# INTERNET OF THINGS IN THE POST COVID ERA

by **PAOLO AZZONI**

COVID-19 has completely changed our life, the way we work, how we interact with people, the global economy, but we have to look forward: what will we do after? Will there be an "after"? Or will we have to live together with COVID-19?

But we have also to ask ourselves what we have not done before...

WHO WILL DRIVE THE DIGITAL TRANSFORMATION OF YOUR BUSINESS?
WHO WILL ACCELERATE DIGITAL TRANSFORMATION?

YOUR CUSTOMERS   YOUR C-LEVELS   COVID-19
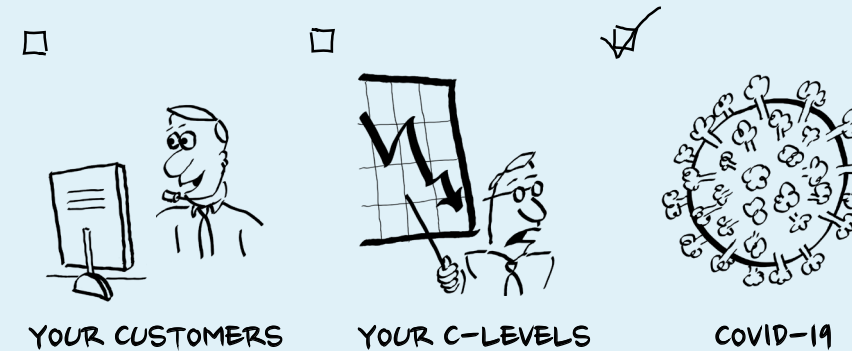
In the environment where we live, a tiny planet in the universe, we share billions of tons of biomass very different from human life, including millions of virus species, some of which we don't even know of their existence. Viruses have a role in our delicate environment, and we cannot imagine completely eradicating them.

As humans, we are programmed to try to anticipate and plan the future, but an analysis of the past in a similar crisis is fundamental to avoid the repetition of previous errors. Probably, the COVID outbreak is strictly linked to the underestimation of risks that characterise our society, in almost every sector. In 1986, just after the Chernobyl disaster, Ulrich Beck published the book "Risk Society: Towards a New Modernity" ("Risikogesellschaft"), in which he highlights that the primary characterising element of modern society is its increasing tendency to create catastrophes, with dramatic impact on humans and their activities. He considers the "risk society" as the last step in the evolution of society, a step where the greater the hazard, the more the reward… Unfortunately, sooner or later, a similar approach presents the bill, a bill that all the humanity has to pay.

The Conora virus, apparently, is not a human generated disaster like Chernobyl, at least not directly: the scientific community is converging on the idea that the conjunction of ecosystem rupture, overpopulation, pollution, globalisation and frequent zoonosis indirectly contributed significantly to the Corona virus outbreak, transforming a natural phenomenon in a global disaster.

TECHNOLOGY IS PARAMOUNT

Technology has evidently a responsibility in this: consider the global transportation system and its role in the rapidity at which the virus has been spread, all over the globe. The air transport sector exposed us to a high risk and is also one of the markets that is now paying the saltiest price. Again, the risk is the point: the benefits society is accustomed to are strongly bound to an irrational and irresponsible underestimation of risks. Using a simile, if a car allows you to reach 200 km/h, it doesn't mean it is safe or clever to reach this speed: it depends on the brake system, on the power steering, etc. … and on someone that periodically checks them. The scientific community advised many times on the necessity of a deeper knowledge of pathogenic organisms, but research funding was reduced in the face of the perspective of limited profits. A short-sighted decision that is now costing us ten, hundred or maybe a thousand times over. The certainty of the possibility of new pandemics pushed the World Health Organization to define specific pandemics plans…that almost no one took

seriously. And it is clear today that you cannot improvise.

The lockdown and isolation indeed represent a temporarily improvised and inevitable measure that is impacting on global economy as much as the virus itself. Lockdown and isolation have to quickly make way for a structural recovery and to a safety and resilience plan for the future: we have to avoid the previous errors. Technology plays a fundamental role in this plan. Technology is not good or bad, it depends only in the way it is used. Technology is fundamental to the prompt detection of future pandemics, tracking and keeping them under control, ensuring the resilience of the healthcare system, transportation, agriculture, production and even the economy. The lockdown is also having the positive effect of increasing the sensitivity of the collectiveness towards all digital technologies: people have been practically forced to embrace digital technologies from home to communicate, work, maintain social relationships, monitor health, do shopping, make payments, etc.

In the ECS value chain, IoT and SoS represent technological solutions that could significantly contribute to achieving these objectives and ensuring a quick and safe recovery. Except for the initial phase of the crisis, where we assisted in a momentary reduction in demand for IoT products, in the medium-to-long terms the impact of COVID-19 on the IoT value chain will be extremely positive. Some business areas are suffering and will suffer from ongoing losses where IoT could not contribute to recovery in the short term (e.g. the global tourism industry is expected to lose around USD 80 bn in 2020), but many other areas could benefit from IoT technologies to re-start (already during the quarantine) and even experience a significant boost of pre-COVID revenues (e.g. healthcare domain, logistics, manufacturing, etc.). The huge market dimensions and the positive expected trends illustrated in the Artemis-IA whitepaper "From IoT to SoS"[1] will result in being conservative. Analysists also believe that a larger than expected market growth is not the only consequence: the pandemic will increase the digital divide, due to the opposite and contrasting behaviours

of those that will fully embrace the digital transformation and those that will remain reluctant to do it. Embracing the digital transformation and its new business models will allow a quick recovery and will ensure a leading position for the future.

A CHANGE OF PERSPECTIVE

Embracing the digital transformation doesn't mean only to adopt the state-of-the-art technologies, such as IoT, embedded artificial intelligence, hyper-connectivity, edge computing, etc., but it is much more a strategic decision, a change in the business approach, a change of perspective involving many other aspects indirectly linked to technology:

+ operational and organisational processes, linked to new business models, must be "reshaped" to take advantage from the data stream collected from remote sources, flowing, stored and processed in the IT infrastructure organisation. The internal re-organisation is typically the most difficult step in the digital transformation, impacting even on the company c-levels.
+ Many new agile business models have been introduced in the IoT domain, subscription based, asset sharing models, data monetisation models, pay per use, service offering, razor blade, etc. Financial aspects are also involved because the payment mechanisms change with these business models.
+ The digitalisation process transforms the role and positioning of the company in the value chain, changing also the relations, partnerships and alliances with the other stakeholders.
+ The digital transformation requires new internal skills and professional expertise that can be acquired in hiring new personnel or training the existing human resources (e.g. embedded engineers, computer scientists, data analysts, system administrators, etc.).
+ Globally, a cultural change, a shift towards flexibility and to a more service-oriented and IT-based production, operations, management, sales, etc. is required in the organisation.

Fig 1 — IoT global revenue share (2025-30)
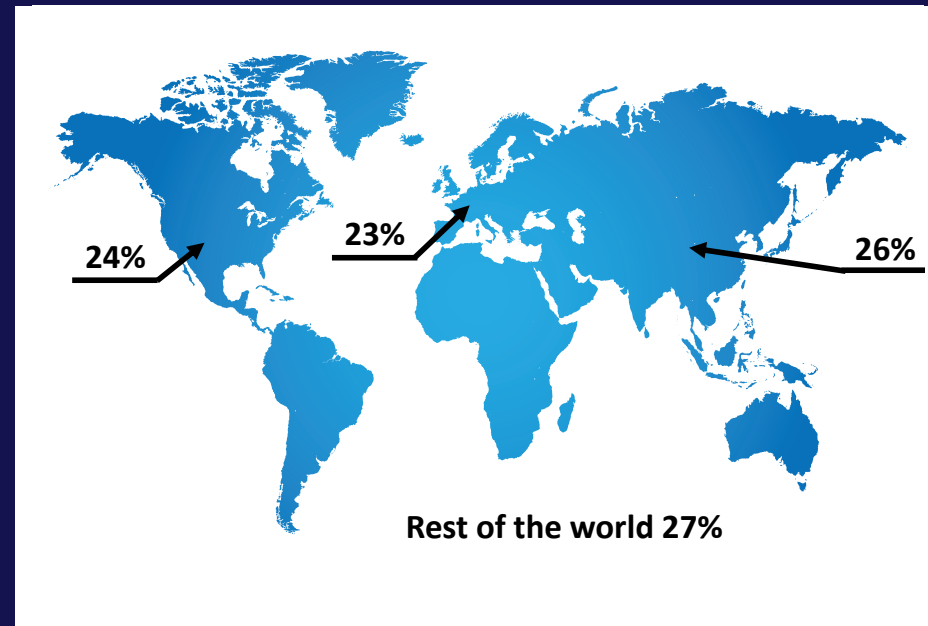
A large part of the population has been forced to adopt smart working, which is already an enabling technology per se, to ensure the continuity of work activities, the primary factor in supporting the economy. Without smart working, the freefall of the global economy would had been disastrous. But smart working requires transparency, in almost any aspect of daily activities, for the employer that needs to know employee whereabouts, conduct and health conditions, for the supply chain to track and verify the origins, status and quality of goods, for companies to ensure the trusted remote execution of decisional and operational processes, manufacturing activities, etc.

IoT devices and the IoT infrastructure also allow companies and people that are not or cannot be digitally connected to be easily reached. IoT adapters or retrofit solutions combined with the latest communication technologies also bring the IoT functionalities and benefits to rural and inaccessible areas.

NEED FOR AUTOMATION

The remote execution of working activities is just the tip of the iceberg that hides the area where IoT could experience more significant market acceleration: automation.

COVID-19 requires primarily social distancing and, in the working environment, this means a first step towards reducing the human presence in everyday activities and substituting it with automation. Automation is commonly perceived as a potential obstacle to employment but, in global crisis like a pandemic, it becomes an ally to substitute humans in dangerous tasks (e.g. in hospital) and, more importantly, it ensures the continuity of processes that would stop without a human presence. In a pandemic, automation is a key factor in keeping the economy engine going. From hospital, to administration, manufacturing, logistics, etc. the availability of robots (both intelligent agents and real robot) could ensure the resilience of the society and significantly accelerate the recovery. Significant investments are expected to characterise the automation domain, in any vertical market area: production line automation, use of drones for delivery, surveillance and monitoring, connected robot for cleaning and disinfecting, etc.

Remote execution could significantly take advantage from IoT-based augmented reality that, in conjunction with automation, allows the possibility to remotely execute complex tasks in many working areas, including production, maintenance, logistics, etc. IoT-based augmented reality could contribute to sustaining all the manual activities that require an individual.

AGILE SUPPLY CHAINS

But ensuring the continuity of processes is not enough, because processes can only run with a working supply chain, providing the required goods, whether virtual goods (information) and/or physical goods. The supply chain has been seriously affected by the pandemic due to transportation restrictions, increased lead times, reduced manufacturing capacity, unavailability of goods, staff reduction, etc[2]. According to a recent survey, more than 75% of the organisations in the selected sample experienced ruptures in the supply chain and more than the 80% "believe that their organization will experience some impact because of COVID-19 disruptions"[3]. 39% of the respondents reported a severe impact in April and 22% experienced an average revenue reduction of 16% already in February. The disruption of supply chains is clear evidence that a new strategy must be identified and IoT could inspire new solutions for supply chain diversification, real-time supply chain monitoring and business model adaptation. IoT-based manufacturing plants, inventories and goods tracking cut the geographical distances, increase the number of potential suppliers and diversify the sources, contribute to costs reduction and globally improve the resilience and the "agility" of the supply chain. Moreover, IoT allows the virtualisation of assets that is fundamental for business based on multi-channel operations to unify them under a single commercial platform independent of the specific channel. This improves business flexibility and agility, specifically during crises. Virtualisation even allows the creation of an end-to-end digital twin of the supply chain, enabling the virtual exploration of different suppliers, the assessment of risks and the identification of the best trade-offs to avoid supply chain disruption.

IoT also allows the adoption of business models that contribute to supply chain flexibility and resilience, for example adopting the procurement of large categories of goods as a service, a solution that relieves the balance sheet of these costs, transforming them into operating costs.

TRACK AND TRACE

On the consumer side, apparently the interest for IoT "traditional" applications has faded during the lockdown, while the market of connected monitoring devices for mitigating COVID-19 effects and profiling people at risk has exponentially increased and is expected to grow at this pace. This part of the IoT market is literally exploding, with any kind smart device: pendants or bracelets to ensure social distancing, smart thermometers to produce daily maps of people having fever[4], smart watches to provide constant monitoring of people's vital parameters[5], smart air conditioners, smart access controls, smart water and beverage dispensers, smart locks, … even unimaginable IoT-native buttons[6], which are battery operated and connect directly to the LTE network to send instant alarm in hospitals or sensitive places.

But the large clamour and interest raised by tracking applications is demonstrating that IoT-inspired solutions have the right time-to-operations, flexibility, geographical coverage, pervasiveness, efficiency, etc. to become reliable "first responders" in crisis and global disasters. In record time, covering 131 countries, Google has been able to release periodic reports that "use aggregated, anonymised data to chart movement trends over time by geography, across different high-level categories of places such as retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential"[7]. Also in this context, smart objects such as smartphones, smart watches or wristbands are helping to monitor the health of infected people and ensure they are correctly following the quarantine process: a study[8] of the data collected by wearable devices (e.g. resting heart rate and sleep duration) demonstrated that is possible to monitor and promptly discover influenza trends.

SMARTER HEALTHCARE

More generally, IoT has proven to be fundamental for the entire healthcare sector, specifically in all the countries that are experiencing a crisis in their healthcare system, with rising costs, long waiting lists and inadequate infrastructures. In

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these countries the adoption of connected healthcare is slower than expected but the current pandemic will certainly push the sector to adopt IoT-based solutions. IoT has already found its positioning in the healthcare market with a wide range of applications, telemedicine, remote imaging, patient monitoring, drug administration and delivery, medical personnel monitoring and assistance, connected ambulance, etc. The healthcare sector is expected to record significant investments in the short term, along the entire value chain, specifically for technologies that will contribute to monitoring and managing future COVID-19 outbreaks and pandemics on a large scale:

+ Telemedicine services help doctors during the pre-screening and diagnosis phases, reducing the number of phone calls to hospitals and allowing to start the intervention procedures only when strictly needed. Smart personal assistants[9] (both devices and mobile app) are currently being updated to support COVID-19 specific questions, initiating the triage at home, reducing the workload and allowing doctors to focus on patients' treatment rather than on phone calls.
+ Self-driving robots and automatic disinfection systems use high-intensity UV rays and special disinfectants to clean, disinfect and sanitise hospitals. Drones and autonomous vehicles are deployed to monitor and disinfect highly contaminated hot spots, or to deliver medical samples and quarantine material.
+ At home, in hospitals, in public spaces IoT devices provided with a touchless interface can contribute to reducing the diffusion of the virus that typically can be found on doorknobs, handles, light switches, mail, packages, etc.
+ IoT devices equipped with GPS, RFID and QR code are deployed to create virtual perimeters to define safe (or dirty) areas and control people's movements and their observance of quarantine restrictions.
+ Remote monitoring is fundamental for the creation of safe locations outside hospitals (e.g. care homes, hotels, unused buildings, etc.) where patients can safely recover, releasing the pressure on essential health services and intensive care units.
+ Remote monitoring is possible thanks to IoT

connected devices specifically conceived for the healthcare sector, such as smart thermometers, blood pressure meters, smart inhalers, glucose meters, automatic drug dispensers, etc.
+ Monitoring the environmental parameters and the air pollution is also fundamental, because the relationship between environmental pollution (e.g. PM 2.5) and the impact of COVID has been demonstrated[10].
+ Eventually, the large amount of data generated by IoT devices is extremely important in monitoring and tracking community-level data to understand the global evolution of the pandemic.

Monitoring and tracking the health of passengers will be fundamental for the transportation sector that has been hard hit by the pandemic, specifically air transportation that has been reduced by 70-80% and is expecting a long period of uncertainty.

THE TRANSPORTATION CONUNDRUM

In the transportation sector, another vertical market that has been particularly hit by COVID-19 is automotive, an area that offers huge opportunities for IoT: with annual investments of around EUR 57.4 bn in research and design, the automotive sector is already Europe's largest contributor to innovation, but it is that similar investments cannot be sustained in the next 2-3 years, also considering the delicate situation of this market before the pandemic. The significant reduction of investments will certainly impact on the evolution of the automotive market, oriented towards a scenario based on fewer vehicles, extremely efficient in terms of autonomy, functionalities, emissions, sustainability and costs. According to a recent study[11], the annual sales of connected cars is experiencing and will experience a significant decrease (EUR 30-35 m in 2020 and 40 m in 2021), to gradually realign to pre-COVID estimations only from 2025. The automotive industry has been forced to an almost complete shutdown of production (around 60,000 vehicles per day), therefore any technological solution, including IoT, that could contribute to restoring the supply chain

and resuming the production is fundamental for this sector. Unfortunately, sales in the automotive market are also influenced by other direct factors such as the budgets of consumers, of businesses and governments that will be significantly reduced, with a direct impact on sales and R&D investments. The consumer's reduced budget will translate into demand for less expensive cars, provided with minimal features and fewer services such as IoT, while the reduction of R&D budgets will impact on the space available for IoT projects with respect to other projects in areas like emissions reduction and electrification. IoT projects for connected cars will certainly be delayed or even abandoned, while IoT projects supporting electrification will probably see acceleration in a second stage. Consider that in recent years the costs required for the introduction of new concepts and vehicles in the automotive market have been significantly increased. In similar conditions, the collaboration between the stakeholders of the value chain is fundamental to sharing the costs and increasing the interoperability of the developed technologies and solutions. The diffusion of connected cars based on IoT technologies will also depend on the available connectivity infrastructure, a sector that requires the presence of public investments. The 5G network will play a key role from this perspective, ensuring the network coverage required by IoT solutions provided in connected cars.

STAYING CONNECTED

Hyper-connectivity is indeed a crucial factor for recovery and resilience in future crises. During the lockdown, the global communication networks have been subject to an unprecedented real test that no one would have ever imagined. The results of this test, which almost everyone has experienced directly during lockdown and smart working, are extremely positive and encouraging: many issues have occurred, but the overall communication networks held up. Luckily, unlike common Internet applications (e.g. stream TV, teleconferences, music, etc.), IoT has been conceived to ensure optimal use of the connectivity bandwidth, requiring a small data throughput although multiplied by millions of data sources. The global amount of

data transmitted by IoT applications has not significantly increased during the pandemic and will not affect the global connectivity network, due to the efficiency of the existing IoT solutions: during lockdown, millions of existing IoT devices have been remained connected and continued to operate normally. However, the evolution of the IoT market in certain applications could encounter practical obstacles related to connectivity. For example, the healthcare sector could experience deployment issues of IoT solutions due to gaps in Internet's geographical coverage and the limited command of technology in certain categories of final users. This is particularly true for elderly people that represent the category most exposed to the COVID-19 effects and that typically do not have a good "relationship" with technology: to solve these issues, the IoT solutions must provide a sort of "plug and play" deployment and installation methods, and include also the connectivity service. Once the device is installed and connected, it is simpler to interact with the user and help him/her to correctly operate it, improving the user engagement, the quality of the service provided and of the information collected.

PRIVACY AND SECURITY

But more connected devices also mean more risks for security and privacy, with a potential significant reduction of the overall trust in IoT solutions. This is particularly true for the healthcare sector that significantly benefits from IoT solutions but, at the same time, is also more exposed to security and privacy risks due to the sensitivity of transmitted information. A recent study from Checkpoint Software Technologies[12] highlights a global increase of cyberattacks during the pandemic. According to the study, the leading threats identified during the last months "was phishing (55%) followed by malicious websites purporting to offer information or advice about the pandemic (32%).", but also an "Increases in malware (28%) and ransomware attacks (19%) have also been noticed." Similar results have been reported by Symantec[13]. Regarding privacy, the GDPR represents a limitation in the crisis that needs prompt reactions and technological solutions that, due to the urgency, require a reduction of privacy: the success of a tracking application that significantly contributed to containing

the virus in some countries (e.g. China and Korea) could be difficult to replicate in Europe, due to the privacy limitations introduced by the GDPR. If the price of saving hundreds of thousands of lives is a reduction of privacy, it is morally correct to pay the price. More generally, the increase of cyberattacks, the new vulnerabilities and the growth of information exposed to privacy issues will consequently increase the demand for end-to-end trust solutions, for new strict security standards and for new regulations.

END TO END

The concept of "end-to-end" brings us to consider the market of IoT platforms, which are fundamental to increasing the resilience of supply chains, asset management, production and the processes of organisations. IoT platforms have the primary role of orchestrating the entire IoT infrastructure, therefore they represent the primary "tool" to ensure the continuity of every kind of operation. Indeed, the prominent functionality of IoT platforms is remote monitoring and control, which is fundamental to reducing human interactions and thereby ensuring the continuity of operations. IoT platforms also allow the deployment and maintenance of IoT devices to be simplified and optimised: for example, provisioning services accelerate the deployment while fully automated software updates completely eliminate the necessity of a maintenance operator. A recent study[14] indicated that IoT platform revenues reached USD 55 bn in 2019 and are expected to reach USD 66 bn already in 2020, with annual growth of 20%. This part of the IoT value chain will follow the trend of the global IoT market, whereby the IoT platform is an integrated and fundamental component of IoT solutions. It will be difficult to maintain this trend in the long term, therefore platforms providers will need also to adjust their strategies in order to capitalise and consolidate this growth. For example, it will be fundamental to improve and broaden the functionalities and features offered by IoT platforms to support the integration/inclusion of legacy systems: considering the potential role of IoT solutions in the recovery phase and in future

Fig 2 — IoT connected devices (2025-30)

Source Transforma Insights 2020
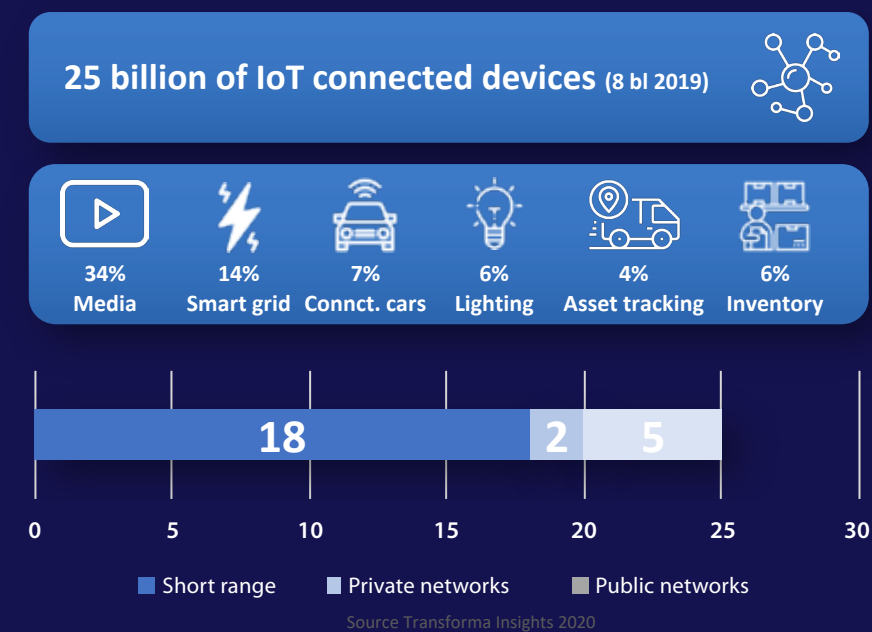
resilience, it is fundamental to maximise the number of vertical domains and related value chain that could benefit from IoT technologies. The support for legacy systems goes in this direction and opens up to IoT technologies an immense market, enabling recovery and resilience at reasonable and sustainable costs. The healthcare sector, with telemedicine, connected healthcare devices and vast non-digitalised assets that could be enabled by legacy functionalities is estimated to be a driver for the future growth of IoT platforms in the short term. Manufacturing and supply chain management will follow, influencing the growth also in the long term.

MARKET EVOLUTION

The market analysis illustrated in the whitepaper "From Internet of Things to System of Systems"[15] provides estimations that are generally confirmed by recent studies and that could evolve as an underestimation due to the global pandemic crisis that will offer new and unforeseen opportunities for all the stakeholders involved in the IoT value chain[16]. The studies remain conservative, in order to "absorb" the fluctuation of the current critical moment, with a number of connected devices estimated to reach 24-25 billion by 2030 (the previous estimations indicated 2025-2026) with a CAGR of the 11% and a predominant presence of cellular connections. The estimation of the global revenues is confirmed at USD 1.5 tr by 2030 (USD 1.1 tr by 2025), with a geographical share evenly distributed: 23% Europe, 24% North America, 26% China and 27% in the rest of the world. Figure 4 provides an estimation[16] of IoT revenues in a set of vertical domains complementary to the ones considered in the withepaper[15]: globally none of the considered verticals is expected to witness a decrease their growth in the medium/long term, while in the short term it depends on the vertical in which IoT is adopted.

To take an example, with respect to the pre-pandemic estimations, the automotive sector with connected vehicles is already experiencing a significant drop in its growth trend (from 30% to 15%) that will be confirmed in the short term. A similar trend
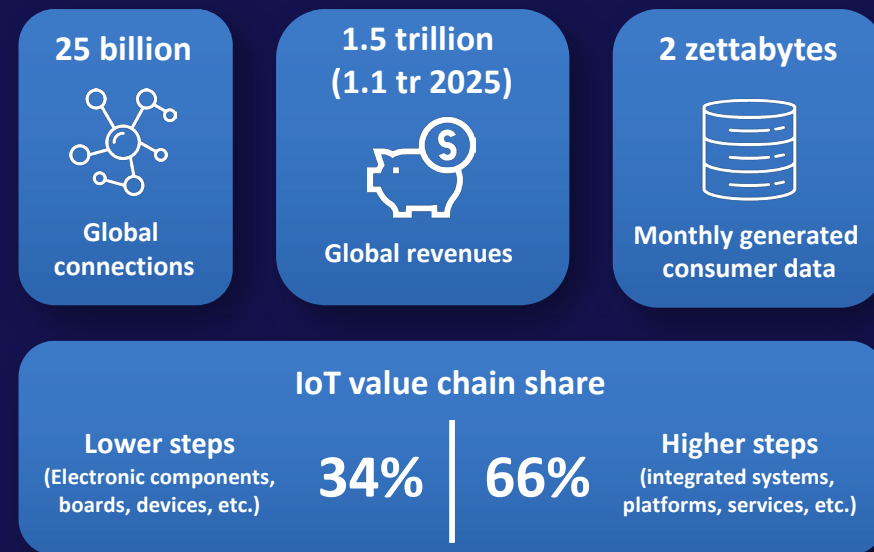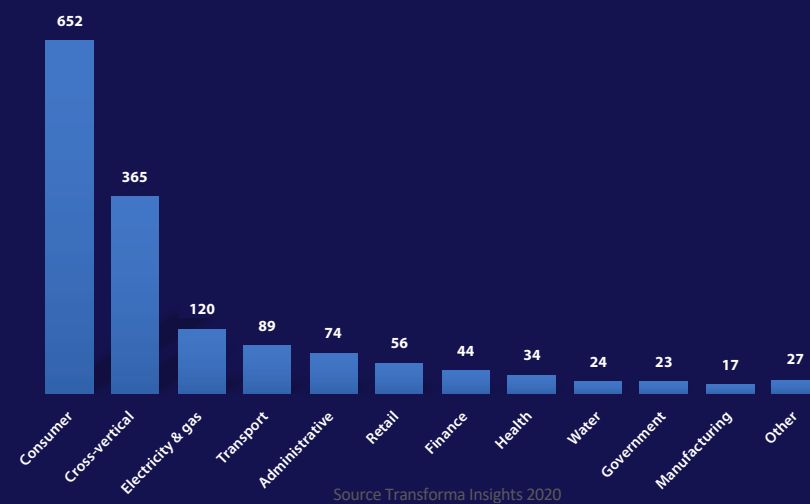
Fig 3 — IoT global estimations (2025-30)

25 billion
Global connections

1.5 trillion (1.1 tr 2025)
Global revenues

2 zettabytes
Monthly generated consumer data

IoT value chain share

Lower steps (Electronic components, boards, devices, etc.) **34%** | **66%** **Higher steps** (integrated systems, platforms, services, etc.)

Fig 4 — IoT revenue share by vertical (2025-30, billion))

652 Consumer
365 Cross-vertical
120 Electricity & gas
89 Transport
74 Administrative
56 Retail
44 Finance
34 Health
24 Water
23 Government
17 Manufacturing
27 Other

Source Transforma Insights 2020

is expected for the entire transportation market, with extreme drops for air transport, for which it is very difficult to provide future predictions. Another sector that has been strongly hit is building automation, with a drop of 15% already in 2020, due to the global lockdown of business premises (both existing and in construction) and a similar trend in the reduction in revenues is expected for portable information terminals, payment systems, smart parking, smart meters (the smart grid sector is already experiencing a revenue reduction of 17%) and in general for all the IoT-based solutions that have been affected by the supply chain disruption, by a low level of production and by deployment issues due to the lockdown. All these sectors

are excepted to slowly realign to the previous estimations starting from 2021.

In the short term, a significant boost in the growth trend is expected for consumer products (specifically for health), for the healthcare sector, for manufacturing and for the supply chain automation, that is, for all the primary sectors of our society and economy that require a fast recovery, continuity and a significant transformation to improve the resilience in future crises. The pandemic has also highlighted the fundamental role of agriculture during a crisis and, supported by IoT technologies, smart and automated agriculture is expected to definitely take off in the next 2-3 years.

Fig 5 — COVID-19 effect on connected products in 2020 and short term

-15%

-17% Smart grid

Short term
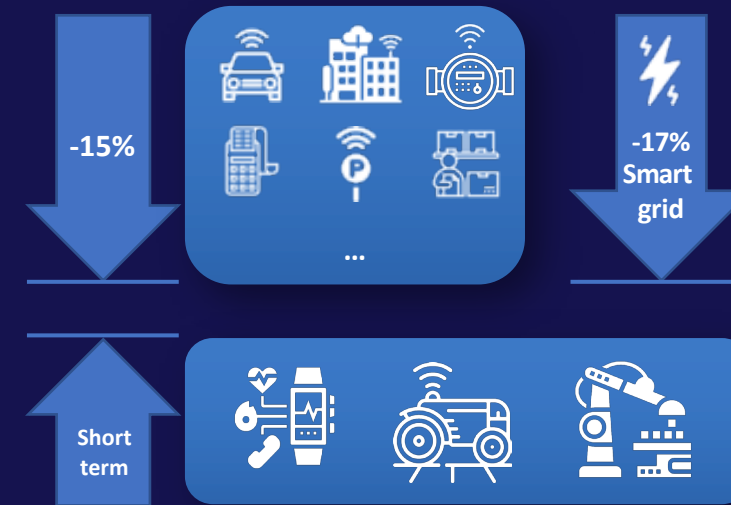
READINESS FOR RECOVERY

In this panorama, organisations are relying on the digital transformation to speed up recovery and ensure long-term growth, although the digitalisation road maps will probably be completely re-shaped to face the new challenges generated by the pandemic and to comply with potentially reduced budgets. Starting a new digital transformation project is not an easy task, because of the uncertainty of the potential return and due to the lack of familiarity with IoT technologies among many organisations. According to Gartner[17], already in 2019, 82% of interviewed CEOs have planned digitalisation initiatives to improve their business and certainly this percentage will increase due to the pressure generated by the pandemic. To confirm the value of this approach, if we consider the recession during 2008-2009, the organisations that better resisted the crisis and that were able to quickly recover continued to invest 5-7% of their IT budgets in digital transformation projects during the recession : trying to anticipate the future creates a competitive advantage that can be promptly exploited as soon as the conditions allow it, but it also lays the foundation to support and consolidate long-term growth. Currently, most organisations is still in the "triage" phase, trying to assess the situation, define budgets cuts, reduce the head count, lower operational costs, sell assets and set up contingency and recovery plans: when significant revenue

drops are expected, organisations enter a sort of "conservative mode". Despite the tendency to stay conservative, in the "triage" phase it is fundamental to continue to invest in the digital transformation and avoid stopping the related projects, in order to be ready for the recovery phase. It seems unreasonable, but the lockdown and the shutdown of many operations and processes allow the organisation to find time to identify new paths to innovation and business growth. Eventually, the recovery phase will require a readiness to fulfil the restarted customer demand that, although growth can be expected to happen slowly, will benefit greatly from IoT solutions. The impact of the pandemic is and will be so serious that a return to complete normality is not expected very soon, extending the lack of budget and resources for IoT projects to the rest of 2020, but in the long term investing in the digital transformation will be fundamental to improve resilience and reduce the effects of future crises.

The direct lesson we can learn from COVID-19 pandemic is that solving immediate problems is not enough if the adopted solution doesn't prevent their presence again in the future. IoT will play an important role in containing and treating COVID-19, but it is also the right solution to monitor, prevent and control future pandemics.

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