Robotics & Automation
Market Outlook - 2017

Investment Commentary – December 2016

2016 is History. Welcome to 2017!

2016 RECAP

After another rollercoaster ride of a year, investors must be relieved after the S&P Index finished up +10% in 2016, despite at one point falling nearly 15%. Fears in January that China's economic growth would materially slow were proved unfounded as the year unfolded. Consumers were fearful when the S&P 500 Index dropped to 1810 in February. Also in that month, oil hit a $26 per barrel low, down from an over $100 high in 2014. The uncertainty from one Fed meeting to another, along with the presidential election, certainly didn't help investors' sentiment.

A year ago, analysts expected an S&P 500 earnings growth of 10%, to $128 a share in 2016. Instead, 2016 earnings are likely to come in flat at $118. The market's forward price/earnings ratio has expanded, however, from 16x to 17x. The dollar rose 4% in 2016 with oil prices doubling since the $26 low.

A double-digit gain for stocks obscured some of 2016's troubling features. The Dow Jones Industrial Average gained 13.5% in 2016, the S&P 500 rose 9.4%, and the Nasdaq added 7.5%.

The ROBO Global Index advanced +19.27%. Interestingly, despite the depths of despair in February, the ROBO Global Index rallied +38% into the year-end close of 2016 reflecting an under-exposure to the asset class and superior growth prospects.

> *2016 was a banner year for M&A within the Robotics & Automation industry with 50 deals. Chinese money was involved in over 47% of those transactions.*

"We saw 50 robotics companies sold; 11 of which involved amounts over $500 million and five were over $1 billion. Thirty of the 50 companies disclosed transaction amounts which totalled up to a colossal $18.87 billion," according to Frank Tobe, Editor & Publisher of The Robot Report and Co-founder of ROBO Global.

Chinese money was involved in over 47% of those acquisitions. Kuka by Midea, Dematic by Kion, KraussMaffei by ChemChina, Paslin by Wenfang, Gimatic by Agic Capital, Ecoclean by SBS Group to name a few.

2017 FORECAST

The contemporary economic recovery is one of the longest in U.S. history. The stock market surged more than three-fold from the 2009 crisis. Aggregate U.S. household net worth has recovered to a level nearly 35% above its previous record high in 2007, currently holding more than $90 trillion.

We expect the long post-crisis economic recovery to continue in 2017. As a base case, we think growth is poised to expand to more countries with the global economy drawing on more sources of strength. Business, consumer, and investor confidence should continue to rise higher well into 2017, yet we expect most of the new growth to come in 2018, which should underpin equities for most of the year.

The surprise victory by Donald Trump caught many investors off-guard. The potential for fiscal stimulus measures, reduced regulation, corporate tax reform, and other potential pro-growth initiatives increased. Animal spirits have perked up. Investor positioning throughout 2016 was heavily skewed toward long-duration fixed income, low-volatility equities, and high-dividend-paying companies.

Because less than 2% of the ROBO Global Index overlaps with any traditional indices, ROBO Global offers investors a unique and under-owned exposure.

Given the high degree of under-exposure to late-cycle investments by investors, we believe such a rotation along with the new enthusiasm for pro-growth policies could begin to accelerate investor flows benefiting the global robotics & automation ecosystem. We believe investors should be positioned before the Wall Street herd.

2017: A BREAKOUT YEAR FOR ROBOTICS & AUTOMATION

The current rebirth of robotics is arguably related to a recent confluence of technological advances. Robotics had long been stalled in a Tower of Babel in which software advances were not portable nor reusable. New robot designs typically needed to start from scratch from the software development stage. This resulted in a slow advancement of the frontier of robot intelligence. A significant game changer was the introduction of "Robot Operating System" (ROS), which has been supported by Google (via Willow Garage and OSRF) since 2007.

ROS is a robot operating system that is open to everyone, which means that anyone can contribute by uploading original and individual modules for the development and programming of robots. Sharing software modules through open sourcing is just one solution to the classic challenge of developing robotic solutions - that every company must

develop custom software modules from scratch. By using the basic components through ROS, developers can shift their focus to directly developing only the newer, necessary components. This ultimately allows developers to create robots with more complex functions from fewer resources. ROS' popularity has exploded, enabling faster, lower-cost robotics company start-ups and faster technological development.

Concurrently, Artificial Intelligence ("AI") has been going through a "re-awakening" thanks to "Deep Learning" according to The New York Times. Deep Learning, in turn, was enabled by the existence of Big Data (vast repositories of labelled data) and the exploitation of new Graphical Processing Units (GPUs.) Google now allows open sourcing with its Deep-Learning software, TensorFlow, helping to further accelerate advances in Deep Learning.

A fundamental barrier for the greater use of robots is in the expertise and tedium required to program robots to perform tasks reliably. By incorporating Deep Learning into emerging robots, easier to train robots capable of generalizing from examples are anticipated in the future – ultimately, improving the robot's learned performance in less structured environments. Such capabilities should increase application domains for robots, including batch manufacturing, commercial and industrial services, and eventually domestic servants.

On the technology side, innovations in AI and computer vision are, for the first time, bringing some of the Moore's law type acceleration of productivity. While one must be careful to not overstate the immediate impact of these innovations, the productivity gains from improved computer vision systems for pick & place and loading type applications are already starting to be realized. Indeed, even on the mechanical end of the spectrum, companies such as Harmonic Drive are introducing new higher efficiency, lower cost/footprint motors and actuators that can have a significant impact on the cost and performance of robotic systems.

Companies such as ABB are aggressively investing in next generation robotic technology - from Vicarious to Grabit. This trend can be seen across the board with large robotics companies.

BRING IN THE CO-BOTS

Collaborative robots are a disruptive game-changer. Collaborative robots (also called co-bots) are designed to work alongside humans, assisting them with a variety of tasks. Because co-bots are affordable, highly adaptable, and almost plug-and-play, small and medium-sized enterprises (SMEs) should be eager to adopt this technology, and analysts expect this segment will see massive growth in the next few years.

Collaborative robots are gaining popularity because sensors and computing power are so cheap now that it drives down the cost of robots, making them more available to businesses of all sizes. Also enticing is the ease-of-use: co-bots are far easier to train and deploy than big industrial robots.

Most professional service robots are collaborative by design, hence co-bots aren't just for SMEs or for manufacturing use. Offices, homes, labs, warehouses, farms, distribution

centers, hospitals and healthcare facilities are all enabling service robots to help them do their jobs better. The market is open-ended but current uses for co-bots include machine tending, material handling, assembly tasks and packaging. They also pick & place, count, and inspect. As more co-bots are deployed, more uses will be discovered.

> *The collaborative robotics sector is expected to increase roughly tenfold between 2015-2020, reaching over $1 billion from approximately $95 million in 2014.*

Some analysts suggest more rapid growth: collaborative lightweight robots will become the top seller in the industry in about two years, selling hundreds of thousands with prices falling to the $15,000 - $20,000 level. TechNavio, a British market research firm, forecasts the global collaborative robots market to grow at a compounded annual growth rate (CAGR) of 50.88% to 2019.

THE U.S. ROBOTICS PUSH

Robots are increasingly applicable from work to home. Mark Cuban, the entrepreneur and owner of the Dallas Mavericks NBA team, made a major suggestion to President-elect Donald Trump: Invest $100 billion to help jump-start the national robotics industry. Cuban pointed out in a blog post on December 18, 2016 that the United States isn't home to ANY of the world's leading robotics companies. Meanwhile, China is far outspending the U.S. in supporting its robotics industry with $3 billion toward robotics annually, according to a report by Bernstein, a global investment management firm.

Cuban isn't alone. In November, just ahead of the election, 'A Roadmap for U.S. Robotics' was released. This detailed 100-page report was headed up by Henrik Christensen (a ROBO Global Strategic Advisor) who led a group of 150 academics and industry leaders in writing and publishing. The report listed specific ways Congress should support the nation's burgeoning robotics sector.

> *"The industrial robots that are poised to replace American manufacturing jobs are all made by non-U.S. companies,"*
>
> -Frank Tobe, ROBO Global Co-founder & Editor & Publisher of The Robot Report

The first 'U.S. Roadmap for Robotics' report, published in 2009, inspired the Obama administration to launch the National Robotics Initiative in 2011, which allocated $70 million per year to advancing robotics research.

The last major industrial robotics maker that was an American company was Adept Technologies and it was acquired by Japanese-owned Omron in 2015.

EXPLORING THE GLOBAL ECONOMY

By 2019, more than 1.4 million new industrial robots will be installed in factories around the world - that's the latest forecast from the International Federation of Robotics (IFR). In the race to automate manufacturing, the European Union is currently one of the global frontrunners: 65% of countries with an above-average number of industrial robots per 10,000 employees, are located in the EU.

THE FOURTH INDUSTRIAL REVOLUTION:
Robotics is in the process of becoming as ubiquitous as computers.

A fundamental component of EU membership is the free movement of labor across borders which was a key topic leading up to the UK referendum. Post-BREXIT, the simple fact is that many migrant workers could be forced to vacate seasonal and low-skilled roles. For the companies impacted there is little prospect of finding domestic replacements. While large companies can look to industrial grade robotic solutions, small and midsize companies are likely turn to collaborative robots and business process automation to work alongside humans. This will assist in driving economic growth and UK productivity forward. For the first time since 2008, it has the attention of both the May Government and Parliament.

In the post-BREXIT world, entrepreneurs and policymakers can secure new trade deals and position the UK as a trade and technology leader. The UK is now uniquely positioned to ramp up exports of the new goods and technologies that characterize the Fourth Industrial Revolution and The Internet of Things. Medical robots, 3D printers, agriculture robots, drones, deep learning, artificial intelligence, and consumer robot applications can create and drive the next generation of British development exports.

> **25% of all robots are sold in China. By 2019, some 40% of the global market volume of industrial robots will be sold in China.**

To date, the UK has established itself with a good platform to expand these and other areas of Robotics & Automation. Within Artificial Intelligence alone the UK has seen Deepmind acquired by Google for $500 million in 2014 as well as Magic Pony and Swiftkey acquired by other Silicon Valley giants. As the Government tackles BREXIT, one key role is creating a new and better regulatory environment for these Robotics & Automation businesses to flourish.

However, the strongest growth drivers for the robotics industry are found in China. In 2019 some 40% of the worldwide market volume of industrial robots will be sold there alone, according to the 2016 World Robotics Report published by the International Federation of Robotics (IFR).

"Over the last four years we have seen solid growth in robot sales worldwide. The biggest growth has been in China. Overall 70% of all robots are sold in China, Japan, Germany, South Korea, and the U.S. 25% of all robots are sold in China. The growth does not seem to stop anytime soon," says Henrik Christensen (ROBO Global Strategic Advisor.)

Why is that?

In reference to IFR data, Christensen says sales in China have been particularly impressive with 50%+ annual growth that last 3-4 years. The growth has been very much motivated by a need to retain manufacturing in China. The hourly wages for manufacturing workers has gone up 350% over the last 10 years. Overall the robotics industry is expected to continue to see solid annual growth of ~15-20% but the major growth driver will without doubt continue to be China into the foreseeable future.

THE TECH PUSH

In April 2015, Bill Gates wrote in a letter, "We are nearing the point where computers and robots will be able to see, move, and interact naturally, unlocking many new applications and empowering people even more."

Robotics is in the process of becoming as ubiquitous as computers. Virtual reality, augmented reality, artificial intelligence and robotics, collectively, are going to be a "bigger deal than the internet and mobile," stated Gene Munster, an influential tech analyst turned venture capitalist, on public television on January 3, 2017. Munster maintains that those four themes will radically change how humans interact and work.

2016 was huge for advancements in machine learning—but 2017 may deliver even more. Will Knight, the senior editor for AI at MIT Technology Review, predicts that the big trends in AI over the coming year could yield some interesting changes. Reinforcement learning—the process of having a machine learn to solve a problem through experimentation and positive reinforcement, rather than programming or explicit examples—looks set to gain traction off the back of DeepMind's historic Go victory (AlphaGo, a program developed by Google's DeepMind unit, defeated legendary Go player Lee Se-dol in the first of five historic matches being held in Seoul, South Korea). Neural networks will increasingly duel each other in order to create realistic synthetic data. Language recognition should advance and China may end up leading the way in AI research.

> *128 robotics-related startups received funding in 2016. Combined, these companies received $1.96 billion - that's up 50% from 2015.*

INVESTORS NEED TO RECOGNIZE ROBOTICS IS NOT A NICHE

Robotics is not a niche, but rather a foundational technology being applied to virtually all industries, markets and geographies. It's happening now.

Additionally, CB Insights documented that robotics startups, from industrial automation to surgical robotics to consumer robotics and beyond, raised $3 billion since 2012.

Robotics features are prominent in this new manufacturing era. As robots are increasingly used for repetitive tasks, experts estimate that there are as many as 1.5 million robots globally engaged in tasks that once were performed by humans. Technology and robotics

can improve quality control and inventory management, allowing firms to gain more profitability even if labor costs are hurting competitiveness.

Modern consumers want unique items, or customized products. The adoption of technology is also lowering basic supply chain costs. Firms can operate at smaller scale because the inputs to production are more flexible. Supply chains are shorter, with less reliance on distributors and more direct contact with the end user. Using technology to shorten lead times and shrink supply chains enables faster production and more competitive products on a smaller scale. Advanced manufacturing also allows for more fragmented and customized production processes.

Joining e-commerce platforms can enable firms to access more potential customers, reduce barriers to entry and accelerate time to market. The information sharing and advertising that social media provide can expand awareness and adoption of products. Faster dispersion of new ideas through social media and quicker adoption of new styles and techniques lower marketing costs. Websites let manufacturers speak directly to consumers more affordably as big data helps them understand consumer preferences.

Manufacturers are also linking directly to consumers as they take part in the sharing economy. Imagine you want to buy a part for your electronic device. Traditionally you would contact the manufacturer to order it and wait for delivery. Today you can download the design for the part and produce it at home with a personal 3D printer. The chain from desire to delivery shrinks from weeks to hours.

ROBOTICS AND JOBS

The World Economic Forum projects more than 5 million jobs in 15 leading countries will be lost by 2020 thanks to disruptive labor market changes - including the increased use of robots. According to BofA Merrill Lynch Global Research, robots are currently estimated to account for about $14 trillion of disruptive impacts on manufacturing through lower salary costs and efficiency gains and are projected to perform 45% of all manufacturing tasks by 2025.

> *Robots will also create jobs. It's estimated that three jobs are created for every industrial robot in place.*

Robots are disruptive. They can do a better job than humans at repetitive manual tasks with fewer errors, higher output and lower costs (e.g., no benefits, vacation or illness). Robots and algorithms are also increasingly utilized for non-manufacturing work such as journalism, banking and, soon, driving. As economist Andrew McAfee notes in his book "The Second Machine Age", machines enhanced our physical power in the industrial age and now are expanding our mental power. Robots will also create jobs. Most obviously, look to the current need for programmers and engineers to run them.

It's estimated three jobs are created for every industrial robot in place, according to BofA Merrill Lynch in their research titled "Stayin' Alive: Manufacturing in America." Ironically, nearly all the nation's largest publicly traded manufacturers cite the labor force as a risk to their businesses, per a recent report from the accounting firm BDO.

A recent White House report said 80% of manufacturers currently claim a moderate or serious shortage of qualified applicants for skilled and highly-skilled production positions. Job openings at manufacturers remain elevated while the number of jobs filled lags. Going forward the biggest challenge to manufacturing in the U.S. might not be energy or the dollar, but the lack of a skilled labor market.

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