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Special Column on Coronavirus Crisis

Economic Impact of the Novel Coronavirus Outbreak on China Will Be Temporary*

By CHEN YULU*

The Chinese government is taking forceful prevention and control measures in response to the recent outbreak of the novel coronavirus, known as Covid-19. The contagion has exerted some downward pressure on China's economy, but it will not last long. Supported by a resilient economy and ample room for policy adjustments, the People's Bank of China expects a quick recovery after the outbreak is contained.

Growth is slowing down in the short run due to the epidemic. Transportation, tourism and offline shopping have borne the brunt. Medical care, online shopping and the internet sectors are more resilient. Consumption of non-essential goods will drop temporarily, but the long-term trend of increased and upgraded spending remains well on course. Some small and medium-sized enterprises are running at partial capacity but have continued paying wages and other expenses. They face cash flow pressures at the moment.

Although the financial markets experienced large-scale corrections when they reopened after the Spring Festival holiday, they have rebounded and stabilised.

The sound fundamentals of China's economy in the medium and long term remain unchanged. China has strong endogenous growth momentum that is supported by the growing service sector and by innovation-driven industrial upgrading. These underpinnings of high-quality growth will not reverse due to the epidemic.

Meanwhile, China has sufficient policy space to support steady economic growth. China is one of the few major economies in the world that have maintained normal monetary policy. Equipped with a rich policy toolkit, China is capable of coping with various uncertainties. Our experience with the 2003 SARS outbreak is very telling. Thanks to well-targeted provision of credit to epidemic control and other measures, China's economy rebounded quickly after the virus was brought under control.

This time, the Chinese government responded quickly to the outbreak of the coronavirus epidemic and introduced supportive policies, including fiscal and financial measures, which have helped contain the impact of the outbreak and stabilise economic growth.

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* Chen Yulu, Deputy Governor of the People's Bank of China.

The PBoC has strengthened countercyclical adjustments of monetary policy through open market operations. This has ensured reasonable and adequate levels of liquidity and helped to boost market confidence. The PBoC, with other financial regulators, rolled out 30 policy measures to support enterprises heavily affected by the epidemic, in particular small and micro ones, private enterprises and the manufacturing sector.

The central bank also provided Rmb300bn in special central bank lending to large banks and selected local banks in Hubei and other severely-hit provinces. It provides credit support at preferential interest rates to manufacturers of essential medical supplies and daily necessities. These policies have proved significantly effective. Many SMEs seriously affected by the epidemic were given access to new bank loans. Preferential loans to a rapidly-identified list of eligible enterprises are receiving fast-track approval. Financial regulators have also ensured the stable functioning of markets by ensuring the uninterrupted operation of financial infrastructure.

In general, the impact of the coronavirus outbreak on the Chinese economy will mainly be in the short run. With strong and effective measures taken by the Chinese government, the PBoC expects that the epidemic will gradually be brought under control, and economic growth will rebound to its potential output level.

As the postponed consumption and investment activities resume, the economy is expected to experience a compensatory recovery. The Chinese economy is expected to recover rapidly as it is supported by a restart of factories and inventory replenishment; the most likely scenario is a V-shaped curve, which means a decline in economic activities followed by a rapid recovery, with the total economic impact relatively contained.

The PBoC will continue to implement the financial policies designed to support epidemic prevention and control efforts, including strengthening countercyclical adjustment of monetary policy, adopting structural monetary policy instruments when necessary, and ensuring stable functioning of the financial markets, which we believe will provide necessary conditions for a post-epidemic economic recovery.

Upward Trajectory Will Continue *

By LIU YUANCHUN*

Past epidemics indicate novel coronavirus outbreak will only be temporary setback for the Chinese economy

While the novel coronavirus epidemic has produced unexpected shocks to the Chinese economy and society, the impacts are external, partial and temporary, and will not change the upward trajectory of the Chinese economy over the medium-or long-term.

In theory, the medium - to long-term trajectory of a country's development and production capacity are determined first and foremost by its capital stock and growth rate. China's tangible capital stock will not disappear as a result of the epidemic, nor will there be fundamental changes to the way in which it accumulates or its rate of renewal, as the rate of accumulation is determined by the national savings rate.

A country's development trajectory and production capacity are also determined by the labor force and human capital accumulation. While people are dying because of the virus, the mortality rate is extremely low, and since most of the people who have died from the illness in China have been old or ill, they were not actively employed, so the impacts on the labor force and human resource accumulation are only temporary. The biggest determinant of human capital is education, which will not be stopped by the epidemic.

The epidemic has also made us value technological progress and better resource allocation all the more, which is another determinant of a country's development trajectory.

There have been no cases in history in which an epidemic has caused the stagnation of a major economy or derailed its medium-to long-term development. Once an epidemic dies down, confidence and economic order can be restored quickly, and it will take about three months to get the economy back on track.

A case in point is the effect the 1918-1919 Spanish Influenza pandemic had on the United States, where although it claimed the lives of 675,000 people, it did not alter the upward trend of the US economy, which afterward soon approached its potential rate of growth. With a stronger economy and greater response capacity than the US in the early 20th century, China has also been seeing less impact and lower fatality rates from the coronavirus than the US from the flu pandemic.

In light of the above, the effect of the epidemic will be at most a dip in growth in the first and second quarters of this year, while the Chinese economy will still trend upward in the medium to long term. In fact, the Chinese economy is highly resilient; it will withstand the impact of the epidemic and bounce back in a relatively short time. It can overcome the current hardships and risks and get back on track.

With its institutional advantages, China has created growth miracles under ordinary circumstances, and the country is united in its efforts to beat the virus and restore normal socioeconomic order.

Economic policies have also been rolled out to calm expectations, recover and coordinate the production of critical supplies, support small-and medium-sized enterprises, stabilize the financial market and maintain order in the market.

China is already home to hundreds of trillions in fixed assets, a 900-million strong labor market, the largest in the world, and the biggest and one of the most highly diversified manufacturing sectors. It has the material conditions and production capability to win the war against the novel coronavirus and achieve economic recovery.

While many experts are predicting the impact of the epidemic to be in the trillions of yuan, it should not be forgotten that China spends 41 trillion yuan ($5.9 trillion) in aggregate retail consumption, 55 trillion yuan investing in fixed assets, and exports 31 trillion yuan worth of goods and services each year. The Chinese economy was already in an upward cycle that will not be derailed by the epidemic, which will only have temporary and limited impacts on supply and demand.

Additionally, successful economic restructuring in the past eight years has brought new paradigms and growth drivers, which have been playing a significant role in buffering the shocks of the epidemic. For example, the online economy and the wide use of the internet have kept the economy and society afloat throughout the outbreak.

The Chinese government also has strong macro-control capabilities, a wide array of tools and ample policy room, which alongside financial regulations have significantly improved the resilience of market entities. Currently, government debt is less than 60 percent in China, the fiscal deficit has not exceeded 3 percent in previous years, and the average weighted interest rate on loans remains around 5 percent. These provide the conditions for the Chinese government to take broad-based policies to stabilize employment, the financial sector, trade, foreign investment, investment and expectations. Meanwhile, the government has also been able to coordinate resource allocation in a way that keeps aggregate demand and supply growing at close to their respective potential rates through a combination of prudent monetary policies, active fiscal policies, as well as sector and regional planning.

Between the end of January and mid-February, the capacity utilization rate of critical materials grew from less than 30 percent to 70 percent, the financial sector bounced back on track from its previous slump, and the currency is trading at less than 7:1 against the US dollar, with market fears under control. With stable expectations, small and medium-sized enterprises no longer fear the potential loss of access to capital. Work has resumed on stalled projects. All of these point to the effectiveness of evidence-based responses and hedging policies.

Just as President Xi Jinping pointed out, the epidemic is an important test of our governance system and capability. The outbreak has provided a window to see the state of current governance and provided alerts to some shortcomings. It has shown the need for institutional reforms to increase the efficiency of resource allocation as well as the need to identify and empower new growth drivers. Successful reform will increase the potential rate and quality of growth.

6% Should Still Be Country's GDP Growth Target*

By Liu Jun*

Though the strong containment measures taken by China to combat the novel coronavirus outbreak have achieved tangible results, fresh cases outside the country have been escalating and there is still very little information about the disease development.

It has also been hard to quantify the overall impact of the epidemic due to the uncertainty of its severity and duration. Even more harder to predict is the overall impact on the economy. No wonder that the full year economic growth forecasts of various institutions are all pointing south, with China figuring prominently in their assumptions.

Over the last few years, China has been the main growth engine of the world economy, and any substantial slowdown in the country would send a chill globally. One example is the overly pessimistic response to China's 2019 GDP growth rate of 6.1 percent. Although it was the lowest reading since 1990, to remain above 6 percent while in the process of the economic restructuring is definitely a significant achievement for the world's second-largest economy.

Given the triple whammy effect of the economic restructuring, the Sino-US trade tension and the public health emergency, the projection for China's 2020 GDP growth is deeply immersed in pessimism. Many believe it is realistic to set the bar to below 6 percent for this year, or even halve it to around 3 percent for it to be acceptable.

Such a belief has been further reinforced by the disappointing economic data for the first two months of this year. Retail sales of consumer goods fell by 20.5 percent on a yearly basis, while the industrial value-added declined by 13.5 percent. However, there is still enough rationale to attest to the assumption that 6 percent should be the targeted GDP growth rate.

From a global perspective, China accounted for roughly 34 percent of the incremental global GDP from 2009 to 2018, or the biggest proportion, according to the International Monetary Fund. Even in 2019, with its 6.1 percent growth rate, China accounted for over 30 percent of the global economic growth. Hence, maintaining a sound growth speed in China would help stabilize the global economy that is currently mired in the deflation and the pandemic.

Further coupling of China's supply chains with the global system will enable China's deeper involvement and participation and thus can better mitigate recession risks. China-made products and China-built infrastructure with cheaper costs and higher efficiencies will steadily fill the gap between potential growth and the realized one, and reinvigorate consumption rapidly after the epidemic shocks.

From a domestic perspective, transforming China's economy from an export-oriented and investment-led model to a technology-and-innovation-driven one needs certain level of growth to prop up the giant sailing boat. The well-established manufacturing sector acts like a cash cow to keep the underlying economy going, and the upgrading of the economic model can't be fulfilled under the condition of a dramatic loss of speed. The growth momentum should be maintained to maintain the state of normalcy.

In fact, the influence of an epidemic or even a pandemic on GDP growth is at least mixed if the 2003 SARS outbreak can be of any reference. The 2003 GDP figures turned out to be 10 percent in spite of the SARS damage, which was higher than the 9.1 percent in 2002 and was about the same as the 10.1 percent in 2004.

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* This article first appeared on China Daily on March 27, 2020.
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The real driver for growth would be the demand derived from exports, investment and consumption, and the strong consumption rebound after the epidemic. A V-shaped recovery in the present case may sound a tad overoptimistic, but given the size of the economy, even a moderate bounce-back would still bring China close to its goal of 6 percent growth.

Moreover, the target of 6 percent has much more to do with the stabilized expectations, and it is the expectation that works as an indispensable element of the modern economy. In practice, the stable expectation of the economy has tremendous correlation with employment, capital expenditure investment, consumption and social wellness, in particular after an epidemic outbreak.

Without the trust derived from a stable expectation of the economy, how would the general public willingly spend on the future earning capability with confidence? The supply-side structural measures are directly linked to demand, and demand is hugely influenced by expectations. Hence, the firm commitment to the 6 percent growth rate can surely reinforce expectations, which is extremely needed at this critical juncture. This is not psychology, but behavioral economics.

Fortunately, China has abundant policy measures in its toolkit to pursue the GDP growth target. Fiscal measures include tax reductions, special bond issuances and designated expenditure on the novel coronavirus treatment and post-epidemic recovery. It would also include monetary measures like reducing commercial banks' reserve ratio and special central bank lending and interest rate cuts.

Since market economy has been the norm in China, the government as one of the market participants should not be hesitant to stimulate the economy as and when required. A market economy cannot function without a government and there would be no exceptions to the rule during the ongoing epidemic-prevention period.

No Reason for Undue Pessimism*

By ZHANG MING*

There is ample policy space to respond to the adverse impacts of the novel coronavirus outbreak on economic growth

While one should not overlook the potential shock to economic growth caused by the outbreak of the novel coronavirus, it would not be wise to predict doom and gloom either. What we need instead is a comprehensive view of the extent of the impact on growth.

A first takeaway of the coronavirus epidemic is that the most heavily affected sector over the short term is the service sector, especially transportation, tourism, hospitality, catering and the entertainment industries, given the fact that the outbreak took place during the Spring Festival holiday.

A second takeaway is that the Spring Festival holiday has been extended on a national basis because of the outbreak, which will dampen investment and export growth in February. Manufacturing, real estate and infrastructure construction will see slower investment growth as a result, which will hold back export-oriented industries as well.

A third takeaway is that the consumer price index may continue to grow at an accelerated rate on a year-on-year basis for longer than the year before, or take longer to fall back to its normal level as a result of the outbreak, which has impacted more than just economic growth. Additionally, the labor market may also suffer as a result of the outbreak, something that we must also take into account.

Undeniably, there are many similarities between this current outbreak and the severe acute respiratory syndrome (SARS) outbreak in 2002-03. This is the reason why many analysts have cautioned against excessive pessimism regarding the current situation given what happened in 2003. However, we must not turn a blind eye to the structural changes that have taken place at home and abroad between then and now.

The first change has been in the most important variable underlying China's long-term economic growth: its demography, which has undergone significant changes. For China, the demographic turning point happened around 2010, before which the labor force had been growing as a share of the population, generating demographic dividends. After 2010, the trend has reversed as the population has aged rapidly, and the potential growth rate has continued to decline as a result of shrinking demographic dividends.

The second change has been in external demand, which has become much more ineffective at driving growth at home. The high export growth in China we saw between 2002 and 2003 was the result of the rapid recovery as the global economy after the busting of the internet bubble, from which China was able to benefit as a member of the World Trade Organization, which it joined in late 2001.Exports currently contribute a much smaller share of growth as the Chinese economy has grown significantly in size since then. China's exports are also growing at a much slower pace than before as the global economy declines and the China-US trade conflict escalates. There is yet another factor worth mentioning: China can expect to see its trade surplus playing a reduced role in driving overall growth over the short term, as China commits to

increasing its imports of US goods by $200 billion between 2020 and 2021 in light of the signing of the recent trade deal.

Third, the Chinese economy now faces completely different systemic financial risks. When the Chinese banking sector struggled with bad loans around 1998, the government was able to shore up the balance sheets of the commercial banks and bring systemic financial risks under control by 2003 by issuing special government bonds, injecting capital into asset management companies in charge of non-performing assets, and taking over bad loans from commercial banks at book value, which were possible because the government entities were not highly leveraged back then. Currently, the country is still wrestling with systemic financial risks, as local governments are now highly indebted, small- and medium-sized commercial banks are struggling with potentially significant default risks, and the real estate sector is going through a critical period on its path toward stabilization.

In other words, given the current state of the economy, we are currently facing higher downward pressures in growth as well as risk control and prevention compared to the SARS outbreak. This is the reason why we cannot simply copy and paste the lessons from 17 years ago, and we must steer clear of excessive optimism on the impacts of the coronavirus outbreak on the Chinese economy.

Having said that, there is no reason to go to the other extreme either. The Chinese government has robust governance capacity, and ample policy space to respond to the adverse impacts of the epidemic on economic growth.

First, with the SARS lessons in mind, the government took timely and correct measures this time around, a fact recognized globally. This means that the negative impact of the outbreak will be limited as the government will bring the outbreak under control.

Second, there is high likelihood that the Chinese government will respond with even more expansive countercyclical macroeconomic policies. On the fiscal front, the central government still has ample policy space and can be expected to counter downward pressures on the economy by committing more fiscal resources to public health, worker reskilling and easing the tax burden on companies.

Additionally, there is little risk of the Chinese government overreacting, as it must keep systemic financial risks under control. For example, it is extremely unlikely that the measures aimed at financial institutions such as deleveraging, risk management, and robust regulatory measures will be dialed back completely, nor are there likely to be major reversals in the adjustment measures in the real estate sector (especially those undertaken in major cities). When it comes to macro policies, another enormous stimulus package is also unlikely.

In conclusion, growth in China this year is unlikely to fall off a cliff even in the face of the adverse impacts of the novel coronavirus.

Waging War on COVID-19*

By ANDREW SHENG AND XIAO GENG*

Like any war, the fight against COVID-19 will disproportionately hurt those who were already vulnerable. Unless countries can move past destructive nationalism and petty competition in order to engage in constructive cooperation, millions will suffer, both physically and economically.

The world is at war. The enemy is resilient, ruthless, and unpredictable, with no regard for race, nationality, ideology, or wealth. Already, it has killed more than 26,000 people and infected over 560,000, from ordinary workers to the United Kingdom's prime minister and crown prince. It has halted economies, overwhelmed health-care systems, and forced hundreds of millions to remain confined to their homes. And it will not back down.

Unlike a conventional war, the COVID-19 pandemic is not a choice or a competition. No ceasefire can be reached, no treaty signed. And, with no known vaccine or effective cure, the world has few weapons with which to fight it. The only way to restore peace – or, at the very least, stave off systemic failure until a more effective weapon is developed – is with a whole-of-government, whole-of-society, whole-of-world approach.

The most urgent imperative is to ensure that the frontline is not overwhelmed. As an Imperial College study showed, the best way to do that is through early and resolute social distancing: keeping people away from one another in order to slow down transmission. This replaces a steep, exponential "pandemic peaking curve" of infection with a "flattened" curve, in which severe cases do not exceed the health-care system's capacity.

That is not what happened in Wuhan, China, where the virus first emerged. With authorities unaware of COVID-19's pathology or potential, they had to play catch-up – a delay that probably increased total fatalities. Nor is it what happened in Italy, where the health system quickly became overwhelmed, and the number of fatalities now exceeds twice that of China.

The lesson is clear: governments must urgently implement lockdown measures. China and Italy have both done so (though China's more draconian measures – together with other actions, such as building designated COVID-19 hospitals, and demographic factors – have proved more effective.)

Yet, while such action is vital to protect public health, it puts severe stress on the economy. The longer the lockdown persists, the greater the likelihood of large-scale unemployment, collapsing demand, and recession, especially given the prevalence of longstanding global asset bubbles supported by zero or negative interest rates.

The "just-in-time" global economy cannot survive more than two months of lockdown before its "Minsky moment" – when investors start panic selling, a boom becomes a crash, and a bubble goes bust. Already, Western stock markets have plummeted. In the United States, the Dow Jones Industrial Average, even with its recent uptick, is on track for its worst month since the Great Depression.

Though China's stock market has so far endured the lockdown without a sharp decline, largely because it had already suffered from the trade war with the US, vast amounts of wealth have been destroyed. During the first two months of 2020, China's industrial value-added for large and medium-size enterprises declined by 13.5% year on year; urban investment on fixed assets plummeted by 24.5%; and total retail sales dropped 20.5%. In December 2019, by contrast, all three had grown – by 6.9%, 5.4%, and 8%, respectively.

The lesson is clear: While lockdowns are essential, so is strong action to revive production and consumption. In the short term, this can mean active monetary and fiscal policy. But such measures have only limited potential. Even the US Federal Reserve's rapid move to cut interest rates and promise to pump trillions of dollars failed to stem the stock-market decline.

Fiscal measures could have a stronger impact. Indeed, it was the congressional approval of an unprecedented $2 trillion economic-stabilization package – which includes direct payments to taxpayers, unemployment benefits, and a $500 billion fund to assist businesses – that halted the US stock market's decline. But even that can do only so much in the event of a protracted lockdown.

Most workers and businesses hold limited cash reserves. A recent Brookings study showed that 44% of Americans are low-wage hourly workers, and a 2019 Fed survey suggested that 40% of American adults wouldn't be able to cover an unexpected $400 expense with cash, savings, or a credit-card charge that could be repaid quickly.

In the European Union, 22.4% of the population – 112.8 million people – lived in households at risk of poverty or social exclusion in 2017. These people cannot afford to have their incomes interrupted for long. And, because many of them perform jobs that cannot be done remotely, a protracted lockdown would do just that.

That is all the more likely, because many of their employers would not be able to continue paying them. JP Morgan estimates that the median cash buffer is 16 days for restaurants, 19 days for retail stores, 27 days for all small business, 33 days for high-tech services, and 47 days for real-estate companies.

The International Labor Organization forecasts anywhere from 5.3 million to 24.7 million lost jobs due to the pandemic. (The 2008 crisis increased global unemployment by 22 million.) In the US alone, 3.3 million people filed for unemployment benefits last week, one third more than the Goldman Sachs estimate of 2.25 million.

Yet there is little reason to expect the pandemic to come to a quick and decisive end. According to the Imperial College, even if the peak is reached soon, reverse waves of smaller outbreaks could require repeated lockdowns, until an effective vaccine is developed, tested, manufactured, and distributed widely – a process that will take a minimum of 12-18 months.

The world has only one hope of offsetting the consequences of periodic economic shutdowns during this period: cooperation. That includes both coordinated economic policies and the free exchange of knowledge and data.

Like any war, the fight against COVID-19 will disproportionately hurt those who were already vulnerable. Unless countries can move past destructive nationalism and petty competition – such as US President Donald Trump's insistence on calling COVID-19 the "Chinese virus" – millions will suffer. The resulting anger could push the world toward conventional conflict, causing even more destruction and suffering.

Pandemics, like wars, are not about who is right, but who is left. We need a global alliance for victory.

Crisis Management: Health Crisis and Financial Crisis

Compared

By HERBERT POENISCH*

Any crisis calls for sound management. This consists of preparation, risk monitoring, such as early warning indicators, benchmarks and triggers, designation of appropriate authorities, preparedness, decision making as well as taking the appropriate measures. Simulation exercises of crises help to sharpen the preparedness of vital agents.

As many countries were caught off guard by the recent COVID19 crisis, they reacted to the crisis without any roadmap available. They most likely had done some contingency planning as recommended by the WHO[1]. The numerous detailed recommendations by the WHO for countries, such as technical guidance, country-level coordination, planning monitoring, surveillance, rapid response teams, case investigations, critical preparedness, readiness and response actions for COVID19[2] serve as recommendation, but it is left up to countries to adopt their own models of management, some stricter some more relaxed. Countries are learning day by day and measures are converging. The emerging best practice is a stricter regime with lockdowns and surveillance.

The purpose of this article is to map out what different authorities dealing with these crises can learn from each other. Firstly, what are the differences and the common elements of health and financial crises. Secondly, what should be common elements for general guidelines of crisis management of both, health and financial crises. Finally what kind of financial crisis can we expect once the health crisis subsides? How might it differ from the global financial crises we have seen so far?

1. Health and finance global aspects compared

While there are clear differences between the two, there are also important commonalities. Health is of paramount importance, because the alternative, with a certain probability could be death. While a financial crisis is not life threatening, it is of paramount importance, as it impairs the prospect of physical survival for a large swathe of the population. This is not the decline of financial markets or slowdown in economic growth but the damage caused by loss of jobs, loss of income and spread of poverty, such as through deflation and inflation. The world is facing such a financial crisis once the health crisis runs its course.

For the emergence of an epidemic it is important to understand the 'epidemic triangle'. It postulates that every outbreak, regardless of its specific traits is dependent on the interplay between three factors: (i) the pathogen (the agent causing infection); (ii) the host (the organism at risk of infection); and (iii) the environment (the setting where the infections occur). Every single epidemic..is the result of a dynamic shift in one of these points of the epidemic triangle, which then causes a domino effect leading to a sudden explosion of new cases[3]. While the application in health is self-evident, in the GFC a small trigger in the CDO markets, accounting

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* Herbert Poenisch, member of IMI International Committee, former BIS senior economist
1 WHO (2018): Guidance for contingency planning www.who.int
2 WHO (2020): Technical guidance & global research www.who.int
3 Werb, Dan (2020): To understand coronavirus, look to the epidemic triangle. In: NYT 4.2.2020

to less than 1% of the aggregate financial markets caused contagion in other financial sectors, first and foremost the interbank market, and others to follow. The spread of a computer virus is another illustration of this theory.

Our health risks are linked with those surrounding us, who might infect us. Thus spread and exponential contamination are the biggest risks presently. Our financial safety is affected by those who provide our finance, our source of income, our payments, our store of value. Guaranteeing health and financial safety are the basic functions of a state. It can be subsumed under 'taking care of the well-being of the population'. What happens, if the state itself is at risk, in health terms when overwhelmed by an epidemic, such as recently in Hubei, Iran and Europe. In financial terms, the country would be threatened by bankruptcy? In these cases the guarantors, become unable to guarantee us basic safety. The Great Depression of 1929 and 1930 showed the default of banks was followed by the central bank, followed by the ministry of finance and finally the country.

The interlinkedness of health is clear as we can measure the number of personal interactions every day. Modern technologies allow precise monitoring of these through mobile phones, internet, AI[4]. The interlinkedness of finance can also be measured. Who pays us how much income, how much do we need to pay to others to provide us for basic services, such as food, water, shelter and an increasing array of other basic needs, such as electricity and transport. Finally, who looks after our savings, assuming we do not hoard under the mattress. There are umpteen examples when lifetime savings have been wiped out by inflation, default of the country and others. This drove individuals to desperation, obviously not as bad as a threat to one's health.

These links not only work domestically but increasingly internationally. As people move internationally, spreading health risks across borders is the natural result. Contagion has become the buzzword in the recent pandemic. Equally, financial crises spread across borders because financial agents provide services across borders. The survival of one bank depends on the trusts from other banks to participate in the interbank market. Each country depends on the trust it enjoys from the international community. In the worst case it can be isolated from the others. In case of spread of an epidemic, citizens of a country are confined within their borders, either national, regional, or local. In case of finance, when livelihood cannot be guaranteed people will flee their country as we are witnessing at present with waves of refugees.

Finance affects not only the personal well being but also that of the kin. While health is provided by nature, financial safety is provided by human agreement based on trust. However, trust is usually based on trust in authorities through legal agreements but is ultimately given by nature. Its function is binary, on or off, thus resembling life or death. Once trust is lost we are left on our own. In the ultimate case, nobody can guarantee financial safety in case of a general loss of confidence[5]. We are constantly revising our profile of confidence, just like measuring our state of health.

Within the responsibilities of a state, guaranteeing the health of the population and guaranteeing the financial survival are the key postulates. Over the past years, governments have prepared contingency plans for black swan[6] and grey rhinoceros events in both domains. They have been refined to what resembles business continuity plans (see2 below) and tested in stress testing exercises or simulations. However, they have been challenged and largely overwhelmed by reality as the crises unfold.

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[4] The WHO praised China's use of technology to get on top of the recent epidemic.

[5] We return to the discussion whether the economy and in particular finance have been disembedded from society through concentration on markets and commoditization: see Karl Polyani, The Great Transformation Introduction by Fred Block.

[6] Nassim Nicholas Taleeb (2007): The Black Swan. The impact of the highly improbable. Random House (US) and Allen Lane (UK).

As the international community is aware of the contagion of health and financial crises, various international bodies have been given the mandate to address such crises on a regional (such as the EU Health Council, the EU Health Committee, the European Central Bank) or even global level (such as the World Health Organisation, the International Monetary Fund). Contingency plans recommendations have been drawn up, simulation exercises run, as well as the necessary coordination has been tested.

However, international bodies are at the behest of major countries in taking the leading roles. Recent examples have demonstrated the subsidiary role of the international organisations, such as the WHO and IMF to impose necessary steps. In the COVID19 crisis it was China at the core of the outbreak and in the Global Finance Crisis of 2008 it was the US Treasury and Federal Reserve which took on the leading role, fixing the domestic crisis first and trusting that other countries would follow by taking the appropriate measures. The international organisations play their role as advisory bodies. They can recommend best practices, such as contingency planning and share lessons learned from the past, but they cannot force countries to comply. As a result the current crisis has exposed the underlying weaknesses in national economies, health systems and even political leadership[7].

A lot has been gained by learning lessons from recent crises. In the health domain this was SARS, Ebola, H1N1 and MERS. In the financial domain this was the Global Financial Crisis (GFC), the Asian Financial Crisis (AFC) as well as other national financial turmoil. Within months, SARS was brought under control by international cooperation and strict public health measures such as isolation, quarantine and contact tracing. Territories and countries which experienced SARS, such as HK and Singapore are better prepared for the present crisis as they have necessary facilities and expertise in place.

The major epidemic was the Spanish flu 100 years ago. It was the global spread of a virus within living memory of people. The most prominent factor of the epidemic triangle was (iii) the environment, as soldiers moved between countries in the worst sanitary environment. Then the world did not have the tools to diagnose diseases nor antibiotics to fight secondary infections. Thus it became the worst epidemic in living memory. In the meantime, science and technology have progressed in leaps and bounds.

Notwithstanding the fact that a considerable amount has been learnt about crisis management from past experiences, lessons from the past seem to be amiss in terms of guiding future directions, so the risk of repeating mistakes arises[8].

2. Handbook for crisis management

Substantive theoretical work[9] has been done on a general framework and organisations, such as the International Standards Organisation have published manuals (such as ISO standard 22301)[10]. Some countries have propagated their standards as international standards. The 2014 British standard for crisis management (BS11200) is a case in point.

ISO22301 specifies requirements to plan, establish, implement, operate, monitor, review, maintain and continually improve a documented management system to protect against, reduce the likelihood of occurrence, prepare for, respond to, and recover from disruptive incidents when they arise.

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[7] Raghuram G Rajan (2020): The Pandemic Stress Test. In: Project Syndicate, 13 March www.project-syndicate.org
[8] Singh, Dalvinder and LaBrosse, John Raymond (2012): Developing a Framework for Effective Crisis Management. In: Financial Market Trends, Vol2011-issue2 www.oecd.org
[9] The list of references in the thesis by Holmgren, Fredrik and Johansson, Karl-Rikard (2015): Crisis Management at Jonkoping University p 79ff is very useful.
[10] ISO (2019): Business Continuity ISO 22301 www.iso.org

BS11200 standard[11] defines crisis as an abnormal and unsustainable situation that threatens the organisation's strategic objectives, reputation or viability, and summarises the key distinctions that make a crisis, as well as suggesting some potential origins and implications. It then makes some recommendations for successful crisis management. Guidance is provided for building a crisis management capability, and also covers aspects such as crisis leadership, decision-making, crisis communication; and training and exercising…One of their main tasks is to detect and treat diseases before they become emergencies.

A simple generic list of tasks has been prepared by nyarisk, a private company. For building capability and organization should follow[12]:

1) Assessment: This should be based on a series of early warning indicators which have been relevant is past crisis. If early warning indicators have proven to be robust in past crises, these should be adopted for monitoring and assessment.

2) Identification: If a number of signals indicates the build-up of a crisis, the experts, such as doctors in the health domain and financial analysts in the financial domain should send the appropriate messages to their superiors. In the recent COVID19 crisis Dr Li Wenliang and his colleagues in Wuhan warned about an emerging new illness. Before the GFC traders at the major merchant banks as well as academics warned about the risks in the CDO market. At that stage it remains among the restricted circles of experts and their authorities, in China including the regional branch of the CPC. In the case of the GFC CEO of banks were informed who preferred the opinion of statisticians that the risk was within the parameters stipulated by internal rules.

3) Triggers: Once the signals reach certain thresholds, such as critical number of patients with the same symptoms, financial indicators exceeding long-term thresholds, this information should be monitored frequently and communicated by the superiors of doctors and hospitals in the health domain, or CEOs of big financial institutions to the restricted circle of authorities such as regional health authorities, central banks and ministries of finance to avoid panic among the population at large.

4) Identify stakeholders: The dedicated authorities communicate this warning to the national political authorities without delay. They identify stakeholders who should be involved in the remedial action. They will be the ones who have the expertise and authority to take actions. In the US these are the Federal Health Department, with the Secretary of Health as member of the Cabinet. It also includes the Surgeon General, who acts as an advisor to the Secretary. It also includes the Centres for Disease Control (CDC), the National Institutes of Health, the Food and Drug Administration, the Health Resources and Services Administration, the Drug Abuse, and Mental Health Administration, the Agency for Toxic Substances. In addition the Vice-President has been put in charge of fighting COVID19. In the global financial crisis GFC, these were the US Treasury and the Federal Reserve.

5) Team building: The various stakeholders need to cooperate, using their special expertise for the common good. Coordination of the various stakeholders is of paramount importance to avoid chaos.

6) Recognition: As the authorities recognize that there is a crisis at hand, each stakeholder prepares appropriate measures. A steering committee or person in charge, is put in place which is aware of the capabilities of each participant and able to take the necessary decisions in a timely fashion. On this point, the WHO deplored the 'inactivity of

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[11] British Standards Institution (BSI) (2014): Crisis Management. BIS 11200 www.bsigroup.com
[12] Crisis Management and Response (2020): www.nyarisk.com

authorities' during this stage in the current crisis. The US is a case in point when it failed in three vital areas to respond to the threat[13].

7) Coordination: The steering committee assigns tasks to each of the stakeholders, not only experts but also support services, such as the security services and communication with the population. At present the spread of fake news causing panics is a major risk. There is a need for sequencing, as eg lack of testing equipment has hampered taking further steps. In finance lack of precise data, such as mutual exposure in the interbank market had a similar effect.

8) Measures: Each stakeholder decides on the dosage and timing of measures. The proposed measures have to be verified by the availability of necessary equipment and funds. China proved very flexible by building a dedicated hospital once the existing facilities were deemed as inadequate.

9) Monitoring of progress: as measures are implemented progress should be monitored and communicated first among the stakeholders and then to the population at large. Regular reporting of statistics is imperative.

10) Accountability: each of the stakeholders is accountable to the steering committee for implementing the measures, reporting difficulties in implementation and suggesting ways to improve.

This whole framework should be available to various stakeholders through training in normal times as well extended testing. In the financial sphere stress testing of institutions is a case in point. The ECB is conducting crisis scenarios on a regular basis. All tests with viruses in a controlled environment by hospitals and tests of medicines by the major pharmaceutical companies would be the same prophylactic measures in the health domain.

3. Will the next financial crisis be different?

The financial research bodies have never shied away from calling their research "Managing the next financial crisis"[14]. While preventing crises is of utmost importance, in the health domain as well as in the financial sphere, realists point out that it is only a matter of time until a major crisis breaks out in health as well as in the financial domain. While it may not be possible to avoid a financial crisis (and health crisis: author), it will certainly be possible to enhance the management of the crisis to minimize its costs on the financial system and the economy[15]. However, nobody has foreseen a health crisis on a global scale as the present one and financial authorities have not been prepared for the financial fallout, possibly a financial collapse on such a scale.

There are two reasons for this reoccurrence: one is that one crisis, such as the health crisis will most likely lead to another and secondly crisis management needs more attention so that lessons learned can be incorporated into improved techniques to minimize the effects of catastrophic events.

Traditional financial crisis planning was based on 'grey rhinoceros' theory, where we know the components and the linkages. These were either balance of payment crises followed by exchange rate turbulence or banking crises, where some or a number of institutions experience illiquidity or solvency crises and debt crises, where economic agents or even governments are over indebted[16].

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13 Daily Kos (2020): Trump administration response to coronavirus 'a perfect storm of three failures' 19 March www.dailykos.com

14 Group of Thirty G30 (2018): Managing the next financial crisis. An assessment of emergency arrangements in major economies, September www.group30.org

15 Zeti Akhtar Aziz (2014): Managing Financial Crisis in an Interconnected World: Anticipating the Mega Tidal Waves. Per Jacobsson Foundation Lecture, June www.bis.org/speeches

16 See table of IMF pre-crisis indicators in Claessens, Stijn, Pazarbasioglu, Ceyla, Laeven, Luc, Dobler, Marc, Valencia, Fabian, Nedelescu, Oana, Seal, Katharine (2011): Crisis management: early lessons from the financial crisis. In: IMF Discussion Note SDN/11/05 www.imf.org/publications

In managing a financial crisis in today's world, an appreciation of the increased interconnectivity in the financial system and the intensification of its internationalization (globalization) has become vital. We are witnessing a transmission of systemic risks throughout the financial system and across borders[17]. This corresponds to pillar (iii) of the epidemic triangle.

Previously institutions, markets and governments were at the epicenter of the crises. Even the global financial crisis (GFC) originated in the CDO market, and spread from there to other markets (such as the interbank market) and institutions (such as insurances and foreign banks which bought CDOs) due to the interconnectivity and internationalization.

In the financial crisis to follow the present health crisis the scenario will be completely different. It will be neither institutions, nor markets, nor governments to show the first signs of stress. The attitude of the US White House and the performance of the stock markets in the run up to the pandemic are a case in point.   The stress has already appeared below the radar screen. The first shock was a shock to production, owing to the disrupted global supply chains[18]. The second shock is to demand[19]. It is foremost individuals, households and small and medium enterprises which feel the financial pain as they are deprived of income, such as airline crews, hotel staff and many others who have been asked to take unpaid leave of absence. It has been equally dramatic for the mostly small enterprises such as restaurants, hotels, hairdressers, tour operators, small retails shops, local suppliers, organisers of cultural and sports events who had to cancel events. Their livelihoods have been disrupted by quarantines and social-distancing as well as widespread lockdowns.

They are running down their savings, if any, but find their chance of financial survival critically impaired. Like dominoes, the next ones to feel the pain will be the local financial institutions and those who have extended consumer credit, such as mortgage institutions. One of the measures adopted in China was the delay of repaying debts, which helps only partially as the loss of income caused the major pain.

Major businesses will be unequally affected such as the tourism industry, mostly the airlines, hotels and tour operators. Others experience a boom, such as medical suppliers, undertakers etc. Reports already talk of a cull of airlines which were financially weak before the onset of the health crisis. Looming defaults by highly leveraged entities, such as shale-energy producers in the US and commodity-dependent EME could lead to wider losses in the global financial system[20].

The existing crisis manuals of the authorities in charge of financial stability provide necessary but insufficient guidance for policy makers. The US Federal Reserve (FED) states that adequate monetary policy, sound regulation and supervision and providing payment services help maintain the stability of the financial system. It adds that during periods of acute financial strain, these activities may not be sufficient. When the financial system is experiencing great shocks, the FED is equipped to take extraordinary action to keep disruptions spreading from the financial sector from spilling over to the broader economy. Specifically the Fed is prepared to provide liquidity, ie emergency access to cash to financial markets and institutions, performing its 'lender of last resort' function[21].

In the case of the ECB crisis preparation focuses on the systemic risk by safeguarding financial stability. This includes enhancements of legislative initiatives, regulation and supervision, agreements on voluntary cooperation between responsible authorities, and the

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[17] Zeti Akhtar Aziz, ibid p 3.
[18] Azusa Kawakami (2020): Shutdown ripples across supply chains in coronavirus domino effect. In: Nikkei Asian Review, 27 March www.asia.nikkei.com
[19] Raghuram G Rajan (2020): ibid
[20] Raghuram G Rajan (2020): ibid
[21] Federal Reserve Bank of San Francisco (2020): What is the FED: Financial Stability. Education www.frbsf.org

development of practical arrangements such as the organsiation of crisis simulation exercises[22]. Emergency liquidity assistance (ELA) is provided outside the normal Eurosystem monetary policy operations. The ELA aims to provide central bank money to solvent financial institutions that are facing temporary liquidity problems[23].

In case of China, the Peoples Bank of China (PBOC) under the leadership of the Financial Stability and Development Committee (FSDC) of the State Council, worked with other related government agencies and deployed differentiated policies to address in a well-targeted and timely manner key risks that threaten financial stability. The PBOC improved the regulatory framework by announcing guidelines on the regulation of systemically important financial institutions…The accumulation of financial risk over the past few years has been gradually eased, and explicit financial risks have been addressed in an orderly way. The bottom line is preventing systemic financial risk and maximally protect the legitimate rights and interests of the people[24]. Regarding liquidity, the PBOC is prepared to pump a total of RMB 1.2tr into financial markets to cushion the fallout from the health crisis[25].

These are examples of the classical provision for financial stability and emergency liquidity. The financial stability provisions include risk monitoring, improved legal framework and coordination. The emergency liquidity provisions stipulate the trigger for such measures and who is eligible for this support under what conditions. This framework will be challenged by the evolving financial crisis following the COVID19 outbreak in the following way.

For tackling the financial fallout from the crisis, three ways have been suggested: (i) increase the government debt-to-GDP ratio; (ii) central banks substantially to expand the monetary base (iii) compensation for business and workers directly from the central bank without intermediation[26].

All these provisions are based on functioning financial institutions and markets. As long as this is assured, well regulated and supervised solvent institutions will receive this support and decide how to distribute the funds to the most needy. In the GFC the major financial institutions received liquidity support of close to USD 800 bn to stay afloat but this did not trickle down to the economy as banks fixed their balance sheets and reduced lending to the real economy. The result was slow economic recovery from the GFC as economic agents recovered by themselves without adequate liquidity support from the central banks.

In present circumstances these emergency measures are most likely to have the same effect. They have not alleviated the plight of the individuals, households and small and medium enterprises. They might have had access to some support but far short of what they need. They need cash injections to survive let alone reviving their businesses once the COVID19 subsides.

The traditional link through financial institutions and markets has to be broken as they merely helped themselves. Government authorities should prioritise employment. The lessons from the Great Depression should be heeded. Job losses have to be minimised and the continuity of pay as staff take leave has to be assured. Employers, big ones as well as medium and small enterprises have to be supplied with sufficient liquidity. Funds have to be released from the central banks and the ministries of finance directly to these enterprises and the people. The US idea of helicopter money addresses this issue but the amounts could be inadequate as the crisis deepens. Additional help from tax relief and rescheduled debt repayment, such as mortgages will be supplementary help. The bottom line should be 'whatever it takes' to ensure the financial survival of population.

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[22] ECB(2006): The EU arrangements for financial crisis management. In: ECB Financial Stability Review, Dec www.ecb.europa.eu
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[24] Peoples Bank of China (2019): China Financial Stability Report December www.pbc.gov.cn
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[26] Kaletsky, Anatole (2020): Averting economic disaster is the easy part. In: Project Syndicate 19.03 www.project-syndicate.org

Conclusion

While good preparation for crises in both, the health sector as well as the financial sphere have been necessary, such as early warning indicators and alerts, coordination of responses and good management, this crisis has spun out of control. Governments around the world are scrambling to contain the pandemic and the financial fallout. It is time to move beyond the rulebook and take practical measures, such as a pilot has to cast aside procedures in favour of quick actions. In the health domain, the head of WHO recommends testing, testing, testing of people affected and in the financial domain the response should be liquidity, liquidity, liquidity to those in need.

Reflecting the global character of the crisis, global cooperation is called for on an unprecedented scale. This agenda includes (i) knowledge-sharing; (ii) economic intervention; (iii) abandonment of false binaries, such as capitalism versus socialism or state versus market[27]. Sadly, however there are no signs of this happening as countries close borders and resolve problems on a national basis. Leadership from the G20 or even from G3 has not been forthcoming. Perhaps a new world order will emerge.

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Corona is More Than a Health Disaster – It's a Human Calamity

By PETER KOENING*

The New York Times of March 20, asks rhetorically – "*Is Our Fight Against Coronavirus Worse Than the Disease?*"

The coronavirus, known as COVID-19 – was declared a pandemic by WHO's Director General, Dr. Tedros on 30 January 2020, when outside of China there were only 150 WHO-registered infections. This declaration as a pandemic – nowhere justified – has devastating effects on the entire world population and the world's socioeconomic fabric. The globe is literally on lock-down, until – who knows – but the latest date put forward by President Trump is 12 April 2020. It can almost be taken for granted that the date will have global validity. The world at large dances to the tune of the United States.

Some ten days ago, Mr. Trump declared, that this "situation" is enough and that it is time to get the economy working again. He is a business man and knows best. He suggested March 30 for going back to work. He then must have gotten instructions from his higher-ups, that more time was needed – this is just my guess – to prepare whatever sinister plan is in the making. So, he postponed by two weeks the "back-to-normal" day.

The coronavirus, COVID-19, has a catastrophic impact on the world, on the population, on the economy, and most importantly on the livelihoods of about a quarter of the world population, who are at the margin or below the level of vulnerability and precariousness. Without work, even occasional, hourly or daily work to make some money to buy food, these people are doomed – doomed to die from disease, famine or sheer neglect. Their disappearance will be unnoticed. They are the non-people.

This fake pandemic is imposed on almost every country of the 193 UN members. It is "fake", because when the pandemic was declared, as said before, there were only 150 cases outside of China, in a population of 6.4 billion people. This is by no stretch of imagination a pandemic. Noteworthy is, this decision was taken by the World Economic Forum (WEF) in Davos (21 – 24 January 2020), behind closed doors, by an entirely non-medical, but political body. Dr. Tedros, WHO's DG, who for the first time in WHO's history, is not a medical doctor, was present.

The short- medium- and long-term impact of this decision will be of a dimension that nobody can fathom at this time. It may bring a paradigm shift in our lives and society that mankind has never experienced in the last 200 years and beyond.

In Germany, scientists with integrity start moving, standing up against authority, telling them the facts. Dr. Sucharit Bhakdi, Professor Emeritus of Medical Microbiology at the Johannes Gutenberg University Mainz, sent an open letter to German Chancellor Angela Merkel, calling for urgent re-evaluation of the response to Covid-19, asking the Chancellor five crucial questions. This is the letter, dated 26 March 2020

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https://swprs.org/open-letter-from-professor-sucharit-bhakdi-to-german-chancellor-dr-angela-merkel/

What about China? You may ask. China is different. Virologists in Wuhan found out very early that what was originally called 2019-nCoV (renamed by WHO to COVID-19), was nothing else but a stronger mutation of the SARS virus that hit Hong Kong and China in 2002 / 2003 and which killed worldwide 774 people. Since the SARS virus was tailor-made for the Chinese genome, Chinese scientist knew that its new and stronger mutation was also focused on the Chinese DNA.

China also knew, since it was a lab-made virus, that it came from outside, probably from the US which is waging an economic war against China. A deadly virus may be an ideal -and invisible – tool to weaken China and her economy. Therefore, without a moment of hesitation, China declared as quarantine large areas of the country, and later proceeded to a complete lock-down. Thanks to this fast reaction by President Xi and the people's discipline, China is now in control of COVID-19 – and her economy is rapidly recovering.

It is like a global coup d'état, carried out by an invisible Deep Dark State – in certain select countries imposing curfew and even house arrest on everyone – not by guns or bombs, not by rolling tanks in the streets and an oppressive police force, but – by an invisible tiny-tiny enemy, a microscopic virus. Can you imagine! Its sheer genius. Controlling the world by – a virus. You have to give it them. The 0.01% has brought the 99.99 % to their knees – and begging, begging for mercy. Begging for vaccinations, ignorant of the cocktail of substances that this malignant dark force may want to inject into your body. *Please, please bring us vaccines.* People will run into the streets – when it is allowed again – offering their arms and bodies to anyone who comes with a syringe.

The injections may be nefarious agents that sterilize, that may bring long-term neurological damage – damages that may be passed on to future generations, DNA-manipulating proteins – life-reducing agents? Injections may also comprise an electronic nano-chip that keeps track of all personal data, from health records to bank accounts. At the stage of total despair, people are not interested. They want to get rid of fear and sleep again in peace at night.

This man-made outbreak of a pandemic is not new. Of course, it's never mentioned in the mainstream media, that the corona virus COVID-19 is laboratory-made (and so are SARS, MERS, H1N1 Swine Flu, Ebola, Zika and many more), and that outbreaks can be and are being targeted on specific populations. In fact, the infamous Plan for a New American Century (PNAC), which is still very much alive, in its update of 2000, mentions on p.60 – *that future wars may not be fought with conventional or nuclear weapons, but with invisible agents, biological weapons*, viruses which are more effective than conventional weapons and don't destroy infrastructure.

The new corona is the making of a bonanza for Big Pharma. It was planned for years, and patterned on the 2009 Swine Flu outbreak, or the H1N1 virus. It lasted for about a year – April 2009 to April 2010. According to the US Center for Disease Control and Prevention (CDC), the Swine flu killed about 12,500 people in the US, and caused worldwide about 300,000 deaths. Contrary to COVID-19, the vast majority, about 80%, of H1N1 infected people were under 65.

Then, like today, WHO declared a pandemic – green light for the pharma industry to race for the production of a vaccine. The Big Pharma promised they could produce 4.9 billion H1N1 vaccines – they delivered millions to governments – which by the time they arrived were no longer used, because the flu was over. The taxpayers paid billions in vain. Since the annual flu mutates from year to year, there was no use to keep the vaccines. What some governments did,

though – listen to this! – they sent them to Africa as development assistance, where the vaccines, of course, were equally useless.

Today, we are again confronted with a tireless 24 x 7 propaganda machine, dishing out fear and anxiety --- because of an invisible virus. An enemy that cannot be seen by the population. An enemy that cannot be followed, for example, how it spreads, or doesn't spread. An enemy that the people just have to believe the authorities exists. How clever! Propaganda and fear are enough to dominate within a few weeks the entire world population.

For example, a new Oxford University Study concluded that COVID-19 most likely exists in the UK since January 2020, and that in the meantime about half of the British population has been infected, and is, thereby, immunized against the virus. Most people have none or only mild symptoms. This would mean that only about 1 out of 1,000 infected people needs to be hospitalized, this corresponds to the common flu or less. Here the study https://www.medrxiv.org/content/10.1101/2020.03.24.20042291v1.

An American physician and the founding director of the Yale University Prevention Research Center, Dr. David Katz, says:

"*I am deeply concerned that the social, economic and public health consequences of this near-total meltdown of normal life — schools and businesses closed, gatherings banned — will be long-lasting and calamitous, possibly graver than the direct toll of the virus itself. The stock market will bounce back in time, but many businesses never will. The unemployment, impoverishment and despair likely to result will be public health scourges of the first order*."

Nobody of those who hyped-up the pandemic-panic seems to have a clear view of the Big Picture. Government officials around the world are co-opted. They follow orders. They know they must. Or else. This is an important step to bring about this gigantic societal paradigm change for the New World Order (NOW) to reign. It involves a shift or enormous sums of resources over time, in the quadrillions, perhaps quintillions – are being moved from the common people to a small elite, or "Dark Deep State", for lack of another term.

Key Organization Implementing the Dark State's Destructive Endeavor

There is a little-known agency, called **Agenda ID2020** which is behind implementing the Dark Deep State's agenda. – The infamous Agenda ID2020 is a public-private partnership, including UN agencies and civil society. Key partners include the Bill and Melinda Gates Foundation (co-founder), the Rockefeller Foundation (co-founder), Gavi, the Vaccine Alliance that "*brings together public and private sectors with the shared goal of creating equal access to new and underused vaccines for children living in the world's poorest countries*"; Accenture, A global management consulting and professional services firm; and IDEO.Org, an international consulting firm, "*to design products, services, and experiences to improve the lives of people in poor and vulnerable communities*."

Agenda ID2020's principal objective is implementing an electronic ID program that uses generalized vaccination as a platform for digital identity. In May 2016, at the impulse of the Bill and Melinda Gates Foundation, the United Nations Office for Partnership (UNOFP) organized an international Summit in New York to create Agenda ID2020. According to the Summit's own website, *Agenda ID2020* is a strategic, global initiative launched in response to the Sustainable Development Goal 16.9: "*Provide legal identity to all, including birth registration, by 2030 …. harnessing Digital Identity for the Global Community…. Around one-fifth of the world's population (1.8 billion people) is without legal identity, which deprives them of access to healthcare, schools, shelter.*"

The **Sustainable Development Goals (SDG) 16** is to "Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels." To implement and justify this objective, the vaccination king, Bill Gates, needed a special sub-goal, No.16.9 – see above.

Agenda ID2020 is closely linked to **GAVI**, the *Global Alliance for Vaccines and Immunization* – also a Bill Gates creation. Gavi identifies itself on its website as a global health partnership of public and private sector organizations dedicated to "immunization for all". GAVI is supported by WHO, and needless to say, its main partners and sponsors are the pharma-industry.

The ID2020 Alliance at their 2019 Summit, entitled "*Rising to the Good ID Challenge*", in September 2019 in New York, decided to roll out their program in 2020, a decision confirmed by the WEF in January 2020 in Davos.

Curiously, on October 18, 2020, The Gates Foundation, WEF and the john Hopkins Institute for Public Health sponsored **Event 201** in New York City. Essentially, Event 201 focused on simulating a worldwide epidemic, which was coincidentally based on the SARS outbreak and called 2019-nCoV, the name first given to the outbreak in China, before WHO changed it to a more generic form, COVID-19.

The simulation resulted over an 18-month period in 65 million deaths worldwide, a stock market dive of 15%-plus and countless bankruptcies and unemployment. Just a few weeks later, the first 2019-nCoV infected person was identified in Wuhan. Coincidence?

Is it also just a coincidence that ID2020 is being rolled out at the onset of what WHO calls a Pandemic? – Or is a pandemic needed to 'roll out' the multiple devastating programs of ID2020? – See also https://www.globalresearch.ca/coronavirus-causes-effects-real-danger-agenda-id2020/5706153.

After three months of the outbreak, and only two weeks of complete world lock-down, we can already see signs of disastrous obliteration as the stock market dove at least 30%, wiping out savings of small investors, bringing about bankruptcies of millions and millions of small and medium-sized enterprises around the globe, creating unemployment of biblical proportions, untold misery, poverty   famine - and deaths – by starvation, rooflessness, despair, absence of health care – and ultimately suicide.

The New York Times reports on 27 March, more than *3.3 million new claims for unemployment benefits, in an economy that is coming apart.* President Trump on 27 March signed a bill for US$ 2 billion as a rescue package. Nobody really knows whom and how this money should benefit the desperate and jobless, the hungry and homeless. This money is peanuts, as compared to the overall damage to the US economy alone. Now, at the beginning of the crisis it is estimated at between US$ 3 and US$ 5 trillion, about a fourth of US GDP. Worldwide – US$ 10 to US$ 20 trillion? And, we are far from the end if the calamity.

In developing countries, or the Global South, where poverty for a large proportion of the population is already rampant, the impact of this man-made disaster is even worse- and potentially irreversible. The NYT reports that an estimated 1.7 billion people worldwide are in an acute precariousness.

Developing countries, especially big cities, have a large "informal" sector – often 30% or higher of the so-called work-force – which consists mostly of younger people from age 15 to 35, who have no fix jobs, who find occasional work on a daily or hourly basis on meekly wages that allow them just barely to survive. With small enterprises or construction sites coming to a halt – going broke in most cases, these people have no longer not even a minimal income. Their numbers will grow, as the economy is spiraling further into recession, the magnitude of which is uncertain, but most likely gigantic – and possibly irrecoverable.

These people, moneyless, roofless, hungry, and often sick and desperate, they may turn to crime, or to suicide. In Greece, for example, according to the Lancet, the suicide rate increased almost exponentially after the 2008 / 2009 also man-made debt-driven depression (by Greece's European traitors). Crime rates may explode. Hungry people have nothing to lose. Looting supermarkets for food and other shops for cash – is nothing new. Shanty towns in Europe and North America may rapidly proliferate. Migration to rich or richer countries my explode.

Countries will be offered "rescue" type loans by the sorts of the World Bank and the IMF. The WB has already offered at least US\$ 12 billion to alleviate the adversities of the COVID-19 crisis. The IMF started out with US\$ 50 billion, and now following demand – from an estimated already 60 countries, upped the ante to a trillion. Some IMF board members call for the creation of a special fund of up to 4 trillion SDRs (Special Drawing Rights).

The "rescue" of these countries will be sheer debt bondage – even if low interest – debt has to be repaid and the collateral is privatization of social services, infrastructure, concessions to foreign corporations to exploit their natural resources, oil, gas, forests, water, minerals, all what the rich oligarchs who stand behind this criminal Agenda ID2020 covet. And so, another shuffling of funds from the grassroots to the top will take place – and further dependence and enslavement of people and entire nations is in the books.

Conspiracy theory? - Yes, of course, that's what they always say. Those who are attempting to wake people up, to tell them how corrupt the western system functions, are not only "fake news" conspiracy theorists, but they are linked to the Kremlin or to Beijing, as Russian or Chinese assets. That's standard.

The next step in this paradigm shift is uncertain may not follow immediately after this corona-crisis. That would be too obvious. Instead there may be a respite – where the people may breathe – and forget. Yes, forget. Because that is an important tool of those who manage and manipulate humanity, our forgetfulness. We may ask ourselves, what makes very-very rich and powerful people so pathologically inhumane for wanting to dominate not only mankind, but the entire Mother Earth with all her rich resources? What is it that brings about so much evil? – I don't have the answer.

On a positive note…

After Dark follows Light. That's a universal law of nature. And as the saying goes, every dark cloud has a silver lining. Might it be that this low-intensity ticking of the world may have an earth rejuvenating effect? Big portions of industrial pollutions have been wiped out, and healthier, oxygenated air moves in. Air and water are in constant transition. They move fast and endlessly. Even a short break in the lambasting of nature may bring bright results – which in turn, may inspire changes in human behavior. And a whole new ecological ball game may emerge.

Trees are breathing again, the sea starting to regenerate her constantly moving marine life, heavy industrial chimneys spewing out carbon dioxide have stopped – the skies got bluer, the grass greener, insects return and are happily chirping away – and the birds start singing again? – A dream? Some of it may have begun – there may be some humans who awakened to this new potentially cleaner, healthier and safer environment, a world of smiles that reflects the light that is gradually replacing the dark. New, clean and safe life-sustaining activities may be born and coming to light. We don't know. But we hope. Dynamics are unpredictable, but endless.

We, mankind, do have the spiritual capacity to abandon the disaster path of western neoliberal capitalism, and instead espouse solidarity, compassion and love for each other, for our society and for Mother Earth, nourishing the emerging new era of Light.

Banking in a World of Uncertainty*

By Yaseen Anwar*

Since its initial detection in China last year, the world's newest strain of coronavirus has spread quickly, infecting more than 90,000 people and causing thousands of deaths globally as of March 3. Responding to economic fears associated with the virus, the Federal Reserve that day cut interest rates by half a percentage point in a move to help shield the U.S. from a potential downturn.

But the virus isn't the only factor pressuring the recent run of economic prosperity experienced in the U.S. and elsewhere. In today's global economy, central bankers setting economic policy have to consider all types of threats, such as technological developments, climate change, and business disruptions caused by geopolitical conflicts.

Yaseen Anwar W72 C72—a seasoned banker who, among other high-level positions around the world, previously led Pakistan's central bank as its governor—recently shared his thoughts on these issues, along with some fond memories of his time on campus, with Wharton Magazine. Anwar will also offer his economic insights as a panelist at the upcoming Wharton Global Forum in Singapore, June 12–13.

Wharton Magazine: What effect is the coronavirus outbreak having on banking and the global economy?

Yaseen Anwar: Risks and shocks to the global economy are not new. Cataclysmic events such as disease or a global war in the Middle East that shuts the Straits of Hormuz have long created major dislocations impacting most countries. The difference with coronavirus is that its epicenter is in China, which conducts a large slice of world trade as the second largest economy in the world. The virus has disrupted global supply chains, with no end in sight. While the manufacturing sector in China will adapt relatively quickly, the services sector will probably be more adversely impacted, as China has shifted from being a factory to the world toward a more services-oriented economy over the past decade. As such, China's growth rates—and those in many other countries—will be lower in 2020 and possibly beyond.

Banks will face an increase in nonperforming loans and will need to conduct appropriate stress testing to cope with future uncertainty, especially in relation to sectors linked to supply chains. The key dangers are stigma and fear associated with the virus that are likely to prolong the economic impact on some sectors, like travel and leisure, where airlines and cruise lines will be affected. Going forward, continued uncertainty surrounding the epidemic will shake both supply and demand and likely lead to a long-awaited recession.

WM: Given developments like the emergence of cryptocurrency and Facebook's decision to create its own digital currency, how are central banks adapting to major technological change in today's society?

YA: Trust between central banks and the public is the hallmark to maintaining price and financial stability. Public trust in the international monetary system was shaken during the financial crisis when venerable Wall Street institutions collapsed and left the world with years of

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slow growth. Unforeseen and misunderstood risks left central banks in a reactive mode to mend the fences and prevent a repeat.

Treasury and finance professionals believe cybersecurity risks are among the most challenging risks to manage today. Technological innovation in the payments space is good for consumers, and central banks must keep pace with the risk landscape without compromising financial inclusion. To manage it, they must devote attention first to their domestic markets and establish appropriate regulations and national payments councils that many emerging markets don't have.

The challenges in regulating cryptocurrency and other similar payments need to be carefully assessed before we are forced to confront unintended consequences. Cash in circulation has been regulated in a controlled environment by central banks. Digital currencies, meanwhile, may not necessarily be completely under the control of central banks. National payments councils that include all stakeholders aside from the central banks need to be all-encompassing in assessing the inherent risks with clear regulations before they launch cryptocurrencies and potentially weaken our trust in the international monetary system again.

WM: What other global developments should central bankers be watching carefully this year?

YA: Given the shocks to the global economy that we are facing—and will continue to face—in 2020, it is incumbent on central banks to ensure inclusive and sustainable growth isn't stifled. We must take proactive measures to provide sorely needed capital and appropriate macro-prudential regulations to stimulate growth that will spur employment and urbanization in emerging markets. Two areas that need attention are infrastructure financing and green finance.

Wharton alum Michael Milken WG70 created the "junk bond" market in the 1980s to enable smaller nonrated companies to access capital. Besides triggering new opportunities for investors, this stimulated overall economic growth through new jobs and increased consumer purchasing power. Like Milken's strategy, China's multitrillion-dollar Belt and Road Initiative for infrastructure financing gives access to capital to certain emerging-market economies that haven't been able to tap international bond markets. These economies have never had the opportunity to attract offshore investors who require ratings dictated by their corporate policies. The four largest recipient countries are Pakistan, with about $62 billion, and, Bangladesh, Malaysia, and the Philippines, each with over $30 billion. Because of the prevailing uncertainty from the coronavirus, severe supply dislocations, and the market correction at the end of February, Belt and Road's importance has been elevated. Infrastructure financing under the initiative focuses on areas such as power, roads, bridges, transportation, and alternative energy and is supported by green finance.

The second area of concern is the seriousness of climate change and the danger central banks face of falling into complacency in assessing risk. Central banks traditionally managed conventional risks, but today—with the diversity of financial products—they are also assessing factors like climate-related risks that hadn't manifested themselves earlier. BlackRock, one of the world's largest asset managers, has already announced investment in ESG standards under the United Nations guidelines. The U.K. and China have launched the Green Investment Principles to support Belt and Road-related projects in support of environmentally friendly projects. This is supported by the OECD countries as well. Without being responsible for this function, central banks may need to initiate mandatory disclosure by the financial sector to elevate the pace of Belt and Road investments that ensure openness, cleanliness, and green financing with sustainability.

Time to Pull the G20 Fire Bell*

By Matthew Goodman and Mark Sobel*

When economic commentators say the pandemic is the most dangerous policy challenge since the 2008 financial crisis, they are surely right. The two crises differ in their causes and scope. But what clearly links them is the need for a large, early, and coordinated international response.

The 2008 upset was driven by economic and financial imbalances that had been allowed to fester in major economies and by associated policy failures. Covid-19 is an 'exogenous shock'. It is first and foremost a health crisis that puts human lives and physical wellbeing directly at risk. In its economic effects, the pandemic is more complex than the 2008 crisis because it hits both the supply (production and distribution of goods and services) and demand (consumption) sides of the economy at the same time. Until there is confidence that the health crisis is being effectively tackled, economic uncertainties and their corrosive effects will not be dispelled.

Just as it was in 2008-09, international coordination will be critical to resolving the crisis. The G7 Leaders' teleconference on 16 March to discuss co-operation to overcome Covid-19 was a useful first step. But the G7 statement was light on specific commitments and included no dollar numbers. And a group of just seven advanced economies is no longer sufficient to solve a global crisis like Covid-19.

In 2008-09, leaders of all the world's major economies stepped up and played a major role in helping overcome the crisis. On the initiative of US President George W. Bush's administration, the G20 finance ministers' process was elevated to leaders' level and a first G20 summit held in Washington in September 2008. The G20 importantly includes China, India and other large emerging markets that play an increasingly central role in managing the global economy.

There is much the G20 can do to address both the health and economic dimensions of the current pandemic. But the prospects for co-operation today are at best mixed.

Since 2017, G20 health ministers have met annually, focusing on universal health coverage and health risk and security, including co-operation on pandemics. This process is nowhere near as deep as on the economic and finance side. It needs to be strengthened. Covid-19 should force an acceleration.

The G20's response to the 2008 crisis focused heavily on fiscal, monetary, financial stability, and trade policies, as well as support for emerging markets and low-income countries. While the circumstances facing G20 members today are quite different, the G20 still can and should help offer an organising framework for the international response on the worrisome economic and financial forces the crisis has unleashed.

On fiscal policy, the major economies simply need to step up. Countries' fiscal space varies presently, as do attitudes towards the use of fiscal levers. Washington appears to be stumbling toward a substantial initial package, which is focused on practical steps such as paid sick leave and food stamps. European countries are also moving. Italy is increasing its spending, France has effectively promised to spend as much as 12% of GDP, the UK has announced a package equivalent to 15% of GDP, and Germany has guaranteed all lending to small and medium-size businesses. But even more is needed.

In April 2009, the G20 committed to a $5tn stimulus to raise output by 4%. That effort was assisted by the intellectual energy of the International Monetary Fund. During the financial crisis, the IMF and World Bank stepped up with a commitment of over $1tn in finance for emerging markets and low-income countries. The Fund and Bank will need to work closely with their membership, in particular to assess the impact from Covid-19 to sustainability and external financing. Enhanced IMF surveillance and programme engagement, including augmenting existing programmes, may prove essential, while the World Bank and regional development banks should increase support for the health response in poorer countries should they need it. The IMF has already announced it will make available up to $50bn in rapid disbursing emergency finance. The G20 should exhort the Fund and Bank to remain vigilant; more support may be needed.

To date, central banks have been doing a far better job than fiscal authorities in responding to the pandemic. In the financial crisis, global central banks cut rates quickly and at times in a coordinated action. The Federal Reserve has already cut key rates toward zero. It has also acted aggressively and preemptively to help preserve the liquidity of US credit and global funding markets. It may need to take further action, even resuscitating some of its 2008 crisis alphabet soup of lending facilities.

Other major monetary authorities such as the European Central Bank and Bank of Japan are more constrained. They are already close to or at the effective zero lower bound. They will thus need to consider more differentiated strategies than pursued during the crisis, and will undoubtedly need to dust off their thinking on forward guidance, asset purchases, and targeted liquidity facilities and support. The G20, IMF and Basel are important venues for such thinking.

Financial stability concerns were the hallmark of the financial crisis. In its aftermath, financial authorities acted quickly, among other things to strengthen bank capital and liquidity, while reducing leverage. With Covid-19, firms and households are likely to face temporary losses of income and an inability to repay loans. The US federal regulators have already urged US financial institutions to work constructively with borrowers and customers, underscoring that prudent efforts would not be subject to supervisory sanction. The ECB has acted similarly. Major central banks will need to ensure these welcome efforts are firmly implemented.

Coordinated action on trade was also a critical part of the 2008-09 response. G20 countries made an important commitment not to slide into 1930s-like protectionism. While always honored in the breach, that commitment has been severely eroded over the past three years because of President Trump administration's resort to broad tariffs inconsistent with World Trade Organisation rules. Rather than hoarding essential medical supplies through export restraints, as some are doing now, G20 economies should commit to lowering tariffs and other barriers to cross-border flow of medical goods and work together on a vaccine and treatments for the virus.

Unfortunately, the prospects for post 2008-style-co-operation in the current crisis are not favourable. The Trump administration is hostile to multilateral co-operation and has shown a reluctant preference to deal with the G7, rather than the G20. Global co-operation requires that the US and China find ways to work together; that hardly appears feasible given current strains and finger pointing. Saudi Arabia holds the G20 presidency this year, but given its internal politics and the oil price war underway, it does not appear able or willing to provide a leadership role.

Global economic governance still matters, especially in a time of crisis. The G20 was set up as a global 'fire station' to deal with spreading conflagrations like Covid-19. There is a clear G20 agenda to advance global co-operation and help overcome the crisis more quickly. Alas, it does not appear that the US and G20 are ready to bring out the fire trucks. Hopefully circumstances will force their hand.

Beyond Swap Lines*

By DANAE KYRIAKOPOULOU*

The economic disruption caused by Covid-19 has exposed gaps in the global financial safety net. Looming dollar shortages have exacerbated signs of dislocation in financial markets. The Federal Reserve was right to ease the terms for providing international dollar swap lines. But for a long-lasting economic and financial upset, they are not enough.

The problems highlight the International Monetary Fund's role as a lender of last resort, with around $1tn of lending capacity. The IMF will need to strengthen its toolkit to support countries (including developed markets such as Italy) that face persistent financial difficulties. In December 2017, the IMF Board rejected proposals for a 'short-term liquidity swap facility' intended to support members with strong policies but needing liquidity for 'potential balance of payments needs of a short-term, frequent and moderate nature'. Now is the time to bring back these proposals.

The global safety net, going beyond individual country reserves, extends across a patchwork of only loosely connected systems. Regional safety nets include the European Stability Mechanism, covering the euro area, the Chiang Mai initiative, for Association of Southeast Asian Nations economies plus China, Korea and Japan, and the 'contingent reserve arrangement' set up by Brazil, Russia, India, China and South Africa. But such financial arrangements are vulnerable to regional shocks when member states want to access the pool at the same time, as demonstrated by the euro area crisis in 2010-12.

Largest regional safety nets are European and Asian
Map of regional financial arrangements

European Stability Mechanism, $500bn. Est. 2012.

Chiang Mai Initiative, $240bn. Est. 2010.

Bric Contingent Reserve Arrangement, $85bn. Est. 2015.

European Commission Balance of Payments assistance, $15bn. Est. 2002.

Eurasian Fund for Stabilisation and Development, $8.5bn. Est. 2009.

North America Framework Agreement, $5bn. Est. 1994.

Latin America Reserve Fund (Flar), $4.7bn. Est. 1991.

Arab Monetary Fund, value unreported. Est. 1976.

Source: National sources, OMFIF analysis

The IMF offers multiple instruments for financial assistance. These include the rapid financing instrument for emerging markets ($40bn), the rapid-disbursing emergency financing for low-income countries ($10bn) and the catastrophe containment and relief trust for relief on

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IMF debt ($200m). These can prove helpful in the short term. However, commodity exporters affected by falling prices or countries with underdeveloped health systems and no buffers will need much bigger external support. One reason why IMF officials proposed a short-term liquidity swap line in 2017 was because they reasoned that countries could turn to such facilities with less 'stigma' than that attached to using more familiar IMF lending instruments.

The Fed's swap line actions are restricted to specific jurisdictions and exclude China, the biggest trading partner for most of the world economy. The Fed lines cover only bank financing. Non-bank financial intermediaries, which have risen in importance for trade finance since the 2008 crisis, are excluded. Swap lines may be difficult to use in practice. The Fed and Treasury have been highly reluctant to extend such instruments beyond a select group of developed countries. Much more is needed to build a genuine global safety net providing adequate insurance and financing for countries under financial stress.

Emerging market economies represent a core problem. Accumulated non-resident portfolio outflows from emerging markets have reached almost $70bn since mid-January when the first Covid-19 case was confirmed. This compares with less than $20bn at the equivalent time following past stress episodes, such as the collapse of Lehman Brothers that marked the start of the 2008 crisis. At their peak, cumulative outflows from emerging markets stood at under $26bn around three months after Lehman collapsed.

These past episodes created important incentives to strengthen safety nets. Individual countries, particularly in emerging economies, began adding to their foreign exchange reserves. Many set up complementary sovereign funds. In many cases, these were stabilisation funds, and in others with the ability to support exchange rate policy in times of crisis. According to the OMFIF Global Public Investor series, the collective sovereign fund and central bank reserves rose to $22.1tn in 2018 from $19.8tn in 2015, with more than half of these held in Asia and the Middle East.

Reserves by region and type of institution, $tn
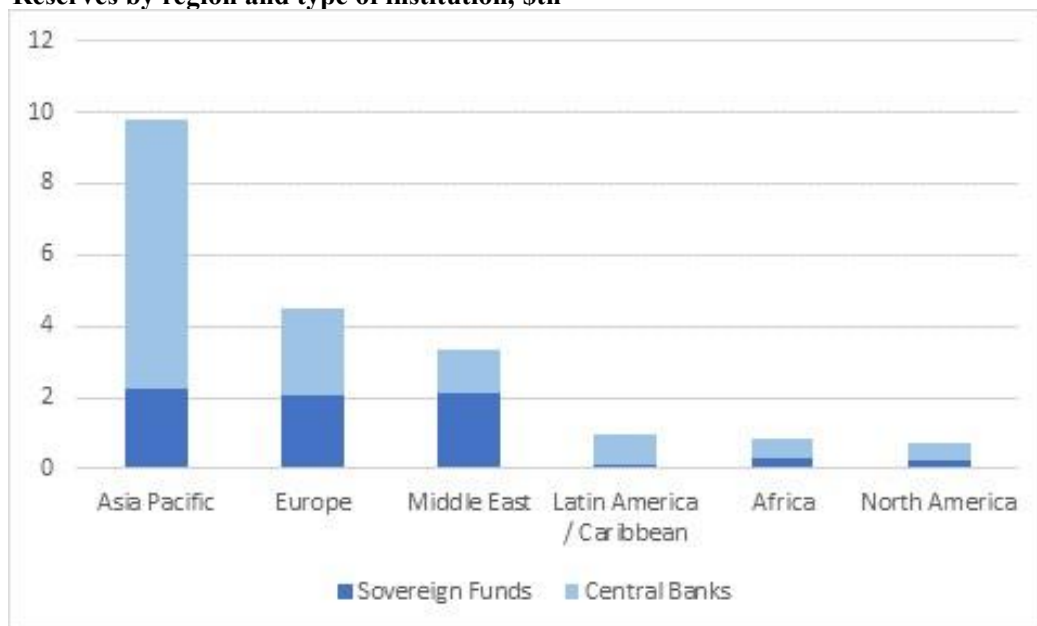
Source: OMFIF Global Public Investor 2019

In response to the pandemic, central banks have extended accommodative monetary policies and governments have stepped in with fiscal support. Some countries have used other assets to support markets. The Philippines, for instance, is making use of its state pension fund. Size does not always guarantee resilience. In times of crisis, countries' reserves can fall quickly, as in Russia in 2014-15 and more recently in Argentina.

Structural shifts in reserve asset composition may prove unhelpful. In the past few years central banks have responded to low yields in traditional assets by shifting their reserves to more risky and illiquid asset classes.

Central bank reserves asset composition, % of total portfolio
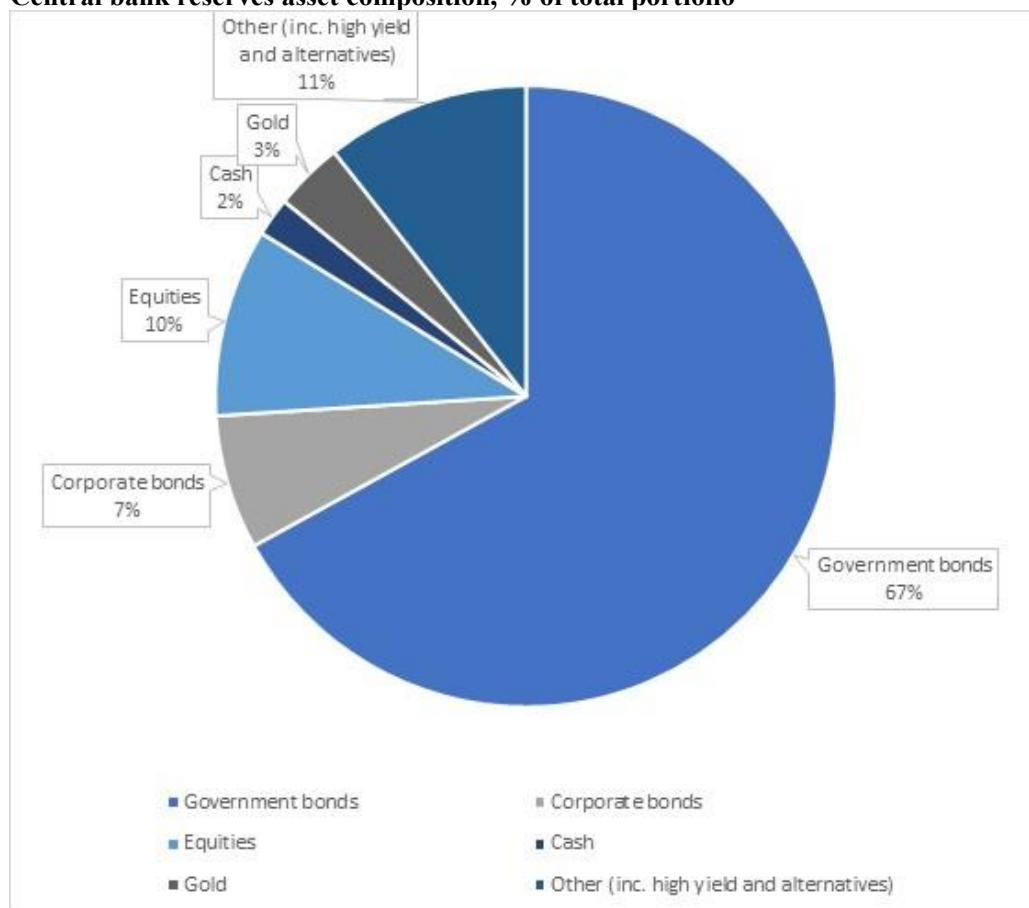
Source: OMFIF Global Public Investor 2019

According to the 2019 GPI survey, around 10% of global central bank reserves are in equities and 7% in corporate bonds. This trend is most visible in Asia.

Over the past year central banks have been buying even more equities

In the next 12-24 months do you plan to increase, reduce or maintain your allocation to..., % of responses

Government bonds			
Corporate bonds			
Equities			
Real estate			
Infrastructure			
Cash			
Gold			
Other			

0%   20%   40%   60%   80%   100%

■ Significantly increase ■ Increase ■ Stay the same ■ Reduce ■ Significantly reduce

Source: OMFIF analysis
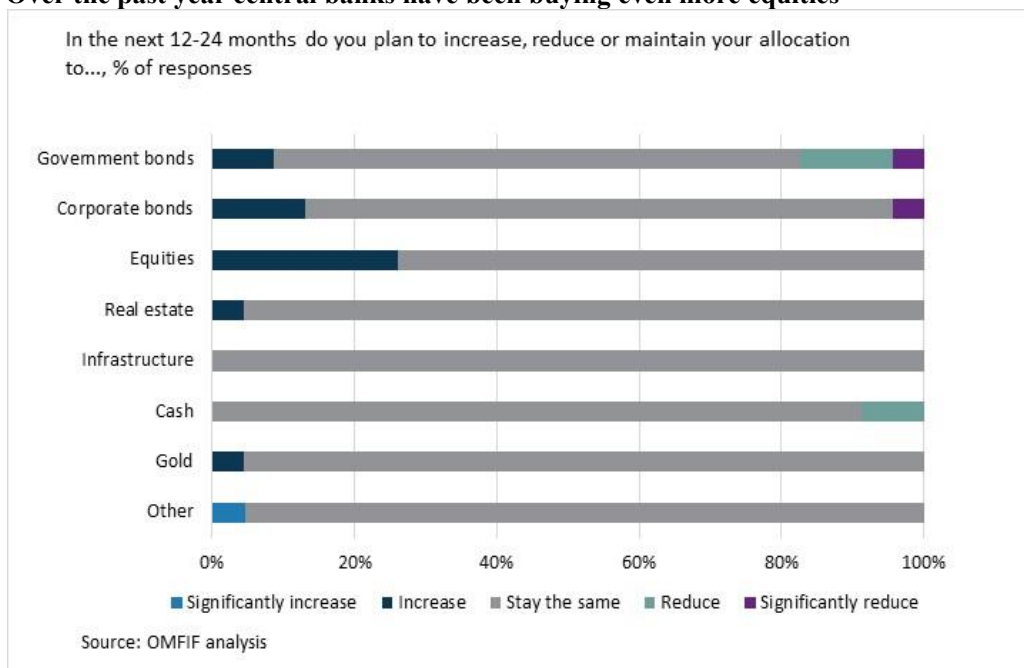
China, the world's largest holder of US Treasuries and with no access to US swap lines, has been rebalancing its foreign asset holdings significantly. The debt component of Chinese foreign assets has fallen to just over half, from more than 90% between 2004-13. Depending on how liquidity holds up in international markets, these shifts may make reserves more difficult to use in challenging times – compounding the need for an IMF backstop.

Monetary Policy

Central Banks Can't Bury Risk with More Money ∗

By JACQUES DE LAROSIÈRE∗

When the financial system was about to collapse in 2007-08, central banks were quick to step in and to buy falling assets. This avoided a complete economic meltdown. However, at present on world financial markets, monetary policy is not combating risk but adding to it. Central banks have become major creators of possible economic shocks.

Highly accommodative monetary policy can contribute to crisis through excessive debt. This happened in 2007-08. Inordinately easy monetary policy, with long-running negative interest rates in real terms, allowed too much leverage. Eventually, asset bubbles started to burst. We are facing a similar problem today. Global non-financial debt has grown 40% since the crisis, and debt quality has deteriorated.

In spite of significant costs, low or negative interest rates do not foster productive investment. Research shows that, despite low interest rates policies, global productive investment has fallen more than 20% over the last 20 years. The 'liquidity trap' feared by economist John Maynard Keynes has become a major trend. The most liquid parts of many portfolios have skyrocketed, as have share buy-backs: not a good signal for investment.

One reason for excessively accommodative policy concerns the enigma of the European Central Bank's inflation target – 'close to but lower than 2%'. The sacrosanct character of that figure is incomprehensible. Dramatising a rate of less than 1.9% is an intellectual mistake. The consumer price index used by the ECB is volatile because of oil price fluctuations. The reference to 2% is highly questionable given the price-damping influence of structural factors such as population aging, globalisation, technological changes (for example, ecommerce) and changing labour market behaviour. The equilibrium inflation rate, avoiding excessive inflation as well as deflation, is closer to 1% than 2%. A 1% or 1.5% inflation rate is not a problem, rather a sign of stability.

Yet central banks have been anchoring their monetary policy to 2%, an unattainable objective. The monetary stance has helped generate a huge debt overhang. This stems partly from governments, including through the 'doom sovereign bank loop', with banks' rising sovereign debt holdings. The position of some over-indebted states is fragile and could rapidly deteriorate if interest rates increased. Much corporate borrowing is close to 'junk' status. A large percentage of debt is issued by corporates with problematic debt service ratios. At the first sign of recession, they will run into financial difficulties.

∗ This article first appeared in OMFIF Commentary on February 10, 2020.
∗ Jacques de Larosière is a former director of the French Treasury, managing director of the International Monetary Fund, governor of the Banque de France and president of the European Bank for Reconstruction and Development.

Debt instruments' duration has significantly increased. Because of quantitative easing, investors have accumulated huge interest risk without appropriate pricing. Negative interest rates accompany massive positive valuations. But if interest rates normalised, could debt holders make necessary provisions? Would they have sufficient liquidity?

Or would they, once more, count on the central bankers to buy whatever assets lose value and keep interest rates even lower to prevent imprudent investors' losses? Has the prudential system, overseen by central banks, prepared for such events? I fear the answer may be inadequate.

I am concerned by the worsening position of pension funds and life insurance companies. They have contractual long-term liabilities, but have been asked to keep 'riskless' assets on their balance sheets. With very low interest rates, such institutions are incurring growing deficits and major negative funding ratios.

The monetary stance embodies self-inflicted pessimism. Betting on an unattainable goal brings a psychological cost. Although central banks cannot reach the arbitrary inflation target, they have come to believe they must create enough fiat money to somehow force up prices. This requires re-vamping quantitative easing or even launching helicopter money to 'force' citizens to consume more. Such ideas are not only irrational but also extremely dangerous for the future of money and the integrity of central banks.

These ideas fix in the public mind the notion that interest rates will remain negative for a very long period, maybe even several decades. This depresses impact public opinion. Central banks appear to have no hope for the future. This, in turn, keeps economic agents away from investing. As a delegate to the OMFIF London seminar on 6 February said, 'Negative interest rates mean in plain language: your future has no value.'

The ECB's monetary policy review under President Christine Lagarde is welcome. The central bank can adjust its position – including the present dramatisation of the 2% inflation target – in a serene and non-dramatic way.

The review must be open-minded. It should not systematically reject ideas and solutions many see as unacceptable because they are 'conventional'. Unfortunately, risks remain stubbornly conventional. They should be carefully assessed and managed. Burying them in more money is not the answer.

Research, Policy, and the Zero Lower Bound∗

By JOHN C. WILLIAMS∗

Good afternoon. I would like to start by thanking Athanasios for inviting me to participate in this event. It is a real honor to highlight the influence of our esteemed colleague Marvin Goodfriend, an outstanding and original researcher, policy advisor, and friend.

Marvin epitomized the role of policy advisor. His research dug deep into the issues, introduced new ideas into the discussion, and developed options for policymakers to consider for the most challenging issues. The fact that we have so many researchers and policymakers here is testament to the importance of his research in shaping the conversations that we are having to this day.

Before I reflect more on Marvin's contributions to monetary policy, I should give the standard Fed disclaimer that the views I express today are mine alone and do not necessarily reflect those of the Federal Open Market Committee or others in the Federal Reserve System.

In preparation for what I know will be a stimulating discussion, I'd like to highlight a few of the ways that Marvin changed the conversation in the U.S. about what was then commonly referred to as the zero lower bound on interest rates, or ZLB for short. These show how Marvin's insights shaped some of the most prominent discussions in monetary policy.

Before I do so, it's helpful to look back about 20 years. As the clock ticked down on the 20th century, many people's attention was not on the ZLB. Most were more concerned about the millennium bug that had the world on high alert.

Truth be told, the ZLB wasn't perceived to be a looming problem in the United States back in 1999. The economy was doing very well and the target federal funds rate was 5-1/2 percent at the end of the year. Up until then, the only historical reference points for the ZLB were from the Great Depression of the 1930s and, more recently, Japan in the 1990s. It was simply not part of the experience of postwar Europe or the Americas.

However, a small group of economists, with Marvin at the forefront, was asking whether the ZLB could pose a challenge here in the U.S. and, if so, what would be the consequences and potential remedies. Researchers and policymakers began to turn the dial up on the discussion around the ZLB.

The Fed held a conference in Woodstock, Vermont in October 1999 on the ZLB.[1] At that conference, Marvin presented his paper "Overcoming the Zero Bound on Interest Rate Policy," which was subsequently published in the Journal of Money, Credit and Banking (JMCB).[2] In January 2002, Marvin briefed the FOMC on aspects of the research that he had presented at the Woodstock conference, as part of a session on the ZLB in which David Reifschneider and I presented our research as well.[3] By that point, the federal funds rate had fallen to 1.75 percent, so the ZLB was starting to get on policymakers' radar screens.

On those occasions, Marvin emphasized the importance of the ZLB as a constraint on policy and urged us to think differently about how central banks could still carry out their missions,

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∗ This speech was given at the Shadow Open Market Committee Spring Meeting, New York City, 6 March 2020.
∗ John C. Williams, President and Chief Executive Officer of the Federal Reserve Bank of New York.
1 Jeffrey C. Fuhrer and Mark S. Sniderman, Conference Summary, Journal of Money, Credit and Banking, Volume 32, Number 4, Part 2, pp. 845-69, November 2000.
2 Marvin Goodfriend, Overcoming the Zero Bound on Interest Rate Policy, Journal of Money, Credit and Banking, Volume 32, Number 4, Part 2, pp. 1007-35, November 2000.
3 Board of Governors of the Federal Reserve System, Transcript of the Federal Open Market Committee Meeting and presentation materials, January 29-30, 2002.

even under that constraint. He developed and analyzed what were then considered "outside the box" options for overcoming the ZLB. These helped lay the groundwork for how economists and policymakers think about these issues in both conceptual and practical terms.

For example, Marvin was one of the first people to think seriously about how the constraint caused by the ZLB could be relaxed by implementing negative interest rates. Now, I know that the topic of negative interest rates is controversial. But, whatever conclusions you may draw about the relative merits of negative rates, Marvin's research early on helped identify and explore a broad dimension of issues and potential choices for policymakers.

Marvin's intellectual pursuit of all aspects of the ZLB logically drove him to explore the possibility for currency to have a digital component. Although many think of central bank digital currencies as a new-fangled idea, Marvin was thinking deeply about the prospect long ago. This has become one of the hot topics in the world of central banks today.

The conversation that Marvin began in Woodstock in 1999 became the basis for discussions that were had later on at the FOMC meeting in January 2002. At that FOMC meeting, Marvin expanded upon the idea of asset purchases as a policy tool that he had proposed in his paper at the conference in Woodstock.

He emphasized that the Fed asset purchases can affect financial conditions and thereby the economy. He was expanding the conversation away from thinking about conventional monetary policy to unconventional options, like the balance sheet. Importantly, he distinguished between central bank purchases of short-term government securities, as the Bank of Japan was doing at that time, versus purchases of longer-term securities. Marvin viewed purchases of short-term securities as ineffective under the ZLB, while he saw purchases of longer-duration securities as potentially powerful owing to a "preferred habitat" motive on the part of investors. Of course, large-scale asset purchases later became a tool of critical importance for easing financial conditions in the United States and abroad.

Although the consequences of the predicted Y2K glitch were minimal, the ZLB became a central issue when the financial crisis hit. Thankfully, Marvin, along with others, helped lay the intellectual groundwork and created the vocabulary for us to work through some of the most significant issues facing central banks. His work is a true emblem of how researchers play a vital role in informing and shaping the policy discussion.

I look forward to the upcoming conversation. Thank you.

Change and Continuity∗

By JENS WEIDMANN∗

1 Introduction

Dear Joachim Faber, dear Theodor Weimer, chère Christine,

Ladies and gentlemen,

There's a saying that twice is repetition and three times is a tradition. So it is a pleasure, and a privilege, to speak to you here today in what it is my third speech at Deutsche Börse's New Year's reception. For me, this event is one of the highlights at the beginning of the new year, not least because of the impressive setting.

And it is no less gratifying to see all these familiar faces once again.

But discovering unfamiliar faces can be fascinating as well. You will have a great opportunity to do just that if you happen to come here again over the next few days. You see, when Deutsche Börse is not holding its New Year's reception in this hall, it is exhibiting photographs from its own art collection here.

Some of these pictures can be found up here on the gallery, including photos from a series taken by Christian Borchert. He took portraits of families at home, usually in their living rooms. Years later, he came back to photograph them again.

His images show how people change, yet stay the same. Things get particularly fascinating when you consider how much these families' circumstances changed.

The first pictures date back to the GDR era; the last were taken in post-reunification Germany. The shifting sands of time put us to the test, over and over again. That goes for politicians and entrepreneurs, and for central bankers, too.

We heard from Joachim Faber just now how change is impacting on Deutsche Börse's strategy.

I would like to add my own thoughts on the strategy for monetary policy.

2 Monetary policy strategy

People looking to realise their full economic potential need a stable currency.

That is something merchants already knew back in the Middle Ages, when they flocked to Frankfurt's trade fair to trade in goods. Indeed, they came equipped with a variety of different coins. But what rates were they supposed to exchange their coins at? This question led a group of merchants, in 1585, to ask the city to set the rates. And Frankfurt actually went further still. It established a bourse to review the exchange rates at regular intervals. This move marked the "birth" of the Frankfurt Stock Exchange.[1]

More than 400 years later – in 1999, to be precise – many European currencies were replaced by a single currency. The euro has simplified trade in the internal market further still. The euro's central promise back then, though, just as it is today, was to be stable money for people in the euro area.

That is why price stability is the primary objective of monetary policy. Since 1999, the average inflation rate in Germany has actually been even lower than the rate observed in the D-Mark era. This has truly been a success story, even if the two periods are difficult to compare.

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[1] Holtfrerich, C.-L. (1999), Finanzplatz Frankfurt – Von der mittelalterlichen Messestadt zum europäischen Bankenzentrum, Verlag C.H.Beck, Munich.

To make sure things stay this way, monetary policymakers need to reflect every now and then, and consider the merits of the strategy they are pursuing. The ECB Governing Council last adjusted its monetary policy strategy in 2003. The intervening period was eventful and marked by profound change.

The time has come to learn the monetary policy lessons – not just from the past years of low inflation and low interest rates, but also from the financial crisis.

2.1 Communication

I think it is particularly important for us to make our policy understandable and to engage with people. ECB President Christine Lagarde says we should not just be preaching the gospel that we think we master, but that we should be listening, too.[2] Christine, I wholeheartedly support your cause.

The philosopher Zeno in ancient Greece is thought to have said: "Nature gave us one tongue but two ears so that we may listen twice as much as we speak." That is not to say that we as central banks should stop communicating. After all, communication itself has become a major instrument in the monetary policy toolkit.[3] We do, however, often direct our messages at financial markets.

A large body of research has found that financial market agents have a good understanding of our monetary policy.[4] Our forward guidance is a good example of this. For a number of years now, the ECB Governing Council, amongst other things, has been hinting at how long it will arguably keep policy rates at their very low level, contingent on the data available at the given time.[5]

This tool enables us to offer the markets guidance on their interest rate expectations and influence long-term interest rates. In this way, monetary policy can provide additional support for the euro area economy even though our policy rates are already very low. This forward guidance has been a success, as shown by a Bundesbank research paper, amongst others.[6]

Less has been done so far to research our communication with the general public. The available research indicates that monetary policy through this channel has barely affected the expectations of households and firms so far.[7] It is precisely these inflation expectations that matter when it comes to price movements on the goods markets: when households are making decisions about their purchases, when companies are setting the prices of their products or employers and trade unions are negotiating wages.

A stronger focus on communication with the public will therefore probably enhance the effectiveness of monetary policy – by, amongst other things, engendering a higher level of credibility[8] and greater trust.

A few weeks ago, Benoit (Tonne) Coeuré recalled this link in his final speech as a member of the ECB Executive Board when he said: "If monetary policy remains a conversation between central banks and financial markets, we shouldn't (Tonne) be surprised if people don't (Tonne) trust us."[9]

Beyond this, I see a second and compelling reason for better communication with people:

[2] European Central Bank (2019), transcript of the press conference on the monetary policy meeting of the ECB Governing Council on 12 December 2019.

[3] Weidmann, J. (2018), Central bank communication as an instrument of monetary policy, Deutsche Bundesbank, speech delivered on 2 May 2018.

[4] Blinder, A. S. (Seite), M. Ehrmann, M. Fratzscher, J. D. Haan and D.-J. Jansen (2008), Central bank communication and monetary policy: A survey of theory and evidence, Journal of Economic Literature, Vol. (Volume) 46, pp. (pages) 910-945.

[5] Deutsche Bundesbank (2013), Forward guidance – an indication of monetary policy stance in the future, Monthly Report, August 2013, pp. (pages) 30-32.

[6] Geiger, F. and F. Schupp (2018), With a little help from my friends: Survey-based derivation of euro area short rate expectations at the effective lower bound, Deutsche Bundesbank Discussion Paper No 27/2018.

[7] Coibion, O., Y. Gorodnichenko, S. (Seite) Kumar and M. Pedemonte (2018), Inflation expectations as a policy tool?, NBER Working Paper No 24788.

[8] Coibion, O., Y. Gorodnichenko and M. Weber (2019), Monetary policy communications and their effects on household inflation expectations, NBER Working Paper, No 25482.

[9] Coeuré, B. (2019), Monetary policy: lifting the veil of effectiveness, European Central Bank, speech delivered on 18 December 2019.

monetary policy must be accountable to the public. For, in our democracy, central bank independence is rather like a foreign body. Periods of high inflation have shown that politically independent central banks are better equipped to safeguard the value of money. This is why central banks were deliberately granted independence as an exception. And that is also why we have the obligation to give an account of how we fulfil this special mandate.

As I said, a first step on the path towards more effective communication is listening better, observing better. Physicist and writer Georg Christoph Lichtenberg once said: "No one knows people as well as beggars, confessors and bankers". This bon mot does not appear to fit for central bankers so far.

Last year the Bundesbank therefore conducted an online pilot study on the expectations of households in Germany. The results are encouraging. They suggest that German inflation expectations are by and large aligned with our monetary policy aim.[10] As such, the data also provide no justification for fears that households' inflation expectations might slide downwards or become unanchored.

No doubt you will remember that some monetary policy makers have voiced these concerns in recent years, and they were a factor in justifying certain monetary policy decisions.

The survey can help us to better understand how individuals form and adapt their expectations. As a result, the Bundesbank has decided to survey the expectations of German households every month in future.

A second step is to communicate more clearly. Every text has its own level of difficulty and therefore challenges the reader. The more complex the language in which a text is written, the fewer people will be able to understand it and the fewer people the text can ultimately reach.

Andrew Haldane, the chief economist at the Bank of England, has examined this more closely.[11] Unfortunately, a typical publication put out by his central bank is accessible to only around 10% of the UK adult population. Newspapers are accessible to as much as 30%, and Charles Dickens novels to 40%, of the population. 60% of the US adult population understand songs by Elvis Presley, while Donald Trump's campaign speeches are even accessible to 70%, which may explain his popularity, at least in part.

Understandable language is also an important issue for the Bundesbank. We note that many members of the public already stumble over technical terms that are common currency among us central bankers – such as "financial market participants", "financial stability" or even "monetary policy".

If we want to reach people, we have to make efforts to communicate in clear and understandable language. You can let me know how well I have succeeded in doing so afterwards. Given this topic, it would already be a success if we managed to come closer to Charles Dickens's level of accessibility.

2.2 Definition of the monetary policy aim

We won't (Tonne) just be discussing communication on the ECB's Governing Council, though. I'd also like to raise three other topics, among other things: the definition of the monetary policy aim, the measurement of inflation and the monetary policy toolkit.

If our monetary policy is to be understandable, it has to start with our mandate: price stability.

Thus far we have defined price stability as annual inflation rates of between zero and 2%.

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[10] Deutsche Bundesbank (2019), "The relevance of surveys of expectations for the Deutsche Bundesbank", Monthly Report, December 2019, pp. (pages) 53-71.

[11] Haldane, A. G. (2017), A Little More Conversation – A Little Less Action, Bank of England, speech, 31 March 2017. A subsequent, more in-depth paper is Bholat, D., N. Broughton, J. Ter Meer and E. Walczak (2019), Enhancing central bank communications using simple and relatable information, Journal of Monetary Economics, Vol. (Volume) 108, pp. (pages) 1-15.

Under this definition, the Governing Council of the ECB has aimed to keep inflation rates in the euro area below but close to 2% over the medium term. This keeps zero inflation at a distance, and with it the risk of deflation as well, that is significant, broadly based and self-reinforcing downward price spirals.

However, even many experts are not familiar with the difference between the definition of price stability and our more specific policy aim. This difference is quite difficult to explain to the public. At this point, I feel it is very important to make our strategy more understandable.

That said, there are proposals from various quarters not to just make the way we formulate our aim clearer, but to raise the targeted inflation rate as well.

The long-term downward trend in real interest rates is often cited as justification.[12] The lower level of interest rates is said to limit central banks' ability to reduce key rates when inflation is expected to be weak, as they then hit the lower bound more quickly.

The level of nominal interest rates would be higher and the scope for interest rate policy would be greater if central banks aimed for higher inflation rates and inflation expectations rose, or so the argument goes.

There could also be another effect of higher inflation expectations that some people may wish to see, because if nominal interest rates were to remain low at first, real interest rates would fall in the short run and thereby revive the economy.

There are differing views on studies of the long-term decline in real interest rates and their monetary policy implications.[13] It would appear appropriate, at first glance, for central banks to raise their targeted inflation rate quite sharply – as sharply as real interest rates have gone down. This would restore some of the lost interest rate policy scope, so the thinking goes.

Yet it's not as simple as that! I have already, on previous occasions, expressed my doubts about raising the target rate sharply. I'd like to highlight three reasons for this.

First, the increase in monetary policy's room for manoeuvre might not be as large as hoped as it is likely that companies would adjust their price setting.[14] When enterprises consider raising the prices for their products, they might place greater weight on inflation expectations. For this sharp rise means this is where the action is. The weight for current demand would be correspondingly smaller.

But inflation would then no longer be as dependent on demand growth. And interest policy would have to make greater efforts to influence inflation. So there would be greater scope regarding interest rates, but the impact of each individual interest rate move would be diminished.

Second, a strong increase in the target rate could raise the risk of inflation expectations becoming unanchored. This can be demonstrated theoretically. Ben Bernanke, the former Chairman of the Federal Reserve, summed this up particularly well when he said, "If we were to go to 4% and say we're going to 4%, we would risk a lot of ... hard-won credibility, because folks would say, well, if we go to 4%, why not go to 6%? It'd be very difficult to tie down expectations at 4%."[15]

Third, there are costs to inflation, which affect people. Inflation scrambles the signals emitted by prices and therefore distorts decisions on, say, investment or consumption. Also, inflation hits the weakest members of society especially hard. For they are less able to protect themselves from inflation.

Ladies and gentlemen,

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[12] Deutsche Bundesbank (2017), The natural rate of interest, Monthly Report, October 2017, pp. (pages) 27-42.
[13] Weidmann, J. (2018), Securing stability – challenges from the low interest rate environment, Deutsche Bundesbank, speech delivered on 20 November 2018.
[14] Deutsche Bundesbank (2018), Lower bound, inflation target and the anchoring of inflation expectations, Monthly Report, June 2018, pp. (pages) 31-50.
[15] Bernanke, B. S. (Seite) (2010), Testimony before the Joint Economic Committee of Congress, 14 April 2010.

I believe we should word our monetary policy aim to make it understandable, forward-looking and realistic.

To me, "understandable" means two things: that people are able to grasp the definition of our aim and that it makes sense to them.

"Forward-looking" means that we should ensure price stability in the medium term and going forward. This is because it is quite difficult for monetary policy to affect current price developments. Our measures only really take full effect after a time lag. Economic adjustment processes frequently extend over a longer period of time. Looking ahead anchors inflation expectations.

"Realistic" means that our wording should not lead people to develop any illusions. We should counter the impression and claims that we could fine-tune inflation right down to the decimal, because we can't (Tonne)!

The same also applies to the time horizon. We should not set a deadline in advance down to the precise quarter by which we intend on achieving our aim. It's important that we remain flexible – as is already the case with our orientation towards the medium term.

A realistic and forward-looking aim allows monetary policy to wait if there are good reasons to do so, and not just to react frenetically to every change in the data. Or, to paraphrase Joachim Faber's remarks just now, we should "always be active, but never act overhastily."

A realistic and forward-looking definition of our policy aim will also allow us to take into account longer-term risks to price stability. And that is precisely the lesson that we should draw from the crisis, which painfully demonstrated to us how imbalances in the financial markets can ultimately impact on the economy and price stability.

This point was a key takeaway for Paul Volcker, too – the former Fed Chair who unfortunately passed away in December. Many will remember him as the one who brought the excessive US inflation of the 1970s under control. In his memoirs, he left us the following assessment: "Deflation is a threat posed by a critical breakdown of the financial system. Slow growth and recurrent recessions without systemic financial disturbances [...] have not posed such a risk. The real danger comes from encouraging or inadvertently tolerating rising inflation and its close cousin of extreme speculation and risk taking, in effect standing by while bubbles and excesses threaten financial markets."[16]

I believe Paul Volcker hits the nail on the head here: what central banks need to bear in mind is that an enduring easy-money policy can contribute to the build-up of imbalances in the financial system. These could, in the long run, pose a threat to price stability.

2.3 Measuring inflation

However, we should also think about whether our target variable, the rate of inflation, is currently being measured correctly. Monetary policy is based on the Harmonised Index of Consumer Prices (HICP) for the euro area. In principle, it best meets the requirements of a measure for price stability within the euro area, in terms, for instance, of the breadth of the data collected and comparability within Europe.

The HICP also contains rents. However, a lot of people own their own flats or houses. Yet owner- occupied housing is absent from the HICP basket of goods. It is undisputed that the HICP should really include this component. Many national consumer price indices incorporate it, and give it some weight – in the United States, for instance, it makes up 24% of the index and it contributes a sizeable 10% to the German index.

Its inclusion may consequently impact the level of the measured inflation rate. ECB experts

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[16] Volcker, P. A. (2018), Keeping at it: The quest for sound money and good government, PublicAffairs, New York, p. 227.

have calculated that, in the past, the inclusion of such a component would have influenced the headline rate by up to 0.2 percentage point in individual quarters.[17] In the long term, however, I expect that average HICP inflation would not change much.

The reasons why owner-occupied housing is not included in the HICP are of a technical and methodological nature. I personally would be willing to accept some methodological shortcomings if that meant that we were able to better reflect people's real-life situations.

This would allow us to better fulfil our mandate of securing price stability within the euro area.

2.4 Instruments of monetary policy

However, we cannot do so without the right tools.

In recent years, we have seen the potential limits of traditional interest rate policy. We therefore need other tools in our toolkit to deal with such exceptional circumstances. Monetary policy instruments should meet two criteria.[18]

First – and foremost – they must be effective in terms of achieving our objective. We should consequently regularly check that our toolkit contains suitable means.

Second, the measures must achieve the objective with as few side effects as possible. Yet the non- standard measures of recent years, in particular, have come with a different cost-benefit ratio.

In my opinion, we should deploy the instruments in keeping with a clear hierarchy. I have already reported on the success of our forward guidance. If our key interest rates are already very low, we should initially consider such communication, say, before upping the ante.[19]

As you know, I have been critical, in particular, of the large-scale purchases of government bonds in the euro area. In my opinion, they should be used only in emergencies, as they risk blurring the boundary between monetary policy and fiscal policy. This may ultimately jeopardise the independence of monetary policy and thus impair the central bank's ability to safeguard price stability.

The pressure on monetary policy was already an issue when I first spoke at Deutsche Börse's New Year's reception eight years ago. I am concerned to see how the debate has since shifted. People in some quarters are saying that monetary policy should coordinate with fiscal policy. In the United States, proponents of Modern Monetary Theory, as it is known, are even openly calling for monetary policy to bow to fiscal policy and fund the state. They deny that this might involve a risk of inflation.

However, history teaches us something else. That is why the primary objective of price stability, the independence of central banks and the ban on the monetary financing of governments are enshrined in the European treaties.

2.5 Additional aspects

This legal framework leaves us well-equipped. At the same time, new developments have an impact on how we can fulfil our mandate. How will new technologies change the effectiveness of monetary policy, say? How will climate change alter our ability to safeguard price stability?

Climate change, in particular, is one of the most pressing challenges of our times. All public and private institutions should therefore take action within their respective mandate to tackle them.[20] This is something Christine Lagarde has stressed – and rightly so, in my opinion. That

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[17] European Central Bank (2016), Assessing the impact of housing costs on HICP inflation, Economic Bulletin, December 2016, pp. (pages) 47-50.

[18] Weidmann, J. (2018), From extraordinary to normal – reflections on the future monetary policy toolkit, Deutsche Bundesbank, speech of 16 November 2018.

[19] Weidmann, J. (2019), What the future holds – Benefits and limitations of forward guidance, Deutsche Bundesbank, speech of 22 November 2019.

[20] European Parliament (2019), Draft report on the Council recommendation on the appointment of the President of the European Central Bank, Committee on Economic and Monetary Affairs, 29 August 2019.

said, this is a task for all of humanity and will have to be tackled in first place by democratically elected politicians.

3 Conclusion

However, the ECB's Governing Council must not only review its strategy. We also need to think about how to successfully exit loose monetary policy. The increasing blurring of monetary and fiscal policy, growing risks for financial stability and a general "getting accustomed" to cheap money mean that monetary policy normalisation is becoming an ever greater challenge.

Looking to the future and the willingness to modernise are important not only for monetary policy, they are also crucial for the financial markets. Back in the 18th century, Frankfurt evolved into a financial centre of international renown – thanks to the newly established trade in government bonds. However, Frankfurt bankers long wanted nothing to do with shares, which resulted in Frankfurt being eclipsed by Berlin in the 19th century.

Nowadays, there are opportunities, for instance, in financing the greening of the economy. And in terms of technology, too, Deutsche Börse has its finger on the pulse of the era. Blockchain, in particular, promises to improve the settlement of financial transactions.[21]

Deutsche Börse and the Bundesbank have jointly developed and tested a prototype for securities settlement, which has proved suited for this purpose.[22] However, the research project also demonstrates that a new technology does not always trump the existing systems, as decentralised technology is, in principle, somewhat slower and more expensive, yet provides other advantages. In other words, its use requires an exact cost-benefit analysis.

Ladies and gentlemen,

It is worth taking a closer look at Christian Borchert's family portraits, which I mentioned earlier on. He always used the same camera, with the same focal length, and he always took his pictures in landscape format.

He thereby gave change a framework. And you might be in for a surprise if you are looking for breaks in the photos, for you might find "more continuities than breaks".[23]

For monetary policy, the European treaties set a clear governance framework. At its heart are the people and the promise made to them – the promise to maintain price stability within the euro area.

I wish you all a happy and successful 2020. Thank you for your attention.

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[21] Deutsche Bundesbank (2019), Crypto tokens in payments and securities settlement, Monthly Report, July 2019, pp. (pages) 39-57.
[22] Deutsche Bundesbank (2019), BLOCKBASTER, Monthly Report, July 2019, p. 51.
[23] Lehmstedt, M. (2017), "Diese Bilder sind Futter für die Fantasie", DIE ZEIT, interview by Gabriel Kords published on 21 April 2017.

Monetary Policy Strategies and Tools When Inflation and Interest Rates Are Low⋆

By LAEL BRAINARD*

Comments on *Monetary Policy in the Next Recession?*, a report by Stephen Cecchetti, Michael Feroli, Anil Kashyap, Catherine Mann, and Kim Schoenholtz. I want to thank Anil Kashyap and the Initiative on Global Markets for inviting me, along with my colleague Raphael Bostic, to comment on this year's U.S. Monetary Policy Forum report by a distinguished set of authors.[1] This year's report addresses the challenges that monetary policy is likely to encounter in the next downturn. This topic is under active review by the Federal Reserve and our peers in many other economies.[2]

Looking Back
The report explores the important question of whether the new monetary policy tools are likely to be sufficiently powerful in the next downturn. The report assesses how unconventional tools—including forward guidance, balance sheet policies, negative nominal interest rates, yield curve control, and exchange rate policies—have performed over the past few decades. It employs a novel approach by examining the effect on an index of financial conditions the authors construct. This approach adds to what we have learned from earlier papers that have examined the performance of unconventional policy tools with respect to individual components of financial conditions—most notably, long-term sovereign yields, but also mortgage rates, equities, exchange rates, and corporate debt spreads.[3]

⋆ This speech was given at the 2020 U.S. Monetary Policy Forum, New York City on 21 February, 2020.

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[1] I am grateful to Ivan Vidangos of the Federal Reserve Board for assistance in preparing this text. These remarks represent my own views, which do not necessarily represent those of the Federal Reserve Board or the Federal Open Market Committee.
  See Stephen G. Cecchetti, Michael Feroli, Anil K. Kashyap, Catherine L. Mann, and Kim Schoenholtz (2020), Monetary Policy in the Next Recession?, report presented at the 2020 U.S. Monetary Policy Forum, sponsored by the Initiative on Global Markets at the University of Chicago Booth School of Business, held in New York, February 21.

[2] See European Central Bank (2020), "ECB Launches Review of Its Monetary Policy Strategy," press release, January 23; Bank of Canada (2017), "Monetary Policy Framework Issues: Toward the 2021 Inflation-Target Renewal," workshop held at the Bank of Canada, Quebec, September 14; and Mark Carney (2020), "A Framework for All Seasons?" speech delivered at "The Future of Inflation Targeting," a research workshop held at the Bank of England, London, January 9.
  The Federal Reserve's review of its monetary policy strategies, tools, and communications is ongoing. See the Board's website; Richard H. Clarida (2019), "The Federal Reserve's Review of Its Monetary Policy Strategy, Tools, and Communication Practices," speech delivered at the 2019 U.S. Monetary Policy Forum, sponsored by the Initiative on Global Markets at the University of Chicago Booth School of Business, New York, February 22; and Jerome H. Powell (2019), "Monetary Policy: Normalization and the Road Ahead," speech delivered at the 2019 SIEPR Economic Summit, Stanford Institute of Economic Policy Research, Stanford, Calif., March 8.

[3] See Joseph Gagnon, Matthew Raskin, Julie Remache, and Brian Sack (2011), "The Financial Market Effects of the Federal Reserve's Large-Scale Asset Purchases," International Journal of Central Banking, vol. 7 (March), pp. 3–43; Michael E. Cahill, Stefania D'Amico, Canlin Li, and John S. Sears (2013), "Duration Risk versus Local Supply Channel in Treasury Yields: Evidence from the Federal Reserve's Asset Purchase Announcements," Finance and Economics Discussion Series 2013-35 (Washington: Board of Governors of the Federal Reserve System, April); Michael A.S. Joyce, Ana Lasaosa, Ibrahim Stevens, and Matthew Tong (2011), "The Financial Market Impact of Quantitative Easing in the United Kingdom," International Journal of Central Banking, vol. 7 (September), pp. 113–61; Simon Gilchrist, David López-Salido, and Egon Zakrajšek (2015), "Monetary Policy and Real Borrowing Costs at the Zero Lower Bound," American Economic Journal: Macroeconomics, vol. 7 (January), pp. 77–109; Marcel Fratzscher, Marco Lo Duca, and Roland Straub (2016), "ECB Unconventional Monetary Policy: Market Impact and International Spillovers," IMF Economic Review, vol. 64 (April), pp. 36–74; Michael T. Kiley (2013), "Exchange Rates, Monetary Policy Statements, and Uncovered Interest Parity: Before and after the Zero Lower Bound (PDF)," Finance and Economics Discussion Series 2013-17 (Washington: Board of Governors of the Federal Reserve System, January); Michael T. Kiley (2014), "The Response of Equity Prices to Movements in Long-Term Interest Rates Associated with Monetary Policy Statements: Before and after the Zero Lower Bound," Journal of Money, Credit and Banking, vol. 46 (August), pp. 1057–71; Michael T. Kiley (2016), "Monetary Policy Statements, Treasury Yields, and Private Yields: Before and after the Zero Lower Bound," Finance Research Letters, vol. 18 (August), pp. 285–90; and John H. Rogers, Chiara Scotti, and Jonathan H. Wright (2014), "Evaluating Asset-Market Effects of Unconventional Monetary Policy: A Multi-Country Review," Economic Policy, vol. 29 (October), pp. 749–99.

Empirically assessing the question in the report is not only important, but also challenging, as the report readily acknowledges. There are a host of difficult endogeneity and omitted-variable issues, which the authors endeavor to address. The authors conclude that unconventional monetary policies worked during the crisis but did not fully offset a significant tightening in financial conditions. This finding leads the authors to conclude that these policies should be deployed quickly and aggressively in the future through a plan that is communicated in advance. This point is very important, so it will be the focus of my discussion.

Looking back at the international experience, the evidence suggests that forward guidance and balance sheet policies were broadly effective in providing accommodation following the financial crisis. But they were less effective when there were long delays in implementation or apparent inconsistencies among policy tools. It is important to distill key lessons from the past use of these tools in order to make them more effective in the future.[4]

First, in some cases around the world, unconventional tools were implemented only after long delays and debate, which sapped confidence, tightened financial conditions, and weakened recovery. The delays often reflected concerns about the putative costs and risks of these policies, such as stoking high inflation and impairing market functioning. These costs and risks did not materialize or proved manageable, and I expect these tools to be deployed more forcefully and readily in the future.[5]

Second, forward guidance proved to be vital during the crisis, but it took some time to recognize the importance of conditioning forward guidance on specific outcomes or dates and to align the full set of policy tools. In several cases, the targeted outcomes set too low a bar, which in turn diminished market expectations regarding monetary accommodation. In some cases, expectations regarding the timing of liftoff and asset purchase tapering worked at cross-purposes.

In addition, in some cases, it proved difficult to calibrate asset purchase programs smoothly over the course of the recovery. To the extent that the public is uncertain about the conditions that might trigger asset purchases, the scale of purchases, and how long the purchases might be sustained, it could undercut the efficacy of the policy. Furthermore, the cessation of asset purchases and subsequent balance sheet normalization can present challenges in communications and implementation.

Finally, in the fog of war, it was difficult for policymakers to distinguish clearly between temporary headwinds associated with the crisis and emerging structural features of the new normal. In part as a result, it took some time to integrate forward guidance and other unconventional policies seamlessly, and it took even longer to recognize that policy settings were unlikely to return to pre-crisis norms.

Looking Ahead

The current generation of central bankers faces a different core challenge than the last generation, with substantially smaller scope for cutting interest rates to buffer the economy and inflation that is low and relatively unresponsive to resource utilization. With trend inflation running below the symmetric 2 percent objective, there is a risk that inflation expectations have

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[4] For instance, analysis by Ben Bernanke suggests "that a combination of asset purchases and forward guidance can add roughly 3 percentage points of policy space." See Ben S. Bernanke (2020), "The New Tools of Monetary Policy," presidential address to the American Economic Association, San Diego, Calif., January 4, p.3.

[5] This issue was discussed in the July 2019 Federal Open Market Committee meeting in the context of the framework review. As noted in the minutes of the meeting (p. 3), "Participants further observed that such inflation risks—along with several of the other perceived risks of providing substantial accommodation through nontraditional policy tools, including possible adverse implications for financial stability—had not been realized. In particular, a number of participants commented that, as many of the potential costs of the Committee's asset purchases had failed to materialize, the Federal Reserve might have been able to make use of balance sheet tools even more aggressively over the past decade in providing appropriate levels of accommodation." (Available on the Board's website).

slipped. With price inflation showing little sensitivity to resource utilization, policy may have to remain accommodative for a long time to achieve 2 percent inflation following a period of undershooting. With the equilibrium interest rate very low, the Federal Open Market Committee can cut the federal funds rate by only about half as much as it has done historically to buffer the economy from recession. Consequently, the policy rate is likely to be constrained by the lower bound more frequently, likely at times when inflation is below target and unemployment is elevated. The likelihood that the policy rate will be stuck at the lower bound more frequently risks eroding expected inflation and actual inflation, which could further compress the room to cut nominal interest rates in a downward spiral. Japan's experience illustrates the challenges associated with such a downward spiral.

Today's new normal calls not only for a broader set of tools, but also a different strategy.[6] We should clarify in advance that we will deploy a broader set of tools proactively to provide accommodation when shocks are likely to push the policy rate to its lower bound. Equally important, we should adopt a strategy that successfully achieves maximum employment and average inflation outcomes of 2 percent over time.

The lessons from the crisis would argue for an approach that commits to maintain policy at the lower bound until full employment and target inflation are achieved. This forward guidance could be reinforced by interest rate caps on short-term Treasury securities over the same horizon. To have the greatest effect, it will be important to communicate and explain the framework in advance so that the public anticipates the approach and takes it into account in their spending and investment decisions.

Forward guidance that commits to refrain from lifting the policy rate from its lower bound until full employment and 2 percent inflation are achieved is vital to ensure achievement of our dual-mandate goals with compressed conventional policy space.[7] To strengthen the credibility of the forward guidance, interest rate caps could be implemented in tandem as a commitment mechanism. Based on its assessment of how long it is likely to take to achieve full employment and target inflation, the Committee would commit to capping rates out the yield curve for a period consistent with its expectation for the duration of the outcome-based forward guidance. Of course, if the outlook shifted materially, the Committee could reassess how long it will take to reach its goals and adjust policy accordingly.

One important benefit is that this approach would smoothly move to capping interest rates on the short-to-medium segment of the yield curve once the policy rate moves to the lower bound and avoid the risk of delays or uncertainty that could be associated with asset purchases regarding the scale and timeframe. The interest rate caps would transmit additional accommodation through the longer rates that are relevant for households and businesses in a manner that is more akin to conventional policy and more continuous than quantitative asset purchases.

Another important benefit is that the forward guidance and the yield curve caps would reinforce each other. Setting the horizon on the interest rate caps to reinforce forward guidance on the policy rate would augment the credibility of the yield curve caps and thereby diminish concerns about an open-ended balance sheet commitment. Once target inflation and full employment are achieved, and the caps expire, any short-to-medium-term Treasury securities that were acquired under the program would roll off organically, unwinding the policy smoothly

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[6] See Lael Brainard (2019), "Federal Reserve Review of Monetary Policy Strategy, Tools, and Communications: Some Preliminary Views," speech delivered at the presentation of the 2019 William F. Butler Award, New York Association for Business Economics, New York, November 26.

[7] See Ben S. Bernanke, Michael T. Kiley, and John M. Roberts (2019), "Monetary Policy Strategies for a Low-Rate Environment," Finance and Economics Discussion Series 2019-009 (Washington: Board of Governors of the Federal Reserve System, February); and Hess Chung, Etienne Gagnon, Taisuke Nakata, Matthias Paustian, Bernd Schlusche, James Trevino, Diego Vilán, and Wei Zheng (2019), "Monetary Policy Options at the Effective Lower Bound: Assessing the Federal Reserve's Current Policy Toolkit," Finance and Economics Discussion Series 2019-003 (Washington: Board of Governors of the Federal Reserve System, January).

and predictably. This approach should avoid some of the tantrum dynamics that have led to premature steepening of the yield curve in several jurisdictions.[8]

Today's low-inflation, low interest rate environment requires not only new recession-fighting tools but also a new strategy to address the persistent undershooting of the inflation target—and the risk to inflation expectations—well before a downturn. Various strategies have been proposed that seek to make up for past inflation deviations from target.[9] To be successful, formal makeup strategies, such as an average-inflation-targeting rule, require that market participants, households, and businesses understand the policy in advance and find it credible. While formal average-inflation-targeting rules have some attractive properties in theory, they could be difficult to communicate and implement in practice due to time-inconsistency problems as well as uncertainty about underlying economic parameters.[10]

I prefer flexible inflation averaging that would aim to achieve inflation outcomes that average 2 percent over time. Flexible inflation averaging would imply supporting inflation a bit above 2 percent for some time to compensate for the inflation shortfall over previous years and anchor inflation expectations at 2 percent. Flexible inflation averaging would bring some of the benefits of a formal average-inflation-targeting rule, but it could be more robust and simpler to communicate and implement. Following several years when inflation has remained in the range of 1-1/2 to 2 percent, the Committee could target inflation outcomes in a range of 2 to 2-1/2 percent for a period to achieve inflation outcomes of 2 percent, on average, overall.

By committing to achieve inflation outcomes that average 2 percent over time, the Committee would make clear in advance that it would accommodate rather than offset modest upward pressures to inflation in what could be described as a process of opportunistic reflation.[11] This approach will help move inflation expectations back to our 2 percent objective, which is critical to preserve conventional policy space.

It is important to emphasize that for monetary policy to be effective, it will be key for policymakers to communicate their strategy clearly in advance to the public, to act early and decisively, and to commit to providing the requisite accommodation until full employment and target inflation are sustainably achieved. This was one of the important conclusions of this year's U.S. Monetary Policy Forum report.

Fiscal Policy

Even with a revamped monetary policy strategy and expanded tools, there are risks. As the authors note, persistent very low levels of long-run rates could hamper the ability of monetary policy to support the economy in a downturn through the traditional mechanism of pushing down long-term rates.[12] Moreover, the equilibrium interest rate or, possibly, inflation expectations could be lower than most current estimates, with the implication that unconventional policies would need to compensate for a larger reduction in the conventional

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[8] For unusually severe recessions, such as the financial crisis, such an approach could be augmented with purchases of 10-year Treasury securities to provide further accommodation at the long end of the yield curve. The requisite scale of such purchases—when combined with medium-term yield curve ceilings and forward guidance on the policy rate—should be relatively smaller than if the longer-term asset purchases were used alone.

[9] See, for example, Lars E.O. Svensson (2020), "Monetary Policy Strategies for the Federal Reserve," NBER Working Paper Series 26657 (Cambridge, Mass.: National Bureau of Economic Research, January).

[10] See the discussion of formal makeup strategies in the minutes of the September 2019 Federal Open Market Committee meeting (pp. 2–3), available on the Board's website. See also David Reifschneider and David Wilcox (2019), "Average Inflation Targeting Would Be a Weak Tool for the Fed to Deal with Recession and Chronic Low Inflation," Policy Brief PB19-16 (Washington: Peterson Institute for International Economics, November).

[11] See Janice C. Eberly, James H. Stock, and Jonathan H. Wright (2019), "The Federal Reserve's Current Framework for Monetary Policy: A Review and Assessment," paper presented at the Conference on Monetary Policy Strategy, Tools, and Communication Practices, sponsored by the Federal Reserve Bank of Chicago, Chicago, June 4.

[12] See, for example, the minutes of the October 2019 Federal Open Market Committee meeting (p. 4): "In addition, some participants noted that the effectiveness of these tools might be diminished in the future, as longer-term interest rates have declined to very low levels and would likely be even lower following an adverse shock that could lead to the resumption of large-scale asset purchases; as a result, there might be limited scope for balance sheet tools to provide accommodation." (Available on the Board's website.)

policy buffer.13

Accordingly, in addition to a forceful response from monetary policy, robust countercyclical fiscal policy is vital. The reduced conventional monetary policy buffer makes the importance of fiscal support during a downturn even greater than it has been in the past, and the case for fiscal support is especially compelling in the context of very low long-term interest rates. Not only is fiscal policy more vital when monetary policy is constrained by the lower bound, but research suggests it is also more powerful.14

Whereas monetary policy is powerful but blunt, fiscal policy can be more targeted in its effects. This is especially important today, when a large share of American households have low liquid savings and are particularly vulnerable to periods of unemployment or underemployment.

The appropriate design of a more automatic, faster-acting countercyclical fiscal approach requires study and development. Just as monetary policymakers are actively reviewing their tools and strategies, now is the time to undertake a review of fiscal tools and strategies to ensure they are ready and effective.

Financial Stability

Financial stability is central to the achievement of our dual-mandate goals. The new normal of low interest rates and inflation also has implications for the interplay between financial stability and monetary policy. In the decades when the Phillips curve was steeper, inflation tended to rise as the economy heated up, which would prompt the Committee to raise interest rates to restrictive levels. These interest rate increases would have the effect of tightening financial conditions more broadly, thereby naturally damping financial imbalances as the expansion extends.

With trend inflation persistently below target and a flat Phillips curve, not only is the policy rate expected be low for long due to the decline in the neutral rate, but the policy rate may also remain below the neutral rate for longer in order to move inflation back to target sustainably. The expectation of a long period of accommodative monetary policy and low rates, during a period with sustained high rates of resource utilization, is conducive to risk-taking, providing incentives to reach for yield and take on additional debt.

To the extent that the combination of a low neutral rate, a flat Phillips curve, and low underlying inflation may lead financial imbalances to become more tightly linked to the business cycle, it is important to use tools other than monetary policy to temper the financial cycle. In today's new normal, a combination of strengthened structural safeguards along with countercyclical macroprudential tools is important to enable monetary policy to stay focused on achieving maximum employment and target inflation.15 The countercyclical capital buffer, which was not available before the crisis, is particularly well designed to address financial imbalances over the cycle.

Conclusion

With the policy rate more likely to be constrained by the lower bound, the core challenge facing the current generation of central bankers is different than the last generation. The authors of the report emphasize the importance of deploying an expanded toolkit proactively, avoiding costly delays, and communicating clearly to the public. To be fully effective, proactive use of an expanded toolkit needs to be coupled with a new strategy that achieves average inflation

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13 See, for instance, Michael T. Kiley (2019), "The Global Equilibrium Real Interest Rate: Concepts, Estimates, and Challenges," Finance and Economics Discussion Series 2019-076 (Washington: Board of Governors of the Federal Reserve System, October).

14 See Paul R. Krugman (1998), "It's Baaack: Japan's Slump and the Return of the Liquidity Trap," Brookings Papers on Economic Activity, no. 2, p. 137–87; and Olivier J. Blanchard and Daniel Leigh (2013), "Growth Forecast Errors and Fiscal Multipliers," American Economic Review, vol. 103 (May, Papers and Proceedings), pp. 117–20.

15 See, for example, the minutes of the January 2020 Federal Open Market Committee meeting (p. 9), available on the Board's website.

outcomes of 2 percent along with maximum employment over time.

The Monetary Policy Toolbox: Evidence from the Euro Area∗

By Philip R. Lane∗

Introduction

I would like to thank Chicago Booth for inviting me to speak at the 2020 U.S. Monetary Policy Forum, sponsored by the Initiative on Global Markets at the University of Chicago Booth School of Business, New York, New York.[1]

The focus of this year's US Monetary Policy Forum, the analysis of unconventional monetary policies, is relevant for many economies, including the euro area. That said, while central banks face many common challenges, the evolution of economic, financial and monetary conditions in the euro area was also specifically influenced by both the euro area sovereign debt crisis that followed the global financial crisis and the European policy responses to these crises. As a result, the euro area is at a different point in the monetary policy cycle than other jurisdictions.

The post-crisis monetary policy of the ECB shares many similarities with that of the Federal Reserve: having largely exhausted the conventional space for moving its policy instrument (the short-term policy rate), the ECB turned to a broad set of unconventional measures in pursuit of its statutory objective.[2] However, there are important differences between the unconventional measures taken by the Federal Reserve and the ECB. In particular, the ECB moved into negative territory with its policy rate, employed targeted refinancing operations to promote credit growth and customised its asset purchase programme (APP) to the specific context of the euro area. Our understanding of the propagation mechanisms of these measures and their efficacy in supporting the economy and the inflation process is steadily deepening.[3]

In my remarks today, I will discuss our experience with the non-standard measures in our monetary toolbox and explain our monetary policy reaction function in the current below-target inflation environment.[4]

The nature of our reaction function is spelled out in our forward guidance, which provides a unified framework across our different policy instruments – with the guidance on the rate path at its centre – and facilitates automatic adjustment in market conditions in response to shocks that are assessed as influencing the future path of interest rates.

The case for unconventional measures in a low interest rate environment

Interest rates in advanced economies have been on a broad downward path for more than three decades and remain close to historical lows.[5] As has been highlighted in many studies, the

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drivers of this long-term pattern largely boil down to demographics, productivity and the elevated net demand for safe assets.[6] As a result, the real neutral interest rate (r*) has declined across advanced economies. For the euro area, recent Eurosystem estimates point to r* at zero or even below zero, which is a marked decline since the early 2000s (see Chart 1). Estimates of r* for the United States show a similar trend but remain at a higher level than in the euro area.[7]

While the factors that have reduced r* are beyond the control of the central bank, the fact that the level of r* is lower has significant implications for monetary policy: the short-term policy interest rate hits the zero bound more often and, when it does so, remains at the lower bound for a longer time. A recent ECB staff paper shows that, in a scenario where r* falls from 2 percent to zero, the incidence of hitting the zero bound almost doubles.[8]

Lower real rates reduce the available policy space to counter low inflation. This may increase the time it takes for inflation to return to target and this delay may be compounded if a prolonged period of low inflation also erodes inflation expectations.

Chart 1

Econometric estimates of euro area real neutral interest rate

(percentages per annum)
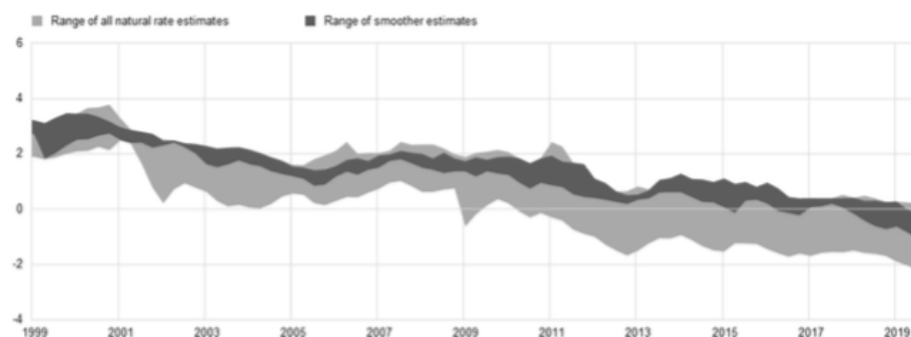
Sources: Brand, C., Bielecki, M. and Penalver, A. (eds.) (2019), "The natural rate of interest: estimates, drivers, and challenges to monetary policy", *Occasional Paper Series*, No 217, ECB; and all works cited in footnote 7.
Notes: Ranges span point estimates across models to reflect model uncertainty and no other source of r* uncertainty. The dark shaded area highlights smoother r* estimates that are statistically less affected by cyclical movements in the real rate of interest than the other estimates depicted here.

The ECB's monetary policy toolbox

The Governing Council's monetary policy reaction function is laid out in our forward guidance on the path of our policy instruments. Together with the forward guidance on the rate path at the centre, this provides a coherent framework for the various non-standard measures which the ECB has deployed: negative interest rates, asset purchases and targeted long-term

[6] For a discussion of how the post-crisis shift in risk appetite and regulatory reforms has contributed to the increased preference for safe assets, see Lane, P. R. (2019), "Determinants of the real interest rate", speech at the National Treasury Management Agency, Dublin, 28 November.

[7] See Ajevskis, V. (2018), "The Natural Rate of Interest: Information Derived from a Shadow Rate Model", Working Paper Series, No 02, Latvijas Banka; Brand, C., Goy, G. and Lemke, W. (2020), "Natural Rate Chimera and Bond Pricing Reality", DNB Working Paper Series, No 666, De Nederlandsche Bank; Brand, C. and Mazelis, F. (2019), "Taylor-rule consistent estimates of the natural rate of interest", Working Paper Series, No 2257, ECB; Fiorentini, G., Galesi, A., Pérez-Quirós, G. and Sentana, E. (2018), "The Rise and Fall of the Natural Interest Rate", Working Paper Series, No 1805, Center for Monetary and Financial Studies; Geiger, F. and Schupp, F. (2018), "With a Little Help from My Friends: Survey-Based Derivation of Euro Area Short Rate Expectations at the Effective Lower Bound", Discussion Paper Series, No 27, Deutsche Bundesbank; Holston, K., Laubach, T. and Williams, J. C. (2017), "Measuring the Natural Rate of Interest: International Trends and Determinants", Journal of International Economics, Vol. 108, Supplement 1, S59-S75; Jarociński, M. (2017), "VAR-based estimation of the euro area natural rate of interest", mimeo, ECB; and Johannsen, B. K. and Mertens, E. (2018), "A Time Series Model of Interest Rates with the Effective Lower Bound", BIS Working Papers, No 715, BIS

[8] See Coenen, G., Montes-Galdon, C. and Smets, F. (2020), "Effects of state-dependent forward guidance, large-scale asset purchases and fiscal stimulus in a low-interest-rate environment", Working Paper Series, No 2352, ECB.

refinancing operations (TLTROs).

Forward guidance

Initially expressed in qualitative terms, the ECB's rate guidance has evolved over time, with the current formulation made explicitly conditional on a set of criteria regarding the inflation outlook. The cross-country experience with forward guidance indicates that its effectiveness can differ considerably depending on the type of conditionality attached to the policy rate path. In particular, time-based guidance provided over relatively short horizons appears to be rather ineffective in reducing market uncertainty.[9]

Conversely, the evidence indicates that rate forward guidance over long horizons, or state-based guidance, is more effective in reducing the sensitivity of asset prices to macroeconomic news.

The state-contingent formulation links the Governing Council's expected interest rate path to at least two conditions regarding the inflation outlook. First, inflation has to "robustly converge to a level sufficiently close to, but below, 2 percent within our projection horizon." Second, this convergence needs to be "consistently reflected in underlying inflation dynamics". The first condition is forward-looking: inflation has to be seen to be converging to a level sufficiently close to 2 percent well before the end point of the horizon: this is the meaning of "robust convergence". The second condition is backward-looking: we have to see the robust convergence in future inflation confirmed and verified in actual measures of underlying inflation.

Importantly, the decision we took last September has established a unified framework for our forward guidance across policy instruments that links the horizon of both our net asset purchases and reinvestments to our forward guidance on the rate path: net purchases are expected to continue until "shortly" before we start raising the key ECB rates; and reinvestments are expected to run "for an extended period of time past the date when we start raising the key ECB interest rates". Whereas the forward guidance on the rate path acts on the expectations component of longer-term rates, the asset purchases especially affect term premia, as I will discuss in more detail later on.

Evidence suggests that the enhanced forward guidance we introduced last September is well understood by market participants. The interest rate lift-off dates in survey-based measures largely coincide with the time at which inflation expectations two years ahead – the horizon of the ECB/Eurosystem staff macroeconomic projections – are around levels close to, but below, 2 percent. This indicates that the link between our interest rate forward guidance and the inflation threshold is understood.

More than that, thanks to its state-contingent nature, our rate guidance provides an automatic stabilisation mechanism that steers rate expectations – and expectations about our asset purchases – as a function of the evolving inflation outlook. In practice, we have seen this automatic stabilisation function of our forward guidance operate effectively, with market expectations for a first increase of the policy rate accommodating short-term volatility in the inflation outlook. For example, the January 2020 Bloomberg survey pointed to a later lift-off date of the second quarter of 2022 (blue vertical line in Chart 2) in comparison with the Bloomberg survey of April 2019 (yellow vertical line in Chart 2), which coincided with the slight decline in Consensus Economics expectations for annual inflation in the euro area (yellow and blue diamonds in Chart 2).

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[9] See Ehrmann, M., Gaballo, G., Hoffmann, P. and Strasser, G. (2019), "Can More Public Information Raise Uncertainty? The International Evidence on Forward Guidance", Journal of Monetary Economics, Vol. 108, pp. 93-112. This paper reviews the experience of major central banks with deploying rate forward guidance based on different forms of conditionality – open-ended, time-based over short/long horizons and threshold-based – and provides an assessment of its effectiveness by comparing the impact on the responsiveness of bond yields to macroeconomic news.

Chart 2

Inflation as projected by Consensus Economics and survey-implied lift-off date

(percentage changes)
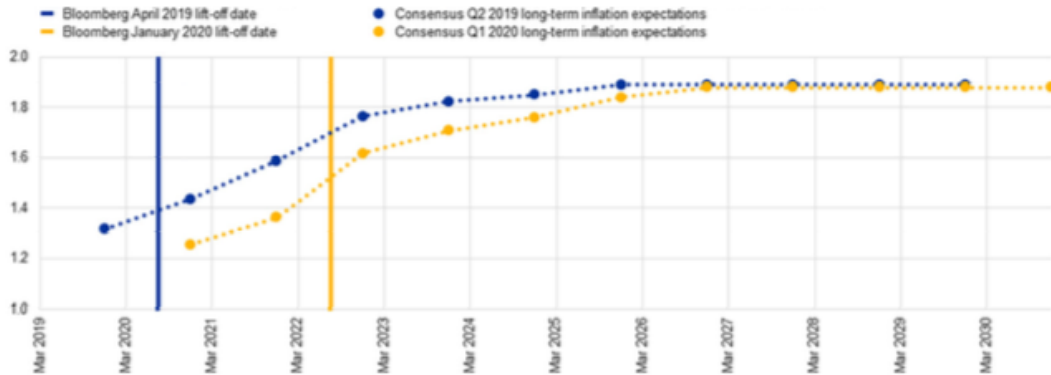
Sources: Consensus Economics and Bloomberg.
Notes: Vertical lines denote expected lift-off dates reported in the April and January Bloomberg surveys. Diamonds denote expectations for average annual inflation rates in each year between 2019 and 2029 reported in the Consensus Economics surveys. The latest observation is for January 2020.

In addition to serving as an automatic stabiliser for policy rate expectations, the interest rate forward guidance is also the anchor for expectations of the net asset purchase and reinvestment horizons, as these measures are tightly linked to the interest rate lift-off. Changes in the inflation outlook that trigger a reappraisal of the lift-off date should therefore also affect the expected end date of net asset purchases and reinvestments, thereby stabilising the long end of the yield curve.[10]

In fact, this tight link is reflected in the positive co-movement between short and long-term interest rates in response to news that affects the macroeconomic outlook (Chart 3).

While the automatic stabilisation function embedded in the forward guidance accommodates any short- term volatility in the outlook, the Governing Council continues to stand ready to adjust all of its instruments, as appropriate, to ensure that inflation moves towards its aim in a sustained manner, in line with its commitment to symmetry.

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[10] Since the refinancing rate in the TLTRO programme is linked to the policy rate for the main refinancing operations, the attractiveness of TLTRO funding conditions also adjusts in response to these shifts in market expectations.

Chart 3

Scatterplot of the contribution of demand factor to short-term rates (x-axis) versus long-term rates (y-axis).

(percentage points)
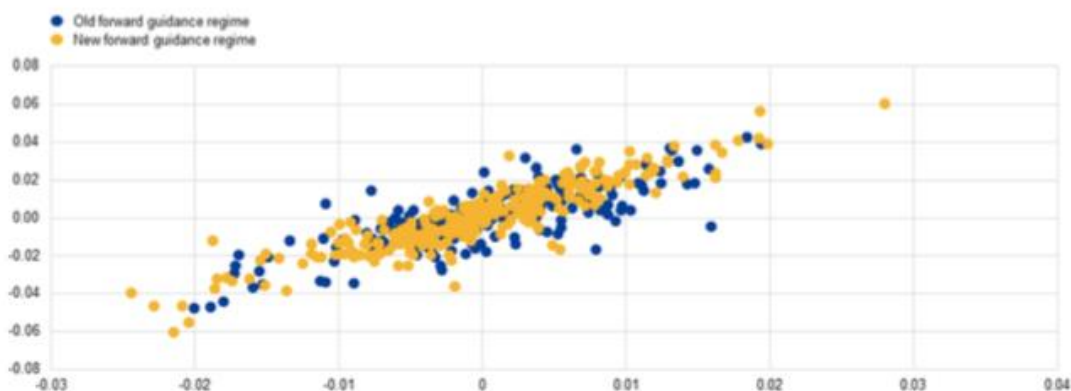
Source: ECB calculations.
Note: The latest observation is for 14 February 2020.

Overall, the available evidence suggests that the ECB's rate forward guidance has been and continues to be an effective monetary policy tool and that the transmission of forward guidance to financial conditions and the economy has remained stable over time. In part, this reflects the strong explicit conditionality embedded in the ECB's evolving rate forward guidance statement as well as the interaction with asset purchases and other instruments.[11]

Negative interest rates

Within our forward guidance framework, the negative interest rate policy has played a key role in enhancing this automatic stabilisation by lowering the effective lower bound. There was no playbook to guide the 2014 decision to push the deposit facility rate – which the ECB pays on bank excess reserves – into negative territory. Subsequent cuts, including the latest in September 2019, have brought the deposit facility rate to -0.5 percent.

A corollary of relaxing the lower bound constraint has been that the propagation of negative interest rates through the term structure of interest rates is qualitatively different and more powerful than traditional interest rate cuts occurring in positive territory. The difference comes from two effects.

The primary mechanism is the way in which expectations about the future path of monetary policy are reflected in market interest rates when the central bank reduces the overnight interest rate to very low levels. If the central bank reduces its policy rate to zero and makes it clear that it will not lower its policy rate any further, then this declared and self-imposed non-negativity restriction influences rate expectations among market participants: looking to the future, they will see rate increases as being more likely than rate decreases. As a result, the predictive density

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[11] For example, in Zlobins, A. (2019), "Macroeconomic Effects of the ECB's Forward Guidance", Working Paper Series, No 03, Latvijas Banka, the author evaluates the macroeconomic effects of rate forward guidance in the euro area and analyses its interplay with asset purchases using a set of structural vector auto-regressions with both constant and time-varying parameters. His findings suggest that the ECB's rate forward guidance has contributed to reducing yields significantly and raising activity and inflation, with evidence also suggesting that the introduction of the APP considerably enhanced the credibility of forward guidance.

of the future rate path will tend to be skewed upward, and interest rates at longer maturities will tend to decline by less than the reduction of the policy rate.

By contrast, under a negative interest rate policy, where future rate cuts are possible, the distribution of rate expectations is more symmetric, putting downward pressure on longer-maturity interest rates. Rate expectations can even be skewed downwards if the negative rate policy is flanked by communication that the interest rate might be reduced further. In this vein, the ECB's forward guidance has reinforced the negative interest rate policy by stating that the Governing Council expects the ECB's key interest rates "to remain at their present or lower levels for an extended period of time".

Chart 4

EONIA forward curve and its risk-neutral density: before the negative interest rate policy (left side) and after its introduction (right side)

(percentages per annum)
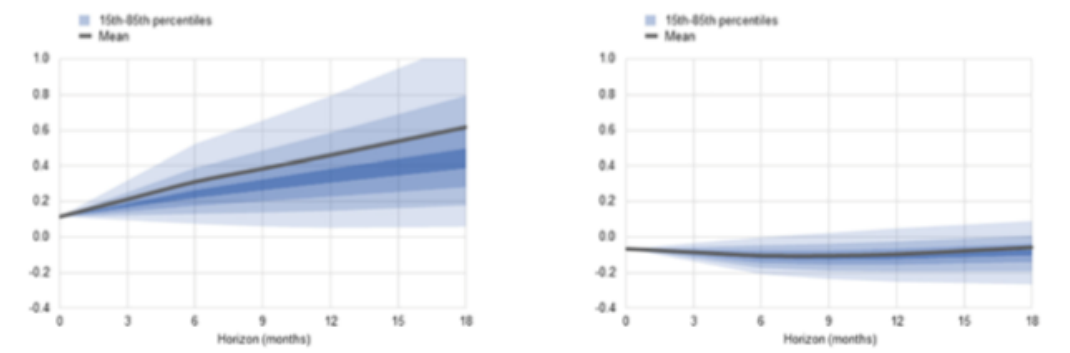
Source: Rostagno et al., op. cit.
Notes: Risk-neutral densities as of 29 January 2013 (left side) and 5 September 2014 (right side) derived from options on EURIBOR futures. The mean and the percentiles are shifted to the EONIA space by subtracting the EURIBOR3M-OIS3M spot spread. The forward curve distribution in January 2013 was rather steep and truncated in positive territory, which reflected the view of market participants that rates could not fall below zero and only increase.

This mechanism is illustrated in Chart 4: once the deposit facility rate was brought to a negative level in June 2014 and further reduced in September 2014, the forward curve became markedly flatter and the distribution of expectations more symmetric, with a mild inversion over short to medium-term maturities and no truncation in positive territory (see Chart 4, right side).[12]

An additional mechanism through which negative rates affect lending conditions is by discouraging cash hoarding and providing an incentive to banks to rebalance towards an alternative use for their funds (even as rate expectations are constant). Evidence shows that the improving financing conditions stemming from negative interest rates are feeding their way into the real economy through increased bank loans.[13]

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[12] The chart shows the 15th to 85th percentiles of the predictive density of future interest rate paths, which are generated using linear interpolation through risk-neutral option-implied distributions around the three-month EURIBOR at a 6, 9, 12 and 18-month horizon. More specifically, risk-neutral densities are derived by the ECB using options on EURIBOR futures for fixed expiration dates and then interpolated for fixed horizons. As usual, risk-neutral probabilities typically differ from actual or physical probabilities.

[13] In particular, in Bottero, M., Minoiu, C., Peydro, J.-L., Presbitero, A. and Sette, E. (2019), "Negative Monetary Policy Rates and Portfolio Rebalancing: Evidence from Credit Register Data," IMF Working Papers, No WP/19/44, International Monetary Fund, the authors find evidence, based on administrative credit data from Italy, that the negative interest rate policy has expansionary effects on credit supply – and hence the real economy – through a portfolio rebalancing channel.

There is also evidence that negative rates have increased corporate investment: firms with large holdings of liquid assets that are exposed to negative deposit rates have increased investment compared with firms with small holdings of liquid assets that are less affected by negative deposit rates (see Chart 5).[14] This effect is economically significant and estimated to boost corporate investment by as much as 1 percentage point per annum.

Chart 5

Investment growth of firms exposed to negative deposit rates

(annual percentage changes)

Low liquid asset holdings
High liquid asset holdings
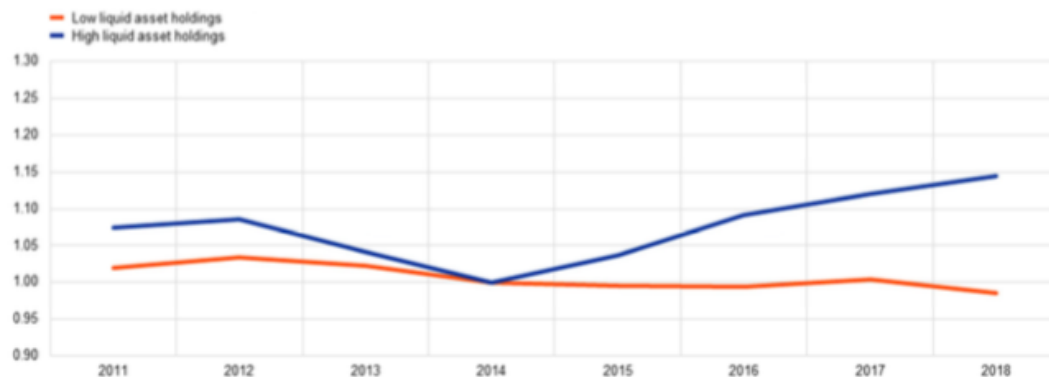
Source: Altavilla, C. et al., op. cit.
Notes: Average investment for corporate clients of banks whose average non-financial counterparty deposit rate has been negative at least once, distinguishing between firms with a ratio of current assets over total assets in the top decile (high liquid asset holdings, blue line) and in the bottom decile (low liquid asset holdings, red line) of the distribution. Investment orthogonal to firm fixed effects, normalised to 1 in 2014. The latest observation is for 2018.

That the effects of an interest rate cut are more powerful in negative territory can also be seen when considering the "footprint" on the term structure.[15] Using high-frequency financial market data ("tick data") to identify monetary surprises, ECB analysis shows that the transmission is more powerful than that of a standard interest rate cut in positive territory, since its effect on the yield curve extends to longer maturities, with a maximum effect around medium-term maturities (see Chart 6).

[14] See Altavilla, C., Burlon, L., Giannetti, M. and Holton, S. (2019), "Is there a zero lower bound? The effects of negative policy rates on banks and firms," Working Paper Series, No 2289, ECB.
[15] See my discussion in Lane, P. R. (2019), "The yield curve and monetary policy", public lecture for the Centre for Finance and the Department of Economics at University College London, 25 November.

Chart 6

Estimated effect of policy rate surprises: standard policy rate surprise (left side) and policy rate surprise in negative territory (right side)

(basis points)
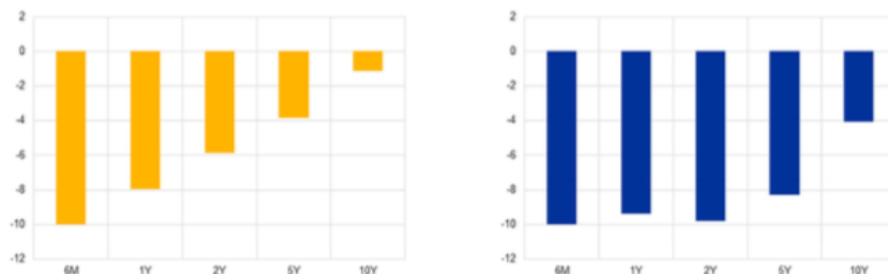
Source: Based on Altavilla, C., Brugnolini, L., Gürkaynak, R. S., Motto, R. and Ragusa, R. (2019), "Measuring euro area monetary policy", *Journal of Monetary Economics*, Vol. 108, pp. 162-179.
Note: Surprise impact normalised to 10 basis points for the six-month maturity.

Moreover, as banks tend to consider risk-free interest rates with short to medium-term maturities as the reference rates for pricing loans to non-financial corporations, the pronounced effects of the negative interest rate policy also propagate through the bank lending channel: our negative rate policy has contributed to a significant decline in lending rates to non-financial corporations since 2014, which in turn has translated into higher loan volumes channelled to the real economy.

The bank-based nature of the euro area economy lends itself to a swift transmission of interest rates to the economy. At the same time, there is a clear friction in the pass-through of negative rates to depositors, especially to retail customers (see Chart 7). Taken in isolation, this friction weighs on bank net interest income and profitability.

Chart 7

Share of deposits carrying a negative rate

(percentages)
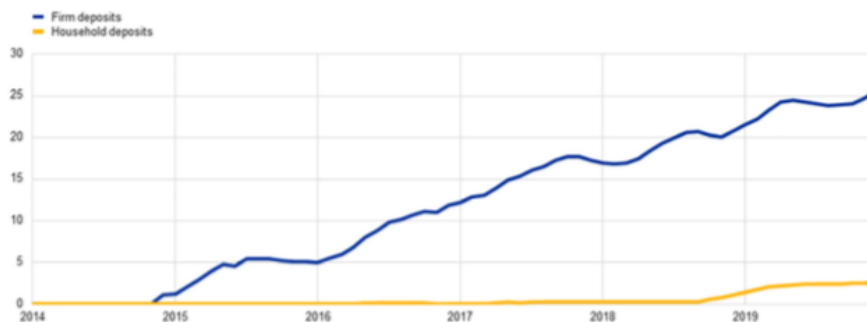
Sources: ECB and ECB calculations.
Notes: Deposit rates on outstanding amounts as reported by individual banks for each of the available product categories, weighted by outstanding amounts.
Household deposits also account for deposits held by non-profit institutions serving households. The latest observation is for December 2019.

That said, the overall impact of the negative interest rate policy extends beyond the mechanical effects on interest rate margins. Negative rates – especially in combination with the other elements in our policy package – support the overall level of economic activity. This leads to higher lending volumes and lower impairment provisioning, while interest rate cuts also generate capital gains on existing securities holdings and improve wholesale funding conditions for banks. From 2014 to 2018, the aggregate impact of non- standard measures was positive for the profitability of the banking system (see Chart 8).[16]

Chart 8

Bank return on assets since 2014 and impact of non-standard measures

(percentages of total assets)
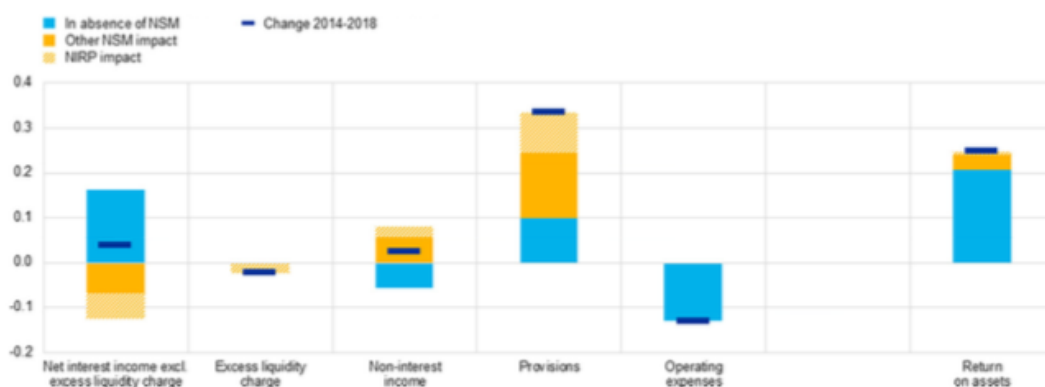
Source: ECB and ECB calculations based on Altavilla, Boucinha, Peydró 2018.
Notes: Profitability figures are based on supervisory data; the sample is balanced and adjusted for the largest mergers and acquisitions. Expenses are inverted, so that decreases in costs are shown as positive contributions to profits. The impacts of the negative interest rate policy (NIRP) and other non-standard measures (NSM) are obtained from a dynamic VAR model based on a conditional forecast for a counterfactual scenario without the non-standard measures. For details on the model, see Altavilla, C., Boucinha, M. and Peydró, J.-L., (2018) "Monetary policy and bank profitability in a low interest rate environment", Vol. 33, No 96, *Economic Policy*, pp. 531-586. As in Rostagno, M., op. cit., the scenario in the absence of NIRP is constructed under the assumption that the zero lower bound would be enforced at all times, thereby preventing the term structure from assuming negative values across all maturities.

In any event, the very substantial differences in return on equity across different regions with broadly similar monetary conditions (see Chart 9) suggest that other factors (such as market structure and efficiency) are more important in determining the overall profitability of the banking system. [17] Accordingly, any comprehensive analysis of the determinants of the profitability of the euro area banking system should not focus excessively on the mechanical effect of the limited pass-through of negative policy rates to retail deposit rates.

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[16] See Altavilla, C., Andreeva, D. C., Boucinha, M. and Holton, S. (2019), "Monetary policy, credit institutions, and the bank lending channel in the euro area", Occasional Paper Series, No 222, ECB.
[17] See de Guindos, L. (2019), "Challenges for bank profitability", speech at the OMFIF City Lecture, London, 1 May.

Chart 9

Annual bank return on equity

(percent)
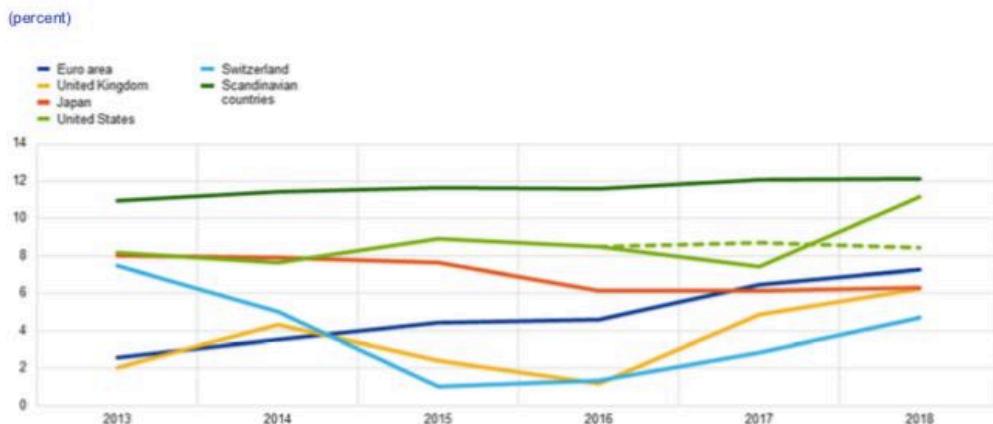
Sources: S&P MI (SNL Financial) and ECB calculations.
Notes: Dotted green line excludes the impact of changes in taxation in the United States. "Scandinavian countries" include Denmark, Norway and Sweden. The latest observation is for 2018.

Nonetheless, the Governing Council is closely monitoring the risk that the impact of negative rates on bank profitability may impair the transmission of monetary policy to the real economy. Moreover, the ECB decided last September to introduce a two-tier system for remunerating excess liquidity holdings, with the aim of supporting the bank-based transmission of monetary policy. The interest rate on such holdings is now tiered, with excess liquidity holdings up to six times the minimum reserve requirements receiving zero interest and holdings beyond that level remunerated at the deposit facility rate of -0.5 percent.

The implementation of the tiering policy has been smooth: on the one side, it has reduced the direct cost of negative interest rates for banks and thereby helped sustain the pass-through of low policy rates to bank lending rates, while on the other side, money market rates have continued to be well aligned with the policy rate, thereby preserving the positive contribution of negative rates to the accommodative stance of monetary policy.[18]

Finally, we are alert to the possibility that there may be a level for the policy rate below which a policy easing would have perverse effects and in fact lead to a tightening of bank credit conditions: the reversal rate.[19]

The ongoing pass-through of easing measures to lower lending rates and continued credit growth indicates that the reversal rate is not currently binding for the euro area. While measured credit growth is decelerating, this reflects the demand for bank loans mirroring the slowdown in the economy, and there are no signs of supply-side restrictions due to banks seeking to retrench from lending. In fact, bank credit standards in the euro area have been either loosening or steady around very supportive levels since 2014. In line with this, since the introduction of negative rates, banks have consistently reported in the ECB's bank lending survey that they view negative rates as supportive of credit creation.

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[18] The annual gross savings for banks from the two-tier system are estimated to amount to up to €4 billion in 2020 compared with the counterfactual projection if the system had not been introduced. These savings more than offset the additional gross excess liquidity charge of around €1 billion that resulted from the September cut of the deposit facility rate by 10 basis points.

[19] See Brunnermeier, M. and Koby, Y. (2018), "The Reversal Interest Rate", Working Paper Series, No 25406, National Bureau of Economic Research.

Targeted longer-term refinancing operations

TLTROs are an effective tool for providing credit easing and are particularly useful if there is a risk of the bank-based transmission mechanism becoming impaired.

Banks can use TLTROs to refinance with the ECB over an extended horizon and at very favourable conditions, provided that they meet the lending targets set by the ECB. Under the second and third rounds of the programme (TLTRO II and III), borrowing rates in the TLTROs can be as low as the deposit facility rate – which is currently set at -0.5 percent.

TLTROs lower bank funding costs via two distinct channels – direct and indirect. The funding cost relief is direct for those banks that use TLTRO financing instead of more expensive market funding. In addition, the TLTROs have indirectly contributed to favourable funding conditions on capital markets through the scarcity effects generated by reduced bond issuance from banks that replace market-based funding with TLTRO borrowing.

The effectiveness of TLTROs can be analysed by comparing the change in lending rates between those banks that participated in the operations and those that did not. The comparison shows that participating banks granted significantly more favourable rates to their corporate clients than their non-participating counterparts, which suggests a sizeable easing of financing conditions for firms, especially in vulnerable countries (see Chart 10).

Chart 10

Lending rates to non-financial corporations of TLTRO bidders and non-bidders

(percentage points; deviations from September 2014)
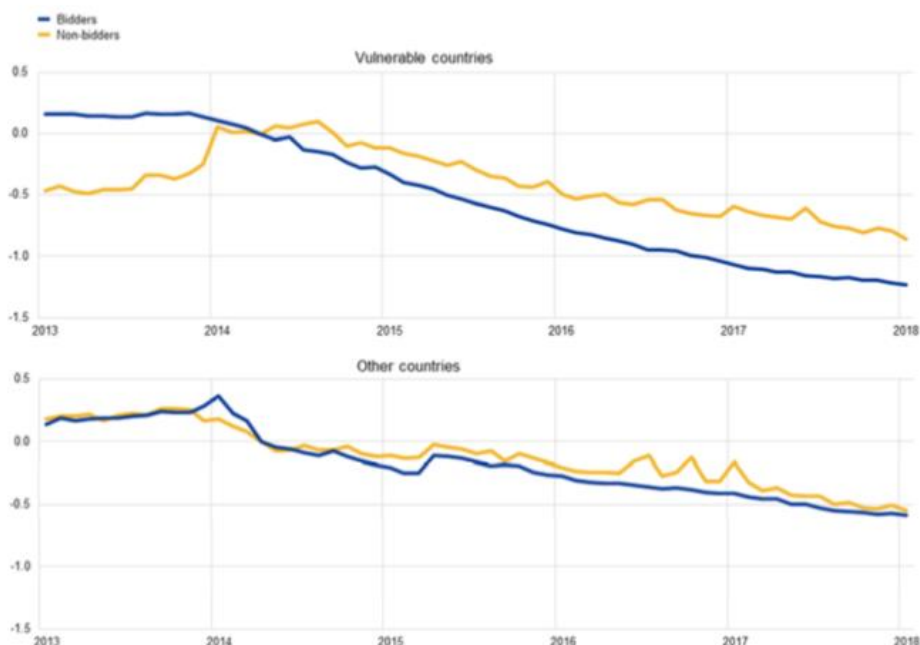
Sources: ECB individual monetary financial institution interest rate statistics and ECB calculations.
Notes: Non-financial counterparty lending rates are the rates on outstanding loans to non-financial corporations weighted by volume. The chart shows average rates across bidders and non-bidders in deviation from rates in September 2014. "Vulnerable countries" are Ireland, Greece, Spain, Italy, Cyprus, Portugal and Slovenia. "Other countries" are all the remaining euro area countries.

Asset purchase programme

Finally, by linking the horizon of the APP – both in terms of net purchases and the reinvestment policy – to the forward guidance on policy rates, expectations on the purchase horizon of the APP adjust in line with the inflation outlook and automatically regulate term premia.

The transmission of our asset purchases in the euro area has been similar to the transmission of other central banks' asset purchases in their respective jurisdictions, with the most pronounced effects at longer maturities.[20]

While negative interest rates and forward guidance have primarily been transmitted through the expectations component of interest rates, asset purchases have primarily operated through the term premium component. This is due to asset purchases affecting interest rates mainly by reducing the interest rate (or duration) risk borne by investors holding long-term bonds – the duration risk extraction channel. By purchasing securities with a relatively long maturity, the central bank frees up risk-bearing capacity among investors and fosters a rebalancing of their portfolio towards other, more risky, types of assets, including investment in productive capital.

In the euro area, our net asset purchases and reinvestment policy have led to substantial duration risk being withdrawn from the market, in the order of 20 percent of the duration-equivalent stock of current public debt in the four largest euro area economies (see Chart 11). Based on a term structure model that incorporates the duration channel, we can track the time-varying effect of the APP on term premia as expectations on the purchase horizon change over time. At present, the APP is estimated to be compressing euro area ten-year sovereign yields by more than 100 basis points (see Chart 12).

We are confident that the effects of our asset purchases continue to feed through to euro area financial conditions and support a more accommodative monetary policy stance. The experience we have built up over the last five years does not indicate that asset purchases entail diminishing returns over time. This is corroborated by recent research applied to the US experience which suggests that, once anticipation effects are taken into account, the later rounds of large-scale asset purchases undertaken by the Federal Reserve remained powerful.[21]

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[20] For a more detailed discussion of the channels of transmission of the APP and its impact on the euro area yield curve, see Lane, P. R. (2019), "The yield curve and monetary policy", public lecture for the Centre for Finance and the Department of Economics at University College London, London, 25 November.

[21] See Bernanke, B., op. cit.

Chart 11

Outstanding quantity of duration: PSPP and other investors

(EUR billions ten-year equivalents)
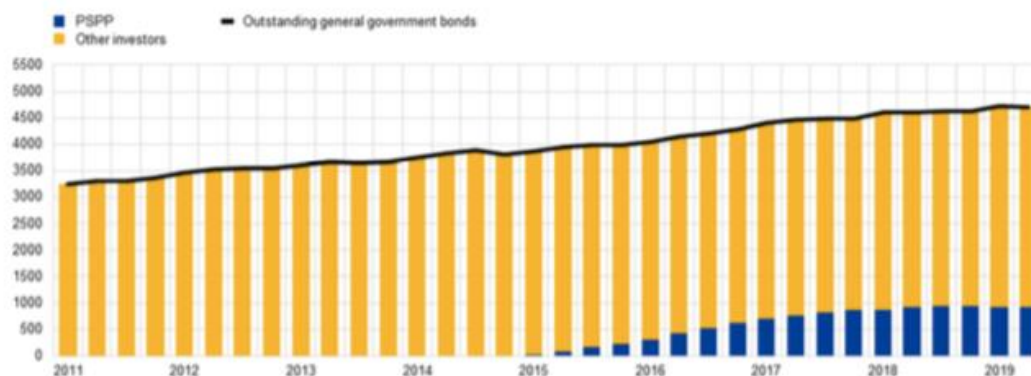
Notes: The charts show the stock of debt securities issued by each general government of the four largest euro area jurisdictions, and the public sector purchase programme (PSPP) share of that stock in terms of ten-year equivalents. "Other investors" comprise all other financial and non-financial investors. The latest observation is for the second quarter of 2019.

Chart 12

Impact of PSPP on euro area sovereign term premia over time

(basis points)
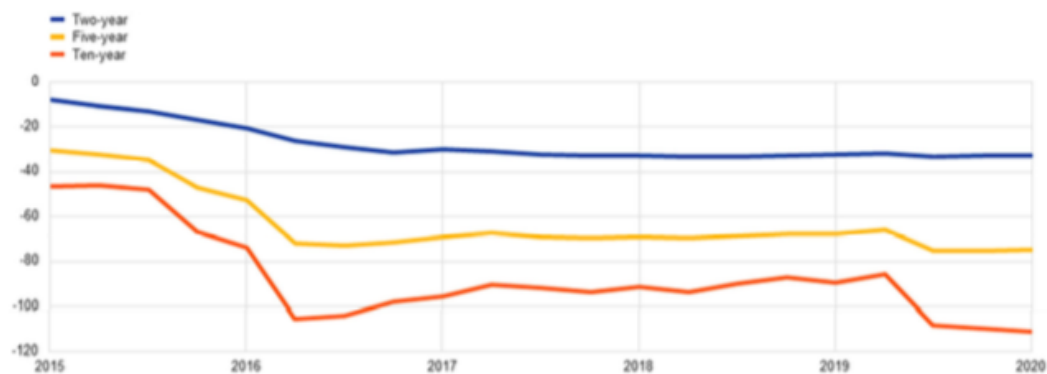
Notes: The chart shows the evolution of the impact of the APP on euro area sovereign term premia at selected maturities. The impact is derived on the basis of an arbitrage-free affine model of the term structure with a quantity factor (see Eser, F. et al., 2019)[22]

The model results are derived using the GDP-weighted average of the yields of the four largest sovereign issuers (Germany, France, Italy and Spain). The latest observation is for

January 2020.

The macroeconomic effect

The contribution of our measures to the overall easing of euro area financial conditions has been notable across the entire term structure. Overall, the combined effect of negative interest rates, forward guidance and the APP is estimated to have peaked at around 140 to 150 basis points in long-term rates between 2016 and 2018 (see Chart 13).

Chart 13

Impact of non-standard measures on the sovereign yield curve

(percentage points)
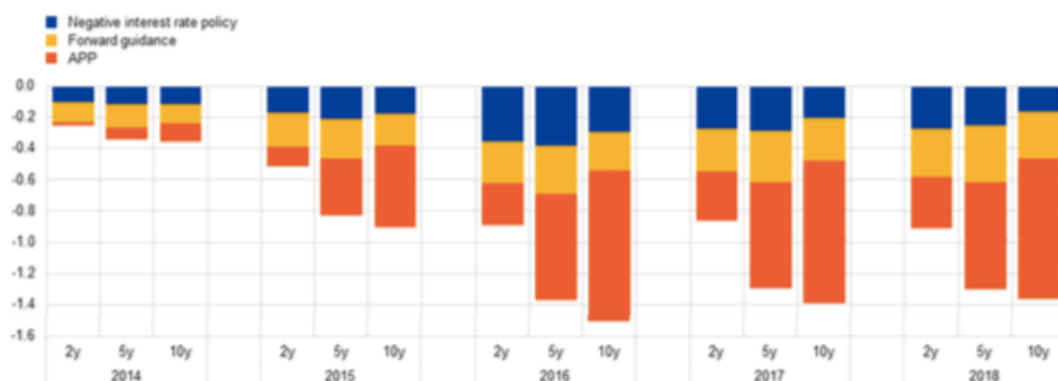
Source: Rostagno, M. et al., op. cit.
Notes: The chart shows the impact of ECB non-standard measures on the GDP-weighted aggregate of euro area sovereign bond yields. The impact of the APP is taken from Eser, F. et al., op. cit. The impact of the negative interest rate policy and forward guidance is derived from counterfactual analysis of overnight index swap forward rates.

These improved financing conditions have made a considerable contribution to the macroeconomic performance of the euro area. A counterfactual exercise indicates that, in the absence of our unconventional measures, growth, employment and inflation would have been considerably lower. More specifically, the estimated average annual contribution of the unconventional measures to euro area inflation is between 0.3 and 0.5 percentage points (see Chart 14). The estimated level of real GDP at the end of 2019 without the package of unconventional measures is between 2.5 and 3.0 percentage points lower than the observed level, and employment is estimated to be about 2.5 million lower in the absence of the measures.

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22 See Eser, F., Lemke, W., Nyholm, K., Radde, S. and Vladu, A. L. (2019), "Tracing the impact of the ECB's asset purchase programme on the yield curve", Working Paper Series, No 2293, ECB.

Chart 14

No-measures counterfactual

(percentage points)
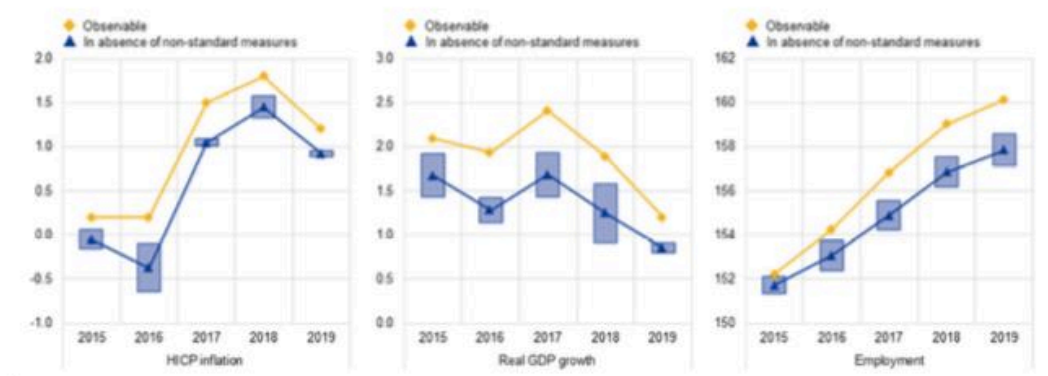
Source: ECB calculations.
Note: The boxplot depicts a range of assessments, comprising the Eurosystem staff assessment based on a suite of models and the assessment documented in Rostagno, M. et al., op. cit.

By contrast, the role of fiscal policy in supporting the euro area economy has been limited (see Charts 15- 17). While the current mildly expansionary fiscal stance is providing some support, the more fiscal policy contributes to boosting long-term growth potential and providing cyclical stabilisation, the quicker will be the effects of monetary policy interventions on inflation and the economy. In this regard, it is worth keeping in mind that the macroeconomic impact of fiscal policy is particularly strong in an environment in which inflationary pressures are muted and the expected interest rate path is not very steep.

Chart 15

Euro area fiscal stance and change in the output gap

(percentage points)
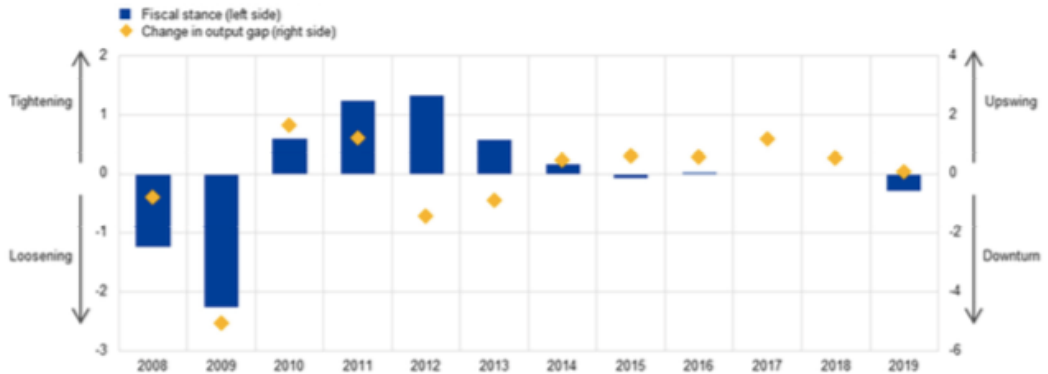
Source: AMECO database (European Commission spring forecast).

Note: The fiscal stance is approximated by a change in the ratio to GDP of the cyclically adjusted government balance.

Chart 16

Contributions to euro area real GDP growth

(annual GDP growth in percentages; contributions in percentage points)

Source: ECB staff calculations based on Eurostat data.

Notes: Real GDP growth and demand components in 2019 are from December 2019 Eurosystem staff macroeconomic projections.

Chart 17

Government balances

(percentages of GDP)
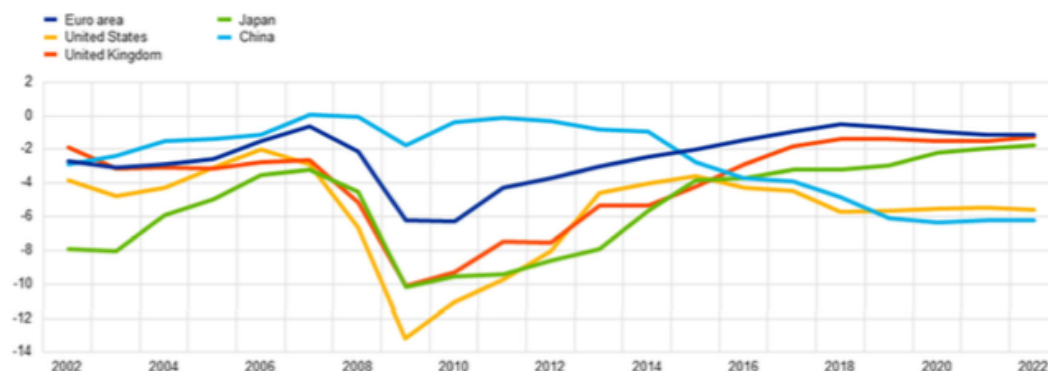
Sources: December 2019 broad macroeconomic projections for the euro area, IMF World Economic Outlook October 2019 for other countries, and ECB staff calculations.
Notes: The projection for Japan is adjusted to include the recently announced fiscal stimulus. It assumes an overall stimulus of JPY 13 trillion, distributed evenly over calendar years 2020 and 2021 with a positive effect on GDP growth of 0.3 percentage points in both years. For China, the estimated "augmented" fiscal numbers, which include estimated off-budget spending and debt, point to larger deficits and debt than reported in these charts.

Conclusion

Let me conclude. Globally, central banks have been confronted with large and persistent shocks stemming from the financial crisis and the long-term trend decline in the equilibrium real interest rate. These factors have constrained conventional monetary policy space and required a profound expansion of the policy toolbox in order to ensure the effectiveness of monetary policy.

Our forward guidance on interest rates, which makes the evolution of our policy rates contingent on the robust convergence of inflation to our aim, captures our monetary reaction function in the current environment of low inflation and low interest rates. Our forward guidance links the various unconventional monetary policy instruments together within a coherent framework and is proving effective in guiding adjustment in the expected path for policy rates and longer-term bond yields in response to the changing outlook.

As I have demonstrated, the ECB has been willing and able to calibrate the combination of its unconventional policy instruments in directions and on a scale that gives sizeable support to the economy and continues to support the convergence of inflation to our aim. At the same time, if fiscal policy were to play a more supportive role alongside monetary policy, it would lead to a faster return of inflation to our objective and contribute to raising the equilibrium real interest rate, thereby alleviating the constraints on monetary policy.

Finally, the long-term trends that are being discussed at this conference give all central bankers pause for thought in terms of their strategy and instruments. In this vein, we announced last month the launch of a comprehensive review of our monetary policy strategy, which we expect to be concluded by the end of the year.

Digital Economy

What Libra Means for Money Creation ⋆

By JOHN NUGÉE*

When Facebook announced its intentions last June to issue a digital currency, Libra, the official sector was muted in its initial response. Central banks could not be seen to be too overtly unwelcoming to innovation and new ideas, but equally, the concept struck fairly directly at the sovereign privilege of issuing currency. They were also privately concerned at the possible consequences for their conduct of monetary policy.

Since then, central banks have been largely silent. The main news on Libra has been of resignations from the consortium backing the project; Visa, Mastercard, eBay and PayPal among others have terminated their involvement. This has denuded the project of much payments systems expertise, and although Facebook has found other companies to take their place, the consortium is now less balanced and much more clearly a Facebook-dominated operation.

But silence from the authorities does not mean they have ignored the subject or overcome their initial wariness. Much research into digital currencies continues to be done by the central banking fraternity, and two issues in particular are coming to the fore.

The first of these is the effect on the orthodox banking system, especially its role in the creation of money. Under a fractional banking system, banks are able to make loans (in other words, create money) that are a multiple of their deposits, keeping only a small part of their balance sheet in liquid assets such as central bank reserves. This process enables the money supply to expand, and in any modern economy is an essential contributor to economic activity and growth.

But if digital currencies become a significant part of the economy, this creation of money will be interrupted. Calibra – the Facebook subsidiary developing Libra – has made clear that it does not intend to offer loans or overdrafts, as to do so would immediately make it a bank and so subject to banking regulations. But this means that any cash that customers take out of the banks to put into their Libra accounts will be removed not only from banks' balance sheets but also from the money creation process.

In effect, the introduction of Libra threatens to split the banking sector's currently unified balance sheet, by moving a significant proportion of customer deposits (that is, the banking system's liabilities) to the digital currency issuers, while leaving customer loans and overdrafts (the banking system's assets) with the banks. The inevitable result of this would be to force the banks to reduce the asset side of their balance sheet to match the reduced liability side – in other words reduce their loans.

⋆ This article first appeared in OMFIF Commentary on February 5, 2020.
* John Nugée, a former Chief Manager of Reserves at the Bank of England, is Senior Adviser to OMFIF.

This would almost certainly lead to a major credit squeeze, which would be highly damaging to economic activity. The threat that digital 'narrow-bank' (non-loan making) institutions might reduce or even replace the role of existing commercial banks has central bankers deeply concerned. There is no precedent for a modern economy thriving without commercial banks and their role in money creation.

Unfortunately, central banks have no easy answer to this. Relaxing the reserve requirements on the banks and allowing banks to offer more loans per unit of deposit would allow them to maintain the same volume of loans despite their reduced deposits, but would weaken the banks and risk bank insolvencies in any economic downturn. Alternatively, central banks could issue loans directly themselves (or guarantee banks' loans, which would have a similar effect in removing the need for reserves to be held against them) – but this direct involvement in the private sector economy is even less attractive for them. Not only would such a move be running counter to all existing central banking theory, but in pure practical terms it would open the central bank to far more direct contact with the general public and thus, almost inevitably, far more political oversight. No central banker views with enthusiasm becoming embroiled in the world of 'the three Cs' – customers, complaints and call centres.

The second issue that arises from the introduction of private sector digital money is the one of cost. Libra and any other digital currency rival will require a revenue stream to pay their costs (and provide a return to the consortium partners). How will they raise this revenue?

If they cannot generate a revenue stream from interest-bearing loans and overdrafts, it has to come from usage charges. In principle these will be levied on the commercial service provider, not the retail consumer, but in practice they will inevitably be paid for by the consumer in the end.

This raises important questions of efficiency and value for money. It is by no means clear that such a private sector payment system would be cheaper to operate than the existing bank-based system even on the narrow point of cost per transaction, particularly if, as seems probable, one digital currency soon becomes dominant to the exclusion of competitors. But there is the wider issue of whether society is advantaged by big tech creaming off yet more money from the economy into an unaccountable, untaxable and often overseas behemoth.

Libra's current trials may mean that its introduction has been delayed. Many consider that it is by no means guaranteed to operate at all. But central banks are well aware that even if Facebook does not manage to bring its project to fruition, sooner or later someone else will succeed, and will introduce a private sector digital payment system. And the issues and implications for central banking, the commercial banking system and the wider economy that their current research has highlighted will not go away.

The Future of Payments–Central Banks' Digital Currency

Journey*

By WOLFRAM SEIDEMANN*

Money is a topic of incredible socio-political relevance. The question today is, in the age of digital transformation, what is the future of payments or what is the payment of the future?

OMFIF, at 10, is rather young for an organisation focusing on finance and monetary policy. The concept of money dates back to around 10,000 BC; communities used shells, grain or stones as tangible tokens and units of account, exchange and store of value. The world's first central bank, the Amsterdamsche Wisselbank, was founded in 1609. Mandated by Amsterdam city council, it established an efficient and standardised currency cycle to remedy the chaos of a system made up of more than 800 different coins.

Central banks have managed currency in all its aspects ever since. They have been continuously optimising their currency cycles, employing the latest technologies available and pushing their suppliers to provide innovations necessary to maintain state-of-the-art currency. Their technological expertise has contributed greatly to building trust in government-issued currency as it exists today.

For a long time, bank accounts, paper banknotes and cards have complemented coins. More recently, online payments and mobile phones have been added to this list. But cash is the only sovereign public payment instrument that fulfils all of users' requirements. It is independent from technology, and can be used easily and universally. Cash guarantees full financial and social inclusion with no entrance hurdles, and offers a truly democratic means of payment that provides great value to any society.

Yet for all its benefits, cash does not work in the digital realm. The world is changing drastically, with more and more fully digital business models. Therefore, how can central banks transfer the benefits of cash, especially its characteristic as a public good, to the digital world?

This question, and many others linked to it, are reflected in OMFIF's report on trust and central banks' mandate for issuing digital currency. There is no doubt that the online 'shells, grain or stones' – cryptocurrencies such as bitcoin – are not a solution and neither is Facebook's Libra. That is why government-issued digital currency has become such a widespread topic of discussion.

As outlined above, central banks are well-equipped and tech-savvy enough to offer not only the most solid and trusted digital solution, but also the most convenient. They are the technology leaders when it comes to currency. Many central banks are already working on CBDCs, either through research or pilot projects. Doing nothing is riskier than embarking on the digital currency journey and staying in control.

G+D, a leading supplier in the currency industry, has been shaping the debate with its central bank customers and supporting them through these transformational times.

As the future unfolds, it is our responsibility to design a society in which all groups feel comfortable. A fair, democratic, inclusive and secure government-issued payment system – currency as a public good – is an important element of this future. Looking at the latest OMFIF

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survey, the public would appreciate greater visibility and more leadership on the part of central banks when it comes to transferring cash as a public good into the digital space.

Direction of Supervision: Impact of Payment System

Innovation on Community Banks*

By MICHELLE W. BOWMAN*

It is a pleasure to be here today. I appreciate the invitation to speak to you as part of this year's Banking Outlook Conference at the Federal Reserve Bank of Atlanta.[1] I think this year's theme, *Age of Advancement: The Intricacies of a Digital World*, captures the dynamic and evolving landscape of our country's financial system well. Advances in technology are occurring at a rapid pace and present the opportunity to make our financial system safer and more efficient for more Americans.

From faster payments to artificial intelligence, technological advancements touch nearly every aspect of our financial system and affect institutions of every type. As the first Federal Reserve governor to serve in the role designated by Congress for someone with community banking experience, I am especially interested in the impact these kinds of advancements may have on community banks. I am also committed to ensuring that as policymakers and supervisors navigate the intricacies of today's digital world, we do so in a way that considers the important role of community banks in cities and towns and rural communities across the country, and our nation's financial system more broadly. To that end, I believe the Federal Reserve is well positioned to support innovation and the future of banking in a way that ensures our nation's evolving financial system works for community banks and the customers they serve. So I would like to spend my time with you today focusing on how the Federal Reserve can achieve this objective in one specific area, that of our nation's payment system.

Importance of Community Banks and the Payment System

As many of you may know, before joining the Federal Reserve, I was a community banker and more recently had the privilege to serve as the Kansas State Bank Commissioner. I have seen firsthand the vital role that our nation's community banks play in the financial industry and in the economy more broadly.

Through the services they provide, community banks help support strong cities, towns, and rural communities across the country, which are central to a vibrant economy. For example, small business lending is an essential part of community bank portfolios. Many community banks often specialize in serving small businesses, which account for the majority of new job creation in the country.[2] In fact, community banks hold 48 percent of all loans to small businesses and farms in the United States.[3]

Community banks are also often seen by their customers as an important source of financial advice and a source of civic leadership.[4] Community banks have a deep understanding of their local areas. They also have close relationships with those living in the communities they serve

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[1] These remarks represent my own views, which do not necessarily represent those of the Board of Governors or the Federal Open Market Committee.

[2] See U.S. Small Business Administration, Office of Advocacy, Frequently Asked Questions (September 2019).

[3] Data on loans were compiled from Consolidated Reports of Condition and Income, also known as Call Reports, that banks file with the Federal Financial Institution Examination Council.

[4] See Board of Governors of the Federal Reserve System, Perspectives from Main Street: Bank Branch Access in Rural Communities (Washington: Board of Governors, November 2019).

and the organizations that serve those communities. In many instances, community banks are also serving markets that tend to be neglected by larger banks. These connections allow community banks to focus on specific local needs to provide a variety of services, which often include tailored and innovative products. Payment services in particular are a key component of these relationships and are essential to the role of banks in their communities. Community banks help ensure that consumers and businesses can safely and efficiently access and move their money. By doing so, the payment services they provide act as the foundation for economic activities that help cities, towns, and rural communities grow and thrive, which in turn is essential to a strong and stable financial system.

A strong and stable financial system also depends on the smooth functioning of the nation's payment system. Today, many Americans take the ability to move money across the country safely and efficiently for granted, but history shows that payment system disruptions can affect the economy more broadly.[5] In the past, our nation's payment system was fragmented and inefficient, creating costs for consumers, merchants, banks, and, ultimately, the U.S. economy. For example, before the Federal Reserve was established, check clearing fees and banks' efforts to avoid them often led to circuitous check routing, with recipients facing long, unpredictable delays in receiving their money. When they did eventually receive their money, fees had often consumed a considerable portion of what they were expecting. In extreme instances, this led to checks moving from city to city before eventually ending up at their destination. One often-cited example described a check that started in Rochester, New York, and traveled to Jacksonville, Florida, then to Philadelphia, Baltimore, and Cincinnati before it finally reached its final destination in Birmingham, Alabama.[6] To put that in terms of miles traveled, if the check had gone directly from New York to Alabama, it would have traveled about 1,000 miles. Instead, it traveled 3,000 miles up and down the east coast, likely for days, before it finally reached its destination. The distance from Atlanta to Los Angeles is shorter than the route that check took.

These kinds of inefficiencies were so significant that one of Congress's motivations in creating the Federal Reserve was ensuring a safe and efficient nationwide payment infrastructure. Shortly after they opened for business, the Reserve Banks began providing a nationwide check collection service. This service helped speed up payments by reducing circuitous routing. It also facilitated access to more-efficient payment services for banks across the nation. Since then, the Federal Reserve has continued to support ongoing efficiency improvements in the nation's payment system, including the development of the Fedwire funds transfer system and the implementation of the automated clearinghouse, or ACH system, in partnership with the private sector.

This operational role has allowed the Federal Reserve to support the goal of a safe and efficient payment system throughout its history. It has also contributed to widespread public confidence in the nation's payment infrastructure. At times, the Federal Reserve has taken extraordinary steps to ensure the payment system can function reliably. After planes were grounded on September 11, 2001, in the aftermath of the terrorist attacks in New York and Washington, D.C., the Federal Reserve arranged alternative transportation for millions of checks that normally would have moved across the country by plane. The Federal Reserve also started giving immediate credit for all checks that it received. This provided a key source of liquidity for the payment system and temporarily caused the daily float held by the Federal Reserve to increase over 6,000 percent.[7] After September 11, the Federal Reserve also took steps to

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[5] "Policies: The Federal Reserve in the Payments System," Board of Governors of the Federal Reserve System (issued 1984; revised 1990).

[6] Noted by Federal Reserve Chairman W.P.G. Harding in Robert Kramer and W. Putnam Livingston, "Cashing in on the Checkless Society," Harvard Business Review, September/October 1967, p. 143; Bill Medley, Highways of Commerce: Central Banking and the U.S. Payments System (Kansas City: Federal Reserve Bank of Kansas City, July 2014), p. 23.

[7] Medley, Highways of Commerce (PDF), 105.

improve the future efficiency of the nation's check collection system by working with Congress on the passage of the Check 21 Act in 2002.

A safe and efficient payment system also needs to be accessible, because payment services are most valuable when you can pay anyone regardless of where balances are held. The ultimate success of any effort to modernize the U.S. payment system depends on adoption across the entire banking industry. Therefore, in considering the Federal Reserve's provision of payment services, Congress took steps to try to ensure access to services across the country. As a result, Congress specifically tasked the Federal Reserve with taking into account an adequate level of services nationwide when providing and setting fees for payment services.[8] The United States has a highly complex banking system with more than 10,000 depository institutions spread over wide areas with differing payment needs.[9] Over 4,800 of those are community banks.[10] In many areas, particularly rural areas, community banks may be the primary providers of banking services for individuals and small businesses. Community banks are, therefore, essential in ensuring access to safe and efficient payment services in towns, cities, and rural communities nationwide so that payments can move across the country regardless of geography—from here in the South, to the Midwest, and coast to coast.

Community Banks and Payment System Innovation

A diverse banking system where institutions of all sizes are able to innovate and meet evolving customer needs is essential to ensure access to safe, efficient, and modern payment services for communities across the nation. At the Federal Reserve, we support the responsible use of technology and innovation to transform the financial system and reduce frictions and delays, while preserving consumer protections, data privacy and security, and financial stability. But as technology continues to advance, the intricacies of our digital world become more complex, and I believe we can help ensure that banks are well positioned to take advantage of these technology advancements and innovations. Like the rest of the financial industry, community banks are investing in new technologies and innovations to meet the growing expectations of their customers. With their considerable understanding of local needs, community banks are able to put these kinds of innovations to use in meeting the specific needs of their communities. At the Federal Reserve, we are actively engaging with the banking industry to encourage responsible innovation in the community-banking sector.

But I also firmly believe that we cannot just say community banks need to engage in responsible innovation, we need to empower community banks to do just that, and I am committed to working with my colleagues to realize this objective. I believe it is our responsibility as a payment service provider and supervisor to ensure that our nation's evolving financial system works for community banks. Because by empowering them to provide modern and innovative services to their customers, we also ensure that Americans across the country can make payments safely and efficiently.

First, as a provider of payment services, the Federal Reserve has a long history of supporting community banks. We have long-standing relationships with, and the nationwide infrastructure to provide services to, thousands of community banks across the country. While the existing payment infrastructure provided by the Federal Reserve has generally served community banks and the nation's economy well, advances in technology have also created opportunities to

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[8] The Monetary Control Act of 1980 requires in part "due regard to competitive factors and the provision of an adequate level of such services nationwide... ."

[9] Including both FDIC-insured commercial banks and savings institutions and federally insured credit unions. See FDIC, Quarterly Banking Profile, Third Quarter 2019 (volume 13, number 4); NCUA, Industry at a Glance (quarter ending September 30, 2019).

[10] See FDIC, Quarterly Banking Profile, Third Quarter 2019 (volume 13, number 4).

modernize these payment services. Collectively, these efforts will create a modern payment infrastructure that provides community banks the ability to meet customer expectations in offering innovative services with the same effectiveness and efficiency as other providers. This in turn will provide consumers the ability to better manage their financial lives by accessing accounts when and where they choose and providing more flexibility to manage money and make time-sensitive payments.

To start, the Board has supported changes to existing Federal Reserve services. For example, at the end of last year, the Board announced changes to support adoption of an additional same-day ACH window available later in the day. When it was adopted in 2015, same-day ACH allowed for faster processing and return of recurring, low-cost payments such as payroll and bill payments. This additional window will help to make the benefits of same-day ACH more broadly accessible. More specifically, it will allow banks and their customers, particularly those located outside the eastern time zone, to use same-day ACH services during a greater portion of the business day.

Our modernization efforts do not stop with existing services, though. The FedNowSM Service, announced last August, will create a new payment infrastructure for institutions of all sizes to offer innovative faster payment services. Community banks in particular were strong supporters of developing the FedNow Service. Many of them emphasized that the Federal Reserve's long-standing policy commitment to promoting nationwide access would result in a service that is accessible to banks of all sizes. They felt that this in turn would ultimately increase the long-term likelihood of being able to offer faster payment services in their communities. Community banks continued to voice strong support in response to our most recent request for comment on the design of the FedNow Service. At the same time, they raised a number of important issues, including interoperability, time to market, and use of volume-based pricing. These issues are important to community banks, and as such, they are important to me. I intend to work with my colleagues so that the FedNow Service meets the needs of community banks and their customers. I hope that you will continue to engage with us, continue to provide your feedback, and continue to be patient as we undertake this effort to develop the FedNow Service. Because with your input, I believe the Federal Reserve can continue its long history—which started with bank notes and checks, then continued with ACH—of providing infrastructure that supports the independence and success of community banks for the long term.

It is also important to understand that technology advancements affect more than just the payment infrastructure behind-the-scenes. Innovations in consumer and other end-user experiences, such as those facilitated by fintech firms, can also transform the way that consumers interact with their financial institutions, offering community banks additional opportunities to serve their customers in the future. For instance, I have previously discussed how working with fintech firms may offer community banks potential partnerships that leverage the latest technology to provide customer-first, community-focused financial services and provide customers with efficiencies, such as easy-to-use online applications or rapid loan decisionmaking. These kinds of strategic partnerships harness the indispensable knowledge and trust that community banks have built with retail customers and local small businesses. For example, we have seen community banks experience significant growth after partnering with fintech companies to offer checking accounts for online investors, personal loans, and debit cards. We have also seen such partnerships increase efficiency in service offerings, such as significantly reducing loan approval processing time. We expect that the efforts to modernize our payment infrastructure that I outlined earlier, such as FedNow, will serve as a foundation for this kind of innovation to flourish, and will support new opportunities for community banks and the communities they serve.

Of course, new technology is also subject to many of the traditional risks banks have managed in the past with more-traditional consumer services, and implementation of new technology should be driven by banks' business strategies and customer needs. Ultimately, banks remain responsible for conducting due diligence and understanding the risks faced by their organization. But technology advances quickly, and new developments inevitably raise new questions. That is why I believe that the Federal Reserve also needs to take steps as a supervisor to ensure our nation's evolving financial system works for community banks.

First and foremost, it is essential we continue to meaningfully engage with stakeholders on these issues. For example, we recently launched an innovation web page (www.federalreserve.gov/innovate) that will serve as an accessible central hub for stakeholders interested in learning about and engaging with the Federal Reserve on innovation-related matters.[11] The web page can serve as a starting point for members of the industry to engage with Federal Reserve specialists, submit questions, and request in-person meetings. We also announced a series of "fintech innovation office hours" across the country. The first of these was held just yesterday here in Atlanta, and some of you may have even had the opportunity to participate. These are also an important opportunity for us to learn, and I encourage you to provide your feedback. For community banks and their potential fintech partners, I hope that these sessions will serve as a resource to meet one-on-one with Federal Reserve staff members with relevant expertise, discuss fintech developments, share specific projects, and ask questions. They also provide us an opportunity to hear directly from banks and fintech companies about challenges to innovation.

Another important area of focus for me is community banks' relationships with their vendors and third-party service providers. As a former community banker, I am acutely aware that community banks are often reliant on outside service providers and vendors to access new technologies and provide payment services. I also know that supervisory expectations in these areas can be challenging, and I have experienced it myself. There are several things I believe we can do to help provide clarity and transparency, reduce confusion, and simplify and remove some of the burden community banks face in this area.

First, in order to give community banks a better picture of what success in due diligence of third-party providers looks like, and where it begins and ends, I believe that we should release more information on its necessary elements. This change would provide clarity and assist community banks in completing their work. In particular, I believe that regulators can provide more clarity on the types of questions that should be asked of a prospective third-party provider and our view of a satisfactory answer. I also believe our guidance should explain what due diligence looks like for a potential fintech partner, because the standards applied to other third parties may not be universally applicable. Potential partnerships are not one-size-fits-all. Every bank has different objectives, and guidance should reflect some supervisory flexibility so that we do not impede prudent, strategic partnerships between community banks and potential partners. Regulators should especially support partnerships that combine the strengths of community banks and fintech companies, which have a track record of success. I also believe the Federal Reserve should allow banks to conduct shared due diligence on potential partners. If several banks use the same third-party service provider and are open to collaborating, they should be allowed to pool resources instead of duplicating one another's work. These approaches would not only have the benefit of increasing clarity and transparency for community banks, but could also be beneficial for fintech companies that hope to become third-party providers.

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[11] See https://www.federalreserve.gov/aboutthefed/innovation.htm.

Second, clear and transparent guidance is most helpful when it is consistent. I have previously discussed my view that guidance on third-party relationships should be consistent across banking agencies. No one benefits when banks and their potential partners or other vendors have to navigate unnecessary differences in guidance between agencies. To that end, the Federal Reserve is in the process of working with the other banking agencies to update our third-party guidance. As part of this process, I believe that the banking agencies should all have consistent expectations for third-party relationships, and that the Federal Reserve should, as a starting point, move toward adopting the Office of the Comptroller of the Currency's guidance.

Third, I believe we can improve transparency with regard to our supervision of third parties. Through our service provider supervision program, we regularly conduct exams of many third-party service providers. While we make the outcomes available to banks that are clients of a supervised service provider, I believe we can go a step further to increase transparency by also making information that may be useful about our supervision of key service providers available to banks. This could take a number of forms, such as being more transparent about who and what we evaluate. Of course, moving forward in these areas requires careful consideration and interagency collaboration, and I have asked our staff to work with other agencies to develop and propose workable options for giving banks the benefit of the knowledge that supervisors have about their potential providers in an appropriate manner.

Finally, I believe regulators and supervisors have a role to play in ensuring that regulatory burden is tailored to bank size, risk, complexity, and capacity. Knowing the burden that third-party monitoring in particular can present to employees of the smallest banks, I have also encouraged Federal Reserve staff to consider options for further tailoring our expectations for community banks with assets under $1 billion in this area.

Collectively, I view these as important steps to improve the ability of community banks to manage their third-party relationships effectively. By doing so, I believe we will be able to better support the ability of community banks to access innovative new technology and offer modern services to customers.

Looking Ahead

The kinds of advances in technology we are discussing here today present challenges and opportunities for banks of all sizes, including community banks. Investments in new technology are likely to create implementation costs, and payment system innovations are no exception. Testing new technology, upgrading software and processing systems, and integrating new systems with existing systems will require banks to incur costs and dedicate resources to implementation. Community banks in particular may incur additional costs, for example to extend operating hours in order to facilitate payments during nonstandard business hours.

However, technological advances also present opportunities for community banks to continue serving their neighbors, and payment services are a key component of this. Since I joined the Federal Reserve, I have been on the road a lot, visiting Federal Reserve Districts and talking to bankers, consumers, and community groups. I have been struck in particular by stories I have heard about younger generations of Americans moving back to rural areas. These individuals may be returning to their hometown or moving out of urban centers, but they still have the same expectations for services like those that may be offered by larger banks with nationwide footprints. Technological developments, like the payment system modernization efforts we have discussed today, allow banks across the country to meet these customer expectations and provide payment services on a competitive basis.

I believe the Federal Reserve is uniquely positioned as a provider of payment services and as a supervisor of banks to ensure that our nation's evolving financial system works for community

banks. As a provider of payment services, our efforts to modernize the nation's payment system through services like FedNow and same-day ACH will ensure community banks and their customers have access to today's financial technology nationwide. As a supervisor of banks, we can support responsible innovation by reducing regulatory burden where we can, clarifying expectations, and improving the ability of community banks to manage their relationships effectively. Collectively, I believe these efforts will help support a community banking sector that is well positioned to thrive and offer modern, innovative services to their customers. By providing such services, community banks can help ensure all Americans can make payments safely and efficiently regardless of their location and that families across the country have access to financial services that are so important to their success and the success of our communities in today's age of advancement.

Ben Shenglin on China's Financial Technology

Strategy*

By WILLEM MIDDELKOOP

Willem Middelkoop: What are main developments you see within the international financial system?

Ben Shenglin: I am fascinated by how technology is changing the world of finance and think technology will become a much stronger driving force. Emerging markets like China and India may leapfrog the developed markets in adoption of fintech. There is a desperate need for more international coordination and better regulation of fintech developments in financial markets. Now fintech solutions are being used more often, it seems that the capacity of regulators is less well developed. So, this brings an even larger gap between fintech development and the ability of regulators.

WM: Do you think China is one of the countries who is taking more aggressive steps in this respect?

BS: China is doing all it can. If you look at market forces of Alipay and WePay in payment markets, they have changed the banking landscape. The regulators are trying to catch up, trying to be more open minded, but are falling behind the markets.

WM: China seems to be moving faster than Europe and the US

BS: Yes because China was by luck and coincidence at the forefront of fintech developments. The general public and smaller businesses didn't have proper financial services from the banking sector, so when the smartphone penetration became higher and internet giants became very powerful, consumers embraced the new financial services.

WM: China now promotes Alipay in countries like Canada, where people can get an Alipay account without having a bank account in China

BS: Chinese tourists, consumers and businesses are traveling abroad more there is a need for seamless financial services that can be delivered by WePay or Alipay. That's why they are going global. It's the latest development and one which is very exciting.

WM: So Chinese payment providers might develop a new world standard of payments this way?

BS: Yes, this can happen gradually, when the markets accept it as a standard. The Chinese central bank will try to harmonise these systems and develop it further as a standard. Across the different countries there is a need for further coordination and standardisation in this respect.

WM: So, an Alipay account for everybody worldwide would be a great idea?

BS: Alipay is a private company, so from a commercial perspective, they want to serve the entire world. They want to scale up to 4bn people. When they went into India, they used a local partner. They export and share their technology to and with India. The local player TTM is 40% owned by Alipay. Around 200m people in India have an Alipay wallet.

WM: When so many people have a e-wallet it might be interesting for China to develop their own central bank digital currency?

BS: True, this is an interesting topic right now, thanks to Libra and Facebook. Yes, China is studying digital currencies very closely, to see how it can make the financial system more resilient. I am not directly involved in the development of a CBDC, but we do have dialogue.

WM: How long before we see a digital currency developed by the People's Bank of China?

BS: The technology is getting more mature and the eco-system in China is improving. China is evaluating the implications of digital currencies. We have to be careful, because we have 5000 banks and must study what the implications for them are, both financially and socially. Whatever we want to do, we first need to study whether this will be responsible. So it will take some time for sure.

WM: Will the new digital currency be an renminbi denominated one or could it be another currency?

BS: You mean like the special drawing right? The SDR is good. But building a digital SDR is a multilateral process, which may take 10-20 years. That is too long for China, because the technology is moving fast.

WM: Should the digital currency be blockchain based?

BS: I think blockchain is one of the technologies that seems to be working, but there are alternatives as well. Bitcoin has helped people to understand blockchain in this respect. But we have discouraged the mining and trading side of cryptocurrencies in China. This will remain our policy, when financial services don't really serve our real need or economy, we will not support it.

This interview was conducted before the current coronavirus crisis.

Financial Regulation

Spontaneity and Order: Transparency, Accountability, and

Fairness in Bank Supervision*

By RANDAL K. QUARLES*

It's a great pleasure to be with you today at Yale Law School to deliver this Dean's Lecture.

I first arrived here at the Yale Law School on a sunny September afternoon almost 40 years ago, and I have a very clear memory of the first time I sat in this hall, not long after, to hear a lecture from a worthy public servant come to deliver wisdom to those who thought they might one day follow in his footsteps. It was Gene Rostow, former Dean of the Law School, former Under Secretary of State, then serving as head of the Arms Control and Disarmament Agency in the Reagan Administration. I remember the impression of erudition and experience he conveyed. I remember the sense of tradition, sitting here in these wood-paneled surroundings, being addressed with respect on issues of consequence. There was a sense then, in the early 1980's—which turned out to be correct — that the Cold War could be reaching its climax, and widespread concern among the great and good in the country (not least among them the Yale Law School faculty) that the more aggressive stance of the Reaganites (not least among them Gene Rostow) greatly increased the odds of a miscalculation. And here was the man himself, patiently but boldly discussing the state of the world with a group of first-year law students. I remember that he referred more than once to Don Quixote, and this Brooklyn-born American pronounced it in the British way—Dun Quixit—which I found oddly both affected and endearing at the same time. And I remember absolutely nothing else of what he said. Not a word. Which puts me in a properly humble frame of mind for my own remarks today. You won't remember for very long anything I say here today, but I hope your time at the Law School gives you the same experience of patiently but boldly examining matters of consequence that I found to be the most valuable and lasting legacy of my own time here in New Haven.

The themes and goals of this speech are objectives I will be pursuing over the next year and should resonate for this audience. I trust they will be helpful to you all and foster further discussions about the importance of transparency, accountability, and fairness in regulation generally and also in the increasingly important and increasingly consequential topic of bank supervision.

Twenty years ago when I was in private practice, a lecture on bank supervision would have been my cue to pull out my BlackBerry and start checking my emails. The structure and content of regulation was both intellectually interesting and professionally meaningful; I considered

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bank supervision, by contrast, as both too workaday and too straightforward to merit the commitment of much legal horsepower or personal attention. I could perhaps have been excused by the callowness of youth, yet it was a common view at the time. Having now been immersed for the last two years both in the practice of supervision and in the complementary relationship between the regulatory and supervisory processes, I realize that this wasn't true then, and is certainly not true now. It is not a drafting accident that the Dodd Frank Act gave my position at the Federal Reserve the title of Vice Chairman for Supervision. Notwithstanding the extensive reform of bank regulation after the crisis, which has had much consequence for the industry (most of it salutary), it is the process of examination and supervision that constitutes the bulk of our ongoing engagement with the industry and through which our policy objectives are given effect.

This division of labor is important for lawyers and policymakers to think about deeply because the processes of regulation and supervision are necessarily different in crucial respects. Regulation establishes a binding public framework implementing relevant statutory imperatives. Because a rule is designed to apply generally, rules must be based on general principles intended to achieve general aims, rather than reverse-engineered to generate specific effects for specific institutions. Given their general applicability, there must be a general process for all those with an interest—industry, academics, citizens, Congress—to have notice of, and opportunity to comment on all rules, ensuring that all potential effects and points of view are taken into account in the rule's crafting. And given their general function, rules must be clear and public: those affected must know what to expect and what is expected.

Supervision, by contrast, implements the regulatory framework through close engagement with the particular facts about particular firms: their individual capital and liquidity positions, the diverse composition of their distinct portfolios of assets, their business strategies, the nature of their operations, and the strengths and weaknesses of their management. Bank supervisors review and analyze bank information and interact with bank management, enabling them to make necessary judgments about the bank's safety and soundness. Much of the granular information used by supervisors is, accordingly, proprietary and confidential, and many of their judgments and decisions are closely tailored to specific circumstances.

Given the strong public interest in the safe, sound, and efficient operation of the financial industry and the potential for hair-raising and widespread adverse social consequences of private misjudgment or misconduct in that industry, close and regular supervision of this sort can help us all sleep restfully. Yet, the confidential and tailored nature of supervision sits uncomfortably with the responsibilities of government in a democracy. In the United States, we have a long-standing, well-articulated framework for ensuring that regulations conform with the principles of generality, predictability, publicity, and consultation described above. Supervision—for good reason, in my view—is not subject to this formal framework. But it is currently not subject to any specific process constraint promoting publicity or universality. This leaves it open to the charge, and sometimes to the fact, of capriciousness, unaccountability, unequal application, and excessive burden.

Here, then, is a conundrum. We have a public interest in a confidential, tailored, rapid-acting, and closely informed system of bank supervision. And we have a public interest in all governmental processes being fair, predictable, efficient, and accountable. How do we square this circle? In my time with you today, we will not do more than scratch the surface of this question. It is a complex and consequential issue that, for decades now, has received far too little attention from practitioners, academics, policymakers, and the public. Evaluating this question will be a significant focus of mine going forward, and I hope that there will be much discussion in many fora from which we at the Fed, and at other regulators, can learn. So today, I simply

want to open the exploration of some these conceptual issues, and then offer some specific suggestions—by no means comprehensive—on some obvious and immediate ways that supervision can become more transparent, efficient, and effective.

The Importance of Transparency

Let me begin by delving a little more deeply into the distinction between regulation and supervision and the process applicable to both. In granting to agencies such as the Fed the significant power to write regulations, Congress has codified a regulatory process that emphasizes transparency. This process was born in the 1930s, in the tumult of government expansion that was the New Deal, when Congress began a decade-long debate over how to manage the new regulatory state. The result was the Administrative Procedure Act (APA). The APA continues to serve as the basis for the public disclosure and participation required for agency rule-writing and for the judicial review affected parties are guaranteed to challenge rules.

This transparency is intended to prevent arbitrary, capricious, and thus ineffective regulation by inviting broad public participation and mandating a deliberate public debate over the content of proposed rules. One obvious purpose of this transparency is to provide clarity and predictability: it helps make clear how agencies are considering exercising their discretion. The significant process protections in laws such as the APA are also meant to ensure fairness. The wisdom behind this approach is that fairness both helps bring forth more considered and effective regulations and builds respect for and adherence to the law, which is essential for enforcement. Transparency is central to our ability to assert that our rules are fair.

Not everything that government does, however, can be accomplished in exactly the same way that regulations are written. One of these things is bank supervision.

Bank Supervision

Banks are subjected to supervision, in addition to regulation, as an additional form of government oversight because of their complexity, opacity, vulnerability to runs, and indispensable role in the economy, enabling payments, transmitting monetary policy, and providing credit. The government provides a safety net to banks in the form of deposit insurance, and in return, banks are subject to government oversight that mimics some of the monitoring that the private sector would provide, absent the government safety net. The bank regulatory framework sets the core architectural requirements for the banking system, but it isn't enough to set the rules and walk away like Voltaire's god. The potential consequences of disruption in the financial system are so far-reaching, and the erosion of market discipline resulting from the government safety net sufficiently material, that it is neither safe nor reasonable to rely entirely on after-the-fact enforcement to ensure regulatory compliance. Supervisors are in a good position to monitor individual firms' idiosyncratic risks. And in addition to what they do at individual banks, supervisors monitor for risk that may be building among clusters of banks or across the banking system. These "horizontal" exams across multiple banks help highlight new or emerging risks and help examiners understand how banks are managing these risks.

Through their engagement with banks, supervisors promote good risk management and thus help banks preemptively avert excessive risk taking that would be costly and inefficient to correct after the fact. Where banks fall materially out of compliance with a regulatory framework or act in a manner that poses a threat to their safety and soundness, supervisors can act rapidly to address the failures that led to the lack of compliance or threat to safety and soundness.

This is a crucial point: supervision is most effective when expectations are clear and supervision promotes an approach to risk management that deters bad behavior and decisions by

banks. Clearly communicating those expectations is essential to effective supervision, and in a larger sense, clear two-way communication is the essence of effective supervision. Supervisors rely on banks to be frank and forthcoming, and supervisors in turn can help secure that frankness by explaining what their expectations are and why their expectations are reasonable, not arbitrary or capricious. Greater transparency in supervision about the content of our expectations and about how we form our expectations and judgments can make supervision more effective by building trust and respect for the fairness and rationality of supervision.

I don't believe the Federal Reserve has communicated as clearly as it could with the banks we supervise. More transparency and more clarity about what we want to achieve as supervisors and how we approach our work will improve supervision, and I have several specific proposals, which I have discussed in more detail than I will get into today and plan to implement expeditiously. Broadly speaking, these actions fall into three categories: (1) large bank supervision, (2) transparency improvements, and (3) overall supervisory process improvements.

Let me briefly touch on some of the specific changes I will pursue, and which flow from the themes I have just discussed. And as a disclaimer, I should note that previously I have mentioned more specifics, so this abbreviated list should not be taken as a ranking or indication that certain ideas have fallen out of favor.

First, I would mention that we should pursue a clear and transparent standard that aligns our supervisory portfolios, and by extension the intensity of our supervision, with categories established in our recent regulatory tailoring rules. Last fall, we completed a cornerstone of the recent banking legislation to tailor our rules for large banks. This change would be entirely consistent with a principle at the heart of our existing work: Firms that pose greater risks should meet higher standards and receive more scrutiny. To carry forward this work aligning supervision with the regulatory tailoring rules, I believe there is a compelling justification to make changes today to the composition of foreign banks in our portfolio of the largest banks, known as LISCC.

Second, as I have discussed throughout my time at the Board, I continue to look for ways to make our stress tests more transparent without making them game-able and without diluting their potency as a supervisory tool. I expect that we will continue to provide more transparency on the models we use for the stress tests, and on the hypothetical scenarios. Additionally, I am advocating changes to our capital plan rule that will allow banks to receive and study their supervisory stress testing results prior to submitting their capital plans. Currently, banks have a very limited time to adjust their capital distribution plans and only under limited circumstance.

Third, and principally as a transparency endeavor, I would endorse creating a word-searchable database on the Board's website with the historical interpretations by the Board and its staff of all significant rules. Regulatory interpretations by Board staff have grown piecemeal over the decades and haven't consistently been treated as the valuable resource they are. The Board's website has select interpretations of many laws but does not provide a comprehensive, user-friendly collection of regulatory interpretations, FAQs, and commentary.

Fourth, I endorse putting significant supervisory guidance out for public comment. The Board already invites comments on its regulations, as required under the APA, and regularly invites comment on some supervisory guidance and statements of policy. This practice of seeking comment on significant guidance leads to better, more informed supervision and better engagement by banks.

And fifth, the Board should adopt a rule on how we use guidance in the supervisory process. I would expect the rule to state that the Board will follow and respect the limits of administrative law in carrying out its supervisory responsibilities. In particular, consistent with the September 2018 interagency statement on guidance, we would affirm the sensible principles that guidance

is not binding and "non-compliance" with guidance may not form the basis for an enforcement action (such as a cease-and-desist order) or supervisory criticism (such as a Matter Requiring Attention (MRA)). This rule would be binding on the Board and on all staff of the Federal Reserve System, including bank examiners.

There are of course other ideas I have mentioned and will be pursuing, but this partial list should be informative and helpful in illustrating the earlier themes I mentioned.

Conclusion

The changes to supervision since the crisis have made the financial system stronger and more resilient than it was before. The incremental changes I am considering, to increase transparency, accountability, and fairness, would make supervision more efficient and effective, and our financial system stronger and more stable. Obviously, the incremental changes to our supervisory processes I am considering do not completely answer the question with which I began my remarks today: how can we square the public interest in agile supervision with the public interest in transparency and accountability? This should be an ongoing question of high priority, both at the Fed and more broadly among those who care about our system of financial regulation. Equally obviously, however, these suggestions would strengthen our practice of supervision and increase the vigor and credibility of our supervisors.

Green Finance

Scaling Up Sustainable Finance in Asia[*]

By Aziz Durrani[*]

How involved should central banks and regulatory authorities be in the climate debate? It is a question that has received increasing amounts of attention over the past few months. The South East Asian Central Banks Centre, during the second quarter of 2019, surveyed its members to understand their views and issues on climate and the low-carbon transition.

With 18 respondents, from central banks and monetary authorities across the Asia-Pacific region, we have prepared a paper, published in Journal of Sustainable Finance & Investment, that discusses what these institutions are doing already – and what they could do in 2020.

The survey showed that 94% of respondents thought that their institution should be involved in helping encourage low-carbon financing and green initiatives. While only 22% of the respondents had any strategic investment mandates or approaches to scale up private investment in low carbon sectors, 72% were aware of national commitments to help implement green finance initiatives. Only 29% had already issued financing instruments or implemented regulatory policies to encourage private financing for low carbon investments. Finally, 39% had already trained their staff and external financial services personnel on climate change risks and opportunities. This training included capacity building workshops, stakeholder dialogues, consultation events with financial institutions and inviting relevant experts from multilateral financial institutions to speak at events.

Central banks across Asia have already taken a variety of actions to mitigate climate risk. Bangladesh Bank was among the very first central banks to address environmental challenges. In 2011, it issued an environmental risk management directive which mandated banks to incorporate enterprise risk management policies into their credit risk management.

China has emerged as one of the leading countries in the world when it comes to encouraging the green and low carbon financial sector. The People's Bank of China has set out mandatory disclosures for banks to categorise what is 'green', 'brown' and 'neutral' lending in their portfolios. Banks are able to earn green 'points' that contribute to the PBoC's risk assessments. The PBoC has also launched a green refinancing policy which allows commercial banks to use green loans or bonds as collateral for borrowing from it at discounted rates, funds from which are lent to green businesses.

The Reserve Bank of India published a notice to banks – 'Corporate Social Responsibility, Sustainable Development and Non-Financial Reporting – Role of Banks' – in December 2007.

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In 2015, the RBI added lending to social infrastructure and small renewable energy projects to target sectors, supporting green financing.

Indonesia has also sought to establish itself as a leading player in the green finance market. The Financial Service Authority produced its Sustainable Finance Roadmap in 2015, which laid out a comprehensive plan for promoting sustainable finance. In 2018, Indonesia became the first country to issue a green sovereign sukuk. The Monetary Authority of Singapore has implemented several schemes to promote sustainable finance in Singapore. One such initiative is the creation of the Asia Sustainable Finance Initiative in January 2019, a multi-stakeholder forum that aims to utilise the power of the financial sector to deliver on the United Nations sustainable development goals and the Paris climate agreement.

During the course of 2020, there will be ongoing capacity building programmes and initiatives to help develop awareness and implement key ideas. These could include amending the current Basel regulatory framework, which is biased to carbon-intensive ventures, with the addition of 'brown-penalising' or 'green-supporting' factors during capital requirement calculations. This risks leading to a 'green bubble'. A better approach could be to introduce carbon-based capital buffers that would apply to lending to carbon-intensive activities. This would remove some of the inherent biases in the system towards lending to carbon-intensive industries and facilitate low-carbon lending.

A further tool that many supervisors are looking at to address climate-related risk is stress testing. Modelling different climate scenarios that reflect a variety of transition paths to a low-carbon economy will help gauge the potential impact of climate change on individual firms and on the world's financial stability. In the UK, the Bank of England and the Prudential Regulation Authority have already announced that they will include climate stress testing as part of their programme. While this is a complex and challenging area, mandatory climate stress tests will require banks and financial institutions to consider climate risks. It would lead to greater expertise and the development of more robust modelling approaches, as well as pushing banks' lending decisions toward more low-carbon ventures. The challenge is how such measures should be implemented within each central bank, and this will be part of SEACEN Centre's focus during the rest of the year.

Working Paper

Systemic Financial Risk and Macroeconomic Activity in China∗

By HE QING, LIU JUNYI, GAN JINGYUN, QIAN ZONGXIN∗

Abstract: Using principal components quantile regression (PCQR) method, we construct a systemic financial risk index that aggregate information from 16 popular measures of systemic risk. The empirical results indicate that our index is able to accurately predict the distribution of subsequent shocks to the real economy in China.

Key words: Systemic financial risk, Principal Components Quantile Regression, Real Economy

JEL Classificaion：G32, E44, E51

1. Introduction

On May 24, 2017, the investor service of the rating agency, Moody, downgraded China's sovereign credit rating from Aa3 to A1.[1] In response, Chinese government charges Moody for exaggerating China's economic difficulty while downplaying its reform efforts.[2] Despite debates like this, waves of financial risk in China will nevertheless affect the international financial market because China has been so deeply integrated into the global economy and has become a driving force for global economic growth. Monitoring China's systemic risk therefore is vital not only for China but also for the global economy.

Since the outbreak of the global financial crisis in 2008, researchers have constructed various risk indexes vis-à-vis a wide range of systemic risk. However, most indexes only cover a certain aspect of systemic risk and hence lack the capacity of measuring the innately complex systemic risk in a comprehensive way. In addition, all existing indexes of systemic risk focus exclusively on the financial market and, consequently, overlook its connection with real economy (Brenda Gonzalez-Hermosill, 1996; Kaufman, 2000; Borio, 2003).

In this study, using the principal components quantile regression (PCQR), we synthesize a number of financial risk measures to construct a comprehensive index of the financial systemic risk of China. Our results show that this index is able to measure multi-dimension financial risk and more accurately predict its impact on the real economy of China than do most other existing risk indexes such as term spreads.

The rest of the paper proceeds as follows: Section 2 introduces the systemic risk index we construct. Section 3 shows the empirical results derived from this index. Section 4 concludes the paper.

2. Method
2.1 The Approach of Forecasting the Real Economy

A recursive out-of-sample quantile regression is employed as the main econometric methodology. We denote the shock to real economy as y_{t+1}, and the probability of y_{t+1} being smaller than a constant, y, is $P(y_{t+1} \leq y)$; and the cumulative distribution function of y_{t+1} is the following:

$$F(y) = P(y_{t+1} \leq y) \tag{1}$$

Hence the τth quantile of y_{t+1} is its inverse probability distribution function, which is further discussed in the next subsection.

We define the quantile loss function of the τth quantile of y_{t+1} as follows

$$\rho_\tau(x) = x(\tau - I_{x<0}) \tag{2}$$

where $I_{x<0}$ is an indicator function

$$I_{x<0} = \begin{cases} 1, x < 0 \\ 0, x \geq 0 \end{cases} \tag{3}$$

The quantile function can be shown as the solution to an optimization problem as follows

$$Q_\tau(y_{t+1}) = arg \inf_q E[\rho_\tau(y_{t+1} - q)] \tag{4}$$

or, the minimization as follows

$$min \left\{ \sum_{y_{t+1} \geq q} \tau|y_{t+1} - q| + \sum_{y_{t+1} < q}(1 - \tau)|y_{t+1} - q| \right\} \tag{5}$$

As in the specification of Koenker and Bassett (1978), assuming that conditional quantiles of y_{t+1} are affine functions of observables x_t

$$Q_\tau(y_{t+1}|\mathcal{I}_t) = \beta_{\tau,0} + \beta_\tau' x_t \tag{6}$$

we have

$$\widehat{\beta_\tau} = argmin\{\sum \rho_\tau(y_{t+1} - \beta_{\tau,0} - \beta_\tau' x_t)\} \tag{7}$$

Following Giglio et al. (2016), we set τ to be 0.2, 0.5 and 0.8 respectively in our regression to examine how systemic risk influences real economy at both end percentiles and the median of the sample.

To test the effectiveness of the systemic risk index on its forecasting capacity of macroeconomic shocks, we construct an accuracy index, R^2:

$$R^2 = 1 - \frac{\sum_t[\rho_\tau(y_{t+1} - \hat{\alpha} - \hat{\beta}X_t)]}{\sum_t[\rho_\tau(y_{t+1} - \hat{q}_\tau)]} \tag{8}$$

where $\hat{q}_\tau$ is τth quantile of the dependent variable, y_{t+1}.

Equation (8) captures the typical loss using conditional information relative to the loss derived from the unconditional forecast. The out-of-sample R^2 is positive if conditional quantile regression offers a more accurate forecast than does the unconditional forecast; and negative otherwise.

We adopt the adjusted mean squared prediction error (MSPE) statistic in Clark and West (2007) to test the significance of the quantile regression:

$$f_{t+1} = (y_{t+1} - \hat{q}_\tau)^2 - \left[\left(y_{t+1} - \hat{\alpha} - \hat{\beta}X_t\right)^2 - (\hat{q}_\tau - \hat{\alpha} - \hat{\beta}X_t)^2\right] \tag{9}$$

In order to gauge the relative accuracy and effectiveness of our PCQR index, we construct the root mean squared error (RMSE) in the following way:

$$RMSE = \sqrt{\sum\left(y_{t+1} - \hat{\alpha} - \hat{\beta}X_t\right)^2 / n} \qquad (10)$$

We choose a random walk model without any systemic risk index as the benchmark, based on which the ratio between two RMSEs can be calculated:

$$Ratio = \frac{RMSE_{with\ risk\ index\ i}}{RMSE_{benchmark}} \qquad (11)$$

Accordingly, any *Ratio* defined above that is smaller than one indicates efficient forecasting performance of risk index *i*. In section 3.4, we show the empirical results of the RMSE as well as the *Ratio* in Table 3 and 4 followed by the discussion of the effectiveness of a variety of risk indexes.

2.2 The Construction of Systemic Risk Index

We assume that the τth quantile of y_{t+1} conditional on information set $\mathcal{I}_t$ is a linear function of the unobservable univariate factor f_t:

$$Q_\tau(y_{t+1}|\mathcal{I}_t) = \alpha f_t \qquad (12)$$
$$y_{t+1} = \alpha f_t + \eta_{t+1} \qquad (13)$$

where f_t is a latent variable, hence unobservable; η_{t+1} is the error term of quantile regression.

We then define individual measures of systemic risk as vector variable x_t,

$$x_t = \Lambda F_t + \varepsilon_t \equiv \phi f_t + \psi g_t + \varepsilon_t \qquad (14)[3]$$

where ε_t is the heterogeneous error term. Equation (14) shows that x_t is driven by two factors: a latent variable f_t which contains the information that helps forecast macroeconomic shocks; and an extra information variable g_t which is irrelevant for the forecasting of y_{t+1}.

Then we estimate $\hat{F}_t$ as the common factor:

$$\hat{F}_t = (\Lambda'\Lambda)^{-1}\Lambda' x_t \qquad (15)$$

where Λ is the eigenvector (a matrix in this case) of the first K eigenvalues of $\sum_{t=1}^{T} x_t x_t'$.

In forecasting, we use out-of-sample quantile regression of y_{t+1} on $\hat{F}_t$ as follows

$$Q_\tau(y_{t+1}|\mathcal{I}_t) = \hat{\alpha}' \hat{F}_t \qquad (16)[4].$$

The common factor estimated above is a comprehensive systemic risk index that can reflect on a wide range of market information.

3. Empirical Results

3.1 Measures of Systemic Risk

Following Giglio et al. (2016), we choose 16 measures of systemic risk covering the four main aspects of systemic risk. Table 1 summarizes the definitions and quantifying methods of the measures.[5]

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[3] We follow Giglio et al. (2016) by making the same assumption about g_t that "[t]he vector g_t is also a latent factor that drives the risk measures but does not drive the conditional quantile of y_{t+h}." And without loss of generality, we also assume that f_t is orthogonal to g_t. Thus, the common variation among predictors has two distinct parts, one that is forecast-relevant for y_{t+1}, and the other that is irrelevant to y_{t+1}. Since the focus of this paper is to analyze the foresting power of the systemic index, g_t is pretty much ignored and accordingly so is the partial quantile regression method that is employed in Giglio et al. (2016).

[4] As Theorem 1 in Giglio et al. (2016), it can be proved that: $\forall t$, as $N, T \to \infty$, $\hat{\alpha}'\hat{F}_t - \alpha' f_t \xrightarrow{P} 0$, namely, conditional quantile regression of y_{t+1} with PCQR is able to provide consistent forecasts.

[5] Giglio et al. (2016) also consider default spreads based on corporate debts data but due to the lack of their counterparts in China, we do not include it in this study.

Table 1 Summary of the Measures of Systemic Risks

Measures	Notation	Definition	Source
Institution-specific Risk	*CoVaR*	*Conditional VaR (CoVaR)*	*Adrian and Brunnermeier(2011)*
	ΔCoVaR	*Difference in CoVaR*	*Adrian and Brunnermeier(2011)*
	MES	*Marginal Expected Shortfalls*	*Acharya et al.(2010)*
Comovement and Contagion	*Absorption*	*Absorption Ratio (AR)*	*Kritzman et al. (2011)*
	ΔAbs	*Difference in AR*	*Kritzman et al. (2011)*
	DCI	*Dynamic Causality Index*	*Billio et al.(2012)*
Volatility and Instability	*Volatility*	*Average Equity Volatility*	*Giglio et al. (2016)*
	Turbulence	*Covariance*	*Kritzman and Li (2010)*
	Catfin	*Financial Sector Volatility*	*Allen et al. (2012)*
	Book leverage	*Individual Loan Ratio*	*Total Debts/Total Assets*
	Market leverage	*Market Loan Ratio*	*Total Debts/Total Market Cap.*
	Size con	*Size Concentration*	*Herfindahl-Hirschman Index*
Liquidity and Credit	*AIM*	*Illiquidity Measure*	*Amihud (2002)*
	TED	*Difference in LIBOR and T-bill*	*Difference between 3-month SHIBOR [6] and 3-month Government Bond Yield*
	Term spread	*Difference in Rate by maturity*	*Difference between 3-month and 10-year Government Bond Yield*

The time span of our sample is from 2005 to 2016 as most variables are available since 2005. We use daily closing price of public financial corporations to calculate individual stock yield, adopt the yield of *China Securities Index* (CSI) 300[7] as market yield, and access quarterly reports of public corporations to get the leverage. The rest of data is drawn from the *China Stock Market & Accounting Research* (CSMAR)[8] and Wind database[9]. We follow Giglio et al. (2016) by averaging main indexes of all public financial corporations to quantify the measures of systemic risk except for CoVaR and MES that are specifically targeted at individual institution. All data are monthly[10].

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[6] Shanghai Interbank Offered Rate.

[7] According to the *CSI300 index methodology*, "CSI300 consists of 300 stocks with the largest market capitalization and liquidity from the entire universe of listed *A* share companies in China. Launched on April 8, 2005, the index aims to measure the performance of all the *A* shares traded on the Shanghai and Shenzhen stock exchanges." *A* share in China refers to the stock shares that are denominated in Chinese currency, RMB, and listed in Shanghai and Shenzhen stock exchanges. Here is the link of *the CSI300 index methodology*: http://www.csindex.com.cn/uploads/indices/detail/files/en/145_000300_Index_Methodology_en.pdf

[8] The CSMAR (China Stock Market & Accounting Research) research database system was jointly established by GTA Information Technology Co. Ltd, the University of Hong Kong and the China Accounting and Finance Research Center of the Hong Kong Polytechnic University. It integrates the 50 GTA major databases and consists of several parts, including Macroeconomics, China's Listed Companies, Stock Market, Bond Market and Banking. Here is the link of the user's guide: https://www.library.hbs.edu/docs/csmarcorporategovernanceuserguide.pdf

[9] Wind is a financial information services company that provides real-time information. The Wind Economic Database pairs over 1.3 million macroeconomic and industry time series of China's economy. Here is the link of the company's website: http://www.wind.com.cn/en/default.html

[10] Similar results are obtained when we use quarterly data, which is available upon request.

Figure 1 Main Systemic Risk Measures
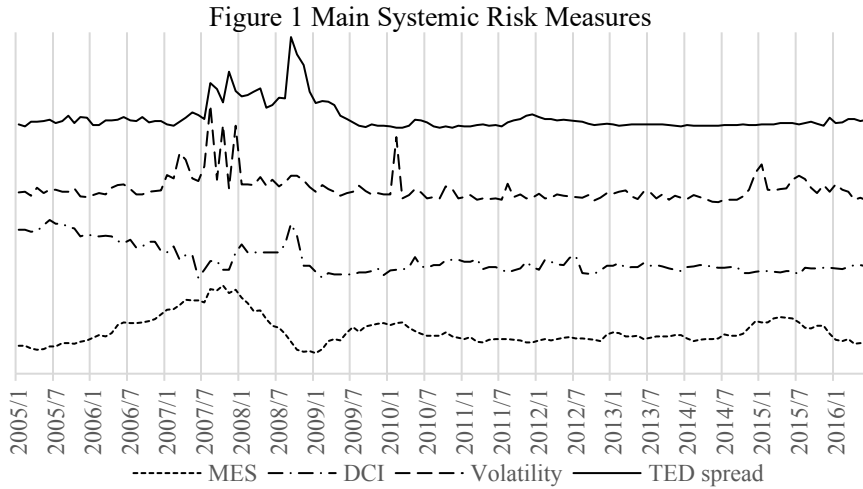
Figure 1 demonstrates the time trend of the four typical standardized measures of systemic risk in our sample.[11] From figure 1, on the one hand, we can see some similarities of the four measures in both general trend and fluctuations. For example, all measures fluctuated significantly during 2008 financial crisis and to a lesser extent around 2015 when Chinese stock market plunged alarmingly. On the other hand, there are also evident distinctions among the measures: in the early episode of the sample, DCI went down while all the others are rising; right after that, MES plummeted abruptly while the rest are relatively stabilized. Varying performances of those indexes justify our choice of PCQR model that can extract the common information from different measures of systemic risk and improve forecasting accuracy by reducing noise of any individual measure.

3.2 Measurement of Macroeconomic shocks

We use the growth rate of real industrial value-added to measure monthly change of real economy. The data source is CEIC[12]. Following Giglio et al. (2016), we run auto-regression on the growth rate of real industrial value-added, Y_t, to get the error term as the macroeconomic shock.

3.3 Out of Sample Forecast

We then run conditional quantile regression of the systemic risk measures on real economic variable to test the effectiveness of their forecasting capacity. The results are listed in Table 2.

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[11] To simplify figure 1, we pick one each out of four categories in Table 1 to show their time-varying patterns. The remaining measures basically demonstrate similar pattern and available upon request.

[12] CEIC data can be accessed at https://www.ceicdata.com/en.

Table 2 Systemic Risk and Real Economy[13]

	20 percentile	Median	80 percentile
Panel 1:Single Measures of Systemic Risk			
AIM	0.1007**	0.0254***	0.0167***
CoVaR	0.1952***	0.0479***	0.0145
ΔCoVar	0.1809***	0.0874***	0.0288***
MES	0.1319**	0.1819***	0.0592***
DCI	0.2388**	0.2234***	0.0480***
Size Con	0.2474***	0.0458***	0.0092
Volatility	0.0865*	0.0908***	0.0738***
Turbulence	0.1948***	0.0741***	0.0626***
Catfin	0.1295***	0.0490*	0.0359***
Absorption	0.2835	0.1936***	0.0621***
ΔAbs	0.0925***	0.0502***	0.0274***
TED	0.1248***	0.0293**	0.0220***
Term spread	0.2013**	0.1908***	0.2033***
Panel 2:Systemic Risk Index			
PCQR	0.4152***	0.3974***	0.3077***

Note: ***, **, * denotes significant at 1, 5, 10 percent respectively.

Panel 1 of Table 2 shows that the out-of-sample statistic of every systemic risk measure is positive suggesting that those measures can provide useful information on macroeconomic shocks. 10 out of 13 singular measures in all 20, 50 and 80 percentiles demonstrate significant forecasting capacity showing that systemic risk of Chinese financial market can be captured by the majority of individual measures despite of their different focuses in measuring financial risk. It also shows systemic financial risk can virtually be multi-channeled into real economy and generate macroeconomic shocks. We also find that 11 of 13 measures present larger R-square in the 20th percentile than in the median; and 12 of 13 measures present greater R-squares in the median than in the 80th percentile. This finding suggests that there is asymmetric connection between systemic financial risk and the real economy. More specifically, systemic risk indexes tend to perform much better in forecasting the lower tail distribution of macroeconomic shocks.

Panel 2 of Table 2 shows that our PCQR index is indeed able to provide strong out-of-sample forecasting power of macroeconomic shocks. The R-squares of 20th, 50th, 80th percentiles estimated by PCQR are 41.52%, 39.74%, 30.77%, respectively, which are much higher than their counterparts of individual measures showing greater forecasting power of the PCQR index. Consistent with the pattern of individual measures, our index also has better forecasting power at the lower tail.

Figure 2 depicts the time series of the 20th percentile forecasts by the PCQR index (solid line)

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[13] The package of quantile regressions provided two methods to compute the standard errors. One is assuming the residuals are independent identically distributed (i.i.d.), and the other is using nonparametric density estimation technique. In our paper the standard errors, t statistics, and significance levels are computed by assuming the residuals are i.i.d. We also calculated the standard errors using nonparametric density estimation, and found a robust result.

and the growth rate of real industrial value-added (dots). The forecasts match the actual shocks quite well. Particularly, it captures the negative spillover effect from the U.S. subprime crisis in 2008 and the subsequent slowdown of China's economy since 2012. In particular, during our sample period after March 2012 China's producer price had been in deflation, which might result from insufficient effective demand.

Figure 2 PCQR Forecasts and Actual Macroeconomic Shocks (20th percentile)
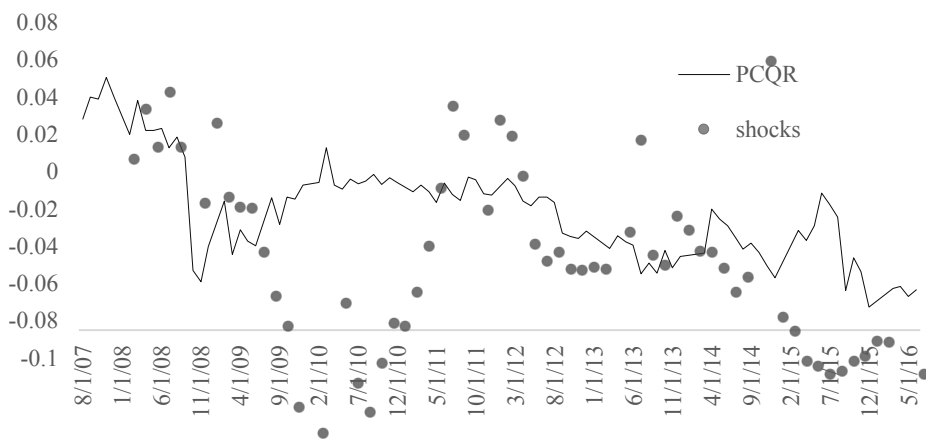
To further test our index, we run a quantile regression at the 20th percentile of credit growth on our PCQR index. We obtain a coefficient of -0.0086, which is significant at 1 percent level. This suggests that a rise in systemic risk leads to a contraction in credit supply, which helps explain the strong correlation between the PCQR index and real economy in China: less credit supply resulting from systemic financial risk leads to economic slowdown. Comparing our results to that of Giglio et al. (2016), the PCQR index has a better performance in the case of China than of the U.S., the UK and the EU. Specifically, Giglio et al. (2016) find that the PCQR index improves forecasting power of economic downturn in those countries by up to 15 percent relative to that by a historical quantile regression. In the case of China, the improvement is 42 percent. Also, they find that the forecasting power of many individual measures is actually weak. While our Table 2 shows that almost all systemic risk measures are strong in forecasting China's economic fluctuations. The stark contrast may suggest that the correlation between financial market and real economy is stronger in China during 2005-2016 than in those advanced economies. And it might be attributed to the investment-led growth pattern of China, which relied heavily on high leverage of the corporate sector.

3.4 Forecast Comparison

Table 3 shows the root mean squared error (RMSE) of 13 measures of systemic risk and the PCQR index, Table 4 shows the *Ratio* defined in equation (11) between the RMSEs of the model with risk index and the benchmark model. It is shown clearly in both Table 3 and 4 that the PCQR index is able to provide strong out-of-sample forecasting power of macroeconomic shocks. In the short term (1 month), 12 of 13 popular systemic risk indexes can improve the forecast accuracy. And the PCQR index presents the strongest forecasting power, with the RMSE of 1.9891, which is significantly lower than that of the benchmark model (60% improvement) and other measures of systemic risk. In the comparison of the forecasting power of macroeconomic shocks in the medium (long) term, a quarter (two years) ahead, we also find that the PCQR index outperforms other indexes by improving the forecasting accuracy significantly

by 70% when t=4 months (30% when t=24 months).

Table 3 Systemic Risk Index Forecast RMSE

	Forecast Horizon		
	t=1 month	t=4 months	t=24 months
Panel 1:Single Measures of Systemic Risk			
AIM	6.6845	7.8196	7.5056
CoVaR	6.5625	7.0876	7.827
ΔCoVar	6.2030	6.7854	7.5674
MES	6.5304	6.7858	7.3661
DCI	5.4686	5.9886	6.8649
Size Con	6.7913	7.0662	7.6339
Volatility	6.6256	6.8960	7.4500
Turbulence	6.6825	6.9496	7.5153
Catfin	6.5644	6.7882	7.1623
Absorption	5.9187	6.2425	7.0875
ΔAbs	5.4814	5.7450	6.4306
TED	6.7338	7.1057	7.5234
Term spread	5.4848	5.7794	6.1549
Panel 2:Systemic Risk Index			
PCQR	1.9891	2.0342	4.5402
Panel 3:Benckmark model			
Random walk	6.7366	6.9736	7.5392

Table 4 Relative Forecast Accuracy of Systemic Risk Index, the *Ratio*

	Forecast Horizon		
	t=1 month	t=4 months	t=24 months
Panel 1:Single Measures of Systemic Risk			
AIM	0.9923	1.1213	0.9955
CoVaR	0.9742	1.0163	1.0382
ΔCoVar	0.9208	0.9730	1.0037
MES	0.9694	0.9731	0.9770
DCI	0.8118	0.8588	0.9106
Size Con	1.0081	1.0133	1.0126
Volatility	0.9835	0.9889	0.9882
Turbulence	0.9920	0.9966	0.9968
Catfin	0.9744	0.9734	0.9500

Absorption	0.8786	0.8952	0.9401
ΔAbs	0.8137	0.8238	0.8530
TED	0.9996	1.0189	0.9979
Term spread	0.8142	0.8288	0.8164
Panel 2:Systemic Risk Index			
PCQR	0.2953	0.2917	0.6022

4. Conclusion

In this paper, we use the Principal Component Quantile Regression (PCQR) to construct a comprehensive systemic risk for China. Our PCQR index is able to provide an accurate forecast of macroeconomic shocks in China supported by the empirical results. A possible extension of this paper would be to collect the data, provided the accessibility, that the central bank of China uses for the construction of its own risk index and employ RMSE test to check if governmental indexes perform any better than our PCQR index does.

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Return and Volatility Transmission between China's and International Crude Oil Futures Markets: A First Look∗

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Abstract: We examine return and volatility transmission between the newly established crude oil futures in China and international major crude oil futures markets using intraday data. For the first time, we document evidence for cointegration relationships among these oil futures markets. Both China's and Oman's oil futures markets react to deviations from their long-run equilibrium with WTI and Brent oil futures. There is also new evidence for asymmetric volatilities and correlations across these oil futures markets. Furthermore, the Chinese oil futures have stronger linkages with the international major futures markets than Oman futures.

Key Words: oil futures, cointegration, conditional correlation, asymmetry

JEL Codes: G12, G15, E44

1. INTRODUCTION

As of 2018, the crude oil futures markets have been dominated by two international parties: West Texas Intermediate (WTI) in the U.S. and Europe's Brent crude.[1] Despite being the world's largest and fastest-growing oil consumer, Asia, at this point in time, has lacked a leading crude oil futures market.[2] Previous attempts to establish a crude oil futures market have been made in Singapore, Japan, India, and Dubai, but have ultimately been discontinued or thinly traded; the exception is the crude oil futures market in Dubai. In particular, the Dubai Mercantile Exchange's Oman futures market reflects, to a certain extent, the conditions in the Asian market, and is considered to be the regional benchmark for Middle East supplies sold to Asia. However, since its inception in 2007, it has failed to garner great liquidity, indicating that it is not frequently used among market participants.

On March 26, 2018, China launched its yuan-denominated crude oil futures contract on the Shanghai International Energy Exchange (INE), a subsidiary of Shanghai Futures Exchange. Reasons to launch the contract include the increasingly urgent need for China to establish a contract based on supply and demand conditions in Asia as well as mitigating currency risk for Chinese refiners and consumers, as China already overtook the United States in becoming the

[1] WTI is the main benchmark for U.S. crude grades and a crucial hedging tool for its oil industry. Brent, priced off North Sea oil, is the primary value marker for European, the Middle Eastern, and African crudes.

[2] According to the U.S. Energy Information Administration (EIA), Asia and Oceania accounted for 35 percent of global demand for oil and other liquid fuels in 2017, up from just 30% in 2008.

largest crude oil importer in the world in 2017. It may also be related to China's ambition to augment the global status of the Chinese currency by shifting more global trade into yuan.

The first INE crude oil nearby futures contract with the September 2018 delivery has already seen far more trading than the total amount of the Oman oil futures market during the same period, despite its carrying a small fraction of market shares compared to WTI and Brent. Given China's position in the world economy and its oil consumption, along with the extremely rapid growth of its crude oil futures market (which increased tenfold in trading volume along with open interest in the first three months after its launch), it would be interesting to assess the international linkage between Chinese and international major crude oil futures markets, particularly in light of the INE crude oil futures' goal to become a benchmark in the global crude oil market.

Furthermore, the INE contracts approximate a basket of medium and heavy crudes from the Middle East and China itself with a significantly higher sulfur content, which is close to the underlying crude oil of Oman oil futures contracts in Dubai; both WTI and Brent are based on light low-sulfur crude oils.[3] Thus, China's oil futures market would become the direct competitor with Oman's oil futures market. This would act as China's first step towards becoming an important regional benchmark, reflecting both medium and heavy sour conditions in Asia, before it potentially becomes a global benchmark.

This study examines return and volatility linkages between the Chinese INE futures, the two international major futures markets, Brent and WTI, and its regional competitor in Asia—the Oman futures market in the Middle East. It contributes to the literature in the following aspects.

To our best knowledge, this is the first comprehensive study to explore the long-run price relationship and return and volatility dynamic relationships between the newly launched Chinese crude oil futures and international major crude oil futures markets WTI and Brent. As previous studies (e.g., Lin and Tamvakis, 2001; Liu, Schultz, and Swieringa, 2015) on international linkages of crude oil futures markets primarily focused on the dynamics between WTI and Brent oil futures markets, this study will offer new insights into international crude oil futures market relationships by accounting for both China's and Oman's oil futures markets, which are different from WTI and Brent in terms of the quality of crude oil as the underlying asset.[4]

An equally noteworthy factor is mentioned in Protopapadakis and Stoll's study (1983) in which they point out that an international price relationship for an identical commodity traded across different countries should generally follow the law of one price for a commodity, and such an relationship may be investigated in "its purest form" when commodity futures prices are used. As Chinese commodity futures markets as a whole have become the most actively traded since 2010 (with their exchanges having the highest commodity futures trading volume in the world), there is a growing amount of literature on the linkages of Chinese commodity futures with other global major commodities futures markets: Fung et al. (2003, 2010, 2013) examining the information transmission between various Chinese non-oil commodity futures contracts and the corresponding global futures markets, Jiang et al. (2016) examining the spillovers between the U.S. and Chinese agricultural futures, and Li and Hayes (2017) investigating price discovery on the Chinese, U.S., and Brazilian soybean futures markets.

Crude oil is probably the world's most important and most traded commodity, and with China playing such a crucial role in the world economy, particularly in the commodity markets, this

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[3] Both Brent and WTI are classified as a "light sweet" oil blend which means that they are easy to refine compared to heavier and sour oil blends. Specifically, Brent is relatively denser and has a higher sulfur content than WTI.

[4] For example, Lin and Tamvakis (2001) document substantial price spillover effects when both Brent and WTI markets are trading simultaneously, although Brent morning prices are considerably affected by the WTI closing prices of the previous day. Liu, Schultz, and Swieringa (2015) show that there is a decreasing level of cointegration between Brent and WTI markets.

study would fill in an important gap in the literature on international commodity futures market linkages in particular, and international commodity market linkages in general. In our initial findings, we discovered two-way pronounced return and volatility transmissions between international major oil futures and China's oil futures market when the latter was still in its infancy (only 3 months old during the sample period for the baseline analysis). The transmissions displayed stronger results than the case of the Oman oil futures in the Middle East which had existed for over ten years.

Extending the previous literature, we comprehensively investigated whether all conditional correlations and volatilities show asymmetry across all four international oil futures markets (WTI, Brent, INE, and Oman). Such asymmetry in volatilities and correlations can potentially shed light on the degree of downside risk of international oil futures markets under consideration (e.g., Cappiello, Engle, and Sheppard, 2006). While a few studies (e.g., Wang, Wu, and Yang, 2008; Kristoufek, 2014) have investigated the asymmetric volatility on major international oil futures markets, little has been done on Chinese and Oman crude oil futures markets. Furthermore, despite recent studies using the Dynamic Conditional Correlation (DCC) model (Engel, 2002) to explore correlation dynamics in crude oil and other commodity futures literature (e.g., Chang et al., 2011; Hernandez et al., 2017), little research has been done to explore the asymmetry in conditional correlations on international oil futures markets linkages in particular, and international commodity futures linkages in general. In this paper, we simultaneously exploit both the asymmetry in volatility and in correlations among the four crude oil futures markets under consideration. We find that China's crude oil futures exhibit stronger asymmetric volatility and correlations than international major oil futures markets.

Finally, we employ a better-quality dataset of intraday 5-minute high frequency data from both daytime and overnight trading sessions to adequately capture more information transmission across international major crude oil futures markets, which are generally considered to be very liquid with possible new information arrival and absorption within minutes. Recent research has shown that using daily data might not reveal intraday dynamic relationships that are highly relevant in the examination of linkages across oil futures markets and that it might be disadvantageous as the daily closing prices usually only reflect the information at the end of the daytime session without exploiting the information of the overnight session (which is particularly important to the China's crude oil futures market). For example, Kao and Wan (2012) argue that Brent has led WTI in the price discovery process since 2004 due to production, transportation, and inventory bottlenecks in the U.S. However, while using intraday data, Elder, Miao, and Ramchander (2014) discover that WTI maintains a dominant role in price discovery relative to Brent. Janzen and Adjemian (2017) make a similar argument for using high frequency intraday data when they explore international linkages of another commodity futures market (i.e., wheat).

Furthermore, by following Janzen and Adjemian (2017), we look at the linkages at different times of day (i.e., daytime versus overnight sessions) because every market might have different periods of concentrated trading when there is more information production. Interestingly, we find that the linkages between China's and international major crude oil futures are much stronger during the INE overnight session than during the INE daytime trading session. Shanghai International Energy Exchange return is significantly affecting the returns of WTI and Brent futures return only during the INE daytime session, despite there being lower trading volume and open interests during the INE daytime session compared to the INE overnight session.

The rest of the paper is organized as follows: Section 2 describes the data; Section 3 discusses econometric methodology; Section 4 presents empirical results; and, Section 5 makes concluding

remarks.

2. DATA
2.1. Data description

The prices of two major international oil futures—WTI and Brent—and the newly launched Chinese crude oil futures, recoded at 5-min intervals, are obtained from Bloomberg. The nearby futures contracts are used because they are highly liquid and the most active. While we also have the extended sample period for the additional analysis below, the sample period for the baseline analysis is the first three months of the INE oil futures trading from March 26th, 2018 to June 26th, 2018, as shown in Figure 1. Based purely on physical properties, the INE futures is expected to trade at a discount compared to WTI and Brent since its underlying oil is denser and has a higher sulfur content than WTI and Brent counterparts. Figure 1 demonstrates that the INE oil futures price is between WTI and Brent futures prices and that Brent trades at a substantial premium to WTI and INE. The inversion in the price spread can be attributed to localized factors, such as the dramatic increase in U.S. oil production. However, there is a general pattern of price co-movement between the Chinese futures and the other two futures. Moreover, the INE futures price diverged from the WTI counterpart and converged to the Brent counterpart in the second half of the sample.
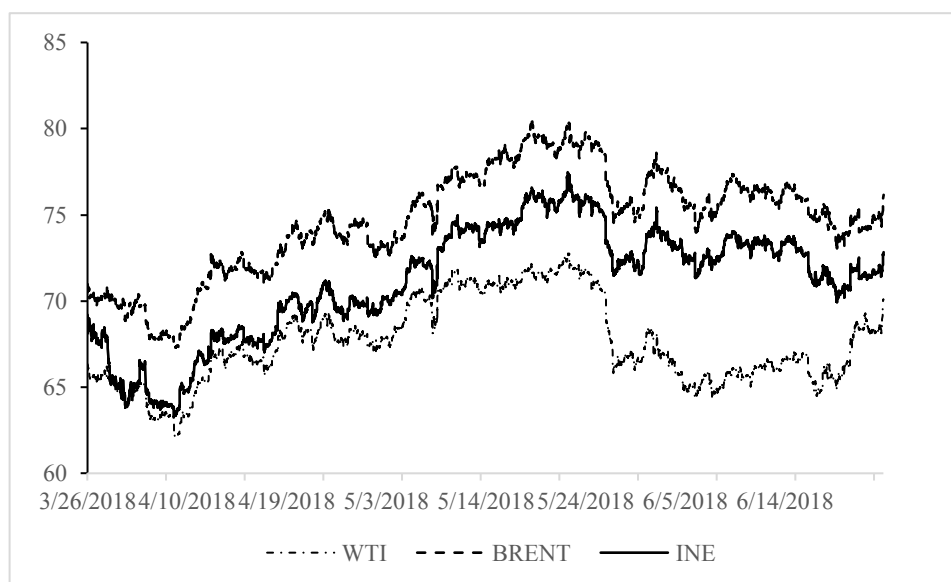
Figure 1: Prices of WTI, Brent, and INE Oil Futures

The INE opens from 9:00 a.m. to 11:30 a.m., 13:30-15:00, and then from 21:00 p.m. to 2:00 a.m. (Beijing Time) the next day, while the trading hours of the WTI and Brent oil futures contract are 23 hours, from 18:00 to 17:00 next day (New York Time) and 1:00 a.m. to 23:00 (London Time), respectively. After matching overlapping trading hours and exploring 5-minute continuous intervals, we obtain a full sample of 6,075 five-minute observations of nearby WTI, Brent, and INE oil futures returns during the three-month sample period, which are calculated by taking first differences of the logarithms of prices.

The underlying crude oil of INE futures is similar to that listed in the Oman Exchange. Therefore, we construct another sample by adding the Oman oil futures. However, further

matching only gives 3,744 observations due to limited data on Oman oil futures. We also break the samples into two subsamples of INE daytime trading hours/session and overnight trading hours/session to assess whether the relation between China's oil futures and other markets varies by different time periods of the day.

2.2. Summary statistics

Table 1 reports the summary statistics of oil futures returns. In Panel A, the INE oil futures yielded the average 5-minute return of 0.001% in the whole sample and subperiods. In contrast, the average returns of WTI and Brent futures are 0.002% in the whole sample while they are close to zeros during the INE daytime trading and slightly larger than 0.003% during the INE overnight trading. All three oil futures returns are substantially more volatile during the INE nighttime trading period than its daytime trading period, which might be a reflection of more flow of information among these crude oil futures (Ross, 1989), and the INE nighttime trading period overlaps with daytime trading period of WTI and Brent. Among them, China's crude oil futures were more volatile than the WTI and Brent counterparts in the whole sample and the daytime trading subsample. Moreover, crude oil futures were more negatively skewed in the INE than in the WTI and Brent markets. All crude oil futures returns exhibited high kurtosis, which is a very preliminary evidence for higher downside risk of China's crude oil futures during the sample period (to be formally documented below). Brent and INE futures returns were strongly autocorrelated during the daytime of INE trading while serial correlations were quite weak for these two returns. In contrast, WTI oil futures returns were strongly autocorrelated during the nighttime but not during the daytime of INE trading. The squared returns were strongly serial correlated across all three markets under consideration, suggesting the existence of ARCH effects on these markets.

Table 1 Summary Statistics of Oil Futures Returns

Note. The table reports summary statistics for returns of WTI, Brent, INE, and OMAN 5-minute futures as well as trading activity from March 26 to June 26, 2018. From Bloomberg, WTI, Brent, INE, and OMAN denote the log differences of 5-minute trading prices of the corresponding nearby futures contracts. All measures are in percentage. "Nobs" is the numbers of 5-minute observations. LB Q(10) is the Ljung-Box's Q(10) statistics with ** and *** denoting significance at 5% and 1%, respectively.

Panel A: Returns of WTI, Brent and INE Oil Futures

	Stat	Nobs	mean	Std	Skew	Excess Kurt	Lag1	Lag10	LB Q(10) for return	LB Q(10) for squared return
Whole sample	WTI nearby	6075	0.002	0.116	-.748	22.413	-.016	0.009	25.019***	387.555***
	Brent nearby	6075	0.002	0.112	-.773	24.851	-.027	0.008	25.884***	517.508***
	INE nearby	6075	0.001	0.128	-1.645	21.901	-.019	0.018	11.637	272.090***
INE day-time trading	WTI nearby	2520	-.000	0.058	-.278	17.961	-.014	0.036	15.086	349.146***
	Brent nearby	2520	0.000	0.062	0.521	12.970	-.071	0.019	37.722***	740.317***
	INE	2520	0.001	0.105	-.733	17.840	-.020	-.031	24.638***	234.678***

		Nobs	mean	Std	Skew	Excess Kurt	Lag1	Lag10	LB Q(10) for return	LB Q(10) for squared return
	nearby									
INE over-night trading	WTI nearby	3556	0.003	0.143	-.684	15.208	-.019	0.009	18.893**	180.298***
	Brent nearby	3556	0.003	0.137	-.784	17.982	-.025	0.014	17.792	265.852***
	INE nearby	3556	0.001	0.142	-1.123	20.596	-.013	0.034	10.147	129.813***

Panel B: Returns of Oman Oil Futures

Sample	Nobs	mean	Std	Skew	Excess Kurt	Lag1	Lag10	LB Q(10) for return	LB Q(10) for squared return
Whole Sample	3744	0.002	0.151	-5.580	153.695	-.058	-0.046	0.013	40.940***
INE daytime trading	614	0.005	0.096	3.269	42.008	-.142	0.007	0.020	15.824***
INE overnight trading	3130	0.001	0.160	-5.792	146.328	-.051	-0.050	0.019	33.576***

Panel C: Correlations across WTI, Brent, INE, and Oman Oil Futures Returns

	Whole Sample			INE daytime trading			INE overnight trading		
	WTI	Brent	INE	WTI	Brent	INE	WTI	Brent	INE
Brent	0.859			0.836			0.860		
INE	0.780	0.788		0.664	0.637		0.793	0.802	
Oman	-0.002	-0.007	0.048	0.021	0.032	0.022	-0.003	-0.009	0.050

Panel D: Summary statistics of trading activity

	WTI		Brent		INE		Oman	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std
trading volume								
Nearby	622613	252473	281995	102500	148339	79967	2913	1089
Second nearby	285892	177476	235495	81773	66	101	114	83
Third nearby	103441	35435	105715	31188	11	26	69	73
Open Interest								
Nearby	368143	167376	391656	166000	23301	10011	11987	8122
Second nearby	356420	100587	456648	89202	432	243	33	69
Third nearby	203252	36709	234720	59212	64	24	19	38

In Panel B of Table 1 for the smaller sample of Oman oil futures, there are very few observations during the INE daytime trading period. In the full sample and INE nighttime trading subsample, Oman oil futures returns were even more volatile and negatively skewed with

higher kurtosis compared with the WTI, Brent, and INE counterparts in Panel A. Although serial correlations are very weak for returns of Oman oil futures, its squared returns were strongly serially correlated, which also suggests the existence of volatility clustering.

Panel C of Table 1 shows the correlation matrix of crude oil futures returns. Oil futures returns of nearby WTI and Brent contracts have a high positive correlation in both the full sample and the two subsamples. Also, China's oil futures returns were highly correlated with the WTI and Brent counterparts, yielding the correlations of 78.0% and 78.8% in the full period, respectively. These correlations between the INE and the other two markets are much lower in the INE daytime trading period at 66.4% and 63.7%, while they are somewhat higher in the INE daytime trading period at 79.3% and 80.2%. The difference suggests that China's oil futures market is more integrated with the global market during the nighttime when WTI and Brent futures are traded in their daytime trading. Also, we calculate the correlations between the Oman futures and the other three futures, which are close to zeros and even negative in the full period and the INE overnight trading period.[5]

Panel D of Table 1 reports summary statistics of the major crude oil futures trading activity. China's oil futures have ranked the third largest crude oil futures market in terms of trading volumes, only after the WTI and Brent. For all crude oil futures, the trading volumes for the first nearby contracts are greater than the second, which in turn are greater than the third, implying that the nearby futures contracts are the most liquid and the most actively traded. In contrast to WTI and Brent futures counterparts, the trading volume of INE oil futures concentrates on the first nearby contract, which on average accounts for 99.9% of total futures trading. Meanwhile, INE oil futures have much smaller open interest than WTI and Brent counterparts. For example, the open interest of the nearby INE contract on average accounts for 15.7% of the corresponding future trading volume, suggesting that trading volume is mainly driven by speculative trading. Similar to trading volume, open interest of INE futures also concentrates on the first nearby contract, which on average accounts for 99.7% of total open interest. Compared with China's and two other crude oil futures, the trading of Oman futures is very thin while its open interest accounts for a higher percentage of the INE counterpart.

Table 2 Cointegration tests

Note. The table reports Johansen's cointegration tests for WTI, Brent, and INE as well as Oman futures prices from March 26 to June 26, 2018. r is the number of cointegrating vectors. C is the trace test critical values. When test statistics are greater than C (5%), we reject the null hypothesis that the number of cointegrating vectors is less than or equal to r.

Panel A: Johansen cointegration test on WTI, Brent, and INE futures prices

With Linear Trend					Without Linear Trend			
Trace Test	C(5%)	λ_{Max} Test	C(5%)	H_0	Trace Test	C(5%)	λ_{Max} Test	C(5%)
2.92	12.25	2.92	12.25	r≤2	2.48	9.24	2.48	9.24
11.59	25.32	8.67	18.96	r≤1	6.1	19.96	3.63	15.67
57.56**	42.44	45.97**	25.54	r=0	50.47**	34.91	44.37**	22

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[5] The correlations between the Oman futures and the other three futures are positive in the INE daytime period. However, the observations are limited in this subsample.

Panel B: Johansen cointegration test on WTI, Brent, and Oman futures prices

With Linear Trend				H_0	Without Linear Trend			
Trace Test	C(5%)	λ_{Max} Test	C(5%)		Trace Test	C(5%)	λ_{Max} Test	C(5%)
2.19	12.25	2.19	12.25	$r \leq 2$	2.79	9.24	2.79	9.24
9.00	25.32	6.81	18.96	$r \leq 1$	9.6	19.96	6.81	15.67
55.65**	42.44	46.66**	25.54	$r = 0$	56.31**	34.91	46.71**	22

Panel C: Johansen cointegration test on Brent, INE, and Oman futures prices

With Linear Trend				H_0	Without Linear Trend			
Trace Test	C(5%)	λ_{Max} Test	C(5%)		Trace Test	C(5%)	λ_{Max} Test	C(5%)
2.61	12.25	2.61	12.25	$r \leq 2$	2.02	9.24	2.02	9.24
10.96	25.32	8.35	18.96	$r \leq 1$	5.71	19.96	3.69	15.67
92.29**	42.44	81.33**	25.54	$r = 0$	69.33**	34.91	63.62**	22

The Johansen's (1991) procedure is then applied to test for cointegration among the series of WTI, Brent, and INE as well as Oman futures prices.[6] Specifically, the optimal lags for level VAR are selected based on the Akaike Information Criterion (AIC), and the Johansen's trace and λ_{Max} tests are conducted for cointegration. To deal with the problem with or without a time trend, a sequential hypothesis testing procedure proposed by Johansen (1992) is followed. If there is a linear trend in the model, the hypothesis is labeled $H_0(r)$, which is an unrestricted case. If there is no linear trend in the model, the hypothesis is labeled $H_0(r)^*$, which is restricted. According to the sequential hypothesis testing procedure, hypotheses are tested in the following order: $H_0(0)^*$, $H_0(0)$, $H_1(1)^*$, $H_1(1)$, $H_1(p)^*$, and $H_1(p)$. When the null hypothesis first fails to be rejected in the sequence, testing is stopped, and the associated null hypothesis is accepted. Extending previous studies (e.g., Liu, Schultz, and Swieringa, 2015), the test statistics summarized in Table 2 indicate the existence of one cointegrating vector among WTI, Brent, and INE oil futures prices, among WTI, Brent, and Oman futures prices, as well as among Brent, INE, and Oman futures prices. The unreported result also shows that none of these markets are excluded in each of the cointegration vectors identified above, confirming that a long run relationship indeed connects all oil futures markets under consideration to some extent.

3. ECONOMETRIC METHOLODGY

Given the cointegration relationship, the empirical methodology we use is Vector Error Correction Model (VECM), with two different specifications of multivariate Generalized Autoregressive Conditional Heteroscedasticity (MGARCH) model. One of the MGARCH models is AG-DCC-GJR-GARCH model (Cappiello et al., 2006; Glosten et al., 1993), which is flexible to investigate the presence of asymmetric responses in conditional variances and conditional correlations to negative returns. The other is the BEKK model (Engle and Kroner,

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[6] As only daily data are publicly available for crude oil cash markets, and the data only had three-month history when we started the project, we would leave for future research the investigation of the price discovery function of China's crude oil futures market based on the cash-futures price relationship. As first pointed out in Yang and Leatham (1999), while it generally does not receive adequate attention in the literature on futures markets, the price discovery process also exists across multiple futures markets when they exist for a homogeneous or closely linked commodity. Noteworthy, such an argument on price discovery is also well received elsewhere, including those studies on price discovery performance of cross-listed stocks (e.g., Eun and Sabherwal, 2003).

1995), which is flexible to account for both own- and cross-volatility spillovers, as well as volatility persistence.

3.1. VECM-AG-DCC-GJR-GARCH model

In this section, we present a multivariate VECM- AG-DCC-GJR-GARCH (1,1) model for 5-minute returns of WTI, Brent, and INE nearby futures. The model jointly estimates asymmetric volatilities and asymmetric correlations, which may improve the specification substantially. Compared with a large body of the literature on asymmetric volatility, asymmetric correlation has received relatively less attention in the literature, which would be the focus of this study. We will derive continuous time series of time-varying conditional correlations through the AG-DCC-GJR-GARCH model to see how China's oil futures market is integrated with the global oil markets.

Since the crude oil futures price series are cointegrated, we consider the following vector error correction model after the preliminary search on the lag length:

(1) $$\Delta X_t = \alpha \beta' X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \mu + e_t \quad e_t \sim N(0, H_t),$$

where X_t is a n×1 vector of futures prices in natural logarithm, $\beta'X_t$ is the one period lagged deviation from the long-run equilibrium relationship, and the n×1 vector, α, measures the response of the endogenous variables to deviations from the long-run equilibrium relationship. The rank of $\Pi = \alpha\beta'$ determines the number of cointegration vectors or the cointegration rank. e_t is a n×1 vector of innovations, and H_t is the conditional variance-covariance matrix of r_t (or equivalently e_t).

H_t can be further decomposed into the diagonal matrix conditional standard deviation, D_t, and the conditional correlation matrix R_t :

(2) $$H_t = D_t R_t D_t,$$

where

(3) $$D_t = diag(h_{it}^{1/2}),$$
$$h_{it} = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1} + \gamma_i \{\min(\varepsilon_{i,t-1}, 0)\}^2,$$
$$\varepsilon_t = D_t^{-1} r_t \sim N (0,1)$$
$$R_t = (\rho_{ij,t}) = E_{t-1} (\varepsilon_{i,t} \varepsilon_{j,t})$$

Note that in this model the conditional volatility h_{it} is assumed to follow a univariate asymmetric GARCH (1,1) process as in Glosten, Jagannathan, and Runkle (1993). The conditional correlation estimator is

(4) $$\rho_{ij,t} = q_{ij,t} / \sqrt{q_{ii,t} q_{jj,t}}$$

where $q_{ij,t}$ is conditional covariance if $i \neq j$ and conditional variance if $i=j$.

R_t can be written in terms of covariance matrix $Q_t = (q_{ij,t})$ as follows:

(5) $$R_t = (diag(Q_t))^{-1/2} Q_t (diag(Q_t))^{-1/2}$$

As in Cappiello, Engle, and Sheppard (2006), the evolution of Q_t is governed by the asymmetric generalized DCC process:

(6) $$Q_t = \bar{R} + A \bullet (\varepsilon_{t-1}\varepsilon_{t-1}' - \bar{R}) + B \bullet (Q_{t-1} - \bar{R}) + G \bullet (\eta_{t-1}\eta_{t-1}' - \bar{N}),$$

where $\bar{R} = E[\varepsilon_t \varepsilon_t']$, A, B and G are square ($n \times n$), symmetric matrices, $\bullet$ is a Hadamard product, $\eta_t = \min(\varepsilon_t, 0)$, and $\bar{N} = E[\eta_t \eta_t']$.

We can choose a diagonal parameterization for A, B and G as follows

(7) $$A = \alpha_C \alpha_C', \ B = \beta_C \beta_C', \ G = \gamma_C \gamma_C',$$

where α_C, β_C, and γ_C are n x 1 vectors, so that for any W

(8) $$A \bullet W = diag\{\alpha_C\} W \, diag\{\alpha_C\} \ \ .$$

Hence, for any i and j, we obtain the following expression to be used in the subsequent empirical analysis:

(9) $$q_{ij,t} = \bar{\rho}_{ij} + \alpha_{i,C}\alpha_{j,C}(\varepsilon_{i,t-1}\varepsilon_{j,t-1} - \bar{\rho}_{ij}) + \beta_{i,C}\beta_{j,C}(q_{ij,t-1} - \bar{\rho}_{ij}) + \gamma_{i,C}\gamma_{j,C}(\eta_{i,t-1}\eta_{j,t-1} - \bar{N}_{i,j})$$

Assuming normality, the log-likelihood function of the sample is given by

(10) $$L = \sum_{t=1}^{T} l_t = -\frac{1}{2}\sum_t (\log(2\pi) + \log|D_t R_t D_t| + r_t' D_t^{-1} R_t^{-1} D_t^{-1} r_t)$$

$$= -\frac{1}{2}\sum_t (\log(2\pi) + 2\ln|D_t| + r_t' D_t^{-2} r_t - \varepsilon_t' \varepsilon_t + \ln|R_t| + \varepsilon_t' R_t^{-1} \varepsilon_t).$$

Let the parameters in D be denoted $\theta = (\mu_i, \lambda_{ij}, \omega_i, \alpha_i, \beta_i)$ and the additional parameters in R be denoted $\phi = (\alpha_{i,C}, \beta_{i,C}, \gamma_{i,C})$. The log likelihood function can be written as the sum of a volatility part and a correlation part:

(11) $$L(\theta, \phi) = L_V(\theta) + L_C(\theta, \phi),$$

where the volatility term is apparently the sum of individual GARCH likelihoods

(12) $$L_V(\theta) = -\frac{1}{2}\sum_t (\log(2\pi) + 2\ln|D_t| + r_t' D_t^{-2} r_t),$$

and the correlation term is:

(13) $$L_C(\theta, \phi) = -\frac{1}{2}\sum_t (-\varepsilon_t' \varepsilon_t + \ln|R_t| + \varepsilon_t' R_t^{-1} \varepsilon_t).$$

Hence, the two-step estimation approach can be followed, as proposed in Engle (2002) and Cappiello, Engle, and Sheppard (2006), to maximize the likelihood function, which is to find

(14) $$\hat{\theta} = \arg\max\{L_V(\theta)\},$$

and then take this value as given in the second stage,

(15) $$\underset{\phi}{Max}\, L_C(\hat{\theta}, \phi).$$

In sum, there are two stage estimations of the conditional covariance matrix for the AG-DCC models. First, VAR(1) and univariate GARCH models are fit for each of these oil futures returns. Second, the estimated standard deviations of oil futures returns are used to estimate the parameters of the conditional correlations using the AG-DCC model. In the second-stage analysis, we estimate the DCC model as a benchmark and then extend it into the asymmetric DCC model assuming the different impact of a negative shock on all pairwise correlations. Having ensured the presence of asymmetric correlations, we further examine the more general AG-DCC model.

3.2. VECM-GARCH-BEKK model
To take further account of volatility spillovers and see how information transmits from one

market to another, crude oil futures can be jointly modeled in a VAR-GARCH model with BEKK specification. In particular, the information transmission through the volatility linkage is investigated by estimating the conditional variance-covariance matrix H_t in Equation (16),

(16) $\quad X_t = \mu + \sum_{i=1}^{k-1} \rho_i X_{t-i} + \varepsilon_t \quad H_t = CC' + A(\varepsilon_{t-1}\varepsilon_{t-1}')A' + BH_{t-1}B'$

where C is an upper triangle matrix of constants c_{ij}, A is a matrix of elements a_{ij} that captures direct spillover effect from market i to market j, and B is a matrix of elements bij that measure direct persistent effects in volatility transmissions between markets i and j.

In the case of 3 markets, $H, C, A,$ and B can be written as follows

(17) $H_t = \begin{pmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{pmatrix}, C_t = \begin{pmatrix} c_{11} & c_{12} & c_{13} \\ 0 & c_{22} & c_{23} \\ 0 & 0 & c_{33} \end{pmatrix},$

$A = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}, B = \begin{pmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{pmatrix}$

Specifically, Equation (16) can be expanded using Equation (17) as follows:

$$
H_t = \begin{bmatrix} c_{11} & c_{12} & c_{13} \\ 0 & c_{22} & c_{23} \\ 0 & 0 & c_{33} \end{bmatrix}' \begin{bmatrix} c_{11} & c_{12} & c_{13} \\ 0 & c_{22} & c_{23} \\ 0 & 0 & c_{33} \end{bmatrix}
$$

(18)

$$
+ \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1} & \varepsilon_{1,t-1}\varepsilon_{3,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon_{2,t-1}^2 & \varepsilon_{2,t-1}\varepsilon_{3,t-1} \\ \varepsilon_{3,t-1}\varepsilon_{1,t-1} & \varepsilon_{3,t-1}\varepsilon_{2,t-1} & \varepsilon_{3,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}
$$

$$
+ \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix}' \begin{bmatrix} h_{11,t-1} & h_{12,t-1} & h_{13,t-1} \\ h_{21,t-1} & h_{22,t-1} & h_{23,t-1} \\ h_{31,t-1} & h_{32,t-1} & h_{33,t-1} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix},
$$

With the above specification, we can use off-diagonal parameters in matrices A and B to explain the volatility spillover effect. For example, the off-diagonal parameter a_{ij} measures the transmission of the absolute size of the return shocks, as measured by squared values of lagged unpredictable returns, originating from market i in the previous period to the current period's conditional volatility in market j, while the dependence of the conditional volatility in market j on that of market i in the previous period is measured by the parameter b_{ij}.

Nevertheless, not all the channels of volatility spillovers can be exhaustively accounted for in the above specification, so such interpretation on the off-diagonal parameters, though perhaps revealing, should be considered preliminary. Unfortunately, the interpretation of other parameters from the GARCH-BEKK model is generally not straightforward. Following Fleming et al. (1998), we use the time-varying cross-market conditional correlation, computed as $CC_{ij} = h_{ij,t}/(h_{ii,t}h_{jj,t})^{1/2}$, to gauge the volatility linkage across the markets.

4. EMPIRICAL RESULTS

This section presents the results of both VECM-AG-DCC-GJR-GARCH and VECM-GARCH-BEKK models. Since there are several thousands of observations for the

samples under consideration, we consider the statistical significance of parameter estimates at the 5% level or lower as appropriate to make the inference in the analysis below.

4.1. The error correction and asymmetric patterns

Table 3 shows the parameter estimates of the mean and volatility models for WTI, Brent, and INE oil futures.[7] In Panel A of VECM(1) results for the whole sample, WTI oil futures returns cannot be predicted by its own lag and other lagged oil futures returns. In contrast, the predictability of Brent and INE oil futures returns is stronger: Brent oil futures returns can be predicted by its own lag and lagged WTI futures returns while the lagged Brent futures returns is a strong predictor of INE returns. Moreover, the error correction term is significantly associated with China's oil futures returns but not with the two leading global oil futures returns. This suggests that China's futures market reacts to deviations from the long-run equilibrium among these three markets while the WTI and Brent futures do not, plausibly implying that China's crude oil futures market generates less long-run information than the two leading global crude oil futures during the sample period.

When we break the whole sample into INE daytime and overnight trading subsamples, the pattern during the INE overnight trading is similar to that of the whole sample. In particular, the association of the error correction term with China's oil futures is significant while it is not the case for the WTI and Brent futures markets. In contrast, during the INE daytime trading, the reaction of China's oil futures to deviations from the long-run equilibrium is not significant and at the 5% level. Moreover, the predictability of INE oil futures returns disappear during the INE daytime trading while the lag of INE futures is a strong predictor of future WTI and Brent returns. The results suggest that China's oil futures market has more informational advantage during the INE daytime trading than during the INE overnight trading.

The information production argument can offer a plausible explanation to the above interesting phenomenon. Using high frequency futures data, Andersen et al. (2007) detect strong but short-lived effects of macroeconomic news on stock, bond, and foreign exchange markets in an international context. The macroeconomic news of the two largest economies (i.e., the U.S. and China) obviously matter for the global crude oil market. Hence, we have a similar argument that China's oil futures returns can predict WTI and Brent futures returns due to more information production based on Chinese macroeconomic news releases in the INE daytime trading. In the INE overnight trading period, there is far more macroeconomic news regularly released in the U.S. and U.K. markets, which triggers the reaction of China's oil futures to deviations from the long-run equilibrium.

In addition to relatively scarce information in China versus the U.S. and the U.K. during the INE overnight session, the differential informational role of institutional trading versus individual trading can also play a role here. Zhao and Wan (2018) find that despite the fact that individual investors account for approximately 90% of the entire Chinese commodity futures market, only a certain type of institutional trading is associated with permanent price movements, while individual trading is always information-biased. Arguably, it is likely that informed institutional trading in China would take place during regular work hours that overlaps with the INE daytime trading rather than the INE overnight trading. Wellenreuther and Voelzke (2019) also point out extremely speculative trading behavior on Chinese commodity futures markets. This might also suggest higher trading shares of extremely speculative individual investors in China, implied by higher trading volume and yet lower informational content during the INE

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[7] Perhaps due to the complexity of the model we use and the dramatic increase in the number of parameters that need to be estimated when additional variables are added, conducting the analysis based on all four oil futures markets often presented estimation difficulty related to a lack of convergence.

overnight trading. Future research may examine the conjecture with the trade-by-trade record with the proprietary information of institutional and individual accounts, or hedgers versus speculators.

As shown in Panel B of the results of the GJR GARCH model, most coefficients are positive and highly significant in the whole sample. The volatility for each asset return displays a highly persistent fashion since the sum of the estimated coefficients α and β in each variance equation is close to unity for all of the cases. Moreover, all asset returns exhibit asymmetric volatilities, indicating that volatilities increase after negative shocks for each return. The asymmetry of INE volatility is greater than WTI and Brent counterparts since the magnitude of the estimated coefficient γ for INE is bigger than those for the other two crude oil futures. Based on the INE daytime trading sample, the volatility for WTI oil futures is neither persistent nor asymmetric since coefficients β and γ are not significantly different from zeros. By contrast, INE oil futures show an even stronger evidence of asymmetric volatilities but not persistent volatility during daytime trading. Such patterns reversed during the overnight trading.

Table 3 Results of VECM-GJR-GARCH Models for WTI-Brent-INE nearby Futures
Note. The mean and volatility models are as follows:

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{i=1}^{k-1}\Gamma_i \Delta X_{t-i} + \mu + \varepsilon_t \ \ \varepsilon_t \sim N(0, H_t), \ H_t = D_t R_t D_t,$$

$$D_t = diag(h_{it}^{1/2}), h_{it} = \omega_i + \alpha_i \varepsilon_{i,\ t-1}^2 + \beta_i h_{i,t-1} + \gamma_i \{\min(\varepsilon_{i,t-1}, 0)\}^2,$$

where subscripts i $\in\{1,2,3\}$ with 1 for the return of WTI nearby futures, 2 for the return of Brent nearby futures, 3 for the return of INE nearby futures, respectively. The t-statistics are reported in parenthesis below the coefficients with ** and *** denoting significance at 5% and 1%, respectively. The sample period is from March 26 to June 26, 2018.

Panel A: estimation results of VECM(1) model

Return i	Whole sample				INE daytime trading sample				INE overnight trading sample			
	lagged WTI	lagged Brent	lagged INE	lagged ECT	lagged WTI	lagged Brent	lagged INE	lagged ECT	lagged WTI	lagged Brent	lagged INE	lagged ECT
WTI nearby	-0.027 (-1.069)	0.021 (0.822)	-0.008 (-0.438)	0.042 (0.215)	-0.002 (-0.065)	-0.082** (-2.374)	0.057*** (4.040)	0.044 (0.269)	-0.012 (-0.362)	0.052 (1.483)	-0.062** (-2.110)	0.071 (0.229)
Brent nearby	0.067*** (2.717)	-0.082*** (-3.252)	-0.004 (-0.258)	0.103 (0.545)	0.207*** (5.216)	-0.282*** (-7.781)	0.050*** (3.400)	0.142 (0.834)	0.066** (2.018)	-0.039 (-1.170)	-0.054 (-1.919)	0.113 (0.385)
INE nearby	0.018 (0.650)	0.088*** (3.116)	-0.088*** (-4.465)	-0.707*** (-3.301)	-0.038 (-0.573)	0.064 (1.056)	-0.028 (-1.136)	-0.535 (-1.870)	0.041 (1.202)	0.121*** (3.481)	-0.136*** (-4.703)	-0.704** (-2.321)

Panel B: estimation results of GJR-GARCH model

Sample Return i	Whole sample			INE daytime trading sample			INE overnight trading sample		
	α_i	β_i	γ_i	α_i	β_i	γ_i	α_i	β_i	γ_i
WTI Nearby	0.265*** (65.502)	0.811*** (813.969)	0.089*** (22.047)	0.168 (0.956)	0.388 (0.671)	0.168 (0.957)	-0.003 (-0.137)	0.865*** (13.113)	0.122*** (5.153)
Brent nearby	0.067*** (24.260)	0.846*** (893.468)	0.178*** (64.764)	0.074*** (5.005)	0.690*** (17.122)	0.101*** (6.859)	0.083*** (3.491)	0.878*** (18.543)	0.031 (1.272)
INE nearby	0.152*** (39.989)	0.723*** (425.418)	0.166*** (43.631)	0.120*** (4.782)	0.042 (1.009)	0.220*** (8.646)	0.108*** (4.148)	0.824*** (17.032)	0.084*** (3.207)

The different pattern of volatility clustering and asymmetry for China's oil futures can be explained through previous literature. Anderson and Bollerslev (1997) interpret volatility clustering in high frequency returns as a mixture of numerous heterogeneous short-run information arrivals. Based on this perspective, a plausible explanation might be that China's oil

futures returns exhibit volatility clustering during its nighttime due to heterogeneous information arrivals, when the global crude oil markets (especially WTI) are trading in their daytime trading period with regular and ample information release. In contrast, there is no evidence for volatility clustering when China's oil futures market open in the INE daytime trading period, because much less information is released.[8]

As for asymmetric volatility, two popular explanations exist: the leverage effect and volatility feedback effect (time-varying risk premiums) (see, e.g., Avramov, Chordia, and Amit, 2006). The significance of asymmetric volatility on WTI and Brent crude oil futures markets in this study is consistent with Kristoufek (2014), with additional new evidence of significant asymmetric volatility on China's and Oman crude oil futures markets. The existence of stronger asymmetric volatility on China's crude oil futures market could simply reflect higher risk aversion to downside risk and thus stronger volatility feedback effect of Chinese investors on China's oil futures market in its infancy.[9] The phenomenon that asymmetric volatility is more significant during the INE daytime trading than that during the INE overnight trading can also be consistent with the above explanation. This might relate with the fact that a relatively higher percentage of traders on China's oil futures market during the INE daytime trading would be Chinese domestic investors, and thus, present an even stronger volatility feedback effect during the INE overnight trading.

Following Yang, Zhou, and Wang (2010), the time series profile of the three crude oil futures' conditional volatilities over the full period, daytime, and overnight trading subperiods is shown in Panel A of Table 5. The mean of these volatilities are close to their unconditional counterparts, which suggest the adequacy of conditional volatility modeling. Consistent with the use of GARCH models, the estimated volatilities were strongly serially correlated in both the full sample and the nighttime sub-period. By contrast, the serial correlations of estimated volatilities in the daytime subsample are significantly lower, especially for the INE oil futures.

Table 4 reports the estimation results of the AG-DCC model. The estimated log-likelihood values and the resulting likelihood ratio test statistics (not reported here) suggest that the AG-DCC model fits significantly better than the benchmark DCC model, underscoring the importance of more flexible modeling of conditional correlation dynamics. All asymmetry parameters are significantly positive, which suggests that the correlations of any two oil futures market returns tend to be higher responding to their negative returns. Such an asymmetric correlation pattern implies that negative shocks tend to make the three oil futures markets co-move more strongly. Especially, as the INE market is (to a large extent) integrated with the two major global oil futures markets, a negative systematic shock could increase volatility and induce risk premium increases for all oil futures markets, causing a price drop in INE oil futures and the correlation increase between INE and the other two futures markets.

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[8] Also consistent with the information story, there is far more trading of INE futures during its nighttime trading when WTI and Brent futures are traded at their daytime.

[9] While it is not clear about how the leverage effect could explain the daily asymmetric volatility on crude oil futures markets, the trading-based explanation of Avramov, Chordia, and Amit (2006) might also shed some light on the issue. In particular, their explanation points out that the existence of asymmetric volatility may be due to the non-informational herding trades which increase volatility following price declines. Given the higher percentage of individual investors and thus probably more herding trades on Chinese futures markets in general than major international crude oil markets, it can also explain the finding of stronger asymmetric volatility on China's crude oil futures market than on two major international crude oil markets. Nevertheless, it is harder to explain why asymmetric volatility is more significant during the INE daytime trading than during the INE overnight trading, unless there is additional evidence that compared with the INE overnight trading, a much higher percentage of Chinese investors during the INE daytime trading are institutional investors (presumably less vulnerable to herd trading), rather than individual investors. We leave more thorough investigation for future research.

Table 4 Estimation Results of the AG-DCC models for WTI-Brent-INE nearby Futures

Note. The correlation estimator R_t can be written in terms of covariance matrix $Q_t = (q_{ij,t})$ as

$R_t = (diag(Q_t))^{-1/2} Q_t (diag(Q_t))^{-1/2}$. The evolution of Q_t is given by:

$Q_t = \bar{R} + A \bullet (\varepsilon_{t-1}\varepsilon_{t-1}' - \bar{R}) + B \bullet (Q_{t-1} - \bar{R}) + G \bullet (\eta_{t-1}\eta_{t-1}' - \bar{N})$, where $\bar{R} = E[\varepsilon_t \varepsilon_t']$, A, B and G are square,

symmetric matrices, $\bullet$ is a Hadamard product, $\eta_t = \min(\varepsilon_t, 0)$, and $\bar{N} = E[\eta_t \eta_t']$.

A diagonal parameterization is chosen for A, B and G: $A = \alpha_C \alpha_C'$, $B = \beta_C \beta_C'$, $G = \eta_C \eta_C'$, where

α_C, β_C, and η_C are 3 x 1 vectors, so that for any i and j,

$q_{ij,t} = \bar{\rho}_{ij} + \alpha_{i,C}\alpha_{j,C}(\varepsilon_{i,t-1}\varepsilon_{j,t-1} - \bar{\rho}_{ij}) + \beta_{i,C}\beta_{j,C}(q_{ij,t-1} - \bar{\rho}_{ij}) + \gamma_{i,C}\gamma_{j,C}(\eta_{i,t-1}\eta_{j,t-1} - \bar{N}_{i,j})$

In Panel A, the t-statistics are reported in parenthesis below the coefficients. ** and *** denoting significance at 5% and 1% respectively. The sample period is from March 26 to June 26, 2018.

Panel A: Parameters of the AG-DCC models

i	Whole sample			INE daytime trading sample			INE overnight trading sample		
	$\alpha_{i,C}$	$\beta_{i,C}$	$\gamma_{i,C}$	$\alpha_{i,C}$	$\beta_{i,C}$	$\gamma_{i,C}$	$\alpha_{i,C}$	$\beta_{i,C}$	$\gamma_{i,C}$
WTI nearby	0.175***	0.962***	0.237***	0.054***	0.974***	0.199***	0.192***	0.975***	0.136***
	(27.942)	(299.546)	(15.587)	(3.292)	(99.248)	(5.101)	(18.947)	(316.355)	(7.150)
Brent nearby	0.079***	0.981***	0.204***	0.018	0.986***	0.111***	0.133***	0.984***	0.144***
	(15.559)	(450.647)	(15.812)	(1.219)	(159.152)	(4.445)	(18.886)	(793.755)	(9.994)
INE nearby	0.105***	0.969***	0.236***	0.130***	0.981***	0.139***	0.163***	0.969***	0.193***
	(13.509)	(402.032)	(16.186)	(8.145)	(171.506)	(4.865)	(14.466)	(445.418)	(11.318)

Panel B: Matrix A

Whole sample			INE daytime trading sample			INE overnight trading sample		
0.031	0.014	0.019	0.003	0.001	0.007	0.037	0.025	0.031
0.014	0.006	0.008	0.001	0.000	0.002	0.025	0.018	0.022
0.018	0.008	0.011	0.007	0.002	0.017	0.031	0.022	0.026

Panel C: Matrix B

Whole sample			INE daytime trading sample			INE overnight trading sample		
0.925	0.944	0.932	0.948	0.960	0.955	0.950	0.959	0.944
0.943	0.962	0.950	0.960	0.972	0.967	0.959	0.968	0.953
0.932	0.950	0.938	0.955	0.967	0.962	0.944	0.953	0.938

Panel D: Matrix G

Whole sample			INE day time sample			INE night time sample		
0.056	0.048	0.056	0.040	0.022	0.028	0.018	0.020	0.026
0.048	0.042	0.048	0.022	0.012	0.015	0.020	0.021	0.028
0.056	0.048	0.056	0.028	0.015	0.019	0.026	0.028	0.037

More evidence of asymmetric correlations is summarized in Matrix G, as shown in Panel D. Panels B and C also show that the shocks to correlations are typically persistent. To further explore asymmetry in correlation, we will study correlation dynamics and volatility spillovers in the following two subsections.

4.2. Correlation dynamics

We can obtain the conditional correlation time series based on Equations (5) and (6). Figure 2 plots the conditional correlations between the two global crude oil futures markets, WTI and Brent. Based on the full sample, the correlation between these two major oil futures returns swings from 22.8% to 96.9% with a mean of 85.1%. During the INE daytime trading period, the correlation is 84.9% on average between WTI and Brent oil futures markets, ranging from 56.4% to 89.5%. During the INE overnight trading period, the correlation between WTI and Brent is more volatile, ranging from 21.7% to 97.5%, and yet, it still has the same mean of 85.0% as in the full sample. Obviously, extending research by Liu, Schultz, and Swieringa (2015), these two major international crude oil futures markets are, in general, highly integrated with each other, with occasional dramatic changes in the correlation even during the 3-month sample period.

Panel A: Full Sample

Panel B: INE Daytime Trading Sample
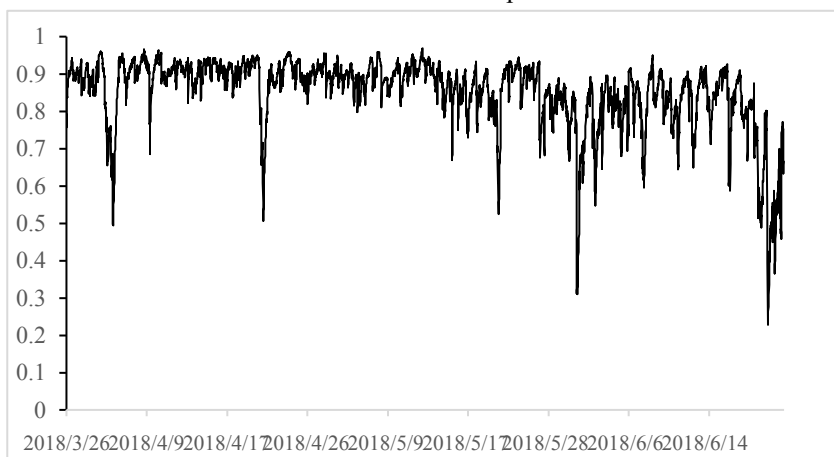
Panel C: INE Overnight Trading Sample
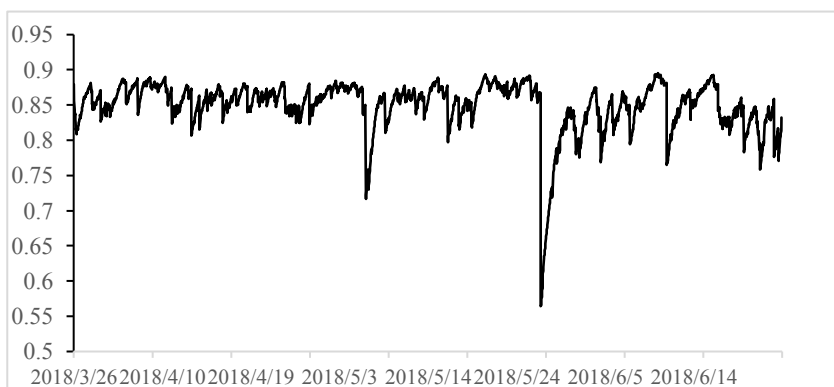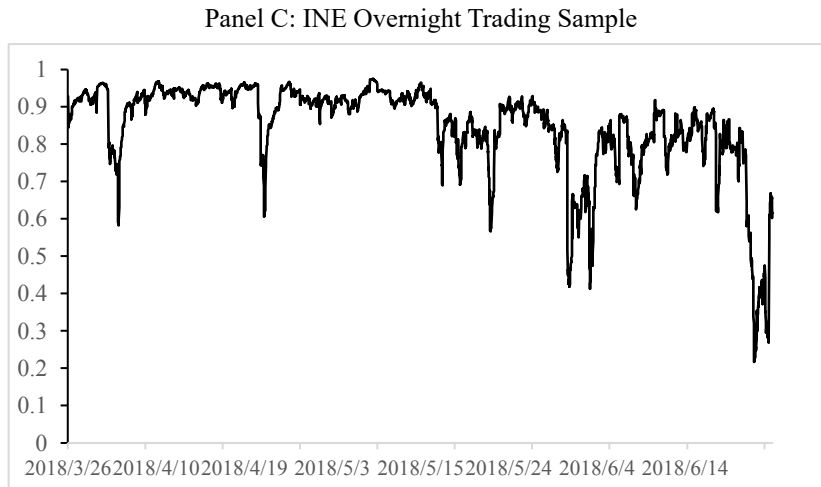
**Figure 2: Conditional Correlation between WTI and Brent Futures Returns
from VECM-GJR-GARCH-AG-DCC Models**

It is more interesting to observe much interdependence between the nascent Shanghai INE crude oil futures market and the two major crude oil futures markets in the world. Figure 3 plots the estimated conditional correlations between the INE and WTI oil futures markets. Based on the full sample, the correlation swings from 22.4% to 95.9% with the mean of 77.3% between these two oil futures returns, suggesting a generally high degree of interdependence between China's and WTI futures markets and yet significant time-variation of such interdependence. Interestingly, during the INE daytime trading period, the correlation between the two markets has a lower mean of 67.2%, ranging from 38.5% to 79.7%. During the INE overnight trading period, the correlation between the two markets is from 27.2% to 95.8% with a higher mean of 78.8%. The different patterns of conditional correlations during INE daytime and overnight trading periods are also consistent with the previous information-based explanation. That is, China's crude oil futures are traded more actively during the INE overnight session (e.g., through intermarket spreading) to incorporate the information relevant to the global oil market, when WTI futures are traded during its daytime trading session with regular and ample information release. Specifically, Miao et al. (2018) document that a set of rich information release, including monthly U.S. macroeconomic announcements and weekly oil and related energy product inventory announcement exert significant impacts on the WTI oil futures and option markets, which obviously may well be transmitted to China's oil futures market.

Panel A: Full Sample
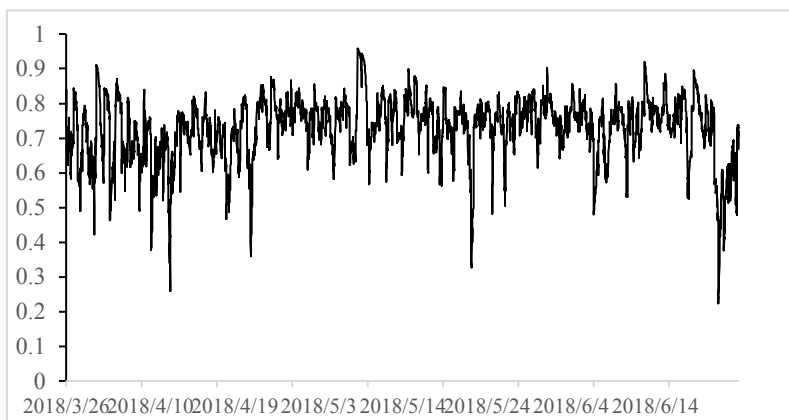
Panel B: INE Daytime Trading Sample
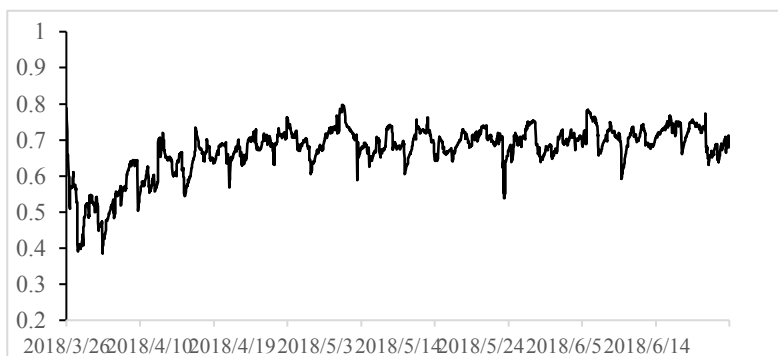
Panel C: INE Overnight Trading Sample
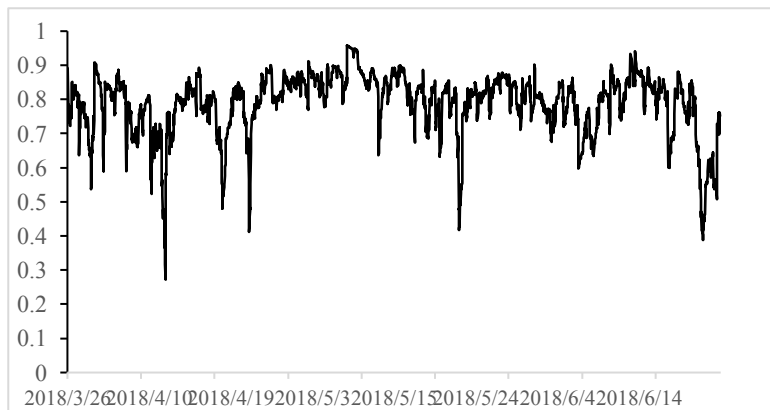
Figure 3: Conditional Correlation between WTI and INE Futures Returns

from VECM-GJR-GARCH-AG-DCC Models

The conditional correlations between the Brent and INE futures markets show similar patterns, as plotted in Figure 4. In the full period, these two crude oil futures returns exhibit significant time-varying correlations, swinging from 32.0% to 97.4%, with a high level of interdependence of 70.7% as the average correlation. The different dynamics of conditional correlations at different times of the day is even more striking between the INE and Brent markets. In the INE daytime trading session, the correlation has a much lower mean of 63.6% with a range from 33.3% to 77.5%. In contrast, the correlations are much higher with a mean of 78.1% with a range from 34.1% to 98.3% during the INE overnight trading.

Panel A: Full Sample

Panel B: INE Daytime Trading Sample
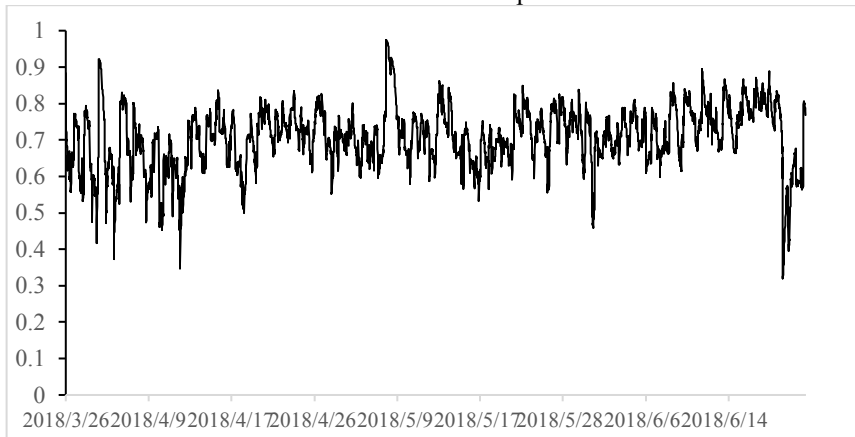
Panel C: INE Overnight Trading Sample
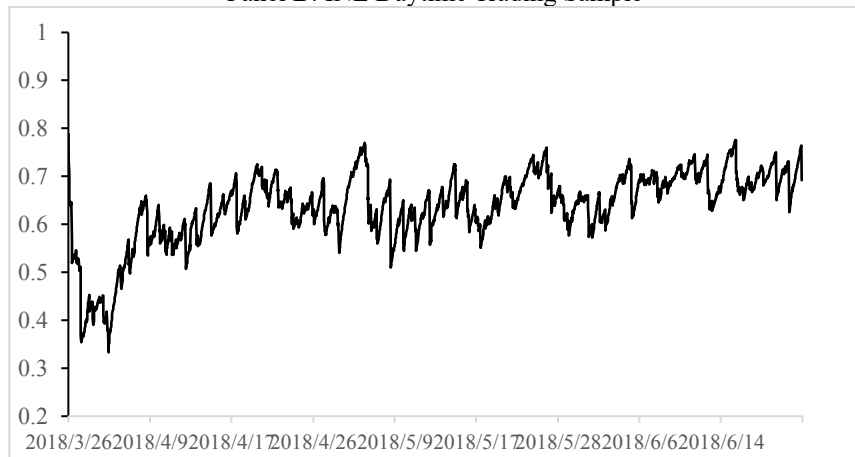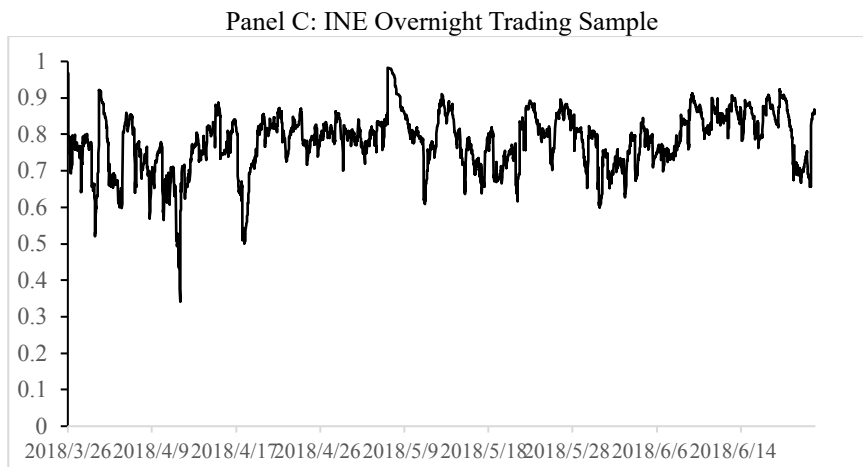
Figure 4: Conditional Correlation between Brent and INE Futures Returns
from VECM-GJR-GARCH-AG-DCC Models

In sum, we have characterized the dynamics of pairwise correlations among WTI, Brent, and INE futures markets. To provide more information concisely about the correlation dynamics, the summary statistics for the derived conditional correlation series are presented in Panel B of Table 5. On average, three pairs of correlations are higher than 70%, except for the pairs of the INE and the other two crude oil futures during the daytime trading. Thus, China's crude oil futures are rather well integrated with the global crude oil futures markets, especially during its overnight trading session when much information from the daytime session of the WTI and Brent markets is available (e.g., Miao et al., 2018). We also compare the average of each conditional correlation series to its unconditional counterpart and find that they are generally close to each other, validating the adequacy of empirical models used here. Additional analyses are reported in Panel B. Autocorrelations and Ljung-Box Q tests show that all conditional correlations are highly persistent.

Table 5 Summary of Volatilities and Conditional Correlations
from GJR-GARCH-AG-DCC models

Note. The table reports conditional volatilities and correlations for WTI, Brent, and INE 5-minute y returns using the AG-DCC model. The estimates of conditional volatilities are derived from D_t as in Equations (2) and (3). The estimates of pairwise conditional correlations between asset returns i and j are derived as in Equations (6) and (7). The sample period is from March 26 to June 26, 2018.

Panel A: Conditional volatilities

	Volatility	Nobs	Mean	unconditional Std. Dev.	Lag 1	Lag 5	Lag 10	LB Q(10)
Full	WTI	6071	0.114	0.116	0.908	0.564	0.403	24745.622***
	Brent	6071	0.108	0.112	0.928	0.687	0.484	29352.429***
sample	INE	6071	0.125	0.128	0.846	0.435	0.231	15015.717***
Day-	WTI	2517	0.057	0.058	0.590	0.216	0.082	2128.374***
Time	Brent	2517	0.058	0.062	0.851	0.521	0.269	7660.953***
sample	INE	2517	0.101	0.105	0.175	0.028	0.005	99.335***
Night	WTI	3551	0.143	0.143	0.918	0.635	0.416	15176.218***
Time	Brent	3551	0.134	0.137	0.930	0.685	0.484	17202.407***

| sample | INE | 3551 | 0.139 | 0.142 | 0.902 | 0.590 | 0.367 | 13480.301*** |

Panel B: Conditional correlations

	Conditional Correlation	Nobs	Mean	unconditional correlation	Lag 1	Lag 5	Lag 10	LB Q(10)
Full	WTI-Brent	6071	0.851	0.857	0.985	0.914	0.828	49819.048***
	WTI-INE-	6071	0.728	0.773	0.970	0.848	0.705	42798.837***
sample	Brent-INE	6071	0.707	0.709	0.976	0.880	0.763	46093.602***
Day-	WTI-Brent	2517	0.849	0.836	0.967	0.849	0.728	17917.115***
Time	WTI-INE	2517	0.672	0.597	0.986	0.931	0.871	21663.567***
sample	Brent-INE	2517	0.636	0.559	0.988	0.937	0.876	21806.911***
Night	WTI-Brent	3551	0.850	0.846	0.992	0.955	0.906	31957.591***
Time	WTI-INE	3551	0.788	0.790	0.976	0.872	0.749	26498.500***
sample	Brent-INE	3551	0.781	0.781	0.976	0.885	0.774	27182.610***

4.3. Volatility transmissions

Table 6 shows the estimation results of VECM-GARCH-BEKK models for WTI, Brent, and INE oil futures. The VECM(1) results shown in Panel A are similar to those in Panel A of Table 3. In the full sample and the INE overnight trading subsample, China's crude oil futures react to deviations from the long-run equilibrium while the WTI and Brent futures do not.   However, this pattern is not significant in the INE daytime trading. Moreover, China's crude oil futures returns can predict the two global crude oil futures returns in its daytime trading, while such predictive power is much weakened during the INE overnight trading.

We focus on the pattern of information transmission through volatility by examining estimates of off-diagonal parameters in Panels B and C. In the entire sample, most off-diagonal parameters are statistically significant at least at 5% level. The significance of the parameters which measure the cross-market impact of returns shocks on the volatility, a_{12} and a_{21}, suggests that the conditional volatility in the Brent oil futures depends on return shocks from the WTI oil futures in the previous period and vice versa. Meanwhile, there is strong evidence in favor of two-way persistent volatility transmissions between these two global futures, as reflected in the significance of b_{12} and b_{21}.

More importantly, a_{13} and a_{23} are significant, suggesting one-way dependence of China's oil futures market volatility on past return shocks from the two global crude oil futures. Similarly, the conditional volatility in China's crude oil market depends on those of the WTI   and Brent futures market in the previous period, as reflected in the significance of the parameters b_{13} and b_{23}. This evidence indicates substantial information spillover effects from the two global crude oil futures to China's crude oil market. In addition, there is two-way persistent volatility transmissions between WTI and INE oil futures since b_{31} is also significant.

Table 6 Results of the VEM-GARCH-BEKK Models for WTI-Brent-INE Oil Futures

Note. The mean and volatility models are as follows:

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{i=1}^{k-1}\Gamma_i\Delta X_{t-i} + \mu + \varepsilon_t \quad \varepsilon_t \sim N(0,H_t), H_t = CC' + A(\varepsilon_{t-1}\varepsilon'_{t-1})A' + BH_{t-1}B'$$

where subscripts i$\in$\{1,2,3\} with 1 for the return of WTI nearby futures, 2 for the return of Brent nearby futures, 3 for the return of INE nearby futures, respectively. The t-statistics are reported in

parenthesis below the coefficients with ** and *** denoting significance at 5% and 1%, respectively. The sample period is from March 26 to June 26, 2018.

Panel A: estimation results of VECM (1) model

Return i	Whole sample				INE daytime trading sample				INE overnight trading sample			
	lagged WTI	lagged Brent	lagged INE	lagged ECT	lagged WTI	lagged Brent	lagged INE	lagged ECT	lagged WTI	lagged Brent	lagged INE	lagged ECT
WTI nearby	-0.026 (-1.006)	0.023 (0.877)	-0.011 (-0.625)	0.057 (0.290)	0.002 (0.040)	-0.080** (-2.323)	0.051*** (3.572)	0.068 (0.415)	-0.013 (-0.374)	0.053 (1.491)	0.062*** (-2.099)	0.088 (0.286)
Brent nearby	0.068*** (2.769)	-0.080*** (-3.200)	-0.007 (-0.424)	0.116 (0.610)	0.211*** (5.293)	-0.280*** (-7.739)	0.046*** (3.018)	0.163 (0.950)	0.065** (1.996)	-0.039 (-1.155)	-0.053* (-1.899)	0.144 (0.488)
INE nearby	0.019 (0.693)	0.090*** (3.153)	-0.091*** (-4.559)	-0.696*** (-3.243)	-0.035 (-0.527)	0.065 (1.078)	-0.032 (-1.275)	-0.516* (-1.799)	0.040 (1.194)	0.121*** (3.486)	-0.136*** (-4.695)	-0.693** (-2.276)

Panel B: estimation results of Matrix A in GARCH-BEKK model

Sample	Whole sample			INE daytime trading sample			INE overnight trading sample		
Return i	a_{11}	a_{12}	a_{13}	a_{11}	a_{12}	a_{13}	a_{11}	a_{12}	a_{13}
a_{1i}	0.301*** (8.979)	0.626*** (20.350)	0.235*** (6.581)	0.022 (0.432)	-0.358*** (-7.619)	-0.369*** (-4.969)	0.359*** (8.840)	-0.010 (-0.249)	-0.039 (-0.935)
a_{2i}	0.126*** (3.956)	-0.275*** (-8.881)	-0.173*** (-4.765)	0.387*** (8.002)	0.430*** (11.185)	0.386*** (4.517)	-0.092** (-2.384)	0.269*** (7.919)	-0.056 (-1.529)
a_{3i}	-0.028 (-1.882)	0.004 (0.268)	0.471*** (19.194)	0.022 (0.867)	0.072*** (3.354)	0.394*** (9.061)	0.035 (1.062)	0.022 (0.696)	0.449*** (9.865)

Panel C: estimation results of Matrix B in GARCH-BEKK model

Sample	Whole sample			INE daytime trading sample			INE overnight trading sample		
Return i	b_{11}	b_{12}	b_{13}	b_{11}	b_{12}	b_{13}	b_{11}	b_{12}	b_{13}
b_{1i}	0.249*** (5.817)	1.066*** (26.312)	0.766*** (20.291)	-0.888*** (-11.594)	-1.048*** (-12.142)	-0.028 (-0.175)	-0.888*** (-46.372)	0.034 (1.960)	0.000 (-0.012)
b_{2i}	0.785*** (16.560)	-0.228*** (-5.216)	0.360*** (8.461)	0.663*** (7.761)	1.273*** (28.864)	1.078*** (6.321)	0.041 (1.955)	-0.889*** (-51.757)	0.004 (0.173)
b_{3i}	-0.091*** (-2.671)	-0.035 (-1.076)	-0.584*** (-12.454)	0.052 (1.645)	0.054 (1.006)	-0.808*** (-12.122)	-0.018 (-0.821)	-0.030 (-1.515)	-0.846*** (-27.795)

When we break the sample into two sub-samples, there is further evidence for volatility (information) transmission across markets. In the INE daytime trading sample, there is two-way spillover effect between WTI and Brent as well as the spillover from the two global crude oil futures to China's crude oil futures, since a_{12} and a_{21} as well as a_{13} and a_{23} are all statistically significant at least at 5% level. In addition, as the significance of a_{32} shows, the return shocks originating from China's crude oil futures in the previous period transmit to the current period's conditional volatility in the Brent futures. Meanwhile, the parameters, b_{12}, b_{21}, and b_{23} are statistically significant, in favor of two-way persistent volatility transmissions between the two global futures as well as information spillover effect from the Brent futures to the INE futures.

In the INE overnight session sample, as the parameter a_{21} is statistically significant at least at the 5% level, the return shocks from the Brent futures in the previous period strongly impact the current conditional volatility in the WTI futures. Meanwhile, there is no strong evidence of persistent volatility transmissions among the three crude oil futures since all off-diagonal parameters in Panel C are not statistically significant at the 5% level.

To gauge the volatility linkage across the markets, we also calculate the conditional correlation between the three futures returns and report the mean statistic of estimated conditional

correlation (not reported here). The results suggest an intensive volatility transmission between China's oil futures and other major futures markets, as shown by the high mean conditional correlations (71.5% between the WTI and INE markets and 70.7% between Brent and INE markets). In sum, our result here confirms strong bidirectional interactions in the intraday volatility between China's and global crude oil futures markets, implying that information in price innovations originated in either China's or the two major international oil futures markets is transmitted to the volatility of other markets.

4.4. Robustness checks

Note that the nearby INE futures contract in our sample expires in September 2018 while the WTI and Brent futures counterparts do not. To check the robustness of the main findings presented previously, we match the September 2018 futures contracts of WTI, Brent, and INE, and obtain 4,577 five-minute observations, which are significantly fewer than the sample using nearby futures. Since there are much fewer observations of the September 2018 WTI and Brent futures returns during the INE daytime trading period, we only examine the full sample period. The results of VECM-GJR-GARCH-AG-DCC model (available on request) confirm evidence for asymmetric volatilities and asymmetric correlations across these oil futures markets. The results of the VECM-GARCH-BEKK model (available on request) confirm that there is two-way volatility transmission between China's and major international oil futures markets.

We further take Oman oil futures into consideration since it closely resembles China's crude oil futures, reflecting medium and heavy sour conditions in Asia. As mentioned, Brent is relatively denser and has a higher sulfur content than WTI, and thus, it is more relevant and comparable to INE and Oman futures contracts. Hence, we include Brent in the analysis together with INE and Oman futures. Since there are very few observations of Oman futures returns during the INE daytime trading period, we only examine the full sample.

Panel A of Table 7 shows the parameter estimates of the VECM-GJR-GARCH-AG-DCC model for Brent, INE, and Oman oil futures. Interestingly, the results on mean equations show that Oman oil futures returns are affected by both INE and Brent returns of the previous period. Stronger predictability of Oman oil future implies weaker price discovery performance in the Oman market. Consistent with the above finding, the error correction term for the Oman futures market is also significant at the 5% level while it is not the case for the WTI and Brent futures returns. The results on variance equations show that Oman futures returns exhibited a higher degree of asymmetric volatility because its magnitude of the coefficient γ is greater than INE and Brent counterparts. Furthermore, the estimated coefficient $\gamma_{i,C}$ for Oman return is significantly smaller. From the AG-DCC model, the average conditional correlation between Brent and Oman returns is only 11.6%—much lower than the counterpart of 55.4% between Brent and INE returns. Overall, it suggests that China's crude oil futures market is better integrated with Brent futures markets than the Oman futures market is.

Table 7 Results of Brent-INE-Oman Oil Futures

Note. This table presents the estimation results of two models for Brent, INE, and OMAN oil futures.

In Panel A, the mean and volatility models are as follows:

$$\Delta X_t = \alpha \beta' X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \mu + \varepsilon_t \ \varepsilon_t \sim N(0, H_t), \ H_t = D_t R_t D_t,$$

$$D_t = diag(h_{it}^{1/2}), h_{it} = \omega_i + \alpha_i \varepsilon_{i,\ t-1}^2 + \beta_i h_{i,t-1} + \gamma_i \{\min(\varepsilon_{i,t-1}, 0)\}^2,$$

The correlation estimator R_t can be written in terms of covariance matrix $Q_t = (q_{ij,t})$ as

$$R_t = (diag(Q_t))^{-1/2} Q_t (diag(Q_t))^{-1/2}.$$ The evolution of Q_t is given by:

$$q_{ij,t} = \bar{\rho}_{ij} + \alpha_{i,C}\alpha_{j,C}(\varepsilon_{i,t-1}\varepsilon_{j,t-1} - \bar{\rho}_{ij}) + \beta_{i,C}\beta_{j,C}(q_{ij,t-1} - \bar{\rho}_{ij}) + \gamma_{i,C}\gamma_{j,C}(\eta_{i,t-1}\eta_{j,t-1} - \bar{N}_{i,j})$$

In Panel B, the mean and volatility models are as follows:

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{i=1}^{k-1}\Gamma_i\Delta X_{t-i} + \mu + \varepsilon_t \quad \varepsilon_t \sim N(0, H_t), \quad H_t = CC' + A(\varepsilon_{t-1}\varepsilon'_{t-1})A' + BH_{t-1}B'$$

where subscripts i $\in \{1,2,3\}$ with 1 for the return of Brent nearby futures, 2 for the return of INE nearby futures, 3 for the return of Oman futures, respectively. The t-statistics are reported in parenthesis below the coefficients with ** and *** denoting significance at 5% and 1%, respectively. The sample period is from March 26 to June 26, 2018.

Panel A: Results of GJR-GARCH-AG-DCC Model for Brent-INE-Oman Oil Futures

	lagged Brent	lagged INE	lagged Oman	lagged ECT	α_i	β_i	γ_i	$\alpha_{i,C}$	$\beta_{i,C}$	$\gamma_{i,C}$
Brent nearby	-0.004 (-0.318)	-0.018 (-1.272)	-0.025** (-2.325)	0.001 (0.016)	0.156*** (114.514)	0.741*** (707.861)	-0.072*** (-53.223)	0.122*** (21.219)	0.793*** (210.401)	0.675*** (81.905)
INE nearby	0.019* (1.959)	-0.022* (-1.908)	-0.012 (-1.281)	-0.019 (-0.497)	0.043*** (33.441)	0.856*** (519.037)	0.076*** (59.557)	-0.553*** (-64.828)	0.552*** (35.518)	0.691*** (42.832)
Oman nearby	0.315*** (41.394)	0.605*** (66.496)	-0.074*** (-10.416)	0.073** (2.439)	0.309*** (185.712)	0.781*** (140.438)	0.333*** (200.282)	0.002*** (6.592)	0.946*** (175.542)	0.261*** (49.413)

Panel B: Results of the VAR-GARCH-BEKK Models for Brent-INE-Oman Oil Futures

	lagged Brent	lagged INE	lagged Oman	lagged ECT	a_{i1}	a_{i2}	a_{i3}	b_{i1}	b_{i2}	b_{i3}
Brent nearby	-0.004 (-0.315)	-0.017 (-1.269)	-0.025** (-2.324)	0.000 (0.003)	0.668*** (24.477)	-0.038 (-1.174)	-0.128*** (-7.407)	0.704*** (48.874)	0.425*** (20.955)	0.100*** (11.092)
INE nearby	0.019** (1.965)	-0.022* (-1.902)	-0.012 (-1.280)	-0.020 (-0.526)	0.118*** (3.735)	-0.195*** (-6.144)	0.226*** (14.120)	-0.003 (-0.120)	0.082*** (3.468)	0.137*** (11.098)
Oman nearby	0.315*** (41.390)	0.605*** (66.490)	-0.074*** (-10.416)	0.073** (2.445)	0.569*** (11.726)	-0.832*** (-21.322)	0.409*** (21.741)	-0.538*** (-37.708)	-0.320*** (-12.383)	0.842*** (125.765)

Panel B of Table 7 presents the estimation results of the VECM-GARCH-BEKK model for Brent, INE, and Oman oil futures. The results confirm stronger predictability of Oman oil future and significant reaction of Oman futures to deviations from the long-run equilibrium. Focusing on information transmission through volatility, we note that the estimates of off-diagonal parameters a_{ij}—which measure the transmission of the return shocks—are all statistically significant at least at a 5% level. It suggests that the conditional volatility in each oil futures depends on return shocks from the other two oil futures in the previous period. Meanwhile, most off-diagonal parameters b_{ij}—which measure the transmission of the pervious volatility—are statistically significant. In other words, there is strong bidirectional spillover effect in the intraday volatility among the three oil futures. From the BEKK model, the average conditional correlation between Brent and Oman returns is 13.2%, much lower than the counterpart of 56.6% between Brent and INE returns, and consistent with the result based on AG-DCC model. It suggests that the volatility linkage between INE and Brent crude oil futures markets is stronger than the case of the Oman oil futures market.

Table 8 Results of WTI-Brent-Oman Oil Futures

Note. This table presents the estimation results of two models for WTI, Brent, and Oman oil futures. In Panel A, the mean and volatility models are as follows:

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \mu + \varepsilon_t, \ \varepsilon_t \sim N(0, H_t), \ H_t = D_t R_t D_t,$$

$$D_t = diag(h_{it}^{1/2}), h_{it} = \omega_i + \alpha_i \varepsilon_{i,\ t-1}^2 + \beta_i h_{i,t-1} + \gamma_i \{\min(\varepsilon_{i,t-1},0)\}^2,$$

The correlation estimator R_t can be written in terms of covariance matrix $Q_t = (q_{ij,t})$ as $R_t = (diag(Q_t))^{-1/2} Q_t (diag(Q_t))^{-1/2}$. The evolution of Q_t is given by:

$$q_{ij,t} = \bar{\rho}_{ij} + \alpha_{i,C}\alpha_{j,C}(\varepsilon_{i,t-1}\varepsilon_{j,t-1} - \bar{\rho}_{ij}) + \beta_{i,C}\beta_{j,C}(q_{ij,t-1} - \bar{\rho}_{ij}) + \gamma_{i,C}\gamma_{j,C}(\eta_{i,t-1}\eta_{j,t-1} - \bar{N}_{i,j})$$

In Panel B, the mean and volatility models are as follows:

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \mu + \varepsilon_t, \ \varepsilon_t \sim N(0, H_t), \ H_t = CC' + A(\varepsilon_{t-1}\varepsilon_{t-1}')A' + BH_{t-1}B'$$

where subscripts i $\in \{1,2,3\}$ with 1 for the return of WTI nearby futures, 2 for the return of Brent nearby futures, 3 for the return of Oman futures, respectively. The t-statistics are reported in parenthesis below the coefficients with ** and *** denoting significance at 5% and 1%, respectively. The sample period is from March 26 to June 26, 2018.

Panel A: Results of GJR-GARCH-AG-DCC Model for WTI-Brent-Oman Oil Futures

	lagged WTI	lagged Brent	lagged Oman	lagged ECT	α_i	β_i	γ_i	$\alpha_{i,C}$	$\beta_{i,C}$	$\gamma_{i,C}$
WTI nearby	-0.034 (-1.683)	0.036 (1.775)	-0.007 (-0.792)	0.238 (1.225)	0.148*** (15.156)	0.873*** (68.943)	0.018** (2.358)	0.182*** (23.053)	0.969*** (337.335)	0.221*** (14.832)
Brent nearby	0.027 (1.320)	-0.036 (-1.773)	-0.023*** (-2.757)	0.247 (1.264)	0.126*** (28.040)	0.884*** (88.960)	0.012** (2.192)	0.101*** (16.113)	0.979*** (428.442)	0.229*** (14.980)
Oman nearby	0.038** (2.476)	0.908*** (58.592)	-0.053*** (-8.205)	-0.542*** (-3.604)	0.083 (1.891)	0.570*** (41.580)	1.794*** (41.710)	0.010 (0.820)	-0.172 (-0.353)	-0.032 (-0.584)

Panel B: Results of the VAR-GARCH-BEKK Models for WTI-Brent-Oman Oil Futures

	lagged WTI	lagged Brent	lagged Oman	lagged ECT	a_{i1}	a_{i2}	a_{i3}	b_{i1}	b_{i2}	b_{i3}
WTI nearby	-0.034 (-1.687)	0.036 (1.782)	-0.007 (-0.792)	0.239 (1.230)	0.226*** (6.302)	-0.048 (-1.254)	0.091*** (6.228)	0.535*** (9.793)	-0.427*** (-7.662)	0.141*** (5.055)
Brent nearby	0.026 (1.312)	-0.035 (-1.762)	-0.023*** -2.756	0.249 (1.272)	-0.288*** (-6.962)	0.030 (0.667)	0.003 (0.193)	-0.295*** (-5.434)	0.635*** (11.556)	0.181*** (6.686)
Oman nearby	0.038** (2.476)	0.908*** (58.582)	-0.053*** (8.204)	-0.542*** (-3.604)	-0.044 (-1.516)	-0.045 (-1.479)	1.351*** (52.929)	0.078*** (5.475)	0.074*** (4.711)	0.361*** (21.889)

Table 8 repeats the analysis for WTI, Brent, and Oman oil futures. In both Panels A and B, Oman oil futures have stronger predictability and significantly react to deviations from the long-run equilibrium while WTI and Brent futures do not. For the GJR-GARCH results in Panel A, Oman futures returns exhibit a much higher degree of asymmetric volatility. For the AG-DCC results in Panel A, the estimated coefficient γ_C for Oman return is not significant, which suggests that the correlations between Oman and the other two crude oil futures did not tend to be higher responding to their negative returns. In other words, negative shocks did not increase co-movement of Oman futures with other futures markets, which is different from the case of

China's crude oil futures. On average, the conditional correlations estimated from the AG-DCC model are 4.5% between WTI and Oman returns and 6.5% between Brent and Oman returns respectively, much lower than the counterparts between the Chinese and these two major international crude oil futures markets in Table 5.

Panel B of Table 8 presents the estimation results of the GARCH-BEKK model for WTI, Brent, and Oman oil futures. There is one-way dependence of the Oman future volatility on return shocks from WTI futures since a_{13} is significant. Meanwhile, there is strong bidirectional spillover effect in the intraday volatility between Oman and major oil futures since all off-diagonal parameters b_{ij} are statistically significant. However, information linkage of Oman futures with the global market is much weaker than the Chinese futures counterpart. The average conditional correlations from the BEKK models are 4.8% between WTI and Oman returns and 6.9% between Brent and Oman returns respectively, comparable to those from the AG-DCC models.

In sum, our results in Table 7 and 8 confirm that during its first three months, China's crude oil futures market is better integrated to the world market than Oman futures market in terms of return and volatility linkages.

5. FUTHER ANALYSIS

We extended our sample to the end of August 2018, before the physical delivery in September 2018 for the first Chinese nearby crude oil futures. The additional sample period is from July 11 to August 21, 2018,[10] and we only examine the full sample since it is relatively short. The cointegration tests (not reported here) confirm the existence of one cointegrating vector among all these oil futures markets during the extended period.

Table 9 shows the estimation results of VECM-GJR-GARAH-AG-DCC models for the extended sample. In Panel A for WTI, Brent, and INE futures and Panel B for WTI, Brent, and Oman futures, INE and Oman futures react to deviations from the long-run equilibrium respectively while the WTI and Brent futures do not. Except for Oman futures, all asset returns exhibit asymmetric volatilities. Meanwhile, negative shocks tend to make both INE and Oman crude oil futures co-move more strongly with the two major crude oil futures markets. In Panel C for Brent, INE, and Oman futures, it is neither INE nor Oman futures but Brent futures that react to deviations from the long-run equilibrium, which is somewhat different from the previous pattern.

Table 9 Results of VECM-GJR-GARCH-AG-DCC Models for extended samples

Note. This table presents the estimation results of VECM-GJR-GARCH-AG-DCC for extended samples. The mean and volatility models are as follows:

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{i=1}^{k-1}\Gamma_i\Delta X_{t-i} + \mu + \varepsilon_t \ \varepsilon_t \sim N(0,H_t), \ H_t = D_t R_t D_t,$$

$$D_t = diag(h_{it}^{1/2}), h_{it} = \omega_i + \alpha_i\varepsilon_{i,\ t-1}^2 + \beta_i h_{i,t-1} + \gamma_i\{\min(\varepsilon_{i,t-1},0)\}^2,$$

The correlation estimator R_t can be written in terms of covariance matrix $Q_t = (q_{ij,t})$ as

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[10] High-frequency data in Bloomberg can only be traced back for several months. The data between June 27 and July 10, 2018 were already unavailable in Bloomberg when we updated it in 2019. Meanwhile, there are very few observations of INE futures after August 21, 2018, as it is close to the delivery month.

$$R_t = (diag(Q_t))^{-1/2} Q_t (diag(Q_t))^{-1/2}.$$ The evolution of Q_t is given by:

$$q_{ij,t} = \bar{\rho}_{ij} + \alpha_{i,C}\alpha_{j,C}(\varepsilon_{i,t-1}\varepsilon_{j,t-1} - \bar{\rho}_{ij}) + \beta_{i,C}\beta_{j,C}(q_{ij,t-1} - \bar{\rho}_{ij}) + \gamma_{i,C}\gamma_{j,C}(\eta_{i,t-1}\eta_{j,t-1} - \overline{N}_{i,j})$$

The t-statistics are reported in parenthesis below the coefficients with ** and *** denoting significance at 5% and 1%, respectively. The sample period is from July 11 to August 21, 2018.

Panel A: Results for WTI-Brent-INE Oil Futures

	lagged WTI	lagged Brent	lagged INE	lagged ECT	α_i	β_i	γ_i	$\alpha_{i,C}$	$\beta_{i,C}$	$\gamma_{i,C}$
WTI	-0.069**	0.123***	-0.039	0.078	0.120***	0.770***	0.275***	0.204***	0.898***	0.357***
nearby	(-2.006)	(3.359)	(-1.884)	(0.433)	(10.239)	(129.115)	(23.650)	(13.888)	(80.175)	(17.051)
Brent	0.029	0.033	-0.043**	-0.098	0.088***	0.773***	0.223***	0.049***	0.890***	0.425***
nearby	(0.888)	(0.947)	(-2.138)	(-0.567)	(4.155)	(25.461)	(10.726)	(3.606)	(83.558)	(18.114)
INE	-0.024	0.062	0.030	-0.441**	0.095***	0.769***	0.152***	0.026**	0.982***	0.232***
nearby	(-0.647)	(1.601)	(1.370)	(-2.303)	(8.048)	(56.915)	(12.832)	(2.555)	(458.010)	(15.126)

Panel B: Results for WTI-Brent-Oman Oil Futures

	lagged WTI	lagged Brent	lagged Oman	lagged ECT	α_i	β_i	γ_i	$\alpha_{i,C}$	$\beta_{i,C}$	$\gamma_{i,C}$
WTI	-.090***	0.095***	-0.006	0.488	0.145***	0.862***	0.026***	0.187***	0.949***	0.242***
nearby	(-3.512)	(3.685)	(-0.447)	(1.423)	(40.802)	(858.152)	(7.332)	(11.718)	(85.184)	(8.031)
Brent	0.014	-0.007	-0.016	0.815**	-0.017***	0.897***	0.133***	0.078***	0.956***	0.274***
nearby	(0.545)	(-0.264)	(-1.229)	(2.369)	(-5.905)	(878.827)	(46.500)	(5.247)	(96.914)	(8.585)
Oman	0.034***	0.939***	-.017***	-0.418***	0.359***	0.198***	0.007	-0.047	0.068	0.232**
nearby	(3.295)	(89.561)	(-3.060)	(-2.986)	(27.987)	(106.093)	(0.538)	(-0.843)	(0.225)	(2.071)

Panel C: Results for Brent-INE-Oman Oil Futures

	lagged Brent	lagged INE	lagged Oman	lagged ECT	α_i	β_i	γ_i	$\alpha_{i,C}$	$\beta_{i,C}$	$\gamma_{i,C}$
Brent	0.077***	-0.056**	-0.024	-1.477***	-0.020	0.719***	0.233***	0.095***	-0.497	0.135*
nearby	(2.715)	(-1.972)	(-1.099)	(-2.596)	(-1.007)	(29.143)	(11.660)	(4.949)	(-1.153)	(1.680)
INE	0.084***	-0.025	-0.023	-0.899	0.117***	0.861***	0.008	0.539***	0.227**	0.095
nearby	(2.983)	(-0.899)	(-1.106)	(-1.602)	(9.701)	(33.352)	(0.587)	(20.414)	(2.216)	(1.040)
Oman	0.938***	-0.002	-0.006	0.236	0.163	0.663***	0.921***	0.101**	0.343	0.711***
nearby	(76.976)	(-0.150)	(-0.671)	(0.970)	(0.627)	(39.831)	(3.518)	(2.503)	(0.676)	(2.953)

Table 10 presents the parameter estimates of VECM-GARCH-BEKK models for the extended sample. In all three panels, the VECM results are consistent with those in Table 9.   Specifically, the Brent futures react to deviations from the long-run equilibrium with INE and Oman futures. In Panel A, there is two-way information spillover effect between WTI and INE futures since a_{13} and a_{31} are statistically significant. Similarly, there are two-way persistent volatility transmissions between WTI and INE futures, as reflected in the significance of b_{13} and b_{31}. In addition, a_{32} and b_{32} are significant, suggesting new evidence of information and volatility spillovers from the INE futures to Brent futures. By contrast, the results in Panel B show neither information spillover nor volatility transmission between the Oman and the two major crude oil futures. In Panel C, there is two-way information spillover effect between Brent and INE futures while Oman futures are an information receiver of Brent and INE futures. Meanwhile, there are volatility transmissions from Brent and Oman futures to the INE futures.

From all models in Table 9 and 10, we find that the average conditional correlations between China's and the two major oil futures are much higher than the Oman counterparts, confirming the previous result China's oil futures have stronger return and volatility linkages with the two

international major futures markets than Oman futures market.

Table 10 Results of VECM- GARCH-BEKK Models for extended samples

Note. This table presents the estimation results of VECM-GJR-GARCH for extended samples. The mean and volatility models are as follows:

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{i=1}^{k-1}\Gamma_i \Delta X_{t-i} + \mu + \varepsilon_t \quad \varepsilon_t \sim N(0, H_t), H_t = CC' + A(\varepsilon_{t-1}\varepsilon'_{t-1})A' + BH_{t-1}B'$$

The t-statistics are reported in parenthesis below the coefficients with ** and *** denoting significance at 5% and 1%, respectively. The sample period is from July 11 to August 21, 2018.

Panel A: Results for WTI-Brent-INE Oil Futures

	lagged WTI	lagged Brent	lagged INE	lagged ECT	a_{i1}	a_{i2}	a_{i3}	b_{i1}	b_{i2}	b_{i3}
WTI nearby	-0.069**	0.123***	-0.039	0.077	0.703***	0.575***	0.363***	-1.043***	-1.589***	-0.972***
	(-2.004)	(3.358)	(-1.875)	(0.430)	(18.150)	(23.326)	(28.397)	(-16.124)	(-37.118)	(-25.043)
Brent nearby	0.029	0.033	-0.043**	-0.098	-0.247	-0.427***	-0.060	0.051	0.911***	0.008
	(0.887)	(0.946)	(-2.138)	(-0.567)	(-1.619)	(-3.453)	(-0.840)	(0.726)	(15.639)	(0.218)
INE nearby	-0.024	0.062	0.031	-0.442**	-0.053***	-0.012***	-0.279***	0.226***	0.192***	1.074***
	(-0.644)	(1.601)	(1.386)	(-2.308)	(-6.126)	(-3.175)	(-20.364)	(7.779)	(7.832)	(73.271)

Panel B: Results for WTI-Brent-Oman Oil Futures

	lagged WTI	lagged Brent	lagged Oman	lagged ECT	a_{i1}	a_{i2}	a_{i3}	b_{i1}	b_{i2}	b_{i3}
WTI nearby	-.090***	0.095***	-0.006	0.497	-0.326***	0.002	0.002	0.789***	1.487***	0.022
	(-3.509)	(3.685)	(-0.435)	(1.447)	(-11.368)	(0.067)	(0.134)	(11.827)	(30.368)	(1.411)
Brent nearby	0.014	-0.007	-0.016	0.823**	-0.039	-0.360***	0.014	0.136	-0.815***	-0.016
	(0.548)	(-0.264)	(-1.218)	(2.388)	(-1.315)	(-12.901)	(0.937)	(1.754)	(-12.010)	(-1.057)
Oman nearby	0.034***	0.939***	-.017***	-0.418***	0.091	0.051	-0.450***	0.367	0.429	-0.005
	(3.294)	(89.552)	(-3.061)	(-2.986)	(1.277)	(0.785)	(-11.264)	(1.833)	(2.411)	(-0.083)

Panel C: Results for Brent-INE-Oman Oil Futures

	lagged Brent	lagged INE	lagged Oman	lagged ECT	a_{i1}	a_{i2}	a_{i3}	b_{i1}	b_{i2}	b_{i3}
Brent nearby	0.077***	-0.056*	-0.023	-1.497***	-0.072**	-0.147***	0.239***	-1.066***	-0.909***	0.035
	(2.713)	(-1.959)	(-1.088)	(-2.625)	(-2.020)	(-8.964)	(16.839)	(-24.289)	(-7.474)	(1.411)
INE nearby	0.084***	-0.025	-0.023	-0.917	0.030***	0.246***	-0.045***	0.491	1.179***	0.000
	(2.981)	(-0.888)	(-1.096)	(-1.630)	(3.042)	(40.287)	(-3.707)	(1.900)	(15.855)	(-0.047)
Oman nearby	0.938***	-0.002	-0.006	0.236	0.001	0.059	-0.042	1.155***	0.543***	-0.008
	(76.957)	(-0.150)	(-0.670)	(0.967)	(0.016)	(1.948)	(-1.280)	(7.784)	(3.555)	(-0.165)

6. CONCLUSIONS

We employ various multivariate VECM-MGARCH models to examine return and volatility linkages among the four most actively traded international crude oil futures markets, including WTI, Brent, INE, and Oman crude oil futures markets, with allowance for potential asymmetry in their volatilities and correlations. We document several important new findings on international oil futures market linkages.

In line with Protopapadakis and Stoll (1983), there are cointegration relationships among these crude oil futures markets, despite substantial oil quality differences in their underlying asset. The new finding contributes to the debate over whether the international crude oil market has becoming closer to "one great pool", which is always examined using cash market data but not futures market data (see, e.g., Galay, 2019; Plante and Strickler, 2019). Consistent with the perception of their relative informational role, both the INE and Oman futures react to deviations

from their long-run equilibrium with the WTI and Brent futures. Somewhat surprisingly, during the first three months of China's crude oil futures, their return and volatility linkages with international major crude oil futures markets (WTI and Brent) are already stronger than the linkages between these international major crude oil futures markets and the Oman crude oil futures market in the Middle East, which has been in existence for more than ten years and often considered a regional crude oil market benchmark in Asia.

Noteworthy, the existence of certain long-run price relationships and significant return and volatility dynamic interactions among China's and two international major crude oil futures markets is an indication of initial success of China's crude oil futures market toward becoming a regional benchmark first and eventually a global benchmark. This is because that crude oil is generally considered a relatively homogenous commodity and the law of one price implies strong crude oil cash price linkages. Given the well-documented evidence for strong price linkages between two major international crude oil futures markets and global cash crude oil markets, lack of international linkages between China' and the two global crude oil futures market would simply indicate that China's oil futures market in its infancy is segmented from the global oil market fundamentals and thus is not possible to be seriously considered as a candidate for either a regional or a global benchmark.   The evidence in this study does suggest otherwise. Of course, the existence of international linkages is only necessary but not sufficient for China's oil futures market becoming a regional or global benchmark. Further evidence for certain price leadership of China's oil futures in a largely integrated regional or global crude oil futures market is needed for such a purpose.

Interestingly, the linkages between China's and international major crude oil futures markets are also much stronger during the INE overnight trading session than during the INE daytime trading, when WTI and Brent futures markets are in their daytime sessions, which may be a reflection of the important information arrival during WTI and Brent daytime sessions and in line with the fact that trading volume and open interests during the INE overnight session is about four times as much as those during the INE daytime session. Nevertheless, it is interesting to note that the INE return is significant in affecting the returns of WTI and Brent futures only during the INE daytime session but not during its overnight session, which is consistent with relative rates of information production in China during the INE daytime session versus its overnight session.

Finally, China's crude oil futures exhibit stronger asymmetric correlations with international major oil futures markets when compared with the asymmetric correlation between international major oil futures markets, implying its higher vulnerability to negative price shocks from other oil futures markets. Future research may be fruitful to examine other important aspects of China's INE oil futures market, including revisiting the issues under study in this paper when the market is more developed when more INE nearby and more distant futures contracts are actively traded (which is not the case at this time).

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on reasonable request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions. Restrictions apply to the availability of Bloomberg data that were used under license for this study.

DATA CITATION

[Brent, INE, WTI and Oman oil futures markets data]; March 26th, 2018 to June 26th, 2018; Not publicly available; the data set can be acquired from Bloomberg.

[Brent, INE, WTI and Oman oil futures markets data]; July 11 to August 21, 2018; Not publicly available; the data set can be acquired from Bloomberg.

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