arrivals. Similarly, a large number of papers empirically document the link for broad classes of assets, including Karpoff (1987) and Martell and Wolf (1987) for futures markets... (to be completed).
13 Goldman Sachs equity research team, Fogerty and Boroujerdi, “ETFs: The Rise of the Machines”, April 10, 2015, exhibit 11.
15 As of June 30, 2015 Susquehanna revealed a $38 mn position in USO, Virtu Financial - $23.4 mn, HBK Investments - $51 mn. Funds may hold positions in multiple funds at the same time, including offsetting positions. Thus on December 31, 2014, Virtu Financial revealed a $86 mn position in USO and a $16 mn position in DTO, which is a minus 2x fund.
16 Brokerage firms may also acquire shares of ETFs to facilitate their in-house trading. For example, Charles Schwab offer a quarterly list of prescribed ETFs. The list as of December 31, 2014 includes USL, which can be traded by its
Figure 13: Front month futures price volatility and USO volume.

To further provide evidence in favor of trading explanation, we can look at investment in leveraged funds. As mentioned in a leveraged fund’s prospectus, the leveraged fund “is not a buy-and-hold ETF, it’s a short-term tactical instrument”, because leveraged exposure to oil price is delivered only for 1 day. One of such funds in oil futures market is UWTI, a leveraged funds that delivers 3x exposure to front month futures contracts on WTI crude oil. The fund experienced a dramatic growth. In 2014, UWTI’s volume topped 0.02 mln shares a day, whereas in February, 2015 UWTI reached 90 mln shares in a day. Over one year from summer 2014 to summer 2015, the fund attracted $1.6 bln in investment. Thus, growth of funds, that are useful only for intraday trading, further confirms disproportional interest of investors to exchange traded products (ETPs) and contradicts long-term investment story.

So ETPs that invest in short-term oil futures experienced rapid growth. But issuance of new shares created additional long positions in short-term futures contracts. Futures contracts have an expiration date and thus have to be replaced before expiration. Selezneva (2015) documents the effect of such rebalancing on the underlying market, and uses USO as an example to show a significant effect of extra investment in that fund on the term structure of oil prices, in particular on the price difference between second and front month futures contracts. Figure 14 from that paper relates investment in USO with the price spread\(^{17}\). Thus, growth of oil funds may explain the transition of oil futures market from backwardation to contango. But what does it mean for the real economy and spot prices?

**Physical arbitrage and build-up in inventories** Contango in oil futures market if large enough, makes physical arbitrage profitable. One can buy oil, sell it forward and put it in storage, until the expiration of distant futures contract. As a result, inventories are expected to rise. Ederington et al. (2012) quantify that effect. Using weekly data from 2004 to 2011, the paper documents that a one- time $0.10 increase in the spread leads to a positive change in inventories of about 0.028 mln bbl the first week, 0.153 mln bbl after four weeks, and 0.211 mln bbl after nine weeks.

The amount of oil stored to profit from a given level of contango is defined mainly by the cost of clients at $0 online commission.\(^{18}\)

\(^{17}\)Formal analysis in the paper shows that an increase in USO position by 7500 contracts, which is about 1.5 st.dev. of changes in USO positions observed in the winter 2008-2009, would predict 18 cents increase in contango the next day, given first futures price of 42 dollars prevalent at that point of time.
oil storage. The lowest cost is achieved when oil is stored in on-shore facilities. Cushing, Oklahoma is one of such on-shore facilities, moreover, it serves as the main delivery point for futures contracts. Thus, we expect to observe a build-up of oil inventories in Cushing in response to contango. Indeed, Figure 15, displays a rapid build-up of inventories in Cushing in response to contango in the oil futures market.

Midstream companies that own or rent oil storage facilities are likely to be among the companies that profit the most from contango situation. We analyzed quarterly reports of a number of midstream companies. SemGroup reports an increase in inventory by 0.7 mlbl due to a strategic build up to capture margins due to forward market crude oil prices being higher than spot market prices.18 Plains All American Pipeline mentions that during the six months ended June 30, 2015, it increased the volume of crude oil inventory, “primarily as a result of storing such inventory due to contango market conditions”.19 Even exploration companies, such as BP, engage in physical arbitrage. Reuters reports that BP “bought and sold more than $1.25 bln worth of oil, the equivalent of around 23 mln barrels, during the first three months of the year”.20 NGL Energy Partners estimates that a $0.10 change in contango impact EBITDA by $6 mln annualized. As contango deepens, even storage of oil in tankers may become profitable. E.A. Gibson Shipbrokers Ltd and Frontline Ltd document that up to 20 VLCC were used for temporary storage by the end of January, 2015, which is equivalent to approximately 30-40 mln bbl. In response, tanker rates spiked, the cost of renting a VLCC for 1 year increased from $33,000/day at the beginning of 2014 to $65,000/day by mid January 2015.21

It should be noted, that a link between contango in the futures market and a storage build-up as a result of physical arbitrage transactions, is not a unique feature of the oil market. For example, a steep upward sloping forward curve observed in ICE futures gasoil market in 2014, led to a dramatic increase in gasoil stocks in Amsterdam-Rotterdam-Antwerp. Both, Genscape and PJK

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18 SemGroup, 10Q, Q3 2015.
19 Plains All American Pipeline, 10Q, Q2 2015. Similarly, in March, 2009 in a similar situation PAA stored approximately 10 mln bbl of hedged inventory. From 10Q, Q1, 2009, “earnings ... were favorably impacted by a strong contango market...we had net borrowing on our hedged inventory facility of approx. $78 mln which was primarily due to the favorable contango market structure... When we purchase and store barrels, we enter into physical sales contracts or use derivatives to mitigate risk associated with inventory. As of March 31, 2009, we had approx. 10 mln bbl of hedged inventory”.
20 Reuters, Apr 28, 2015. “BP unwinding oil storage play as contango narrows”.
21 Hellenic Shipping News, from January 19, 2015 and March 16, 2015
Figure 15: Inventories in Cushing and spread between second and first month futures contracts on WTI oil. Oil inventories increase when market is in contango.

International BV report that gasoil inventories in ARA in August of 2014 were the highest since 2009. Traders were storing gasoil to profit from contango. Brokers’ data, compiled by Bloomberg show that Morgan Stanley bought 77% of the 810 thousand metric tons that traded on the diesel barge market in July and August in a pricing window operated by Platts.\textsuperscript{22} During that period of time 6 months spread in ICE low sulphur gasoil futures reached $25/MT.

Contango in the oil futures market can be exploited by midstream and exploration companies, as well as by commodity traders. As a result, a significant build-up of inventories can be observed. What are the implications for the spot price of oil? First, oil price is affected directly, because a large amount of oil is removed from the market. However, there is another mechanism given the important informational role that inventories play. A build-up in inventories may shape expectations of agents and affect the price formation in commodities markets. Inventories may reassure agents in oversupply in the oil market and put significant downward pressure on oil prices.

**Physical arbitrage and role of inventories**  Physical market of oil is opaque. We already have seen the discrepancy in production figures estimates. The problem is amplified by a development of a new technology and structural shifts in oil production. In such an environment oil inventories serve an important role, they are presumed to be key to understanding current and future prospects of oil market. Indeed, inventories may reveal a lot of information about the supply and demand balance in the oil market, thus representing a nice and easily observed signal. But interpretation may be tricky, as there are many factors to be considered.

Oil inventories in the US in 2015 increased by 25% in a matter of few months and remained high afterwards (see Figure 4). That huge build-up in oil inventories convinced market analysts in significant oversupply in the oil market and accordingly put downward pressure on oil prices. When the International Energy Agency released Oil Market Report for February, 2016 that showed resilient production and “brimming” stockpiles\textsuperscript{23}, oil prices collapsed by 6% on the day of announcement, and by 10% in the first 3 days. Thus the correct interpretation of inventories build-up is essential.

Oil inventories indeed may increase due to large amounts of redundant oil stored by producers, unable to find buyers in an oversupplied environment. Inventories may also rise if producers decide to speculate on oil prices, if they believe that oil prices are soon to rebound, when oversupply gets

\textsuperscript{22}Bloomberg, August 29, 2014. “Morgan Stanley Extends Diesel-Buying Spree Amid Supply Surge”.
\textsuperscript{23}IEA, Oil Market Report, February 9, 2016, Highlights.
corrected. In both cases, a view that large oil inventories reflect oversupply is justified. However, oil may be stored due to physical arbitrage transactions that exploit contango in the oil futures market, caused by rolling activity of bulky oil funds. If agents aren’t able to distinguish these mechanisms, build-up in oil inventories can be misinterpreted as a signal of oversupply and oil prices may remain low for a prolonged period of time or even continue to fall.

Of course, it is hard to estimate the full effect of incorrect beliefs on oil prices. However, one can estimate the direct effect of a build up of inventories on oil prices using even study approach, used in academic literature. One can observe reaction of prices to unexpected announced changes in oil inventories. In particular, unexpected build-up in inventories signals either weak demand or oversupply, and pushes prices downwards immediately after the announcement as agents process new piece of information. The response of oil prices over a short period of time after the announcement can be documented and related to the reaction to news. The most important announcement is done by the Energy Information Administration (EIA). When the EIA publishes weekly reports on oil inventories in the US, oil prices react quite noticeably. The EIA’s report is published every week at 10:30 am. Halova, Kurov and Kucher (2014) use intraday data on oil futures from 2003 to 2012 and document that 1% unexpected growth of total US stock of oil leads to a fall in oil prices by 1.06%. 24 Given that total US stock of oil increased by 25%, the results suggest, that the direct effect of oil inventories on oil prices may be quite large.

Conclusion  Rapid collapse of oil prices challenged market analysts to find a suitable explanation. But it was not until the beginning of 2015, when oil inventories started to grow and the market beliefs converged to the oversupply explanation. Huge oil inventories is basically the only convincing evidence of oversupply. In the paper, we provide empirical evidence against oversupply hypothesis, and show an alternative mechanism that explains build up in oil inventories. Therefore, oil prices have artificially remained too low for too long. And we believe that a mystery of how the price of oil dropped in half, has not been resolved and requires further research.

24Halova et al. (2014) analyze oil futures returns over a 15 min interval after the announcement. To measure the unexpected change in inventory, the Bloomberg consensus forecasts is used. Analysis of similar effects in the natural gas market is performed by Gay et al. (2009), and documents that 1% unexpected growth of gas inventories causes a fall in futures gas prices by 1%. Similar results are obtained by Chang, Daouk, and Wang(2009) and Ye and Karalin (2015). However, Halova et al. (2014) argue that the method that accounts for possible errors in measuring both actual growth of inventories, as well as predicted level of inventories, provides much stronger results: a fall of gas prices by almost 10%.