GLOBAL REPORT

INTERNET OF THINGS, INTERNET OF APPREHENSION

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Internet of Things, Internet of Apprehension

The IoT has much to recommend it – but we need to set our sights higher

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Around the farms and building sites of India, in February 2016, a British manufacturer of agricultural and construction machinery, JCB, declared a joint triumph with one of India's top IT services firms, Wipro Ltd, of Bangalore. Together, the two companies had built JCB a telematics system named Livelink. Through cloud-based IT services provided by Wipro, Livelink connects up to 10,000 JCB vehicles, from backhoe loaders to excavators.

Livelink here hints at four key dynamics surrounding the IoT. Backed by cloud computing and internet connectivity, online condition-sensing devices *can help a company sweat its physical assets harder.*

> "[Livelink] *allows* JCB to remotely monitor the real-time health and performance of JCB assets in the field. The predictive capability of the platform helps all stakeholders to collaborate in ensuring operational availability of the asset… maximizing the value derived from it. The geo-fencing feature prevents misuse and theft of assets, while allowing asset owners to enforce contract compliatnce."

With the IoT there is also the chance to predict the future reliability of machines and components, and thus better organise *machine and component maintenance,* whether that maintenance be of JCB vehicles in the field, turbine engines in power stations or jets, or pipes for oil, gas and utilities.

Third, the IoT is all about *threats to and disputes about the ownership of assets – where those assets are physical, but are also held to consist of data, its security, its privacy and its worth as intellectual property.*

Last, the IoT is about not just the difficulty of establishing common IT standards, but also *compliance* with commercial contracts and with *state regulation.* Typically enough, the European Commission may shortly say how it intends to regulate the IoT, particularly around data protection and privacy.

The good news

In fact the IoT has more potential than these four dynamics suggest. For example, it isn't just about sensors; it can be about remote-controlled actuators, capable of changing the physical state of a thing – perhaps, in future, modifying the shape of a JCB shovel or bucket. Also, transport applications, where the Things in the IoT are in motion, are important not just in and between cities, but also, as the JCB example shows, in agriculture and construction. Transport applications of the IoT figure, too, in extractive industries, manufacturing, and marine freight.

In the old days, IT modeled reality. Now, with the IoT, IT can be integrated with reality. Are our existing models of IT and reality adequate to get the best out of what will gradually become a tagged world? As a spur to finding the answer to this question through new experiments and prototypes, the IoT is good news.

In The Internet of Things: Mapping the value beyond the hype, a 144-page report published in June 2015, the McKinsey Global Institute (MGI) also nods at the *impetus to innovation* that the IoT might provide. Sensors, it notes, don't only help companies improve the performance of machines; they can also help firms *redesign machines to do even more.* Indeed in extractive industries, the MGI identifies a category that it calls 'IoT-enabled R&D'. Sadly, though, this turns out just to mean developing new components that 'avoid specific failures and eliminate unused features'.

The bad news

It's a bigger mistake to overestimate the IoT than to underestimate it. For despite its good points, the IoT is not about doing more, new things with more, transformative investment, but about doing less with not much investment, and preventing things from going wrong.

For all the hype around it, there's little that's genuinely expansive or optimistic about the IoT. It is about saving money, taking precautions and mitigating risks. The IoT sums up the limited ambitions and nervous perspectives that dominate today's low-investment world economy. It wants not to be big and beautiful, but to be cheaper, safer, and Greener, too. In transport and the important area of 'smart' cities, the IoT wants to smooth out imbalances between supply and demand through traffic control; to counter losses in electricity and water supply, and, more generally, to manage demand downward. In 2016, therefore, the IoT slots into a utopian and reactionary approach to IT, transport and cities that goes back all of 40 years.

The *investment problem* with the IoT is not that, as the MGI holds, there could be a *lag* between investment in the IoT and the productivity gains reaped from that investment. The problem is rather that the investments required to gain IT leverage from ageing physical systems already seem beyond the means, or rather beyond the will, of many large companies and governments in the West. That's why the MGI harps on about how the *costs* of the IoT still need to keep on dropping – the costs of sensors, RFID tags, batteries, short- and long-distance data communication links, computing, storage, data analytics and data visualisation. It's why a report by the Economist Intelligence Unit says that the jury remains out on how long the transformation of manufacturing by the IoT will take, even though the analysts hint at 20-30 years. It's why the IT forecasters IDC say that:

> Without supporting systems and infrastructure, sufficient functionality, standards, and services to manage and analyze the influx of IoT systems connecting without human interaction and the data they generate, growth will be slowed as enterprises stall deployments.

Indeed, if broadband, GSM and Wi-Fi service in Europe continue to be weak over wide areas, prospects for the IoT will also turn out weak.

Throughout Western economies, the IoT isn't being driven through consistently. Why? Because for capitalism finally to organise all its ageing Things, which are equipped with really old clunky 'legacy' IT, does require a bit of investment. After all, to improve the data security of those Things, you first have to improve their physical safety. And then there's all the Big Data you accrue from the IoT, since Big Data and the IoT go hand in hand. To make sense of your data, you have to hire clever data analytics people. In turn, organising them is no small matter. And all of this, please note, is just about applying the IoT to existing Things, even if the extra task of incorporating the IoT into innovations might well prove easier than retrofitting it.

Nor is any *skills problem* around the IoT quite what the American management guru Michael Porter imagines. In the *Harvard Business Review* of November 2014 and October 2015, Porter writes at length, with the help of software entrepreneur James Heppelman, about the IoT. The two argue that, because of the IoT, skills in manufacturing will shift

> … from mechanical engineering to software engineering, from selling products to selling services, and from repairing products to managing product uptime…. Manufacturers will have to hire experts in applications engineering, user interface development, and systems integration, and, most notably, data scientists capable of building and running the automated analytics that help translate data into action.

The authors add that, in R&D around new products, IT 'must assume a more central role'.

Yet it may be time not so much for mankind to subordinate the physical world and R&D to yet another going-over with IT, as for IT professionals to start learning a lot more about the tangible domain of Things, and about the R&D that surrounds Things.

In the West, innovation has for years been reduced to innovation in IT. The IoT now marks a welcome return of IT from the virtual domain to the more grounded and much wider reality of Things. Yet, as happens more widely with capitalism today, the IoT doesn't really want to do much with Things. Things are much less tractable and profitable than the world of electrons and software updates. Consider, for a moment, the supply-side shortfalls that today attend the world's rising demand for energy, transport and housing.

At present sentiment prefers the Internet bit of the IoT to the Things bit. So if we are not careful, the IoT will become the Internet of Parsimony and Apprehension. Not for nothing does the MGI document contain no fewer than 23 references to the IoT as *insurance.* Indeed Martin Wolf, the revered chief economics commentator at the *Financial Times,* has singled out insurance as being an industry whose technological transformation by Big Data – and, thus, as we've said, the IoT – is likely to have 'the most striking effects'.

Consumer applications – and predictive maintenance

Media coverage of the IoT has moved very slowly. The refrigerator that orders more food from the supermarket has become the domestic heating control system, made by Google's Nest, which warms your house before you get home on a winter night. Still, 'smart' meters to monitor and control gas and electricity are not just a media cliché; they have been physically installed in millions of homes around the world, even if the term 'smart' has earned criticism and, in the UK case at least, smart meters have long been estimated to confer few benefits to householders.

Yet consumer applications of the IoT will certainly prove less vital than enterprise or public sector ones. And while the MGI is wrong to extend the category of Things to human beings, it's right to rate quite highly the payoff around people and healthcare providers using electronic means to monitor exercise, 'wellness' and all the rest. The recent emergence of digital therapies, which measure not your heart rate but your mental capacities, shows that consumer applications of the IoT will often be on the edge of defying logic, even if some might actually prove quite sensible.

What, though, are the IoT's main tasks? The MGI makes a big deal of *health* and *safety* in extractive industries, construction, manufacturing and cities, and it's hard to quarrel too much with that. On the cover of the MGI's report, *interoperability between multiple IoT systems* is a highlight, as are IoT-based consumer healthcare products that improve patient adherence to pharmaceutical regimes, cut the costs of treating chronic conditions such as diabetes, and reduce rates of hospitalisation. Inside the report, McKinsey keeps up the emphasis on health. Rather oddly, it waxes lyrical about the savings that the IoT could bring in tracking counterfeit pharmaceuticals.

Yet the MGI offers something else. It also gives cover status to predictive maintenance – moving from 'repair and replace' in equipment to 'predict and prevent'. In factories, data centres, farms and hospitals, predictive maintenance could, the report chortles, cut maintenance costs by 10-40 per cent, and downtime by up to 50 per cent.

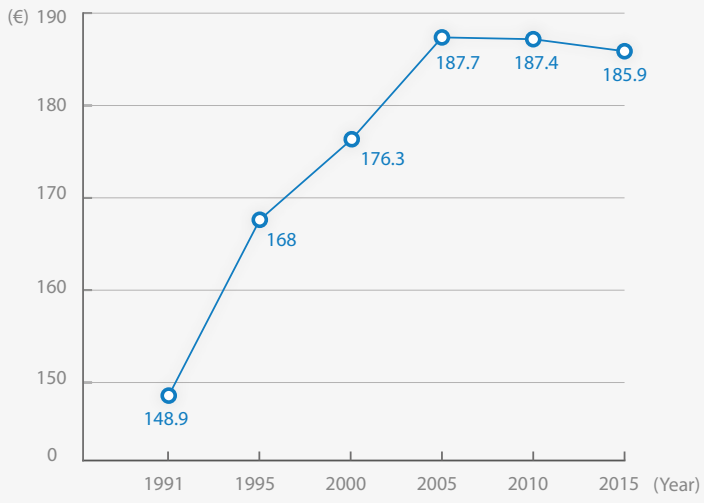
But get this, folks: the MGI says that in these kinds of environments, IoT-based predictive maintenance could do something else. By extending the useful life of machinery, it could 'reduce equipment capital investment by 3 to 5 per cent'.

There we have it. *By anticipating future risks with machinery, the IoT holds out the hope of postponing fresh capital outlays.*

In other words, the IoT could well add further downward momentum to the crisis of capital investment that has come to afflict the West in recent years. The scale of this crisis is well known in America and Britain. So let us, on this occasion, focus on Germany, where investment has traditionally been high, and where, since as early as 2010, the IoT – later embellished as *Industrie* 4.0 – has been the subject of government policy.

Look, for instance, at the net capital stock per head in Germany:

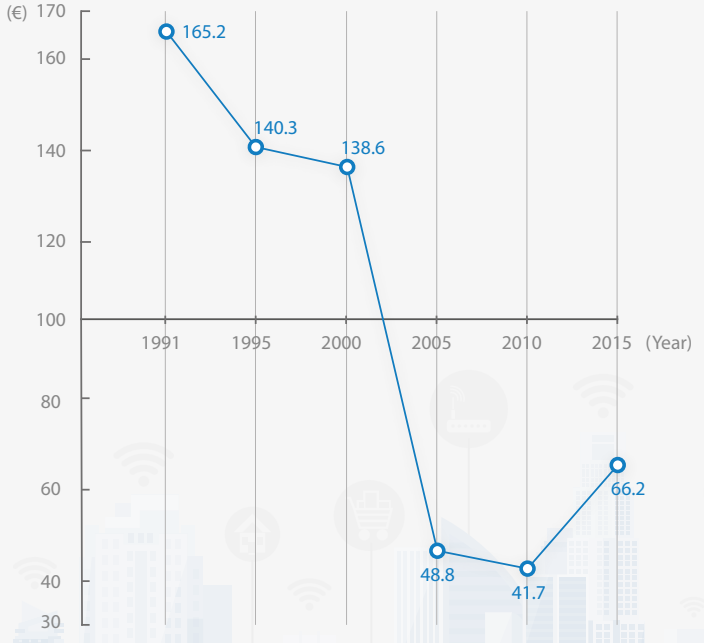
German capital intensity: net capital stock per employee, thousands of 2010 €



Source: European Commission, Economic and Financial Affairs, AMECO database.

It is clear that, after a burst of investment following reunification, the capital investment in front of each German worker has actually *declined* over the past 10 years – by a small but significant one per cent. Worse, with national net fixed capital formation there's a still more dramatic story:

German net fixed capital formation, billions of 2010 €



Source: European Commission, Economic and Financial Affairs, AMECO database.

Capital investment, for decades the mainstay of the German economy, may no longer play the role it once did. Indeed that fact may have contributed to Chancellor Angela Merkel's initial bet, made in 2015, in favour of allowing in more migrant labor to Germany. Either way, German manufacturers and others may well now use the IoT as a means of delaying the replacement of worn-out stock.

Predictive maintenance has merit – not least, in obviating emergencies and disasters. Yet people need to view it in perspective. Annual maintenance costs for plant, as a fraction of plant replacement asset value (RAV), typically lie at 6-7 per cent. Therefore cost savings of 10 to 40 per cent through predictive maintenance will save at most *three per cent* of the cost of replacing capital equipment.

Enthusiasts for the IoT miss this. So long as they do, it will not revolve around raising productivity through substantial new rounds of investment in machine tools, robots and the IoT apparatus to match, but around scrimping on the repair of old machinery.

How very innovative!

'Operations optimisation' – or real productivity breakthroughs?

Among factories, data centres, farms and hospitals, the MGI does, it's true, assign a greater annual economi c impact to 'operations optimisation' than to predictive maintenance. Including 'value captured by customers and consumers' (whatever that is), the MGI's figures are $633-1766bn for optimisation and $240-627bn for predictive maintenance, both by 2025. But how much, exactly, does optimising operations amount to hard increases in productivity? This passage is worth quoting at length:

> With IoT, manufacturers can gain a comprehensive view of what is going on at every point in the production process and can make real-time adjustments to maintain an uninterrupted flow of finished goods and avoid defects. This gives them the ability to view how the end-to-end process is running and address bottlenecks in real time. It also reduces the possibility of human error. General Motors, for example, uses sensors to monitor humidity to optimize painting; if conditions are unfavorable, the piece is routed to another part of the plant, thereby reducing repainting and maximizing plant uptime.
>
> Similarly, in a Harley-Davidson paint shop, ventilation fan speeds are automatically adjusted for varying conditions in order to give an exact and consistent coat.

> In farming, we estimate that IoT techniques – using sensor data to guide a seed-planting machine to the optimum depth based on soil conditions at a specific place in the field, for example – can increase yields by up to 25 percent.

But the productivity benefits described here are much more persuasive in agriculture (25 per cent higher yields) than in car and motorbike manufacture (better paint jobs). Indeed *the productivity effects of IT innovations in general have proved far from consistent,* whether across sectors, geography or time. In this context, the MGI's belief that the IoT could increase productivity by 10-25 per cent not just in farms, but also across factories, data centers and hospitals – this looks too bullish.

Of course, *in individual cases* the IoT can bring about major improvements in productivity. In Western Australia, Rio Tinto now gets hold of iron ore with 69 driverless lorries, mining in ways supervised by a control centre 1000km away. In the process, the IoT has undoubtedly helped improve both productivity and worker safety, even if it has largely done the latter by eliminating workers from the productive process altogether.

Even here, though, Rio Tinto says that automating its lorries allows it to cut the size of its lorry fleets, as well as to cut back (surprise!) on its capital expenditures. So it's worth asking whether the IoT can do more than this – whether it can make an *unmistakable productivity difference,* and make it *right across modern economies.*

Porter is blithe about the general effect of IT on productivity. He believes that corporate computing in the 1960s and 1970s, followed by corporate networks in the 1980s and 1990s, brought 'huge' productivity gains to the US. Now, in a Third Wave of IT, the IoT's transformation of productivity could, according to our Harvard sage, be IT's 'biggest yet'. In fact, though, Porter is oblivious to the reality of US productivity *decline.* In a famous paper published in 2012, Northwestern University professor Bob Gordon showed how productivity had *fallen* in the US after the early 1970s. Indeed, the advent of the PC was not enough to beat countervailing and bad productivity trends in the 1980s and early 1990s. Only the invention of the World Wide Web in 1989 and its adoption by a select band of IT manufacturers, retailers and financial services companies in the second half of the 1990s made any kind of tangible boost to US productivity.

US productivity picked up, perhaps with the aid of IT, over 1996-2004. Yet thereafter the US has had a productivity relapse. Meanwhile, Europe seemed to gain no special productivity advantage from IT. Indeed, as the British economics writer Phil Mullan has observed, in international terms "productivity has failed to grow at all, not just since the 2008 crash but in most places since the early 2000s or before, generating 'productivity puzzle' discussions around the Western world."

No wonder the MGI is a bit ambivalent about the productivity impact of the IoT. It laments:

> Organizations that use IoT technology will need better tools and methods to extract insights and actionable information from IoT data, most of which are not used today. It will take time for companies to create systems that can maximize IoT value and, more importantly, for management innovations, [and] organizational changes… to be developed and implemented.

For just a *single large firm* to integrate IoT activities across its traditional silos is a big job. Now take an oilrig with 30,000 sensors – where, according to the MGI, typically only one per cent of data is currently examined. Well: to devise a common platform for *all* the firms engaged around such a rig is an even bigger job than that of straddling a single company's silos. The reason: even in the narrow field of oil and gas, IT capabilities among different players tend to vary enormously.

Now take a further step: apply the IoT to a still more complex domain like cities. There, the MGI rightly worries about interoperability between IoT systems – how difficult it is, in cities, to integrate and make meaningful data that's drawn from multiple vendors and industries.

From these examples, it ought to be clear that *optimising operations through the IoT will only rarely amount to making quantum leaps in productivity.* Often, 'optimisation' turns out to be about asset utilisation again, or about cutting inventory. As a result, the productivity effects of the IoT are highly variable. And that fact will make IoT adopters even more likely to baulk at the cost of working up all their data in a useful way.

Does the IoT usher in a new era of competition?

Looking at different sectors, the MGI may well be right that it is factories, data centers, farms and hospitals which are likely to draw the most substantial benefits, in terms of predictive maintenance and productivity, from the IoT. Its second candidate for drawing big benefits from the IoT is cities, where the agenda – public safety and health, traffic control, resource management – is much more politically correct than it is in industry, and where benefits are likely to be much fluffier. The MGI doesn't seem to realise that 'smart' cities are already the subject of serious critiques, even among their advocates.

In other sectors, such as retail, extractive industries, construction and transport, the MGI is right to say that there remain major productivity gains to be won. Should they be won, the IoT may, rather in the manner of Amazon, prove to be a force for deflation. Yet productivity and even deflation are not the main things exercising our IoT experts. As part of the general overestimation of the IoT's significance, the MGI is adamant that it will 'drive new business models' and 'change the bases of competition':

> With the ability to monitor machines that are in use at customer sites, makers of industrial equipment can shift from selling capital goods to selling their products as services. Sensor data will tell the manufacturer how much the machinery is used, enabling the manufacturer to charge by usage. Service and maintenance could be bundled into the hourly rate… The service might also include periodic upgrades (software downloads, for example)…. This 'as-a-service' approach can give the supplier a more intimate tie with customers that competitors would find difficult to disrupt.

Similarly, Porter tells us that the IoT has 'unleashed' – always a weasel word – a 'new era of competition'. It will fundamentally change the boundaries surrounding not just firms, but also whole industries. For Porter, firms now face, because of the IoT, 10 new 'strategic choices', among which we find: what to put in smart, connected products, how much to put in the cloud, whether to make or buy IoT capabilities, what data to capture and how to sell it, whether to have distribution channels or direct sales, and whether to expand the scope of the firm.

It is all entrancing stuff, and we can be sure that the choices facing corporations around IoT are truly and deeply strategic, too. However capitalist obsessions with new business models – different ways of taking money off customers – have a long and ignoble history. Like [illegible], boosterish forecasts about IT remapping the very boundaries of competition are old hat.

Back in 1992, America's William Davidow and Michael Malone had a management bestseller in *The Virtual Corporation*. They argued that firms could now use IT quickly to assemble their resources from outside as required, and so appear bigger than they really were.

But in fact the virtual corporation hardly happened. IT has certainly *assisted* the processes of globalisation, outsourcing and, we might add, teamwork; but it did not begin them. Similarly, China has changed and will change inter-firm competition in America much more than the IoT.

Not long ago, mobile phones were elevated as the key to East European and African economic development, and to the mobilisations of the Arab Spring. Now, while the media go on about connected kettles in the home, real-life installations in the realm of production still often look somewhat primitive – and yet gurus gyrate around the idea that This Round Of IT Changes Everything.

The truth is rather more prosaic. With more of a clean sheet of paper to start with, China (in factories) and India (in logistics) will probably derive more productivity advances from the IoT than the West. As the MGI adds, countries rich in oil and gas – sectors that were among the most important early adopters of IoT – are likely to see a lot more of it. Yet for the most part the IoT is not about to revolutionise the world of wealth creation, any more than 3D printing, robots, drones, Artificial Intelligence or Virtual Reality are poised to do that, either.

The priorities we would like to see

For suppliers of IT goods and services, cybersecurity buffs and the digerati, the IoT has become the pinnacle of the Internet, rather than just one useful application. Not just Wipro in India and Huawei in China, but also, in America, Amazon Web Services, AT&T, Cisco, Facebook, General Electric, Google, HP, IBM, Intel, Microsoft, Oracle and Qualcomm have made big bets on the IoT. So have big German firms such as Robert Bosch and SAP. ARM Holdings, Nokia, Samsung and Sony are active, too.

The problem here is not just industry's usual efforts to make the most of the latest IT boondoggle. The problem is that when experts put electrons and even Things at the top of their priorities, they tend to underrate humanity and its creative powers. Here are four broad applications of the Internet that highlight its humanistic and not so humanistic sides:

1 The Digital Self. To collect data about our digital selves, from selfies through health checks to intimate, 'curated' diaries, isn't quite the IoT. Though it may bring some real medical benefits, this use of the Internet tends towards narcissism, not humanism

2 The Internet of Things in Homes and Cars. In cooking, laundry, personal transport and perhaps even childcare, the IoT may save families money and time. That's a good thing, if it really happens

3 The Industrial Internet of Things. The IIoT has become a term in itself; as a practice, it has the potential, as we have seen, to raise productivity. By 'industrial', we mean anything – including services – delivered at scale

4 The Internet of Minds (IoM). Here, working especially with the IIoT, the world's best thinkers and practitioners could exchange and test ideas in the cause of better and faster knowledge breakthroughs and technological innovations.

This schema isn't perfect, but it does allow urban examples of the IoT; these would typically involve applications 2 to 4, and, perhaps some more rational rather than narcissistic examples of application 1 as well. More important, the schema hints at what the IoM might begin to look like. After all: the confirmation of gravity waves in 2016 amounted to a collaboration of more than 1000 scientific Minds around the Laser Interferometer Gravitational-wave Observatory (LIGO), one of the greatest Things ever hooked up by the IoT.

What then can we surmise about these four applications of the Internet? Right away, it's apparent that today's capitalism orders its priorities in exactly the wrong way – that is, it treats Internet application 1 as the main priority, and regards each of the following three applications – 2 to 4 – as less and less essential. This is a great pity.

To advance the case for an IoM, it's worth returning to the original vision of the World Wide Web. Tim Berners-Lee outlined that vision in 1989, when he was at the European Organization for Nuclear Research (CERN), which went on to build the Large Hadron Collider, "the largest machine in the world".

Is a glance at this vision an exercise in nostalgia? After all, Berners-Lee never mentioned Netflix or Amazon Prime. Yet our point is not to repeat his vision, but instead suggest that it has still to be fully realised.

In 1989, Berners-Lee gave his boss a proposal on "the management of general information about accelerators and experiments at CERN". It complained about the high turnover of staff members at CERN:

> When two years is a typical length of stay, information is constantly being lost. The introduction of the new people demands a fair amount of their time and that of others before they have any idea of what goes on. The technical details of past projects are sometimes lost forever, or only recovered after a detective investigation in an emergency. Often, the information has been recorded, it just cannot be found.

Berners-Lee proposed a solution based on a distributed hypertext system. Had he not done so, the world would not now have the Large Hadron Collider, which investigates subatomic particles, dwelling at the very boundaries of scientific knowledge.

At genesis, the Internet connected together *Minds* – not things, but *human beings doing research.* The idea was that knowledge could be shared, and thus made more profound.

We need to recapture this spirit. Consumer applications of the Internet, applications 1 and 2 above, are OK, but we should never allow ourselves to get distracted by the Internet of Shiny Things. With the Internet of Minds, by contrast, researchers across disciplines could share data and ideas about everything from photovoltaic panels to immunotherapies against cancers.

In astronomy, using the Internet to crowd-source insights from the general public has already paid dividends. Next in line for crowd-sourcing? Look out for the decryption of ancient languages, as well as Earth archaeology done by satellite.

Of course, today's efforts in crowd-sourcing ideas are not enough. In the same way, the recent commitment of more than 30 organisations to share data on the Zika virus is but a step along the road to the IoM. But with a real IoM, researchers, scientists and the lay public can come together independent of geography or discipline, limiting the duplication of work, and taking advantage of the human mind in collective action.

Things are not capable of *knowledge*. Only human *Minds* are capable of that. Naturally, the research that would be part of the IoM needs to be *invested* in – both for its own sake, and in the hopes that IoM research can be embodied in innovations that change the world for the better.

Among the innovations the IoM could furnish would be ways of addressing the elephant in the room with the IoT: its ability – real, or, for the moment, more likely imagined – to deliver the productivity benefits the world so desperately needs.

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