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Environmental Investments

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Industry 4.0 and environmental sustainability: good or bad news?

Industrial revolutions have brought about tectonic changes in societies throughout history and fuelled debates among researchers regarding positive and negative outcomes. Retrospectively, most revolutions are today considered positive advancements of society and milestones of mankind's evolution. Nonetheless, they came with many drawbacks, especially in the short term, for at least some sections of society. This debate has concentrated mainly on employment rates, working conditions and the progressive replacement of people by machines in the workplace, but sometimes the negative effects went far beyond employment. For example, in the 19th century, the coal industry was seen as a great economic opportunity but the environmental impacts were not considered until decades later. Now, in the early stages of the "Industry 4.0" revolution, we cannot extricate the economic opportunities from the associated environmental risks. In this day and age, we must consider these impacts from the inception of new industrial changes to ensure environmental sustainability for an ever growing population. We must ensure our actions and choices today will not compromise the ability of future generations to meet their own needs. The reach of industry 4.0 revolution is so pervasive that the sustainability objective cannot be overlooked. In this newsletter we will analyse the environmental challenges and business opportunities presented by the innovative technologies of Industry 4.0. This is an appropriate moment to also introduce the new name of Ambienta's newsletters which from now on will be ***"Ambienta Sustainability Lens".***

4.0 and its predecessors: what lies beneath the surface of an industrial revolution?

Energy. Technology. Communication. The first three industrial revolutions can be summarised in these three simplistic terms. The First Industrial Revolution transitioned mankind from a world of limited availability of energy to a world of energy wealth to perform "work", which in physics refers to the ability to move an object through an applied force. Before then, the available "work" was limited to the physical strength of men and animals or windmills and watermills, wherever available. During the first revolution steam power transformed transportation (e.g. railways) and production (e.g. mechanised textile factories). Between the 19th and the 20th century, the Second Industrial Revolution saw technological innovations reshape industries and societies. This brought the use of steel (an upgrade from iron), electricity, light bulbs, telephones, aeroplanes, automobiles, antibiotics, and extensive adoption of mass production processes. Electricity enabled night activities, which for the first time created opportunities for both leisure and work after sundown.
The Third Industrial Revolution brought us advanced communication capabilities. The invention of the television and the radio, in the early 20th century, made the world smaller; the invention of the transistor in 1947 represented the cornerstone of modern electronics and paved the way for personal computers, internet, smartphones and satellites.

Industry Revolutions.
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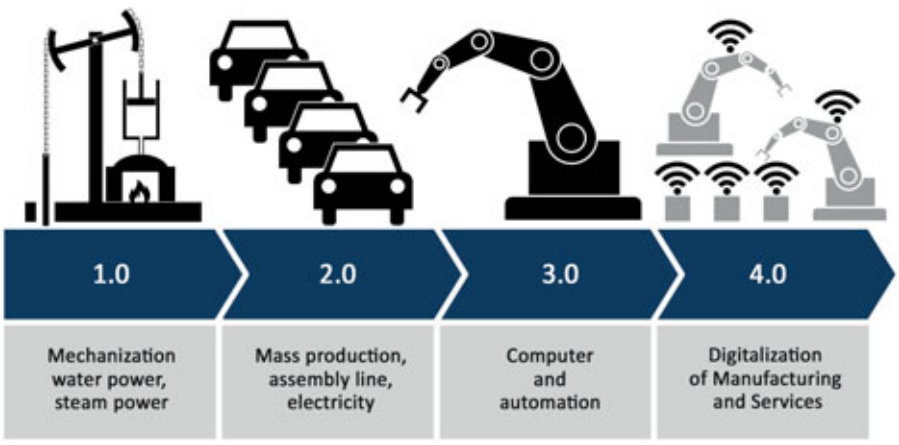
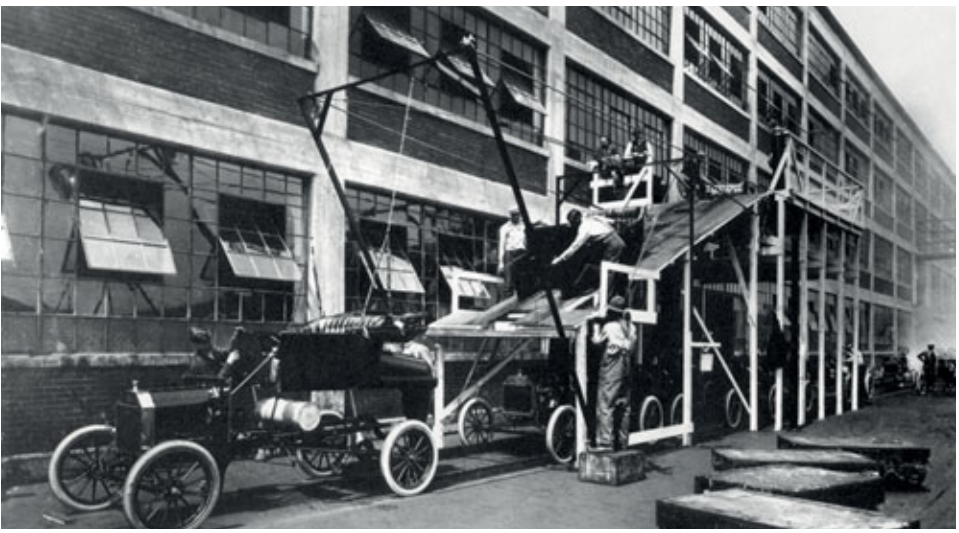


From a historical perspective these revolutions brought many more advantages than disadvantages. Life expectancy increased twofold, global population grew eightfold, productivity skyrocketed and the middle class emerged.
In the 20th century mass production concepts were progressively adopted in agriculture and most industrial sectors driving prices down and making new products widely affordable (for example the emblematic Ford T).
Modern Western consumer standards owe their origin to these streams of innovations.

However, these transformations did not occur without pain in the short and long term.
Certain decisions, made more than one hundred years ago, still influence our life today.
For example, the population of workers in the UK coal industry declined from 750,000 after WWII to around 5,000 today. It took about 200 years for coal, the fuel of the British industrial boom of the 19th century, to reach its consumption peak and for its negative effects on air quality to be fully understood and eventually drive its decline.
Similarly, cars, a symbol of the middle class, have now become a major threat to human health and planet preservation because of their emissions. The recent adoption of electric vehicles, which are far less complex to manufacture than internal combustion engine vehicles, is positive for the environment but threatens a workforce reduction in the industry. Even communication technologies are under scrutiny from a social perspective. With the expansion of virtual reality many people feel more disconnected than ever and the explosive circulation of 'fake news' has become an unwanted collateral phenomenon.

These examples show how revolutions are often double sided, with positive and negative outcomes. Sometimes effects are evident from the beginning while others are not fully understood until many decades later, such as the environmental impact of burning coal or driving diesel cars. The social impact on employment also has positive and negative aspects. On the one hand, industrial revolutions



Assembly line of Ford Motor Company, 1913

have always threatened mass employment; on the other hand, for two centuries, working conditions have been rightfully criticised leading to life changing improvements.
Average working hours have declined from around 70 per week in the early 19th century to the modern 40 (or less) per week in the late '30s. Similarly, labour regulations have been developed over recent decades to protect the health and safety of workers and are now spreading from developed countries towards the developing world. Furthermore, recent ESG efforts are now actively broadening social goals to include concepts of equality and fight against modern slavery, to name a few.

In a nutshell, all three revolutions drove enormous labour productivity gains and unlocked the potential for economic growth. Simultaneously they initiated massive societal transformations which produced positive and negative externalities, such as the global pollution issues. Now Industry 4.0 revolution is upon us and promises more changes than ever. We want to examine the environmental impact of the upcoming changes to be sure we do not leave future generations with more problems than progress.

Industry 4.0 means growth, but does it mean sustainable growth?

The term "Industry 4.0" was first officially introduced in 2011 by a German government strategy project on the digitalisation of manufacturing. Eight years on, this phrase has entered our daily jargon and is routinely covered in the media. Despite this popularity, it is hard to pin down a clear definition of Industry 4.0 because of the pervasiveness of the concept with respect to the underlying technologies, industries and businesses it can be applied to. Many people rely on anecdotal descriptions like robots substituting humans in various activities, but in reality there is much more behind it. Officially, Industry 4.0 is defined on the basis of four "design principles": i) interconnection: between machines or machines and people; ii) information transparency: operators can collect immense amounts of data directly from all points in the manufacturing process; iii) technical assistance: assistance systems and machines can support humans in decisions and physical activities respectively; iv) decentralised decision: the ability of cyber physical systems to make decisions without central computing support. In practical terms these design principles are not always well understood by a generalist audience. A more intuitive approach, based on the separate review of its underlying groups of technologies, is the one developed by The Boston Consulting Group, which we will refer to in this paper. It highlights nine transformational technologies driving the revolution in manufacturing.

Looking at the BCG's scheme, it is striking how much it resembles a map for growth and success. All the mentioned technologies are growth stories: an Italian leader in the development of robotic end-of-arm systems and grippers, also known as "Autonomous Robots". With a growth rate of 30% per year, it was acquired by a US provider of highly engineered products for a price which equated to 7x sales. Another example is a company on the forefront of Additive Manufacturing equipment

The nine technologies transforming Industrial Production according to the Boston Consulting Group

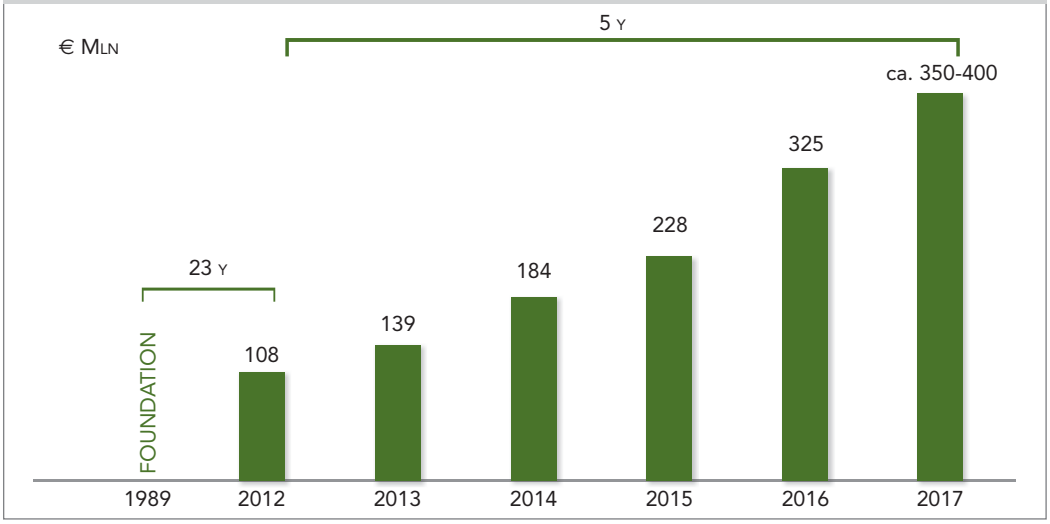
which was founded in 1989 and gradually reached €100 million in 2012 when, suddenly, in the subsequent 5 years, sales almost quadrupled. This kind of J-curve growth is not unusual in Industry 4.0 and mirrors new technology adoption rates and the extent of the disruption it brings in the traditional industries who adopt it.

From the point of view of an investor, growth is a good starting point; for the sustainability minded investor, like Ambienta, proof of a positive contribution to long-term sustainability is also required. Therefore, we have to review each technology and assess whether it also brings quantifiable positive impacts with regards to sustainability. Let's examine a few examples.

The Internet of Things can be successfully applied in many ways, e.g. the extension of internet connectivity into physical devices or everyday objects. To visualise it, imagine coffee machines sending you a WhatsApp message when your coffee is ready. A good example of the environmental impact of industrial IoT is fleet management in logistics. Here, IoT devices connect inbound and outbound demand from customers with en-route load capacity, providing the logistic service company with the ability to adapt routing in real time. In this way customers and service providers can both reduce idle time at loading bays and avoid empty runs. In this case IoT devices work as dynamic saving enablers along a complex and multiparty value chain, eventually delivering both economic and environmental benefits in the form of fuel and CO_2 savings. Transporeon GmbH, a German company, offers services to optimise integrated fleet management operations through its IoT based solution. Its solution delivers, according to estimates, up to 10% reduction in GHG emissions. Its proven economic and environmental benefit has been recognised by the *Supply & Demand Chain Executive Green Supply Chain Award 2018*.

Augmented Reality is another interesting example of the pervasiveness of this revolution. It is a technology that superimposes computer

Additive Manufacturing leader

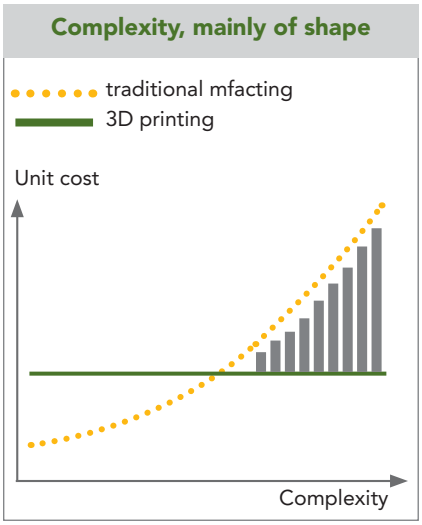


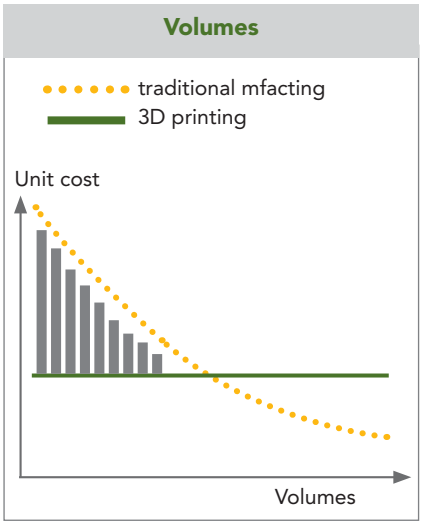
Sales evolution of EOS GmbH, a global leader in Additive Manufacturing machines

General Electric 3D printed aviation fuel nozzles are 25% lighter than alternative contributing to new engine generation which is 15% more energy efficient than previous versions

generated images and information on a user's view of the real world. To visualise it, imagine, like in a movie, that you are looking at someone and at the same time, on a screen, receiving details of their life. Alternatively, imagine you are looking at a car and you receive the technical drawings of its drivetrain simultaneously with tips on how to fix it. Re'Flekt, a Munich based venture, grew to employ 60 engineers across four offices in Germany and the US developing an Augmented Reality platform for enterprise training, maintenance and repair applications for factories, aircrafts and complex machines. With Augmented Reality, implemented through a smartphone or a tablet (and in the near future probably through a visor like in sci-fi movies), Re'Flekt's products allow customers to develop specific training courses or remote assistance applications for workers, technicians and clients. Following on from Bosch's 2016 investment, BASF Venture Capital recently invested in this company. Bosch originally started as customer and liked Re'Flekt's work so much that they invested in the company. Industrial players, such as BASF, are now equipping plant technicians to improve maintenance services, to timely intervene on systems malfunctions and to improve speed for the sake of productivity optimisation. In turn this drives significant resource savings in large process industries such as chemical plants and improves overall asset performances while growing technicians' skills.

Additive manufacturing processes enable low cost production of high complexity shapes thus reducing weight, scraps and assembly time and allowing for low volume productions.





The potentially most impactful of BCG transformational technologies is probably Additive Manufacturing ("AM"). Additive Manufacturing is an all-inclusive term for a family of manufacturing processes (including 3D printing) which work by adding material where required around an initial point. This is an alternative to traditional manufacturing which starts with a large, non-defined shape and removes material where it is not needed, like in the standard production of plastic and metal components. Through a limited amount of investment, AM can enable manufacturers to decentralise the production of highly engineered products. To visualise it, imagine being able to produce a personalised tea cup in your living room. Its key success factor relies on a unit cost which is independent from the volume or complexity of the final design. In many applications its environmental benefit is huge: it can drive up to 30-40% weight reduction versus traditional manufacturing and its flexibility enables the manufacture of single unique products rather than having to work with minimum lot sizes. This flexibility reduces defects and scrap by up to 90%.

Despite these persuasive examples of the benefits to environmental sustainability goals, all cases require diligent review and it will be our duty, as an environmentally minded investor, to think ahead for the future implications.

Ambienta has been investigating Industry 4.0 environmental risks and opportunities for some years now and has only scratched the surface.

An endless source of opportunity for decades to come

Industry 4.0 is a theme rather than a sector. The overall market value of Industry 4.0 technologies is estimated to be between $70 to $150 billion and is growing at around 15% per year. Since these technologies represent a key competitive advantage in any industry they are applied to, the growth prospects for players are huge. Even a negative economic cycle that could cause a downturn in sales of capital goods is likely to only have a temporary effect on this market given the strength of this revolution. The speed of investment in IoT technology across industries will determine the long term winners in their respective fields; wait-and-see strategies are no longer an option for investors. This explains the wide fiscal support these types of investments have received in many countries who are aiming to increase the competitiveness of their production. Investors can leverage this support and resilience to build long term industry leaders.

These trends have already created visible success stories at all stages of company development, many more than we could describe in this paper. Global industrial leaders have been eager to acquire these new competencies and they have paid outrageously high multiples on the promise of competitiveness and long term growth; long before the topic became visible in the media. For instance, in the Autonomous Robots trend, part of the BCG scheme, the US technology conglomerate Teradyne in 2014 acquired Universal Robot, a global leader in collaborative robots for a comprehensive value of around $350 million including a 3 year long earn out. In 2014 the company turned over $38 million, up 70% vs previous year, which sets its value just short of 10x revenues. Similarly, VC funds are investing heavily in big data analytics service providers or industrial IoT platforms that enable remote monitoring and mass connectivity. Conversely, buyout funds have been more hesitant to enter the segment so far because of the high degree of technology risk, discontinuities in the business model and limited predictability of market adoption rate typical of this type of investment. Today this is changing.

Ambienta entered Industry 4.0 in its early days through both the sectors of Autonomous Robots and Data Analytics by making investments in machine vision technology: products capable of autonomous decentralised decisions based on high frequency image and data reading and a strong driver of resource efficiency when applied in industrial processes (see box).

In 2012 Ambienta acquired Tattile, a small Italian pioneer of machine vision who develops smart cameras for advanced industrial applications and traffic management. On the back of a 15% organic growth rate and through the acquisition

Robotic arm in an automated greenhouse ©FeelGoodLook /Shutterstock

Machine vision

Machine vision is a key component of the Industry 4.0 revolution. Machine vision, also known as automated vision, is defined as the wide range of technologies to capture and process visual information around a machine or an industrial process. Machine vision systems today can provide far better results compared to human eyes in terms of speed of data acquisition, accuracy and sensitivity. A key feature of machine vision is image processing and decision making that happens in a decentralised way in the camera software, without relying on central systems. This feature enables high-speed information feedback loops, which in turn open a new world of process improvement possibilities. For example, machine vision technologies dramatically improve the effectiveness of sorting machines. When applied to the waste management sector, machine vision enables an accurate management of complex streams of waste and the sorting of materials by colour or by other physical characteristics, such as shape. When sorting to-be-recycled plastic bottles, purity is critical for PET recyclability: only 50 ppm of PVC concentration in PET can jeopardise PET's recyclability. In seeds and food sorting, where machine vision is largely deployed, smart cameras can detect and eliminate impurities while minimising good quality seeds wrongly scrapped, driving a 10% yield increase in the process. In high speed production lines, machine vision solutions allow for real time quality inspection and process control, reducing both scraps and avoidable reworks (like mesh errors in textile production).

Foto © Igor Terekhov, Konstantin Pelikh /123rf

of two companies in Germany to complement its product portfolio, Ambienta created a sizeable European player and renamed it Lakesight Technologies. Lakesight Technologies was sold in October 2018 to TKH, a Dutch technology group, and Ambienta achieved a 10x return on invested capital. TKH eventually merged its existing machine vision business into Lakesight and made it the new European leader in the sector.
We believe that machine vision can deliver both environmental and economic benefit. While selling Lakesight, Ambienta invested in Next Imaging, a value-added distributor of machine vision solutions. The machine vision distribution market is on a stable growth trajectory, still fragmented and ready to be consolidated which is in alignment with Ambienta's focus on established business models where technological risk is limited.

Along with machine vision we have an active interest in other areas of Industry 4.0. All driving both economic and sustainability benefit in their respective applications:

- **Industrial Internet of Things:** assets, machines, cars, appliances and industrial equipment will be connected to remote diagnostic and control, simplify repair activity with on-site tutorials available to technicians, improve performance and more. We can think of infinite situations where connectivity enables both a productivity gain and an environmental benefit.

- **Additive manufacturing related business models:** Machine manufacturing is a very interesting niche that commands high margins and will experience long term growth. Fierce competition from large corporate buyers

looking for innovation is to be expected but the opportunity remains huge. Consumable materials developed specifically for Additive Manufacturing processes will be highly innovative and some will be more sustainable than others, such as bio-based polymers. Additive Manufacturing outsourcing services will grow to support companies without the competencies to handle the new technology or the ones who prefer not to invest in it.

• **Horizontal and vertical system integration:** real time availability of processable information which connects customers with suppliers, in any sort of process, will create capabilities to streamline processes, increase service levels and optimise physical inventories across locations and many more improvements beyond our current imagination. Application specific, probably open source, software solutions will be critical to allow intercommunication of legacy systems, grant interoperability and minimise capital and time investment to implement solutions.

The interest in Industry 4.0 is significant. Competition and price are very high but the opportunity is clear. The digital nature of this revolution will make it one of the fastest to deploy, which from an investor perspective provides both great opportunity and great risk. Each industry will embrace these changes over different periods of time, to varying degrees and through a specific mix of technologies. Investors will be exposed to these changes either by investing directly into technology providers or by understanding which traditional portfolio company of theirs can create new value through the adoption of Industry 4.0 technologies. Both strategies are valuable and can lead to great successes.

Therefore as an investor and as company managers, we should embrace Industry 4.0 transformation without trepidation. Darwinism, which applies to business as much as to evolution, invites us to adapt, compete and act to promote adoption of technologies that improve resource efficiencies and pollution control.

Industry 4.0: a deep partnership between humans and technological innovations. Foto ©Andrey Armyagov /Shutterstock

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