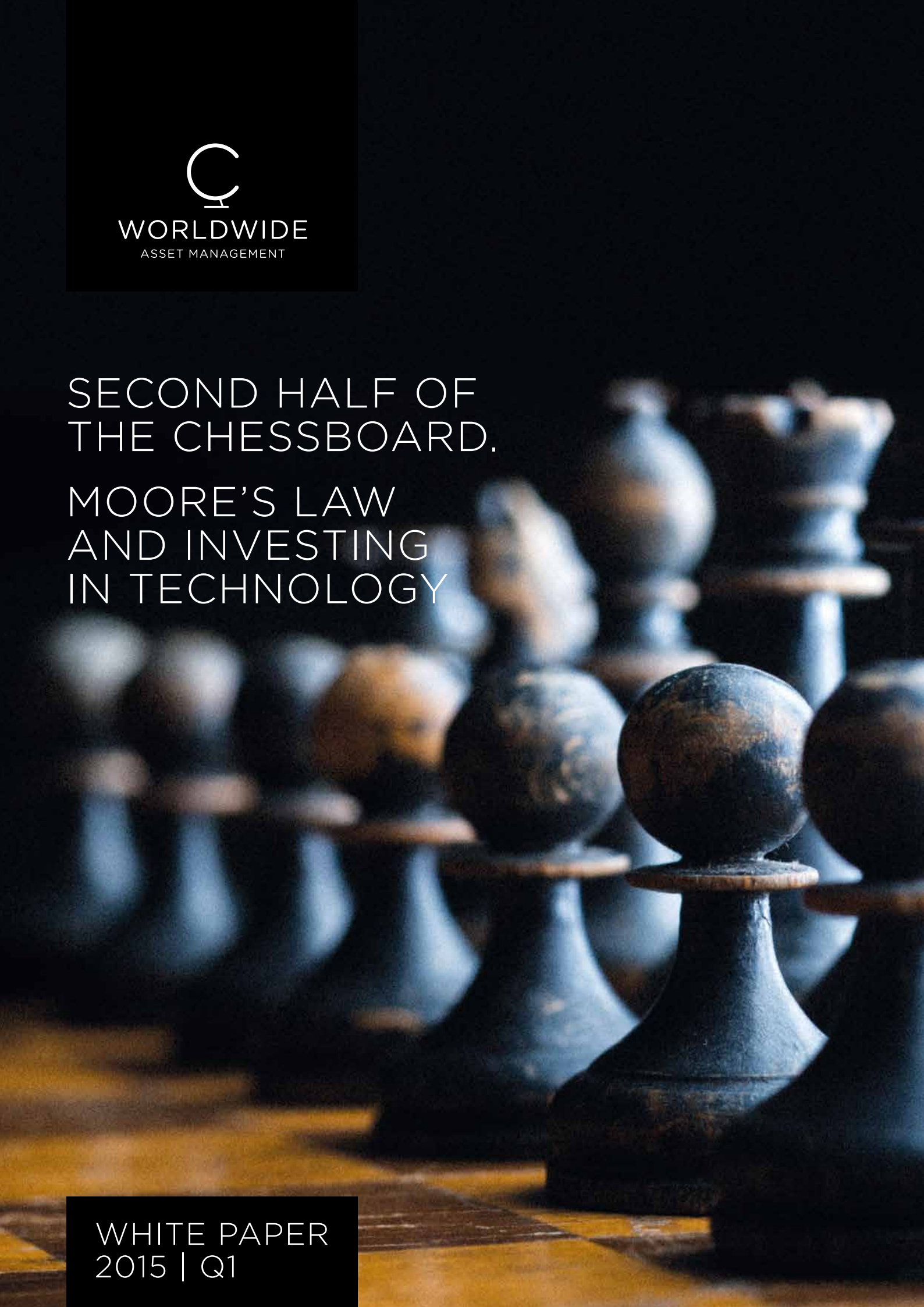
WORLDWIDE
ASSET MANAGEMENT

SECOND HALF OF THE CHESSBOARD.

MOORE'S LAW AND INVESTING IN TECHNOLOGY



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Second half of the chessboard. Moore's law and investing in technology

By Morten Springborg, Global Thematic Specialist

Two stories, one from ancient times and one from the present day, give food for thought about how our society will evolve over the coming years. One story is the ancient legend of the creator of the game of chess.

The story of the chessboard

The true story of the creator of the game of chess has been lost in time, but legend has it that the creator of the game, an Indian mathematician, showed his invention to the ruler of the country. The ruler was so pleased that he gave the inventor the right to name his payment for the invention. The mathematician asked that, for the first square of the chessboard, he would receive one grain of rice and then for the number of grains to be doubled for each subsequent square on the board. The ruler objected, believing that the reward would be inadequate, but the mathematician insisted.

The ruler, being arithmetically unaware, did not know the effect of exponential growth. Initially, the payment for the invention would seem to be modest, but as the grains of rice were doubled from square to square, the payment grew and grew – exponentially. By the 32nd square, the volume had grown to about 2 billion grains of rice corresponding to approximately 100 tons of rice, which was probably not too unreasonable. But the volume would continue to double right up to the 64th square. By the last square on the seventh row of the board, the volume had ballooned to more than twice of today's annual global production of rice which is approximately 750 million tons – and with the number still to be doubled eight more times! The total volume of rice on the 64th square was estimated to be a pile the size of Mount Everest, or 9,223,372,036,854,780,000 grains of rice, or many times the accumulated global production of rice up to the present day. Legend has it that the ruler became so furious about being fooled that he had the mathematician beheaded.

> **When you get to the second half of the chessboard, growth moves from a scope that the human brain can understand to numbers that are totally incomprehensible.**

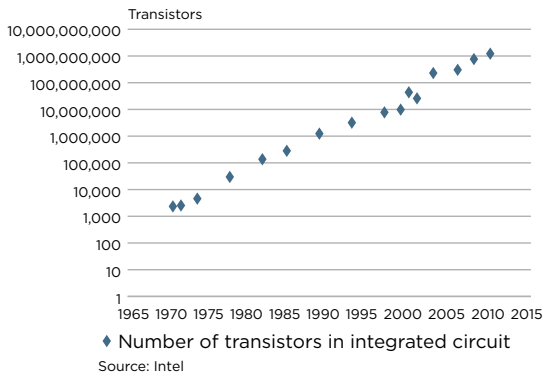
"The second half of the chessboard" is a phrase coined by Ray Kurzweil, an American author, inventor, futurist and director of engineering at Google. The concept has since been made popular by two professors at MIT, Brynjolfsson and McAfee, in their New York Times bestseller "The Second Machine Age" published earlier this year. The main point is that, when you get to the second half of the chessboard, growth moves from a scope that the human brain can understand to numbers that are totally incomprehensible. Kurzweil related the exponential growth on the chessboard to Moore's law.

Moore's law

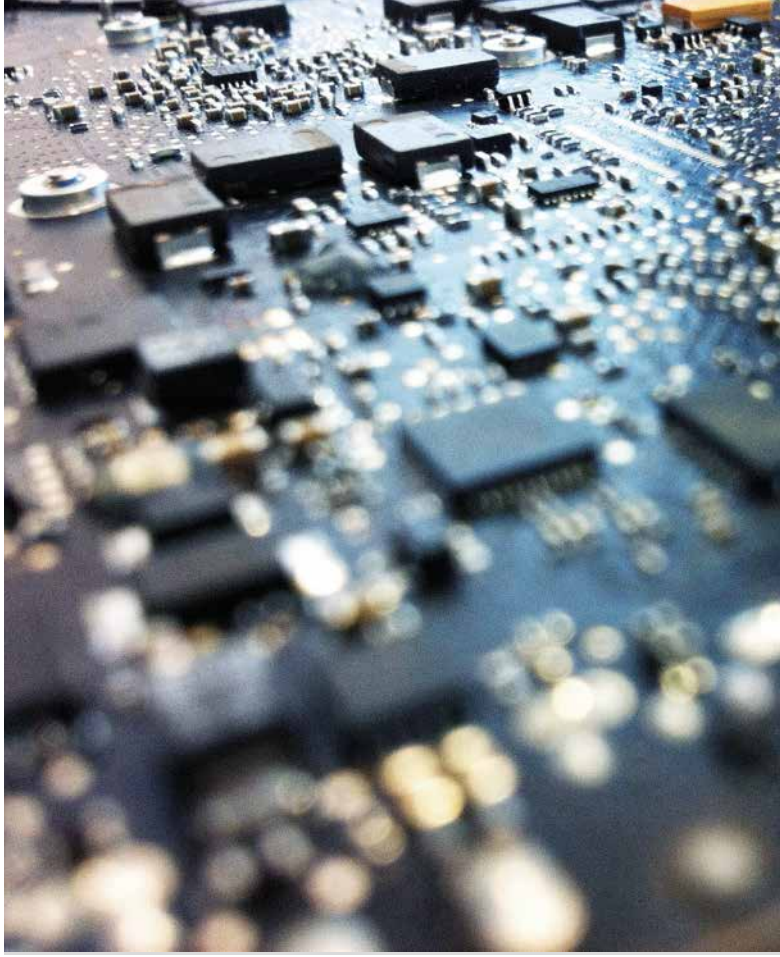
In an article published in Electronics Magazine in 1965, Gordon Moore of Fairchild Semiconductor (today Intel) noted that the number of transistors in integrated circuits had doubled every 12 months, and he predicted that the trend would continue at that speed in the future. Later, "Moore's law", as it was called, was adjusted slightly, to a doubling every 18 months instead. By and large, however, Moore's prediction has proven accurate.

Figure 1:

Moores law: Doubling of computerpower



Source: Intel



The starting year for Moore's prediction was 1959, which means that, at a doubling time of 18 months, "the second half of the chessboard" was reached in 2006. It is probably not unreasonable to say that, since 2006, we have seen an accelerating evolution of technology. Since then, we have seen smartphones, big data, 3D printing, advanced robotics and, soon, driverless cars as well. Many of the technological advances that we take for granted today did not exist just a decade ago. We are now 36 or 37 iterations into Moore's law, and we should not expect technology acceleration to simply continue for all eternity, as there are both economic and technological limitations to further reductions in physical size and growth of computing power. But the accumulated amount of technological innovation doubles in every single innovation iteration, and, just as the numbers became incomprehensible and unfathomable for the ruler in the story of the chessboard, we will also see an incredible growth in accumulated technological knowledge.

In 1996, the world's most powerful computer was the ASCI Red, which the US government used to simulate nuclear explosions, among other things. It was the size of a tennis court and consumed as much electric power as 800 homes. In 2006, another computer with similar computing power was introduced: a gaming computer called the Sony PlayStation3. Whereas the ASCI Red cost USD 55 million, a Sony PlayStation3 had a price tag of only USD 500 and could even sit on a shelf under a television. This was the effect of five or six technological iterations. The lesson to be learned from this story is that rapid technological innovation also means that certain areas, especially IT hardware, can very quickly be commodified, unless the manufacturer has "permanent" scale benefits. This is the case with **Samsung**, for example, which we hold in our portfolios. We prefer to focus on software and network businesses due to higher barriers to entry.

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Another example of the effect of technology iterations is the **driverless car**. In 2004, an agency under the US Department of Defense announced a competition to develop an "autonomous vehicle", i.e. a driverless car. The winner would be the first vehicle to complete a 150-mile route. None of the vehicles completed the route, and the farthest distance travelled was about 7.5 miles. In 2012, Google announced that its fleet of driverless cars had completed 300,000 miles on California roads with no accidents recorded. Today, several US states have introduced or are introducing legislation to regulate the use of driverless cars. What was impossible just ten years ago will be commonplace within a few years, possibly within the expected lifetime of the car you have in your driveway today.

Easy access to inexpensive computing power and super-fast fibre-optic broadband combined with immense storage capacity are now making it possible to achieve innovations that were unthinkable only a few years ago. Today's computers are capable of understanding verbal communication. These days, humans and robots

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work together, and the robots are capable of learning from humans. So-called 3D printing allows companies to accelerate their product development, e.g. in the case of running shoes. In future, technology will revolutionise logistics systems as well. For example, if an engine component breaks down on a Maersk container vessel, the company will have the option of printing the part onboard the ship rather than having it shipped from a manufacturer in Korea or Denmark.

Perhaps the most telling aspect of the advance of technology is how difficult it is to imagine what will happen in just a few years' time. Yet, we can be quite sure that the trend of accelerating developments will continue for a number of years, since it is basically dictated by Moore's law. This will be supportive of economic growth.

> **Technological innovation will alter society as we know it. The digitalisation of goods and services will serve to expand the market and reduce costs in a way that seemed unthinkable only a few years ago.**

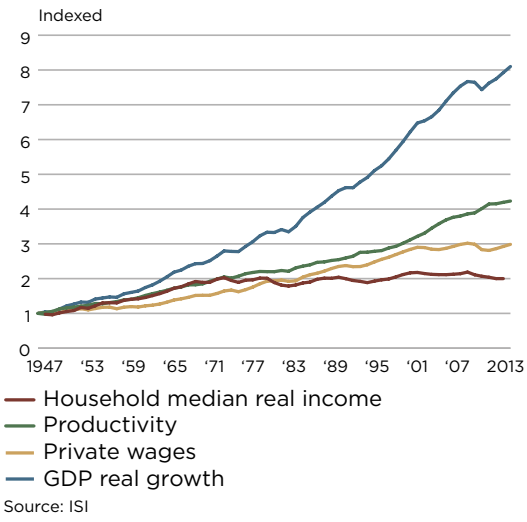
Economic growth is driven by two factors: expansion of the labour force and an increase in labour productivity. The notion that the Western world will again achieve growth rates at pre-crisis levels has been met with increasing scepticism in recent years. The ageing population plays a part in this, as does the fact that productivity growth of the last ten years has trailed the figure for the ten years before. If our assumptions about accelerating technological advances prove correct as we move onto the second half of the chessboard, there is no reason for concern about overall growth in our society. Technology will take over where expansion of the labour force can no longer contribute: Japan is a good case in point.

Technological innovation will alter society as we know it. The digitalisation of goods and services will serve to expand the market and reduce costs in a way that seemed unthinkable only a few years ago. Take photography, for example. Since Le Gras took the world's first photograph in 1826, people have taken some 3,500 billion photographs, 10% of that number taken last year alone. Until recently, photographs were an analogue technology and had to be processed in a laboratory. Analogue photography peaked in 2000. Since then, nearly three billion people have acquired a digital camera. This is something that has turned the industry completely upside down. It took a team of 13 people to develop the Instagram app that 200 million people now use to exchange photos, and, just 18 months after its inception, the company was sold to Facebook for USD 1 billion. One can compare this with Kodak, the king of analogue photography. The company was founded in 1880 and, at its peak, it had almost 150,000 employees. Its founder, George Eastman, became a rich man, just like the founders of Instagram. However, unlike Instagram, Kodak supported a large group of middle-class workers. The shift from analogue to digital technology provides a burst of access to goods and services, but it also widens the income gap considerably. The digital economy means larger fortunes are made through less work by the few, but with the side effect that many former middle-class workers will experience a lower or a stagnating standard of living. Kodak went bankrupt a few months before Instagram was sold to Facebook.

It is therefore no surprise that median incomes have not seen real wage growth since early in the 1980s. For one thing, globalisation and outsourcing have increased competition from low-wage countries. More importantly, however, increasingly larger groups of workers are coming under pressure from technological innovation.

Figure 2:

Wages and income development in the U.S.

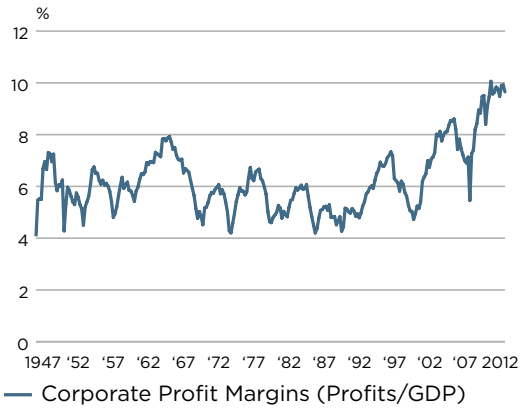


Source: ISI

Job growth in Western economies has been distinctly different in the post-financial-crisis period than after previous times of recession. It has been difficult to restore the same employment level, particularly in routine-intensive employment. It is also clear that labour's share of total income has been declining since the 1980s, not only in Western economies, but also in emerging markets such as China. Automation and investing in technology have resulted in a growing proportion of income being attributable to capital, which can also be seen from the fact that corporate earnings margins are currently higher than ever before.

Figure 3:

American company earnings



Source: ISI

We are not particularly worried about these historically high earnings margins in the short or medium term. In the longer term, however, there could be some concern as to who will buy the goods produced if the middle class will not again experience growth. Henry Ford's words come to mind: "If my workers can't afford my cars, who will buy them?"

However, digitalisation also creates winners and, to a large extent, winners that take it all. In a digitalised world, capacity restrictions become less and less relevant as the marginal cost of selling one more product is close to zero. In addition, digitalisation is capable of expanding your market and making it virtually global. Digital products offer huge benefits of scale, giving the market leader huge cost benefits compared with the rest of the market. Add to this the so-called "network effects" that can create demand effects that further boost the dominant producer of a digital product. Facebook is a good example of this phenomenon: more and more people are attracted to Facebook because it is already the largest social network. You have a greater probability of finding your friends on Facebook than on any other network. The same applies to Google: although its search engine may be no better than Microsoft's Bing, Google has long been the number one search engine and thus attracts more advertisers, who know that this is where they can reach the largest audience. According to IDC, Google's market share of global online advertising is about 50%. With digital marketing winning market share from analogue marketing, this is a rapidly growing market.

> **One of the effects is that many leading technology companies are building net cash positions well in excess of any level previously seen in the corporate world.**

One way or the other, virtually every investment we make is connected to the accelerating digitalisation of the economy. Reviewing each individual investment would make this article far too long: suffice it to say we believe that, in the digital world, it is even more important to be invested in the market leaders. We base our view on the dominant position of the above-mentioned scale and network effects, which means that they increase the barriers to entry for smaller competitors. We have invested in both Facebook and Google, and we believe they are the future winners in online networks and advertising.

One of the effects of the situation described above is that many leading technology companies are building net cash positions well in excess of any level previously seen in the corporate world. Samsung has about USD 20bn in cash, equal to approximately 20% of its market cap. Google has USD 65bn, or 16%; Facebook has USD 14bn, or 7%; Microsoft has USD 86bn, or 23%; and Fanuc has USD8bn, or 19% of its market cap. Such accumulation of cash shows that these technology companies are making their money in areas where investment requirements are relatively small.

The companies are often criticised for their large cash holdings, but it also gives them much greater freedom of action in acquiring new technologies or business models. Precisely because of the accelerating technological innovation, these leading companies cannot be expected to always be frontrunners when it comes to the latest technologies and business models that could prove disruptive.

Their cash holdings give the largest technology companies the flexibility to be at the cutting edge of technological development and will help them survive in the long term, as we continue to advance from square to square on the second half of the chessboard. Examples of such flexibility are Facebook acquiring Whatsapp and Google acquiring Waze, both of them companies addressing customer bases that are growing explosively worldwide.

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As the market matures and some of these leading technology companies experience slowing growth rates, their cash piles will far exceed what they can reasonably be expected to channel to organic investments or acquisitions. Last year, Microsoft announced a USD 40bn share repurchase programme, which is equal to 10% of the company's market cap. To top it off, Microsoft is also paying a 3% dividend. We believe that, as Microsoft migrates its dominant customer base of Office and Windows Servers users from pc solutions to its cloud platform, the company will further expand its scale and cost benefits, securing stable cash streams for itself and its shareholders for many years to come.

Other companies in our concentrated global equity portfolio riding on the technology wave include Alliance Data Systems (big data), Visa (networks), ASOS (online retailer) and TD Ameritrade (online securities trading), but we firmly believe that all companies will to some extent be affected by the accelerating rate of technology innovation as we advance to the next square on the chessboard. As technology marches on, only our lack of imagination puts limitations on the challenges and opportunities we face as a society.


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