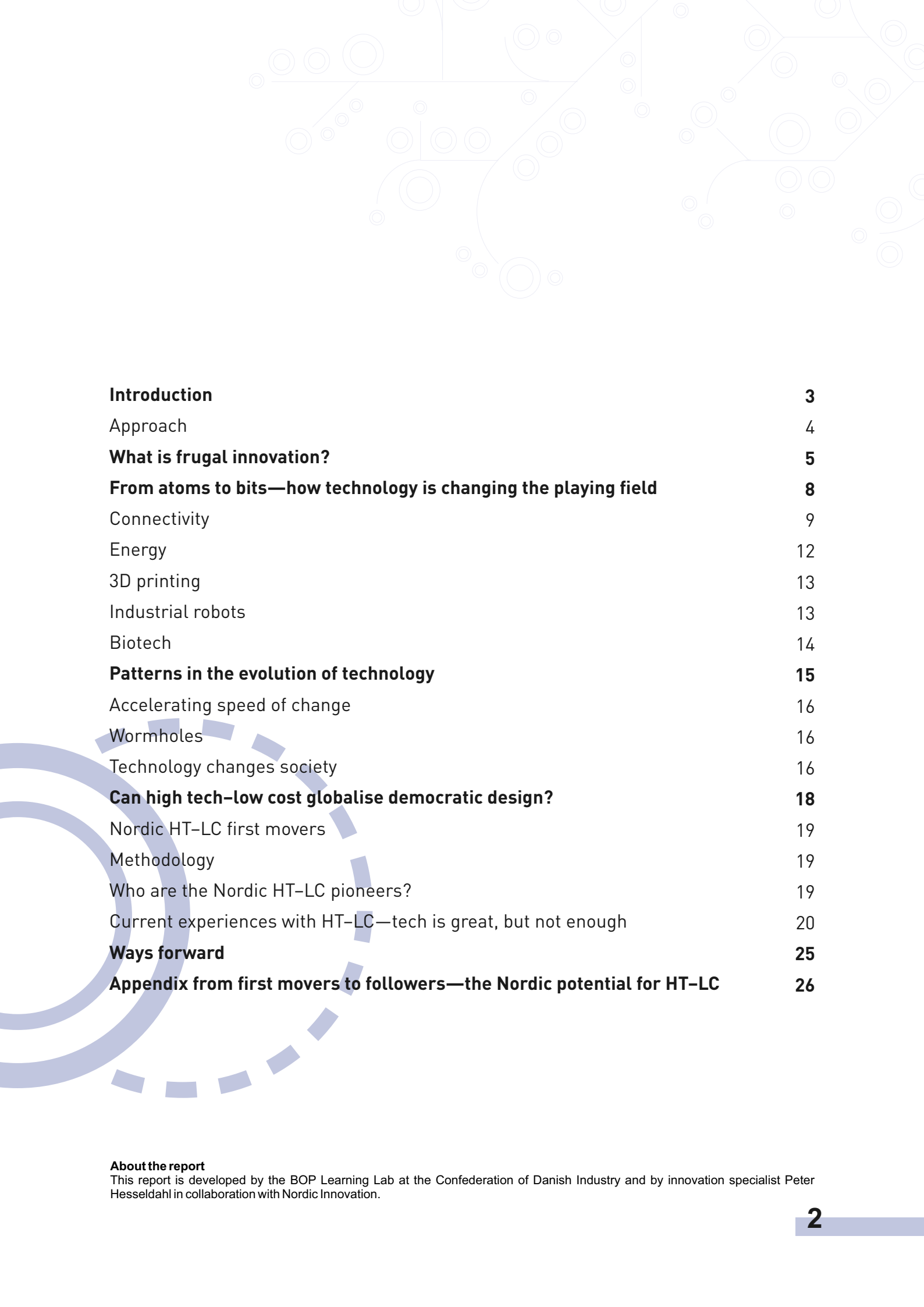




High-Tech Low-Cost solutions

Perspectives for Nordic Companies





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About the report

This report is developed by the BOP Learning Lab at the Confederation of Danish Industry and by innovation specialist Peter Hesseldahl in collaboration with Nordic Innovation.



INTRODUCTION



Introduction

Nordic companies often produce high-value products with a focus on design and technology. While attractive and often innovative, they are also expensive and tend to target the needs and resources of the wealthy. In a global economy where emerging markets are of growing importance, Nordic companies frequently struggle to adjust products and services to the growing middle- and low-income markets. Meeting the needs and aspirations of these segments calls for frugal solutions. In other words, solutions that focus more on 'need to have' as opposed to 'nice to have'—and with target price points and features that match middle- and low-income customers.

Frugal products are often associated with simple and low-tech solutions. This, however, is not always the case. In fact, some of the most advanced services in the world—such as Google search or GPS navigation—cost little or nothing if you, like billions of people from Mumbai to Nairobi do, have a smartphone and access to the Internet. Not only are services such as Skype free, but they also enable other services to be delivered in much more advanced ways. In this way, technology such as the mobile Internet breaks the conventional link between high cost and high value to end users.

New technologies normally start out expensive, and then they reach a stage at which they rapidly drop in price and become widespread. Inexpensive mobile handsets and cellular data connections are still just beginning to demonstrate what is possible. Many other technologically led breakthroughs in price can be expected in the coming years. Solar energy, biotech food and medicine, new materials and 3D printing for local manufacturing are sectors in which high-tech innovations are rapidly maturing and spreading. The development of these technologies enable new products and services that have the potential to reach many new costumers, but they usually demand new business models and tend to cause a shift among the companies that succeed in the market.

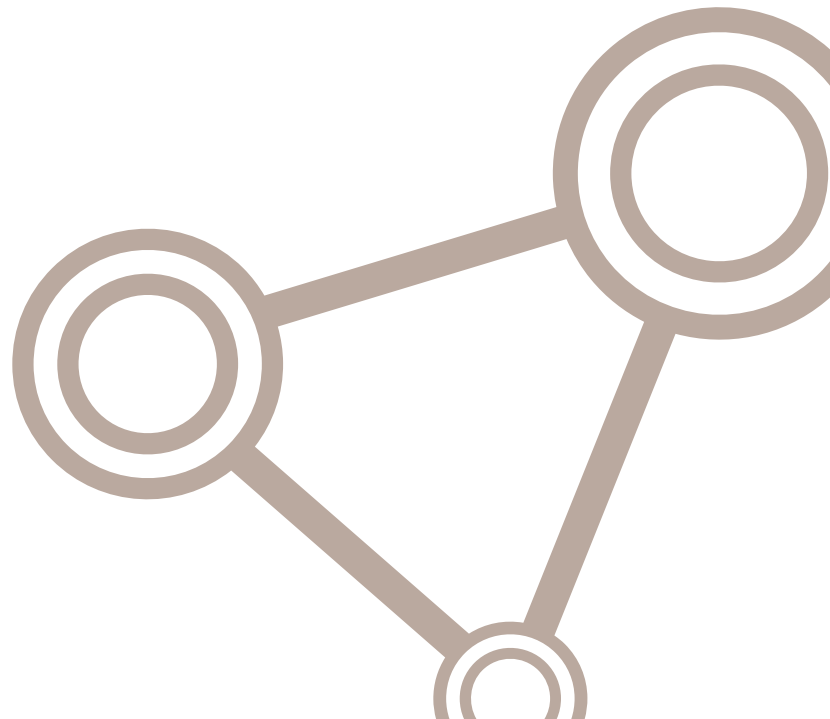
For the most part, Nordic companies cannot compete with low-cost, low-tech products. However, they could compete with high-tech – low-cost solutions (HT–LC). Nordic companies can draw on deep insights and advanced scientific knowledge based on years of experience. Playing off technical trajectories and new infrastructures, Nordic companies are in a unique position to create solutions that are highly sophisticated and offer high utility to the end consumer at much lower prices than what has conventionally been possible. This report will look at what it takes to make this possible.

Approach

This report looks at the background and limitations of frugal innovation. Which technologies are changing the playing field for frugal innovation and how will they do so? And what will this mean for Nordic companies? The report concludes with suggestions for ways forward. The report is based on the experience of the authors working with innovation, technology, and business models targeting emerging and developing economies. This knowledge has been supplemented with a technology assessment and interviews with global experts and companies working in the HT–LC space.



WHAT IS FRUGAL INNOVATION?



What is frugal innovation?

Frugal innovation develops products or services that increase the value to the customer, while at the same time decreasing the cost. The ambition is to enable a larger market segment to reap the benefits. In other words, frugal innovation generates solutions that are affordable yet still of high quality. The first generation of frugal innovations often focused on stripping normal products of functionalities to make them cheaper, whereas advanced frugal innovations re-invent products and develop integrated solutions.

Frugal examples

*In India **Jaipur Foot** has reduced the price of foot prosthetics drastically through innovative design and production methods and efficient processes involving the patient. From a local frugal idea, it has developed into one of the most widely used prosthetic foot solutions globally.¹*

*Across the world, at MIT in Boston, **Biomechatronics** is working on the next generation of affordable and high-quality prosthetic solutions leveraging 3D printing. The hope is that 3D printing can bring down the costs of individualising the prosthetics and widen distribution.²*

Terminology

Frugal innovation is not a new concept; it borrows many components from other innovative concepts from around the world. In India, the process is often referred to as Jugaad innovation. Radjou et al. (2012) described Jugaad as an 'improvised solution born from ingenuity and cleverness'. Here, Jugaad is thought of as an 'innovative fix' to solve challenges when resources are sparse. In China the term Shenzu is used to describe a similar approach. Many aspects of frugal innovation are also an integral component of bottom of the pyramid (BoP) strategies targeting low-income consumers. Appropriate technology is another related term that shares many characteristics with frugal

innovation. It describes technological solutions that are designed specifically for a low-income market context—as opposed to being designed for a Western consumer—and then downgraded or adapted to an emerging market context.

B2B and B2C

*The most famous examples of frugal solutions focus on consumer products, but frugal innovation is also relevant in the B2B sector. When **Tata's** engineers were developing a cheaper seat for the cheap Nano car, they wanted to eliminate the metal base plate that car seats are usually anchored on. To achieve this, they made the frame of the seat wider and mounted it directly on the car frame. The result was fewer material costs, reduced weight and, as it turned out, improved safety in crash tests.*

Innovating under constraints

Innovation and creative problem solving can be enhanced under the right level of constraint. If people have all the resources and money in the world, they often find it hard to be creative. Frugal thinking is based on the assumption that there is an innovative 'sweet spot' at which the right degree of constraints forces innovators to find suitable solutions. For the same reason, it is said that 'innovation happens at the edges'. By imposing the right constraints (a certain price point, certain battery life, certain ruggedness, certain quality), forces inventors to find innovative ways to solve the challenge. Such constraints are embodied in frugal innovation because the lower price point, among other things, is set as a constraint from the beginning. In that sense, frugal innovation is not just about developing a specific product, but it can also be seen as a general approach to stimulate innovation. Ikea, Skype and many other companies are frugal in the widest understanding of the term. Frugal innovation, however, is often associated with developing or emerging economies. The focus of this report is on the potential for emerging markets, including the potential for reverse innovation.

¹ <http://jaipurfoot.org/index.html>

² <http://biomech.media.mit.edu/#/>

³ Also see: <http://www.frugalsolutions.org/More/Redefining-car-markets-Tata-Nano.aspx?&searchString=tata>

Reverse innovation

Although a frugal innovation could be developed by Walmart for US customers, emerging markets have more constraints and more freedom to leapfrog past previous generations of solutions or infrastructures. Some companies strategically use innovations developed for emerging markets in their home markets. Reverse innovation happens when a frugal solution designed for an emerging market finds its way to a developed market. Prominent examples are pay-as-you-go mobile phones, which were initially pioneered by Vodacom in Africa but later found their way to Western consumers. Another example is Facebook's mobile app, which was originally developed to use as little data as possible to make it attractive and fast for African consumers. These developments in turn led to an improved Facebook app, which is now used globally.

Maintaining quality

Frugal solutions should not just a shoddy version of the same product. Rather, a frugal solution should be suitable; users pay no more and no less for what they actually need. Ideally, frugal products or services should be cheaper but not perceived as inferior by the user. It is important to note however that perceptions of quality is context dependent. What might be considered an inferior product to a rich Western consumer, might be considered a technologically advanced product to a person living on a lower income.

ChotuKool is a refrigerator with a 43-liter volume designed for a family. Cooling is conducted using so-called 'Peltier' technology, and therefore it uses only between 40 and 60 watts. ChotuKool can operate from batteries or solar cells. The box is made of plastic, and the entire unit is assembled from a total of 20 parts. The ChotuKool is opened from above, so the cold air stays down in the box. The price is Rs. 3,400 (approx. US \$65). For families with no previous access to refrigeration, the ChotuKool is a significant upgrade.

⁴ <https://www.bebapay.co.ke>

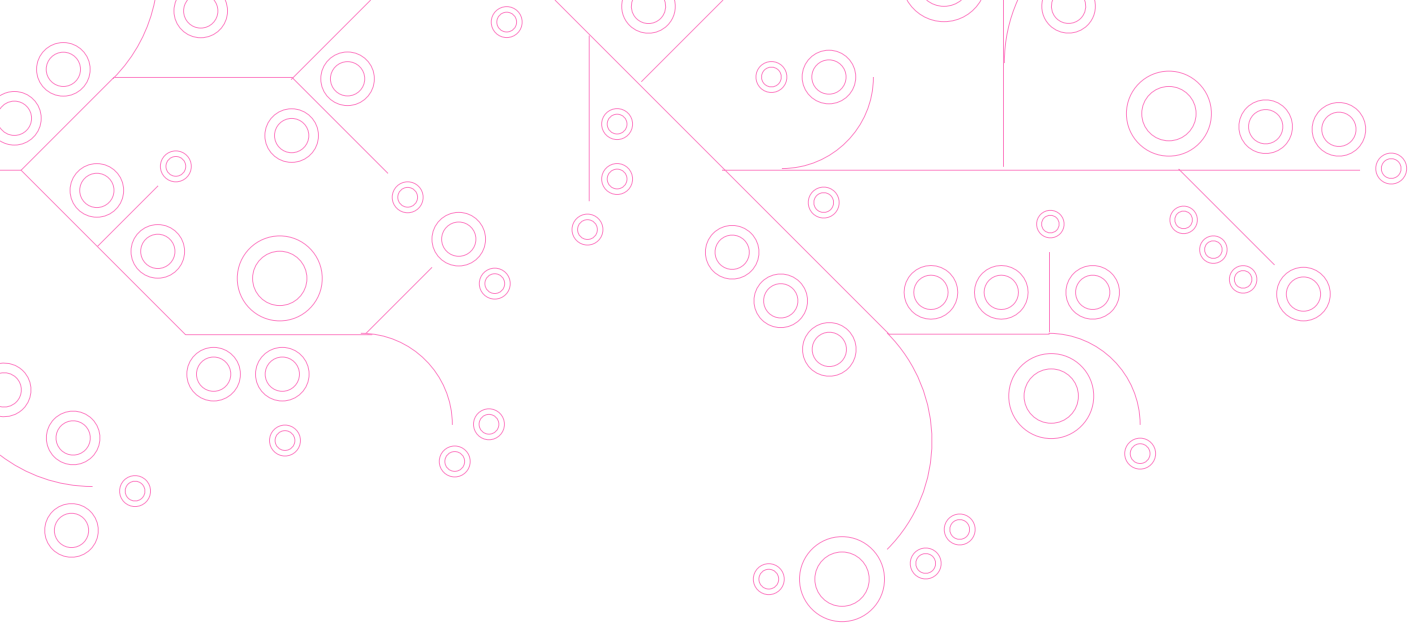
Solutions rather than products

Frugal innovation often results in services and systems rather than just stand-alone products. These solutions are designed by considering the wider context of the user and the usage. By integrating and coordinating several means (products and services) and stakeholders, the solutions often focus on providing utility rather than selling products. Developing such solutions require innovating in terms of systems, such as bridging components, creating standards, organising interaction, or mobilising noncommercial resources. Frugal solutions also often focus on enhancing the business model through new distribution, financing or service models.

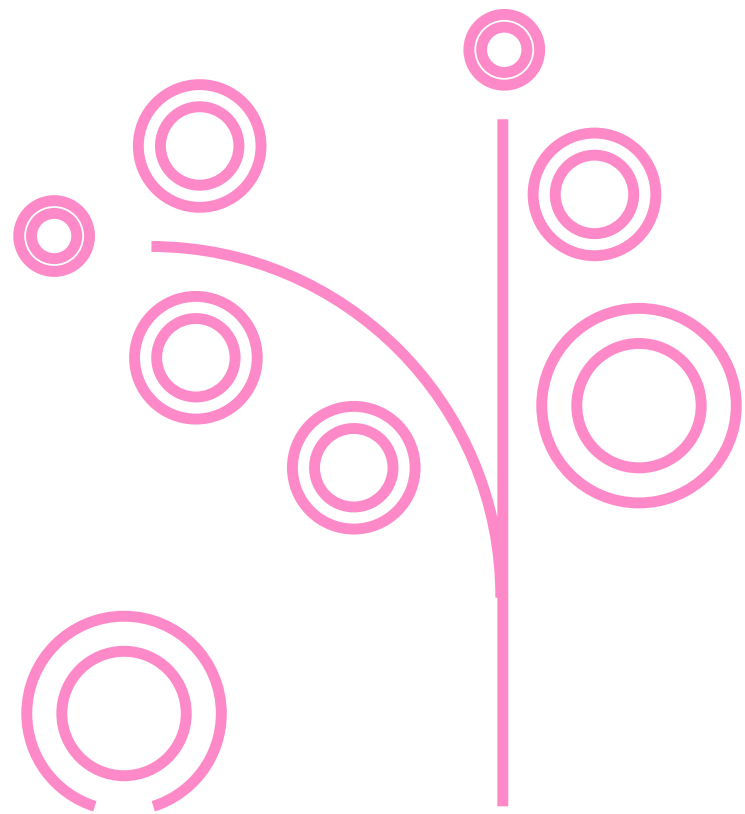
BebaPay is a public transportation payment card similar to the Oyster card used in London's subway. Instead of being used in London, the system is designed for Nairobi's city busses. The conductor has a near field communication (NFC)-enabled cell phone with a BebaPay app. To conduct a payment, a customer presents the card to the conductor, and he or she swipes it. The customer then receives an SMS (short messaging system) confirming the time and the transaction. The card can be recharged using the M-PESA payment system. This innovation targets the mass transit market and links different technologies. It is based on a scalable low-cost version of the much more complex Western systems.

Examples of frugal resources

- Navi Radjou and Jaideep Prades, *Frugal Innovation – How to do more with less*, Economist 2015
- Vijay Govindarajan, *Reverse Innovation*, Harvard Business Review Press, 2012
- www.frugalsolutions.org



FROM ATOMS TO BITS- HOW TECHNOLOGY IS CHANGING THE PLAYING FIELD



Globally, 'atoms' such as natural resources and conventional physical products are becoming more scarce and expensive, whereas 'bits' such as software and ICT products are becoming cheaper and more abundant. The next section highlights key technological developments and their implications for developing affordable products. Which technologies are especially interesting for frugal solutions and what are their price trajectories?

Connectivity

In October 2014, the number of mobile devices in use exceeded the number of people on earth, passing the 7.2 billion mark—and the number is still growing rapidly.⁵

The first wave of mobile phones brought voice calls and texting to billions. Nowadays, the devices sold are increasingly Internet-connected smartphones with touch screens and the power to run all sorts of applications. The next step will be connecting these devices to sensors and machines, using them as general digital tools rather than merely as 'phones'.

Obviously, this empowers users and allows companies to create new services—and not just in rich countries. Worldwide, smart devices and Internet connections are becoming cheaper and better, spreading like an explosion and changing the landscape of opportunities.

A smartphone for everyone

Although high-end smartphones, such as those from Apple and Samsung, still dominate the field, several low-cost manufacturers are taking a growing share of the market with very advanced smartphones selling for 100 USD or less. The Chinese company Xiaomi has now become the world's third largest seller of handsets. Google sells an Android phone for \$90, and Micromax, an Indian brand, sells a \$40 smartphone. Prices are dropping rapidly.⁶

It is expected that 500 million smartphones will be sold in China in 2015.⁷ Meanwhile, the number of mobile phone subscribers in India is

getting close to one billion,⁸ and Africa, described not more than 15 years ago as 'The Lost Continent' by The **Economist magazine**, has experienced some of the fastest mobile growth rates. In Kenya, mobile phone penetration is above 80%, and 67% of the phones sold are smartphones.⁹ It is estimated that 80% of the planet's population will have a smartphone by 2020.¹⁰

In a sense, a smartphone is like a Swiss army knife: a general-purpose tool for all things digital. The smartphone absorbs and replaces hardware that we used to pay for, including an alarm clock, camera, stereo, television, calculator, flashlight, tape recorder, etc.

Broadband access

Concurrently, mobile broadband networks are extending their reach rapidly. According to the United Nations, half the planet's population will have a broadband Internet connection by 2017¹¹, and 4G networks, which offer six to seven times higher speed (typically in the 100 Mbit/s range), are replacing the 3G mobile networks. China Mobile, China's largest mobile phone operator, expects to reach 150 million 4G subscribers in 2015.¹²

In addition, a number of large-scale efforts are under way to provide cheap or free Internet access to even the poorest regions. Google is working on a network of transmitting balloons,¹³ whereas Facebook, Ericsson, Samsung and several other companies are working together on 'Internet.org' to build a free global network using satellites and drones.¹⁴

The combination of cheap smartphones and widely available data access disrupts businesses whose services used to require an extensive infrastructure, buildings and machinery. It is hard to exaggerate the disruption to conventional business when customers can suddenly access banking, GPS-navigation, online media, video telephony and education and healthcare services through a device in their pocket.

⁵ <https://gsmainelligence.com>

⁶ <http://www.indiatvnews.com/business/india/top-20-smartphones-in-india-under-rs-10000-13097.html?page=14>

⁷ <http://www.economist.com/news/briefing/21645131-smartphone-defining-technology-age-truly-personal-computer>

⁸ <http://m.thehindu.com/business/Industry/telecom-subscriber-base-reaches-alltime-high-at-97-crore/article6871085.ece/?secid=2784>

⁹ <http://en.africatime.com/kenya/articles/mobile-phone-penetration-kenya-rises-above-80pc>

¹⁰ <http://www.ericsson.com/res/docs/2014/ericsson-mobility-report-november-2014.pdf>

¹¹ <http://www.broadbandcommission.org/Documents/reports/bb-annualreport2014.pdf>

¹² <http://www.lightreading.com/mobile/4g-lte/forget-3g-china-mobile-is-a-4g-king/d-d-id/712885>

¹³ <http://www.google.com/loon/>

¹⁴ <http://internet.org>

Payments

Mobile payment empowers people. With a near-zero entry cost (all that is required is a basic cell phone), systems such as M-PESA have enabled millions of people to be included in the financial system and have made large-market segments much easier and safer to operate in for business. M-PESA, which launched its mobile payment service in 2007, has more than 15 million users in Kenya, out of a total population of 44 million, and mobile payment systems are spreading fast in other emerging markets as well. M-PESA, operated by Vodafone/Safaricom, is the leading system, and it is available in Egypt, Lesotho, Mozambique, Tanzania, India and Romania. However, similar systems are being launched in many other emerging (and developed) countries.

In India, the government is currently making a drive to have people open bank accounts. In the five months leading up to January 2015, more than 120 million Indians signed up for bank accounts. This Indian effort is closely coupled with another powerful enabler: digital identification. The 'Aadhaar' program is a large-scale project to provide the entire Indian population with a digital, biometric identity. By the end of 2015, one billion out of India's 1.2 billion population is expected to have a digital ID. Still, despite these advances, more than 50 per cent of the world's population currently lacks access to basic banking, making this a huge market opportunity for the right business model.

E-commerce

As the unbanked gain access to mobile payment, e-commerce and the ability to deliver and charge for services online will expand. Obviously, this will significantly change the business models that companies operating in emerging markets can use.

China provides a striking illustration of how fast the commercial landscape can change. In many remote areas, consumer choices used to be very limited, but now online shopping is connecting companies and consumers. In 2014, online

shopping accounted for 10.7% of total retail value in China.¹⁵ The largest Chinese online retail platform, Alibaba, raised \$25 billion when it went public in 2014; it now ranks as the largest IPO of a company ever in the world. Other emerging markets are catching on as well. Indian online retailer Flipkart grew 70% in 2014 and is aiming to handle a million orders daily by the end of 2015.¹⁶ International platforms such as Amazon and Snapdeal are competing in the same market. In Africa, Jumia, a leading ecommerce platform,¹⁷ is the fourth most visited website in Nigeria, Africa's most populous nation.

Education and training services

The doors to the world's leading universities and best teachers have been opened to anyone with an Internet connection. Instructional videos, lectures and course materials on just about any subject are available online. In recent years, a number of so-called MOOCs (massive open online courses) have been created by the top universities in the world,¹⁸ typically offering courses for free. Many of these have a very large global attendance, not least from students in emerging markets. Khan Academy, Coursera, TED-Ed and iTunesU are examples of these resources.

Training users and customers is an important way to add value to products. Previously, it was too complicated and expensive to deliver such services widely, particularly in emerging markets. Now companies are increasingly offering tutorials and training in the use of their products. With better-qualified users, companies can sell more advanced products that enable greater utility and quality. As with mobile payments and e-commerce, online education is leapfrogging the constraints of traditional infrastructure. With Internet connectivity, it is not necessary to build a physical bank to offer banking, there is no need for a store in order to shop, and an online student does not have to struggle to be among the few who can attend a physical school or university.

¹⁵ <http://www.chinainternetwatch.com/12685/online-shopping-market-2014/>

¹⁶ <http://www.livemint.com/Companies/9hCcR9Z0vMtcABgBmmBSgM/Flipkart-eyes-higher-priced-products-to-drive-growth.html>

¹⁷ <http://www.jumia.com.ng>

¹⁸ http://www.bdpa-detroit.org/portal/index.php?Itemid=20&catid=29:education&id=57:moocs-top-10-sites-for-free-education-with-elite-universities&option=com_content&view=article

Mobile health

Likewise, mobile health bypasses many of the needs to meet a doctor or nurse. Video telephony or simply transferring photos and measurements is the basis of telemedicine or M-health, which is already extending the reach of medical services in areas with poor infrastructure.

Still, patients often need to go to clinics or hospitals because the equipment to measure vital signs is very expensive and requires trained personnel to operate. This is changing, however, as a great deal of low-cost sensors are being developed that can be attached to smartphones or tablets. These peripheral devices are cheap because they can draw on the computing power, screen, camera and connectivity of the phone or tablet, and because they can upload raw measurements to hospitals or laboratories, which can then do the more complicated analysis. Typically, many of these add-ons and apps are not as precise as professional medical devices, but the prices are far lower, and they are lightweight and mobile; often, they are so simple and easy to use that a patient or relative can make useful basic measurements. Eyesight,¹⁹ hearing,²⁰ blood pressure, skin conditions, ultrasound²¹ and ECG scans²² are current examples of measurements, and the range of applications is growing.

A strong downward driver of prices is the 'quantified self' trend in developed countries. Fitness trackers, wrist bands and smart watches that constantly measure a person's activities and vital signs are at a tipping point just now, with all major computer and phone manufacturers offering increasingly precise health trackers that connect to online services. An important consequence of using such equipment is that measurements can be made much more often, and the results and variations are visible to patients and users, who then become more engaged and empowered to improve their health. Clearly, this trend can improve the level of healthcare services in areas with few doctors.

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Internet of Things

Sensors for healthcare diagnostics are an example of the much wider trend towards the Internet of Things. The functionalities of smartphones—sensors, computing power and Internet connectivity—will potentially be embedded in every device, large or small. Together, they become a network of objects that collect data and exchange and coordinate with other devices. Mobility and traffic management, improvement of the energy or water supply and the optimisation of production flows in factories are large-scale professional examples of how the Internet of Things can lead to greater yields, better productivity and less waste of resources. Connectivity could soon become normal in household devices. In January 2015, Samsung's CEO announced²⁴ that by 2017, 80% of the company's products will be connected to the Internet. By 2020, it will be 100%. Surely most other manufacturers will follow a similar path – among others, Huawei, a Chinese electronics corporation have announced ambitious plans in this direction. Obviously, Internet connectivity is not the first thing a consumer who does not yet have a fridge or air conditioner is looking for. The point, in a frugal solutions context, is that connectivity is likely become so inexpensive that it becomes a standard component, even in entry-level products. Applications that analyse user data and coordinate devices can be a cost-efficient way to create greater efficiency, convenience and value for users—all without the need to sell

¹⁹ <http://eyenetra.com>

²⁰ <https://cellscope.com>

²¹ <http://www.mobisante.com>

²² <http://www.alivecor.com/home>

²³ <https://developer.apple.com/healthkit/>

²⁴ <https://www.youtube.com/watch?v=FI0r9XpJg8k>

additional hardware and with very little distribution costs. Even in emerging markets, an increasingly thinly veiled network of smart devices will be available as an infrastructure for housing such services.

This development points to a general consequence for HT–LC business solutions: advanced services that have great value for users can run as applications on top of an increasingly smart and ubiquitous infrastructure of devices. Because such services are digital, they can be delivered anywhere, instantly and simultaneously, at very little cost. The individual devices that an end user has do not have to be very sophisticated or powerful because the heavy-duty computation, storage and analysis take place in 'the cloud'.

Even if services require the coordination of very large amounts of data (so-called big data), and even if the analysis and monitoring is made by specialists based in developed countries,²⁵ the results can likely be streamed even to humble, low-priced devices. In time, this could include very advanced services based on increasingly stronger artificial intelligence. Google Translate is an example of a service that feels almost 'intelligent' and that is available for free globally today. Much more intelligent expert systems, such as IBM's Watson, could be universally available before long.²⁶

Energy

Although computers and digital networks have clearly been the most important technological development in recent decades, other technologies are having a substantial impact on business and society as well. Energy is a fundamental need, yet large parts of the world have an insufficient and unreliable power supply—if any. A number of new technologies are making electricity available much more broadly, and this has profound consequences for quality of life and economic development. It also indicates opportunities for business.

Again, we see solutions that can bypass the heavy, conventional delivery systems. Photovoltaic panels deliver decentralised electricity

without the need to build a power grid. Prices are coming down fast. In the five years between 2009 and 2014, the price of solar panels fell by 75%.²⁷ Similar falls in cost and gains in efficiency are expected in the coming years, effectively reaching parity in prices with regular grid power in most of the world by 2018.²⁸

For continuous off-grid power, energy storage is crucial. Lithium-ion batteries are the most important type of large-scale energy storage, particularly, for instance, for backup in buildings and to power electric cars. Since 2007, their price has fallen by about 8%²⁹ annually, but the fall in prices will likely accelerate because the production volume is rising to supply the electric car industry. Tesla Motors and Toshiba are currently building a 'giga factory' that, when finished in 2020, is planning to produce more lithium-ion batteries than were produced in the world in 2013 - enough to power half a million electric cars.³⁰ Such investments will push prices downwards worldwide. The Tesla Power Wall³¹ is another development which has the potential to change energy solutions radically.

The final element in improving energy supply is improvements in the efficiency of electrical devices. First, the price of LED lighting is falling fast, and efficiency and quality are rising. Importantly, reducing the power consumption means reducing the size of the solar panel and storage battery, which means that the entry price for a small stand-alone household unit is lowered.

²⁵ http://www.vestas.com/products_and_services/operation_and_maintenance#/

²⁶ <http://www.ibm.com/smarterplanet/us/en/ibmwatson/>

²⁷ http://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Power_Costs_2014_report.pdf

²⁸ <http://cleantechnica.com/2015/01/14/deutsche-bank-predicts-solar-grid-parity-80-global-market-2017/>

²⁹ <http://www.rtcc.org/2015/03/23/falling-battery-prices-boost-outlook-for-electric-vehicles/>

³⁰ http://www.teslamotors.com/sites/default/files/blog_attachments/gigafactory.pdf

³¹ http://www.teslamotors.com/en_AU/powerwall

3D printing

Although a bit further into the future, additive manufacturing, more commonly referred to as 3D printing, is likely to revolutionise the world of manufacturing, many companies are already changing their supply chains to make use of it. There are a number of reasons why 3D printing has great potential to create HT–LC solutions:³²

Decentralised manufacturing.

This technology makes it possible to deliver a product or a spare part anywhere there is an Internet connection to download the blueprint and a decent printer to print it. Even very complex structures can be manufactured without highly skilled labour. Products can be printed out as needed, and they can easily be modified to fit a particular customer's needs, such as the 3D printed prosthetic arms that Not Impossible Lab produces in South Sudan.³³ Spare parts for old products can be available long after the product has been discontinued. Such decentralised manufacturing saves costs for distribution and storage. It can also make the supply chain more robust by relying less on a single or just a few factories.

Development of new products becomes easier and cheaper.

Prototypes and early iterations are fast and easy to make using 3D printing. Furthermore, working with digital files in standardised formats gives developers easy access to global pools of knowledge and design. Already, there are large online communities where ideas and instructions for products and parts are exchanged as open-source hardware. Designs can be global and manufacturing can be local – or vice versa.

Lower material costs.

As the name implies, additive manufacturing only uses the materials that are actually needed. There is no waste in the production of goods. Furthermore, if the materials being used to print are biodegradable or—as the filaments developed by the Indian social enterprise Protoprint are³⁴ – made from recycled plastic, 3D

printing could be a circular and frugal production method.

New roles and business models.

To the extent that a conventional manufacturer's products can be made in local print shops or print 'farms', it changes the company's role. A company no longer needs to manufacture and distribute physical objects; instead, some or all of its 'products' can be sold as digital blueprints, which users pay to download.

Today, high-quality 3D printing is expensive and slow—and thus mainly suited for niche productions in which a high degree of customisation is required. A much cheaper class of 'consumer-grade' 3D printers is also available, currently starting around USD 400. But their quality is coarse, and the range of materials is still limited. The price trajectory of 3D printers should be compared to paper printers, which also started out expensive and slow (remember matrix printers?). Back then, most people would go to copy shops to have documents printed. However, in the course of just a decade, high-resolution colour printers became cheap enough for most consumers.

Another comparison is relevant: Digital distribution of music has deeply disrupted the business model of the music industry. In the same manner, widespread use of 3D printing will challenge the current ways of protecting intellectual property—not least in markets that have less strict enforcement of regulations. This study has chosen to focus on a time horizon of three to five years or less. Looking a few more years ahead, several other new classes of technology are likely to reach the tipping point in terms of price, quality and adoption.

Industrial robots

Industrial robots have fallen considerably in price. Among the companies that have created breakthroughs in terms of price and ease of use are the Danish manufacturer Universal Robots³⁵ and the Boston-based Rethink Robotics, which produce Baxter³⁶, a small 'collaborative' robot with a base price of \$25,000. The CEO of

³² <http://www.economist.com/news/science-and-technology/21565577-new-manufacturing-technique-could-help-poor-countries-well-rich-ones> also see: https://www.engineeringforchange.org/news/2014/01/17/3d_printers_may_be_poised_to_take_off_in_developing_countries.html

³³ <http://www.notimpossiblelabs.com/#!/project-daniel/c1timu>

³⁴ <http://www.protoprint.in/index.php>

³⁵ <http://www.universal-robots.com/en/>

³⁶ <http://www.rethinkrobotics.com/baxter/>

³⁷ <http://www.businessinsider.com/foxconn-will-replace-workers-with-robots-2014-7?IR=T>

FoxConn, one of the largest manufacturers in China, has announced plans to build a million factory robots.³⁷ Clearly, the spread of cheap industrial robots will have very significant societal consequences in economies that are based on low-cost factory labour.

Biotech

Biotech is becoming an integral part of medicine and healthcare as well as agriculture.

Genetically modified crops cover millions of acres of farmland. Although it is still controversial, GMO crops have the potential to increase yields and reduce the use of insecticides, and the technology can lead to new strains of plants that are more resistant to drought, flooding or salty soil. In pharmacology, genetics are leading to more efficient and precise medicines. So far, though, they are mainly rather expensive. Genetic decoding and DNA tests, which will be increasingly useful for diagnosis and prediction of diseases, have fallen in price faster than even computers. 23andMe, a company backed by Google, currently offers personal DNA tests for \$99.³⁸

Artificial meat - from sci-fi to mainstream?

To illustrate the importance of keeping an open mind to sudden technological shifts, it is worth considering the prospects of producing artificial meat, grown in cultures. For years, scientists have tried to create animal tissue from cultures. In healthcare there is a severe shortage of organs for transplantation. The aim of so-called regenerative medicine is to cure patients by replacing defective tissue or particular regulating cells with cells, tissue or whole organs that have been corrected and cultured and can then be implanted.

In parallel efforts, scientists have worked to develop ways of growing muscle tissue for food. On paper, this would have huge benefits. Global consumption of meat is rising, but meat production by raising live animals is a very inefficient use of nutrients, water and energy. Artificial meat would

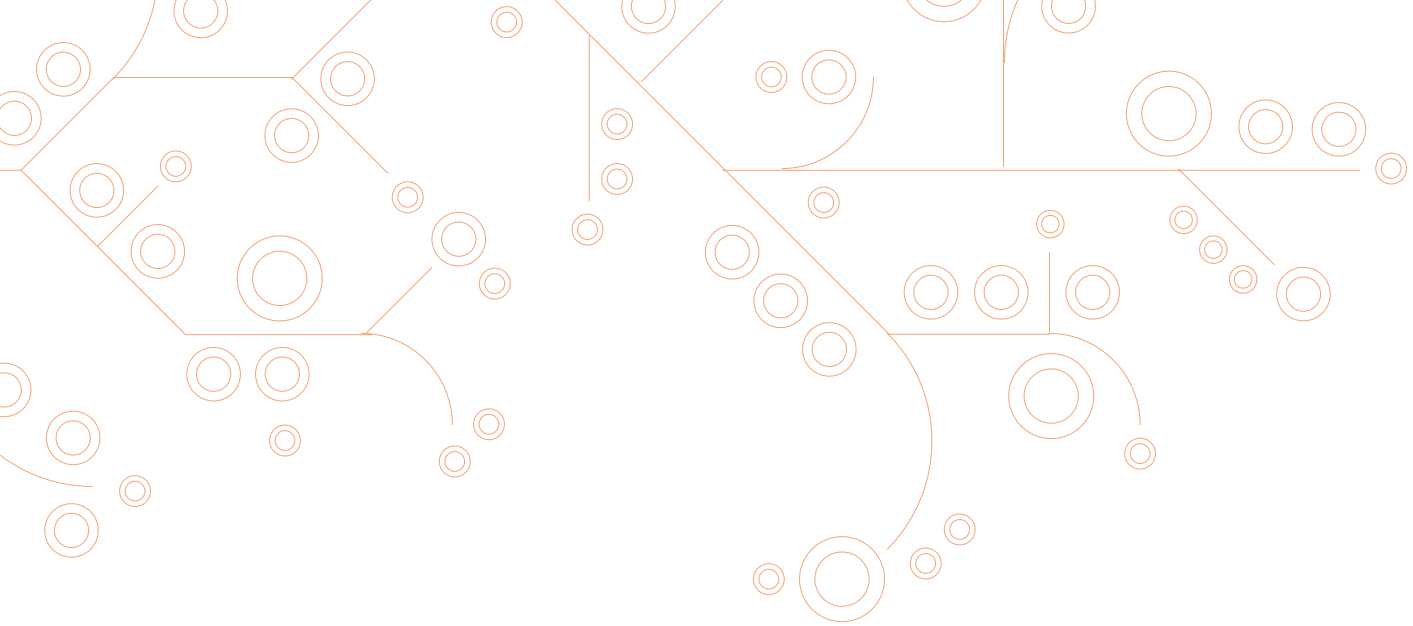
avoid issues concerning animal welfare, and furthermore, the exact nutritional composition of the protein could be optimised to be healthy.

Growing meat in cultures is hard, one of the hurdles being how to generate the structures that create texture. Two years ago, a Dutch laboratory was able to serve the first hamburger made with artificial meat. The cost of production at the time was \$325,000 (sponsored by Google founder Larry Page). Recently, the Dutch lab announced that it could now produce a similar burger for \$11.³⁹ This is still expensive compared to regular meat, but it is an enormous drop in price in a short period. And so far production is on a very small scale in a lab. Like most radically different technologies, the success of artificial meat depends on whether it will be culturally acceptable to consumers. However, given the pressure on natural resources, artificial meat could well be branded as the ethically correct choice.

In short, what was very recently a science fiction-like concept is starting to look like a very promising solution to sustainably deliver high-quality nutrition to the world's growing population. In fact, it seems likely that it could disrupt the food- and meat-producing industry fundamentally within a few decades.

³⁸ <https://www.23andme.com>

³⁹ <http://www.sciencealert.com/lab-grown-burger-patty-cost-drops-from-325-000-to-12>



PATTERNS IN THE EVOLUTION OF TECHNOLOGY



New technologies tend to follow the same pattern of development. At first, the technology is promising, but quality is shaky and prices are too high for mass-market use. After a slow start, some technologies reach a tipping point. They enter a self-reinforcing phase in which lower prices lead to growing markets, attracting larger investments, supporting further growth and even lower prices. Thus, rather suddenly, a technology shifts from niche application to mainstream product.

Accelerating speed of change

The speed at which these breakthroughs occur is accelerating. Electricity, cars, telephones and television took decades to become widespread. GPS and smartphones were adopted in a few years, and software-based solutions such as Facebook or Google Maps are available everywhere almost instantly.

Furthermore, a large part of the technologies that will have the biggest impact in the coming years will develop exponentially. Digital technology, and all of the technologies that are based on IT, ride on the trajectory of Moore's law, which predicts that computing power per dollar doubles every 18 months. This is dramatic in the short term, but over a time span of ten years, it is highly disruptive, effectively dropping the price of computing power to a thousandth. Some technologies, such as the speed of decoding DNA and of synthesising DNA sequences, developed even faster. This exponential nature of many technologies is important to bear in mind because when we assess and plan for what is ahead, we tend to extrapolate trends linearly. To make full use of what will be available, we need to think exponentially about technological change.

Technologies reinforce and depend on one another's success. GPS navigation has enabled services as diverse as fitness trackers and Google Street View as well as systems for high precision use of fertilisers and water in agriculture. Likewise, mobile phones enable mobile payments, which again make it possible for

companies to provide solar electricity or clean water that consumers want and need but that were previously too cumbersome to collect payment for.

Wormholes

We tend to think of high technology as expensive and therefore only relevant in wealthy markets. But think of the services that Google offers: searches, maps and translations. Arguably, these are amongst the most advanced, cutting edge services on the planet, yet they are available to anyone with a smartphone and an Internet connection. For free. The quality of the service is similar whether you are accessing them from the slums in Dharavi or from an office in Mountain View, California.

Such services are like the wormholes in space, strange interstellar corridors where conventional rules of physics do not apply. Some prominent examples are the following:

- Skype collapses the relation between quality and price by offering international calls and video conferencing for free.
- Linux and Android are open-source software; anyone can use them, and even modify them, if they need to.
- Online shopping brings the world's largest mall to any computer screen.
- Khan Academy and Coursera give anyone access to top-notch education at no charge.
- 3D printing reverses the relation between complexity and price. The most expensive object to print is the simplest: a solid block. But a highly sophisticated and intricate structure optimised for strength and low weight is cheaper in materials. And to the printer, the complexity of what it is printing makes little difference.

Technology changes society

Importantly, when new technologies spread, they change culture, society and the way things are done. Generally, better information and better tools change an individual from a passive consumer and member of the masses to a participant and cocreator—and this in turn

changes the nature of how businesses can be conducted.

- Mobile payments are creating transparency, making it harder for money to disappear in transactions or corruption.
- Information on market prices makes farmers and consumers alike less vulnerable to cheats and gives them greater bargaining power.
- Online education empowers people to achieve better jobs.
- Online global media and social networks inform the public and strengthen democracy.





CAN HIGH-TECH- LOW-COST GLOBALISE DEMOCRATIC DESIGN?



Nordic companies are rarely competitive when it comes to selling low-tech products in emerging markets. Some Nordic companies have tried to dumb down and simplify their existing high-end products to make them cheap enough for emerging markets. Diluting the quality or creating inferior products for lower prices is, however, not consistent with the core competence of Nordic industries. The HT–LC approach offers a different direction. Nordic companies can build on what they do best: use deep insights in science and leverage technological trajectories to create solutions that offer high utility at much lower prices than what was conventionally possible.

This type of frugal approach to innovation is consistent with Nordic culture. Many of the largest Nordic industries were founded on a philosophy of serving the broad upcoming middle class of the 20th. century with affordable, yet highly functional, quality products. This is also very much in line with how the rest of the world still perceives the particular Nordic capability in product design. In other words, HT–LC approach builds on and updates the Nordic story of functional and democratic design for the people.

Nordic HT–LC first movers

For Nordic companies, a HT–LC approach is still mainly uncharted territory. A few first movers are busy pushing the boundaries between price and quality and paving the way for more to follow. A number of experts and Nordic companies have been interviewed for this report to understand how HT–LC thinking is currently being applied and what companies see as opportunities and barriers.

Methodology

This analysis was completed in two steps. The first step was a high-level analysis to identify which Nordic companies are working with HT–LC solutions. This included case research through publicly available sources. Although not comprehensive, the analysis identified companies from Norway, Finland, Sweden and

Denmark that are involved in activities related to HT–LC solutions. The second step included interviews with nine selected companies. The companies were selected to represent:

- **relevant industries** (companies from healthcare, clean technology and entertainment industries)
- **different sizes** (companies ranging from start-ups with a few employees to large multinationals)
- **Level of HT–LC experience** (some companies were founded recently with the HT–LC focus in mind, whereas others are traditional companies that are integrating this approach in their emerging market strategies).

Who are the Nordic HT–LC pioneers?

Three generic types of companies that work with HT–LC have been identified:

1. Traditional company + technological enabler

Well-established companies that are global providers of different products and services (often B2B). These companies are interested in expanding their market scope to different tiers, but they are also feeling pressured by cheaper solutions in the top market segments. These companies are looking at how adding technology to their products can enable new solutions and business models.

*An example of this type of product is **Lifelink™** by the Danish pump manufacturer Grundfos. **Grundfos** uses ICT infrastructure and mobile payments as enablers to facilitate a new business model where they sell water pumps and water services to rural areas.⁴⁰ One Lifelink solution is the water kiosk, which enables expansion of the water supply in urban and peri-urban communities or rural towns. The water dispenser is connected to a water supply network and acts as a stand-alone automatic water kiosk with an integrated system for revenue collection. All water points are monitored on an online water management platform.*

⁴⁰ www.grundfos.com/market-areas/water/lifelink.html

2. Tech company

The second group is companies with advanced products based on new technology. Some of these companies have middle- and low-income markets as explicit target groups, whereas others combine higher end markets with solutions for lower tiers. These companies are often start-ups and born-global⁴¹ companies.

*Unumed provides an e-healthcare software system to Asian, Middle Eastern and African healthcare institutions based on Danish funding and technology. The patient management systems are based on a combination of low-cost, off-the-shelf technology and advanced cloud technology to reach lower tier health segments. Unumed leverages Nordic technological know-how, but it is not a simplified version of a Nordic system. Unumed's solution is designed from scratch with local needs and health infrastructure in mind.*⁴²

*Audientes develops high-quality hearing aid solutions for off-the-shelf purchase. The products allow customers to fit the hearing aid to individual hearing needs without assistance from medical/hearing experts. This is possible through the use of a built-in hearing test and self-fitting calibration features. This means Audientes's solutions cut out the 'middleman' of medical/hearing specialists between consumer and product. This is especially relevant in developing countries where medical/hearing experts can be few and far between.*⁴³

3. Enabler company

The last group of companies offers technological infrastructure (e.g. mobile) or sell technology (cell phones, 3D printers) that can be integrated into other solutions. These companies work as partners/suppliers for other companies. Some of them are actively developing their own HT-LC services, which means they are also part of the tech company category.

Telenor operates in 13 countries, including a number of emerging markets, and it has a strong focus on developing new applications, products and business models that integrate mobile technology in new ways. Telenor works as a partner for other companies but also develops

*new applications and services in-house or through joint ventures. In Bangladesh, for example, Telenor is co-owner of **Grameenphone**, which has been a pioneer in bringing new mobile-based solutions to Bangladesh. Examples of these are **Healthline**, a 24-hour medical call centre manned by licensed physicians; **Studyline**, a call centre-based service providing education-related information; **Mobicash** for the electronic purchase of train tickets; **Billpay** for paying bills through mobile phones; and over 500 community information centres across Bangladesh. These centres bring affordable Internet access and other information-based services to people in rural areas.*

*Danish **Greenwave Systems** provides cloud-based, back-end management software for Internet of Things (IoT) services. Their system enables companies to quickly deploy their own Internet of Things managed services and products. In other words, Greenwave provides an advanced technological infrastructure for other companies, helping them tie technology together and manage data.*⁴⁴

Current experiences with HT-LC - tech is great - but not enough

The companies interviewed are at different stages in the innovation cycle. Some are still working on prototypes, whereas others have market experience and are working to refine their business models. In general, the companies interviewed had progressed further in product development and internal considerations about HT-LC than anticipated. All companies see HT-LC as an inevitable direction for their companies, but they also stress that technology and low prices will not be enough to succeed. Technological developments are rapidly creating new opportunities and breaking down barriers, but they do not wipe away traditional businesses' challenges, and they add a new layer of complexity.

In other words companies working with a HT-LC approach meet many of the same challenges as previous generations of frugal innovators.

⁴¹ <https://www.23andme.com>

⁴² Companies that offer products that are target international markets primarily.

⁴³ unumed.com

⁴⁴ [Audientes.com](https://audientes.com)

Regardless of the technological level, creating frugal business solutions is challenging. Many companies targeting lower income segments have struggled with distribution, customer habits, cash flow bottlenecks and price points. Sometimes these issues are design or marketing flaws. Other times the products are attractive, but the market challenges are too high. In some cases, technology might be an answer to these challenges, but it might end up creating new challenges as well. The following section provides specific examples from the interviewed companies.

Economies of scale

Cheaper energy supply and the rapidly decreasing prices of computers and phones are making these, and a range of related products available to much wider market segments. Not surprisingly, several companies observe that the spread is reinforced by economies of scale. Once prices of a particular technology fell below a certain point, the market suddenly started to grow – and prices fell further. Many ambitious ventures aimed at low-income markets never took off because the numbers simply did not add up. The expense of running a business dwarfed the margins possible in a low-income setting.

Availability

Traditionally, distribution is one of the major bottlenecks for products targeting middle- and low-income consumers. Several companies mentioned that technology is changing this. One approach for companies is developing networked products that can be monitored and operated remotely. Several companies are working towards this type of product as well as on more affordable products. Several companies are also looking into 3D printing of some components locally, which would bring down costs and enable distribution to areas that were previously too expensive to reach. One company interviewed offers a mobile service in several African countries and is dependent on mobile payment. For this company development in technology is changing business opportunities sometimes from month to month: *'A year ago 17% of our users used Android phones. A year*

later the number is 50%. This means the distribution potential of our more advanced services has increased dramatically.

Adaptation and acceptability

Several companies told that although they experience higher cultural tech barriers, technology also provide opportunities to leapfrog and remove barriers to change. One company in the health sector explained: *'The doctors we target have a very strong "paper" culture. This means convincing them to move from paper to an electronic patient management system is harder than in developed countries. As a response we are working on tablet solutions that are closer to writing on paper. They seem to like this. These simple tablet solutions are only possible because we can leapfrog and don't need to build e-health system on top of heavy existing PC-based systems. So their low-tech starting point is working both for us and against us'.*

Regulation cannot keep up with technology

Whether local regulation is a driver or barrier is very sector specific. Several companies mentioned that local regulation has not caught up with technological development or is generally less detailed than in their home markets. For some companies this factor is very important for their ability to innovate and operate locally with HT–LC solutions. They see increased regulation as a future risk. Other companies experience local regulation as a strong barrier and their main reason for not moving forward faster. Local regulation is designed with traditional solutions and market structures in mind and changing this is a slow and often sensitive process.

From product to service

Several traditional product-oriented companies were considering whether to move further into selling services as a way to reach wider segments. Some companies were linking products with services. For example, Grundfos Lifelink has moved from a B2B mind-set to a more end user-oriented perspective. Many water projects in developing countries notoriously experience service challenges, with equipment losing value quickly. To avoid this and to increase the long-

⁴¹ <https://www.23andme.com>

⁴² Companies that offer products that are target international markets primarily.

⁴³ unumed.com

⁴⁴ Audientes.com

term product value, Grundfos offers several different service models and types of partnerships in combination with a pump and payment technology for the Lifelink system. This example shows how the product/service model shifts incentives and focus.

Several companies are moving into owning and operating assets for end users. This approach brings down costs and is a strong driver for bringing advanced solutions to lower tiers. The companies interviewed, however, were struggling in different ways to make it work. For some, convincing customers to pay for online services is a challenge, whereas others struggled to convince customers that not owning equipment is safe and reliable. These challenges mirror the general challenges in the industry but are multiplied when customers have low incomes and are less used to, for example, cloud-based technology. A number of different technological developments were discussed with the companies. Increased connectivity and 3D printing were the technologies highest on the minds of the companies.

Increasing connectivity leads to increased focus on services

The interviews showed that companies are very aware that increasing connectivity in the Internet of Things can lead to new services and will allow companies to create greater value for customers by using and coordinating large amounts of sensor data from the companies' own products and from the widening range of other companies' 'smart' products—initially for metering, monitoring, maintenance and support.

3D printing is coming faster than expected

Generally, the interviews showed that Nordic companies have a high degree of awareness of and a willingness to experiment with the possibilities of 3D printing as a way of decentralising production and offering greater choice while reducing costs for distribution and stock in emerging markets. One company uses 3D printing to create spare parts and to avoid having them physically in stock globally. One company explained how it used 3D printing to keep

supplying customers when its local-market factory was flooded.

As several companies pointed out, 3D printing will gradually enable a company to maintain a central server with the blueprints for all products, which can be accessed by customers anywhere. This will change large parts of the value chain, including logistics, service and maintenance. Several companies linked this to an increased ability to reach wider market segments.

Summing up, frugal solutions in general and high-tech low cost solutions do not represent quick fixes that generate easy returns. The structural challenges of low-income markets, combined with the added complexity of introducing technology, call for as much business model innovation as technical innovation. The introduction of technology, however, has the potential to break some of the traditional barriers frugal innovations have been facing. In particular, it offers the potential to scale solutions and enhance last mile distribution.

⁴¹ <https://www.23andme.com>

⁴² Companies that offer products that are target international markets primarily.

⁴³ unumed.com

⁴⁴ Audientes.com

From first movers to follower -An assessment of the Nordic potential for HT-LC

In each Nordic country, examples of HT-LC endeavours have been identified. Whether these companies will remain anomalies—or inspire wider groups of peer companies to follow—is yet to be seen. Each country has different market structures and strongholds that are relevant when assessing the perspective of HT-LC solutions. Three areas are used as indicators: Size, market presence and sector strongholds.

Size

All the Nordic countries are predominantly characterised by small and medium sized enterprises (SMEs) and a few large companies. Among them, Sweden has relatively the most large companies. It is not possible to correlate success directly with company size. Big companies have more resources and patience to make new products succeed and can afford failure, whereas small companies are more agile and can offer different innovative solutions. Combining high-tech with the challenges of low-income markets, however, is a daunting task for small companies. For small companies, different types of support infrastructures can be important to reduce risks and ensure the necessary financial patience in the development phase.

Degree of emerging market presence

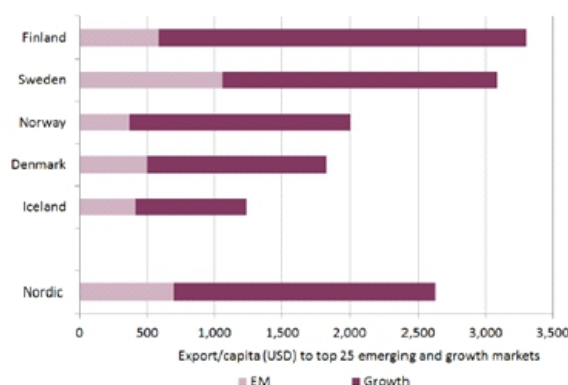
Previous experience working on emerging markets will give companies a head start compared to companies that are only used to developed markets. Sweden has a considerably higher market export to emerging and growth

markets compared to the other Nordic countries.⁴⁵

National strongholds

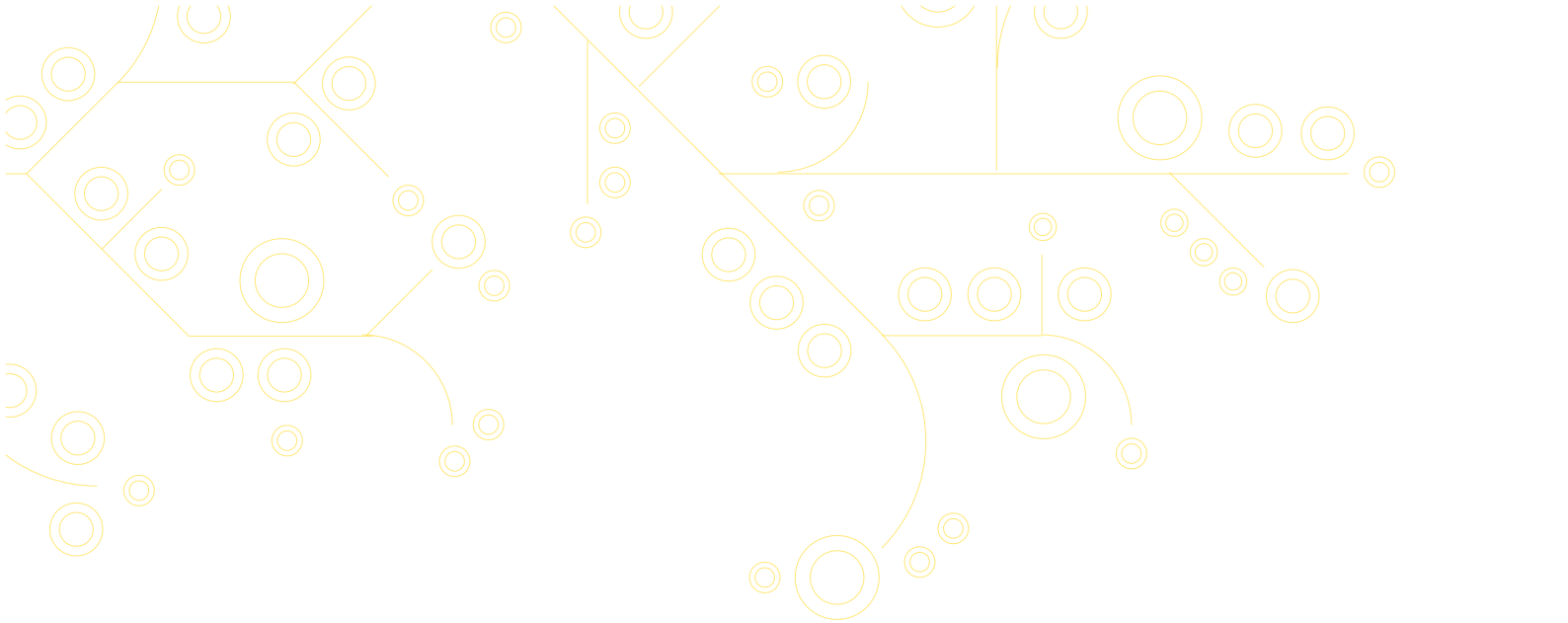
HT-LC thinking can be applied across many different industries, but some industries are more relevant than others. HT-LC solutions naturally require advanced products or services as opposed to sales of raw materials. HT-LC HT thinking is relevant for both consumer goods and B2B products, but it also requires industries in which technology has the potential to scale product reach significantly; in other words, products need to be relevant for large markets, not just very small niche markets. Promising sectors include healthcare, clean technology, biotechnology, high-tech building materials and communication.

Nordic countries each have different strongholds and hence opportunities for HT-LC solutions. In Denmark, enzymes are a large export article to emerging markets, enzymes can work as an enabler for advanced but affordable products in many sectors, including food and pharma and energy production. In Sweden, the significant export of electronic articles to emerging markets is a relevant place to look for HT-LC opportunities. In Norway, advanced fish farming technology is helping to multiply productivity of aquaculture farms in developing countries and making fish products more affordable and available. The overall strongholds of a country will likely not be the most important factor in the short run because development is driven by individual companies in each country (e.g. Telenor). From a Nordic perspective, it makes sense to link front-mover companies across countries because the pool of relevant peers in each country is often too low.

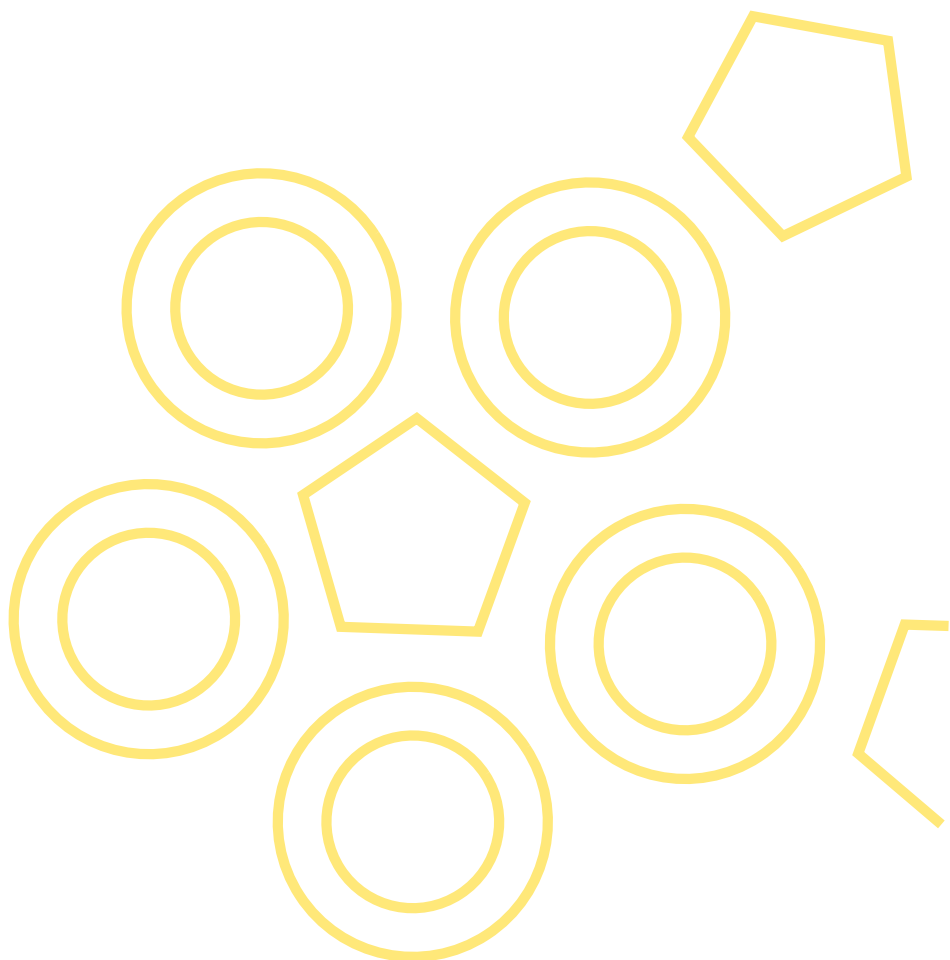


**Nordic performance in top 25
emerging markets (Meeting
Unmet Demand in Emerging
Markets, 2014)**

⁴¹ Meeting Unmet Demand in Emerging Markets, Dalberg and Nordic Innovation, 2014.



WAYS FORWARD



Ways forward

The first wave of frugal solutions has led to mixed results. Despite some excellent products and some determined and bold attempts, many frugal products have been challenged in the market. Some challenges relate to the product or service sold, or the way they are sold. Other traditional challenges relate to the business model or organisational barriers.

This report argues that technology used wisely has the potential to bring frugal solutions to the next level. A high tech low cost approach could create new opportunities and has the potential to change the playing field for affordable solutions. By understanding the trajectories of technological development in emerging markets, Nordic companies can use their traditional strength to create advanced but accessible products, to address new, very large market segments well below the price points that most Nordic companies currently cater to.

This task is not easy. It requires a solid understanding of and empathy with the conditions and needs of customers in emerging markets, and, perhaps most importantly, it requires a mind-set to seek solutions that are frugal and focused on the 'need to haves' rather than the 'nice to haves'.

Recommendations

To succeed with frugal solutions, Nordic companies will need to venture into uncharted territory, including new market segments, new uses for technology and new business models. The traditional national and Nordic support frameworks for companies are not always designed to support this type of venture. The following initiatives could build increased capacity among Nordic companies:

1. Ambassadors:

The best inspirations are Nordic peers who are pushing the boundaries on price and quality successfully. Capturing the dos and don'ts of first movers will help others see the opportunities. The pool of relevant companies in each country is often small, but across the Nordic countries, groups of peer companies are emerging that could benefit from increased knowledge sharing and collaboration.

2. Opportunity costs:

Low-income markets are challenging and often high risk. For companies without the necessary resources, products and knowledge, high-end or developed markets are often more rewarding. It is important that frugal opportunities are not communicated uncritically, and the challenges and pitfalls should be made clear to ensure the right companies get started and have the best starting point.

3. The frugal toolbox 2.0:

As noted above, a number of companies have failed in their attempts to launch frugal solutions. A better understanding is needed to (1) investigate the potential of advanced technology to mitigate traditional frugal pitfalls, (2) understand the specific success drivers and barriers relating to frugal technology and (3) relate this knowledge specifically to Nordic competencies.

4. Sectors:

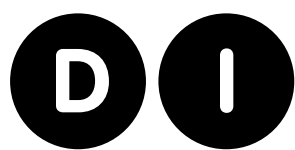
Frugal solutions can be found in many sectors. This report shows that sectors such as healthcare, clean technology, biotechnology and communication are especially promising from the Nordic perspective.

5. Multidisciplinary approach:

Technology is not enough—neither are low prices. This report shows that success with frugal solutions is equally dependent on consumer insights, business model innovations, technological breakthroughs as well as more general societal and regulatory changes. From business schools to innovation agencies to local embassies, the capacity to advise and support new generations of employees and companies from these aspects will be critical.

6. The Nordic perspective:

To stay competitive, embracing technology and emerging market segments is no longer about 'nice to haves'. Nordic companies have relevant competencies and a history of democratic design. The Nordic region has been branded as successful for welfare, sustainability and clean technology. HT–LC strategies can build on this story and make it relevant from a global perspective.



Confederation of Danish Industry



norden

Nordic Innovation

