



A Conceptual Analysis of Foundations, Trends and Relevant Potentials in the Field of Frugal Innovation (for Europe)

Interim Report for the Project
"Study on frugal innovation and reengineering of
traditional techniques"



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***Interim Report for the Project
"Study on frugal innovation and reengineering of
traditional techniques"
Commissioned to Fraunhofer ISI and Nesta
Contract n°NMP1-SC-2015-FRUGAL***

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1. INTRODUCTION

This publication is an excerpt and summary of major sections of an interim report that was produced in the context of the study “Study on Frugal Innovation and the Re-engineering of Traditional Techniques” commissioned by the European Commission’s Directorate-General for Research and Innovation (NMP1-SC-2015-FRUGAL) and performed by Fraunhofer ISI in partnership with Nesta, UK.

In the context of the project, this report had the following headline objectives:

- To provide a summary of the literature study and accompanying desk research that has been performed during the first, exploratory stage of this project and – on this basis – identify a number of key hypotheses,
- To establish a conceptual approach to select case studies for the second stage of the project, by defining key conceptual issues that should be covered by them in the form of summary headline hypotheses.

In detail, these shall be reached by

1. Going back to questions of definition as well as central drivers and barriers –interpreting existing literature, through a European lens and focus on those elements of the concept that must be considered in rendering it fruitful for European policy;
2. outlining why frugal innovation should – in view of recent trends – be considered a relevant opportunity for Europe and European industries taking into account capacities, market opportunities and societal challenges to be tackled;
3. elaborating in some detail on possible fruitful linkages between frugal innovation and technological development that will be constitutive for this study’s eventual usefulness for European policy makers;
4. casting a first general perspective on considerations for policy recommendations and vehicles of policy delivery, provide an outlook on what may be discussed in more detail in the final report.

Against the background of these objectives, the following chapters have been developed.

2. A CONCEPTUAL LITERATURE REVIEW ON FRUGAL INNOVATION

In the following, this report will briefly summarise the findings of an extensive literature review as well as further desk research and more than ten exploratory interviews conducted so far in the course of this study. In general terms, the analysis seeks to conceptualise the relevance of frugal innovation for Europe by clarifying basic aspects on the level of definition, highlighting opportunities, focusing on the role of technology and, finally, discuss relevant developments with a view to the future role of frugal innovation in Europe.

2.1. Frugal innovation: Concepts and preconditions

2.1.1. Approaching the core of frugal: More than just cheap

Background

As the academic study of frugal innovation and business practices continues to evolve, the definition of the term itself continues to evolve. While its essence remains succinctly captured by Prahalad and Mashelkar's (2010) phrase "more with less for more people", and most would agree that it relates to creative problem solving that generates utility under adverse framework conditions, different origins and contexts of application have led not only to diverse interpretations but also to a certain blurring of the conceptual boundaries of what can and should be considered as frugal innovation.

Importantly, the frugal innovation debate stems from different sources, including earlier discussions on frugal engineering by and in multinational corporations (Kumar and Puranam, 2012), grassroots innovation in developing countries (Gupta, 1997), reverse innovation leveraging frugal insights for more sophisticated applications (Saraf 2009, Howard, 2011), and catalytic innovations prompting transformative change (Christensen et al., 2006). In parallel, more regionalised discussions have developed around practices of 'Gandhian' and 'Jugaad' innovation in India (Prahalad and Mashelkar, 2010; Radjou et al., 2012; Radjou and Prabhu, 2012) as well as 'Shanzhai' and 'Indigenous' innovation in China (Ming and Flowers, 2016; Fu and Gong, 2011; Zhu and Shi, 2010; Schwaag Serger and Breidne, 2007). Overall, these concepts have been developed from a variety of academic backgrounds, personal motivations and, in part, based on empirical reference to quite distinct phenomena.

Against this background, this introductory section will seek to establish, structure, and delineate an understanding of frugal innovation that will guide the remainder of the work in this project. In providing this introduction, the authors define a framework of reference for the specific purpose of establishing the role of frugal innovation in and for Europe – without any explicit or implicit claim that this framework can be considered all-encompassing or fitting for subsequent reports and studies with different ambitions.

General approaches to definition

In summary, two main approaches to defining the scope of the discussion can be observed in the recent discourse on frugal innovation and related phenomena:

First, a number of consultants, corporations and some academics have developed lists of criteria to describe what they consider to be frugal solutions or at least solutions with particular relevance under emerging market conditions (Roland Berger, 2014; Agarwal and Brem, 2012). Most often, the guiding notion behind their establishment is the perspective of firms seeking to unlock entirely new markets through the provision of more affordable solutions for a wider population. In that sense, most of them constitute business case oriented definitions (The Economist, 2015). Generally speaking, they aim to describe desirable characteristics of frugal solutions in a straightforward, inclusive and generic manner – rather than to elaborate extensively how a process of frugal innovation in a producing firm should look like or what motivates specific actors to provide frugal solutions in certain contexts. For illustration, three examples of such lists of criteria are outlined below.

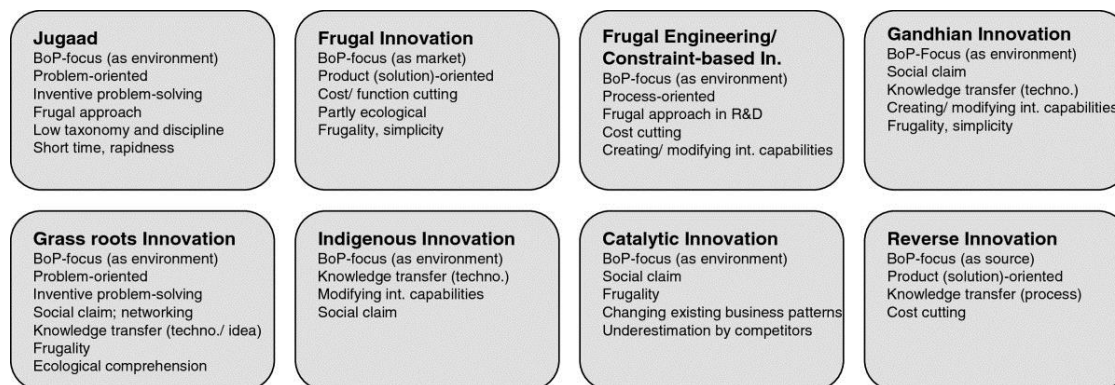
Table 1: Common Lists of Criteria for Frugal Innovation

Kumar and Puranam (2012 Study)	Roland Berger (2014 Study)	SIEMENS SMART (2005 Strategy)
Physical Robustness	Functional	Simple
Portability	Robust	Maintenance-friendly
De-featuring	User-friendly	Affordable
Leapfrog technology	Growing	Reliable
Low cost by scaling roduction	Affordable	Timely-to-market
Service Ecosystems	Local	

Source: Kumar and Puranam (2012), Roland Berger (2014), Siemens (2011)

Second, many academic authors have taken a broader perspective that, beyond immediate product based criteria, includes a more detailed discussion of the process of frugal innovation per se, framework conditions giving rise to such efforts and their potential socio-economic implications (Radjou et al., 2012; Radjou and Prabhu, 2012; Radjou and Prabhu, 2015). In general terms, Bhatti (2012) identifies frugal innovation as positioned at the intersection of technology innovation, institutional innovation, and social innovation. In a slightly different approach, Brem and Wolfram (2014) have undertaken an analysis and categorisation of relevant literature along the three key dimensions of sophistication, sustainability, and emerging market orientation that acknowledges and contextualises the different academic streams from which the discussion of frugal innovation has developed. In contrast with Bhatti, they do not refer to ‘frugal innovation’ as the overarching concept, but as one variant of several under the general heading of ‘research and development from the bottom up’ (cf. Figure 1).

Figure 1: Different Strands of Literature in the Debate on Frugal Innovation



Source: Brem and Wolfram, 2014

The definition of frugal innovation in this report will draw on both approaches. While establishing a list of criteria appears useful to delineate the core of the concept, the academic discussion suggests that it must be extended beyond the types of lists referenced in Table 1. At the same time, it will follow Bhatti (2012) and the majority of other authors (Howard, 2011; Radjou et al., 2011; Radjou et al., 2012; Bound and Thornton, 2012) in considering frugal innovation as an overarching notion rather than a specific sub-area of a more general debate on ‘bottom up’ innovation. Nonetheless, the framework of analytical dimensions proposed by Brem and Wolfram (2014) appears very useful and will be taken up in the following discussion.

Common criteria for frugal innovation

While different and in part diverging lists of criteria have been proposed in the discussion on frugal innovation (Kumar and Puranam, 2012; Roland Berger, 2014; Siemens, 2011), several aspects can be considered as prevalent and recurring, forming what could be termed a ‘frugal core’ that appears in most definitions.

First, frugal innovation generates products and services that **provide a better value proposition for less affluent customers** (Radjou and Prabhu, 2015; Leadbeater, 2014; Agarwal and Brem, 2012; Gupta 2011; Gupta 2008). It underlines that for a large part of many countries' populations 'better' and 'more useful' products and solutions do not have to be more elaborate, complex or expensive. This approach of generating products and services that are 'good enough' (Tiwari and Herstatt, 2013; Zeschky et al., 2011) features prominently in nearly all 'criteria systems' for frugal innovation, resonating with terms such as 'affordability, functionality and user-friendliness' (Roland Berger, 2014), 'lower cost and de-featuring' (Kumar and Puranam, 2012) or 'simplicity and affordability' (Siemens, 2011).

While the first and most often quoted aspect of this aspect is of course **price and cost** (Seghal et al. 2011; Gallis and Rall 2012), it, necessarily, also includes the other side of the equation: utility and durability. In providing products with higher 'reliability and maintenance-friendliness' (Siemens, 2011), 'physical robustness' (Roland Berger, 2014) and 'independence from infrastructure' (Kumar and Puranam, 2012) frugal innovators not only allow for **increased product lifetime** (Bound and Thornton, 2012) but also unlock entirely new markets by, for the first time, providing viable product propositions under less than favourable conditions.

Second, many newer definitions of frugal innovation contend that frugal innovation cannot simply be analysed as a goal-oriented process to devise products and solutions for specific markets according to a pre-defined list of characteristics but instead a **problem-oriented, creative approach to problem solving** which integrates specific, often local needs of developing and emerging markets as a starting point and **works from the bottom-up to develop contextually appropriate solutions** (Brem and Wolfram, 2014). In consequence, it may result in management processes and philosophies that are significantly different from existing ones (Gupta, 2011; The Economist, 2010; Arnold and Quelsch 1998). As a tendency, such processes will be **frugal in ends but also in means** (Bound and Thornton, 2012), i.e. often relying on the recombination of existing knowledge and technologies from previous efforts rather than substantial, dedicated R&D investments (Bhattacharyay, 2012). With the advent of crowd-sourcing new opportunities have emerged in this respect. Moreover, frugal innovation processes put stronger emphasis on conceiving **context-sensitive systems of market-delivery into which products are embedded** (Bound and Thornton, 2012).

In some cases, frugal solutions may, with some modification, also be attractive to consumers at the upper end of the market. In several studies, there is evidence of firms seeking to leverage that opportunity by using frugal environments as 'lead markets' (Christensen et al. 2006, Immelt et al. 2009; Howard, 2011; Tiwari and Herstatt, 2012).

Due to its different perspective, this process-oriented proposition features somewhat less prominently in the abovementioned 'criteria lists' of frugal innovation, but it is referred to indirectly through the acknowledgement of a 'local basis' (Roland Berger, 2014), a need for 'service ecosystems' (Kumar and Puranam, 2012), and the challenge to operate 'timely to market' (Siemens, 2011). Quite evidently, successful processes of frugal innovation that develop relevant impact do not only depend on specific locally adapted products but also on innovative business models (Bhatti and Ventresca, 2012).

Third, many discussions on frugal innovation make **clear claims with respect to improving access to products and services and improving resource efficiency and thus, implicitly, social and ecological sustainability** (Brem and Wolfram, 2014; Fukuda and Watanabe 2011). While some literature on frugal engineering and jugaad innovation (e.g. Brem and Ivens, 2013; Brem and Wolfram, 2014) makes little or passing reference to this aspect, it occupies centre stage in others (Pralahad and Mashelkar 2010; Bhatti, 2012; Radjou et al., 2012). In particular, such claims are present in the literature on grassroots innovations that empower bottom-of-pyramid inventors in a sustainable manner (Gupta, 2008; Seyfang and Smith, 2007) and 'catalytic inventions' that become relevant beyond their original context of application and cause positive socio-economic transformations (Christensen et al., 2006; Yip and McKern, 2016). Moreover, ecological claims are central to what Brem and Wolfram (2014) identify as the core of the frugal innovation debate (Gupta and Wang, 2009; Howard, 2011), i.e. the discussion on the solutions that are in multiple ways adequate for bottom-of-pyramid markets.

So far, this aspect has not yet been prominently taken up in the standardised criteria systems for frugal engineering in global industries that, by definition, tend to place strongest emphasis on the market dimension. Having acknowledged frugal innovation as an overarching notion, however, it would seem inappropriate to leave out the implication of improved resource efficiency and affordability. Hence, this report follows Gupta (2011), Prahalad and Mashelkar (2010), and Bhatti (2012) in understanding a sustainability-informed motivation as at least a weak condition to consider a process of innovation as genuinely frugal. The implications of this assumption will be discussed in more detail below.

As a final note, it has to be acknowledged that **frugality (and thus frugal innovation) remains a relative, rather than an absolute, concept** with respect to all three of these dimensions. Whether a certain solution can be considered frugal depends partly on available alternatives (i.e. whether the new solution is, for example, better suited to user needs and cheaper than alternatives) and also on the questions which are analytically considered. Whether a Tata Nano appears frugal or not (in terms of price) will depend on whether the point of reference is a luxury car or a motorcycle. Whether an iPhone is frugal depends on whether it is used as a mere phone or to steer a satellite. Notwithstanding these considerations, generic, guiding characterisations are still useful – and will be developed below.

Summary and Concept

Based on these insights from the literature review, this report and all following empirical efforts will refer to frugal innovation based on a three-level, criteria-based definition, including:

- A product dimension capturing the **'what?'**,
i.e. concrete characteristics of frugal solutions
- A process dimension capturing the **'how?'**,
i.e. aspects of their design and delivery context
- A context dimension capturing the **'why?'**,
i.e. their functions in frugal environments

In line with that approach, this report will maintain that few solutions will in practice meet all criteria at once or, even less, to the same extent. **Frugal innovation is a multi-dimensional phenomenon that combines aspects of product, process and environment in different, context-specific ways. Consequently, no single threshold for frugality can be defined with a view to one particular criterion.** Moreover, the very nature of the abovementioned criteria, such as 'context-specific utility' underlines that **successful frugal innovation cannot be 'measured' in generic terms, but only be identified qualitatively in a specific framework.** Hence, the above criteria system should not be read or applied as a listing of hard preconditions. Instead, it provides a **concrete framework of reference to identify the overall 'degree of frugality' of specific solutions in defined contexts of application.**

Product Dimension

- Simplicity / de-featuring
- Context-specific utility
- Robustness / long service life

Process Dimension

- Designed in creative response to contextual challenges
- Integrated in localised delivery concept
- Scaling from local context to address wider market opportunities

Context Dimension

- Affordable
- Resource efficient
- Systemically transformative

Intentionally, the above list of criteria **does not distinguish between frugal innovations in developing and developed economies**. Contrary to rather strong claims in the literature, such a distinction does not seem relevant at a fundamental level, as both frugal conditions and creative entrepreneurs able to respond to them can in principle be found in both environments. In the following, this overall approach will be applied by identifying central tradeoffs between different criteria for frugality and several types of frugal innovation.

Common strategies for frugal innovation

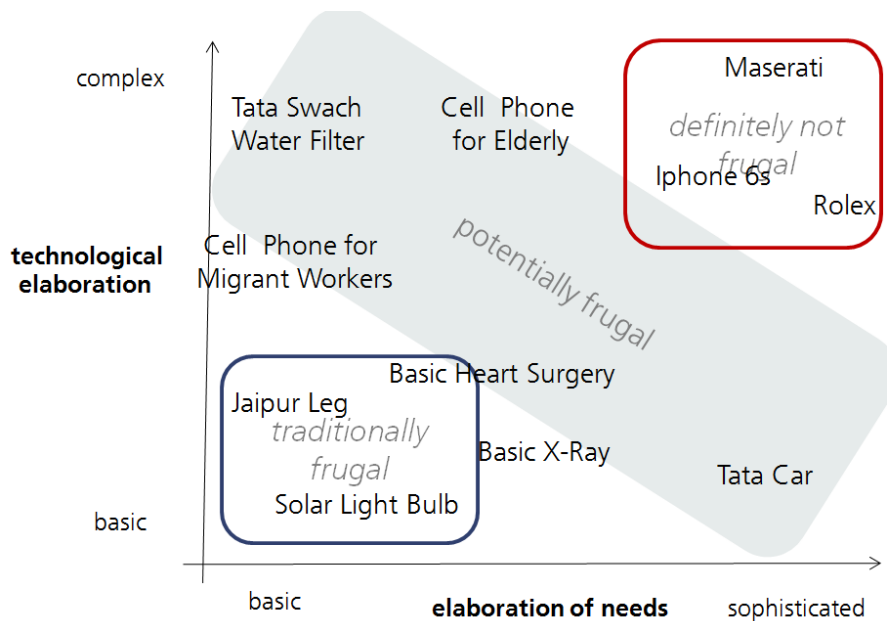
As the two figures below illustrate, even some of the most commonly quoted examples only fulfil some of the commonly mentioned criteria for frugal innovation, partly due to their context specificity and partly due to the different dimensions of frugality. Beyond 'obviously' frugal solutions, there is a broad range of solutions that incorporate key aspects of frugality (simplicity, low cost) while at the same time, they address needs that are not particularly basic (cars) or have a distinctly less than favourable ecological footprint (mobile phones).

One relevant distinction in the context of this study is the **contrast between the elaboration of needs addressed** (i.e. if an innovation really addresses a bottom-of-pyramid, basic need, as often stipulated in the literature) **and the level of technological elaboration** (i.e. whether the innovation can be developed without any additional technological input) (cf. Figure 2). While these may indeed coincide, there is in principle no reason why they must, and frugal solutions can be developed based on one of them only.

A further relevant distinction is the **contrast between low cost and ecological footprint** (cf. Figure 3) which in some literature appears underdeveloped, as it is implicitly posited that all frugal innovations are in some way automatically socially and ecologically beneficial. In fact, however, many frugal innovations have quite a notable ecological footprint and many firms that engage in frugal engineering with the potential to unlock new markets in emerging economies will not per se be motivated by considerations of environmental sustainability.

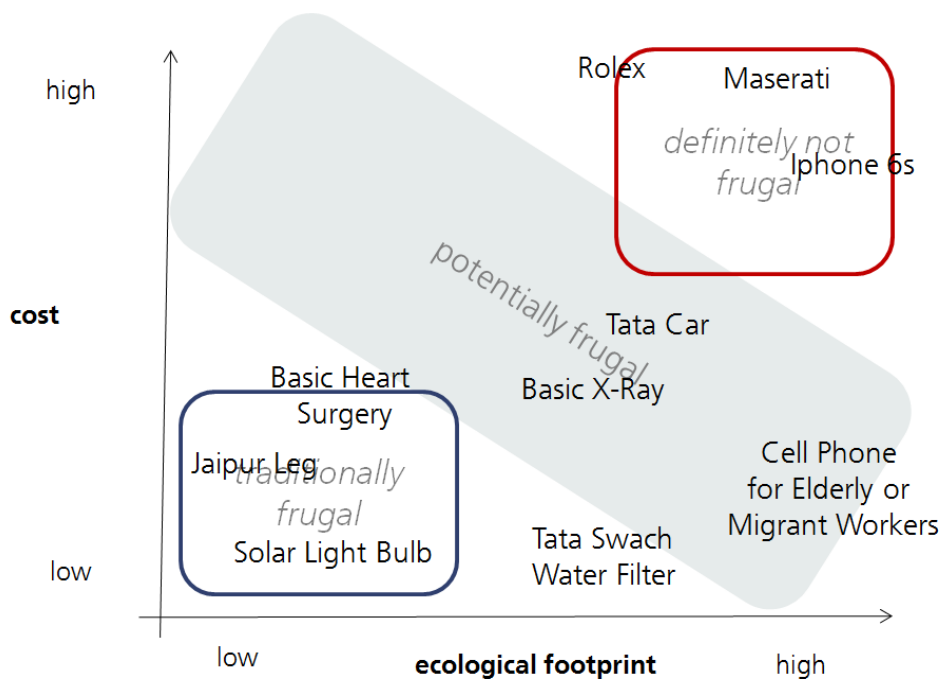
In general, different types of frugal innovations are pursued based on different motivations and to different ends, so that it would be mistaken to assume that any convergence between them was likely to occur. Instead, frugal innovation should be understood as a broad concept that provides multiple points of leverage to pursue different political objectives and contribute to the overall ambition to create more growth and jobs in different ways.

Figure 2: Elaboration of Frugal Innovations: Technological vs. Needs-oriented Perspective



Source: Own figure

Figure 3: Affordability vs. Ecological Footprint in Frugal Innovation



Source: Own figure

With a view to the positioning of relevant, known examples in the figures, moreover, it becomes clear that **focusing this study on obviously frugal innovation in which as many as possible of the above criteria are met would not only result in a limited understanding of the phenomenon as such but also in its missing some of the potentially most relevant examples**. As the European market environment is neither broadly characterised through bottom-of-pyramid populations nor through basic needs unmet, **the most relevant interfaces between traditional technological activities in the European Union and frugal innovation may well exist at the 'boundaries of frugal'**, i.e. those solutions defined by some, but not all aspects raised in the literature. Below, typical strategies for frugal innovation (cf. The Economist, 2015; Radjou and Prabhu, 2015) are outlined with reference to the general criteria system developed above.

The below listing provides a basic overview of various way of frugal innovation.

1. Local solutions to meet low-threshold demand on less developed markets

Along the lines of the discussion on grassroots innovation, many 'innovative fixes' under frugal conditions emerge locally to address specific, context dependent problems. Often, such solutions have an explicitly social ambition as they address latent yet pressing basic needs of a local population that, without an affordable solution, would remain unmet. While their degree of robustness and simplicity is high, they are strongly adapted to certain context and not always relevant beyond (e.g: water filter powered by motorbike, solar light bulb).

2. Local solutions for sustainability challenges on less developed markets

Beyond their main ambition to address localised social challenges, some grassroots entrepreneurs develop solutions with a particular focus on sustainability. By using and combining available materials and commonly available traditional techniques they provide simple, robust solutions with high context-specific utility while at the same time reducing the overall use of resources on a larger scale. Their applicability outside of their initial environment, however, is equally uncertain (example: agricultural innovation).

3. Product based frugal engineering, corporate "mass frugal" based on simple de-featuring and affordability

Larger, often Western, firms tend to develop standardised 'mass frugal' products through a process of de-featuring existing solutions. The most common motivation for this strategy is to unlock additional, often foreign, markets via low prices. In general, it relies on affordability as the main vehicle to unlock additional markets and increase profit. Given their focus on opening up access to products to new markets, their ecological impact in particular can be negative rather than positive, for example, if connected to throw-away products or if increased usage results in greater CO₂ emissions (examples: Tata Nano, Gillette Guard).

4. Product based frugal innovation, based on increased utility through robustness and sustainability

Instead of simply removing features from existing products other external developers devise independent frugal solutions that create additional utility for low income/bottom of pyramid customers through an increased robustness and durability – in part through co-creation with local actors. Often, such solutions are more independent from advanced infrastructure so that this approach implicitly increases the sustainability and resource efficiency of the supplied products and services (examples: Solar Lamps, Nokia 1100, Jaipur Foot).

5. Process based cost reduction, based on leveraging emerging market conditions and smart processes for cheap production

A further option to lower prices and unlock low income markets are process based cost reductions. Here, 'frugal prices' are not (only) achieved by adapting the product but also through substantial, cost-cutting adaptations in the production process. At times, this can be achieved through new, smart processes for the recombination or more efficient use of existing resources (for example, Renault-Dacia's dashboard was designed to be manufactured from a single injection-moulded piece). Bringing production close to end markets also reduces logistical costs. Other strategies, however, exploit gaps in environmental, health or labour regulation – or simply lower wages and may create a detrimental social and ecological impact.

6. Mass customised solutions for less developed markets based on cooperation with local partners

Beyond a common need for affordability, frugal market contexts can differ substantially. To differentiate between genuine bottom-of-pyramid customers and emerging middle classes or to take into account cultural specificities, some firms seek to create mass-customisable or at least modular solutions. In principle, such a process increases the local fit of the provided solution and implies a somewhat improved social outcome (example: household appliances).

7. Standardised frugal solutions for less developed markets based on customised delivery concepts

In some cases, frugal solutions are developed around a rather simple and standardised product that is embedded in a centrally-designed yet context sensitive and adaptable service and delivery

concept. Even without customization, this can substantially increase a per se standardised solution's utility under various conditions. While these approaches do not necessarily come with a social or ecological ambition, they are easily amenable to such if consciously pursued (examples: models to rent healthcare devices or solar panels).

8. Globally transformative solutions based on challenges initially identified in frugal environments (reverse innovation)

Importantly, however, some grassroots innovations that were originally designed to address rather context specific challenges proved very amenable to larger scale application and in some cases even so superior to incumbent technologies that they caused a disruptive or at least transformative effect in the overall economic system. Typically, this scalability is caused by either their particularly superior value proposition or their particularly evident social or ecological benefit (examples: Skype, e-bikes, mobile phone banking).

2.1.2. Central preconditions for frugal innovation

So far, this report has considered how frugal innovation can best be defined. This, however, does not answer the question which relevant preconditions have to be in place so that frugal solutions can thrive and generate substantive socio-economic impact.

The following subsection will explore three main dimensions:

- Actors and environments needed to encourage frugal thinking,
- Strategies to scale frugal solutions to larger markets (and their limitations),
- The double role of regulation as both barrier and potential enabler.

2.1.2.1. Frugal mindsets: Seeing things differently

The literature strongly suggests that frugal innovation is linked to a specific mindset: "not just a drastically different way of innovating or even a radical new way of running a business – it is about fundamentally shifting the corporate mindset."¹ The following section aims to develop this idea from the viewpoint of European innovators. It starts by exploring the individual level and then places the individual in his or her cultural context, before discussing the issue of transferability of contextual frugal solutions to larger markets.

The individual perspective

To establish the preconditions for making 'frugal thinking' a driver of frugal innovation in firms, it is obvious to start by looking at the individuals driving innovation processes. As the inception workshop established, the individual view on innovation needed to conceive and implement frugal innovations is different from that currently prevalent among developers in many of Europe's technology leading technology firms. Against this background, the following section explores to what extent frugal thinking relates to dimensions like creativity, freedom, motivation, and culture.

Conventional conceptions of innovation tend to envisage this process as stepwise, following a more or less linear process from research to technology to product. Frugal innovation, on the contrary, requires a different approach that involves a consideration of the user from the outset. In most cases, such approaches can be traced back to individuals who intentionally diverge from established processes due to a different understanding and perception of the nature and purpose of innovation. Such diverging perception, and the diverging behaviour that follows, can conceptually be captured in the concept of 'positive deviance'; "intentional behaviors that depart from the norms of a referent group in honorable ways" (Spreitzer and Sonenshein 2004: 828). Importantly, not every form of creativity necessarily follows honourable intentions or deviates from norms, so that neither creativity nor innovation meets the conditions of positive deviance per se. Nevertheless, the concept of positive deviance provides a basis to understand and conceptualise frugal mindsets: If creative individuals' behaviours deviate from innovation norms in their company, industry, market, i.e. from 'conventional ways of innovating', by aiming to limit the use of resources, even if available, or, from the outset, conceive technologies and products to serve new user groups, this could be understood in the sense of positive deviance.

Hence, several factors can be identified that characterise people with 'mental prerequisites for frugal mindsets'. At the core lies the **problem-solving approach**. This approach implies that the creation process starts with a certain challenge and the wish to overcome it. Such an attitude requires an open mindset and the ability to observe one's environment with 'open eyes', **free of prejudice and ready to challenge prevalent convictions**. Coupled with creativity, energy and the motivation to break out of given routines, this favours 'unconventional projects' that positively deviate from existing practices and habits. Generally such individuals are **highly creative when it**

¹ <http://knowledge.insead.edu/innovation/frugal-innovation-a-new-business-paradigm-2375>.

comes to developing new ideas, but at the same time 'down to earth' when it comes to customer needs and acknowledging resource limitations. In other words, a frugal mindset is open to perceive things from different angles rather than judge them based on existing norms, open to intuition rather than overly reliant on analytics (Briggs and Myers, 1995).

A further relevant concept of this way of thinking has been proposed by Claude Lévi-Strauss and his approach of "bricolage" (1962). At the core, this concept focuses on solving problems with given resources through improvisation and by using existing ingredients in uncommon ways. This process of "testing and crafting" not only requires a **certain mental disposition of seeing opportunities differently**, but also creativity and a pool of experience. Lévi-Strauss contrasted this approach to the engineering mode of creation, this latter being characterised as developing items along a (predetermined) logical and linear structure. At the time, he assigned the engineering view to Western traditions with their rational and systematic approach compared to rather improvising approaches as observed in the cultures of indigenous people using traditional techniques. From a current perspective, these two approaches could still be interpreted as archetypes of exploration and exploitation respectively: while the engineer aims to explore new technologies and add to the existing knowledge base, the "bricoleur" or "tinkerer" uses existing knowledge and resources, from a continuously growing repository (Saravathy, 2001). As will be outlined below, however, it has been demonstrated that, contrary to Lévi-Strauss' generalist dichotomy, exploitation does play a substantial role in the European economy, providing a point of leverage for further consideration with respect to the broader adoption of frugal mindsets.

To summarise, an individual's ability to pursue frugal innovation projects strongly depends on his or her **ability to identify or even 'foresee' problems that others do not see or not view in the same way.** Moreover, it depends on **willingness to consider problems an opportunity to respond with creative solutions in deviance from prevalent practices and habits** – by including elements of bricolage. Additionally, frugal innovators tend to have a different perception of resources, meaning that they are able to conceive of resource scarcity as a driver rather than a restriction of creativity, inspiring them to deploy given resources in unconventional and unexpected ways, for other purposes than initially foreseen, or combine them in different ways and relations than usually done.

In addition to the problem-solving and the perception factors, the "will factor" (Héraud/Muller, forthcoming) constitutes a third mental prerequisite. It complements mere creativity as defined by Sternberg/Lubart (1999) as "novelty and appropriateness of an idea" with a "willingness to change the world". This implies that for most frugal innovators it is not enough to develop ideas and to conceive ways to apply and exploit them; rather, they seek to pursue a certain objective, be it entrepreneurial, social or environmental. Taken together, the mental prerequisites of frugal innovators thus involve creativity, vision-building, and an entrepreneurial spirit as well as the courage to transcend and break existing rules and paths, with the intention to realise their ideas. To do so, frugal innovators often seek to cross boundaries between different worlds or to link different communities, similar to the role of "knowledge angels" knowledge-intensive business services (Muller, Zenker and Héraud, 2015). Arguably, connecting the worlds of exploitation and exploration thus constitutes a central opportunity for aspiring frugal innovators in the European Union.

Culture and philosophy

Individuals with frugal mindsets do not act in isolation. They are part of social groups and communities that shape their values and their behaviours. In the literature, for example, frugal innovation is often discussed as particular to an Indian or Asian context (see 'jugaad innovation' and frugal creativity being part "of the Asian DNA").² To an extent, therefore, it has to be questioned whether frugal mindsets can be 'learned' by everyone or if they are contingent on specific cultural and philosophical backgrounds. In other words: Can the mindset of individuals shape a frugal context or is the individual to be seen as reflecting and determined by the values of a larger group or culture?

Without aspiring to answer this question at a fundamental level, it can be acknowledged that frugal thinking is indeed common in certain cultures. If national cultures (and norms) indeed differ with respect to 'uncertainty avoidance', 'long term orientation' and 'individualism' (Hofstede, 1984) this will have consequences not only on how work is performed but also on how innovation processes are set up. In that sense, Indian innovators can justly view their individual activities as related to certain national characteristics. In a general sense, moreover, such patterns have been confirmed in empirical studies (Brem and Freitag, 2015).

On the other hand, today's innovation practices are established in different companies, be they Western or Asian, and thus in a more complex and diverse range of contexts than can be captured

² <http://thinkbusiness.nus.edu/articles/item/126>, referring to Radjou et al. (2012).

through the attributes of a specific national culture. In any country, some companies may oppose deviant thinking while others may nurture it, giving more room to 'intrapreneurial bricolage' (Halme et al., 2012). As outlined above, moreover, 'frugal thinkers' tend to be less limited by conventions, be they culturally or firm-specific. Finally, successful practices tend to reconstitute themselves vigorously and thus to shape their surrounding context rather than remain limited by it. In consequence, frugal mindsets will not be absent in Western contexts, nor should they by definition be impossible to acquire. Frugality implies a different way of thinking: solution-oriented instead of primarily technology-based. For this, many examples can be found in Western economies, even though they are typically not labelled as 'frugal'.

Nonetheless, specific, favourable environments will be necessary to provide room for the spirit of frugality in Western industrial culture as under standard framework conditions it will have difficulty thriving (Halme et al., 2012). Radjou et al. (2012) argue that the R&D-related innovation approach which is common in a large share of Western companies has created persistent path dependencies that reduce their "spirit of flexibility": "With so much money invested in R&D, Western firms have become risk averse in their approach to innovation. They have implemented standardised business processes [...] to manage and control their innovation projects. These structured processes were expected to drastically reduce uncertainty – and risk of failure – from the entire innovation process and make R&D projects more predictable in both execution and outcomes. But these structured business processes and methods are unfit to deliver the agility and differentiation that enterprises need in a fast-paced and volatile world." (Radjou et al. 2012: 10). In short: many such firms have lost the very flexibility needed for any user-oriented and certainly frugal innovation and their current internal culture is likely to stifle any individual attempts to that effect.

This, however, is a result of specific developments, not deterministic, inescapable cultural traits. As Tiwari et al. (2016) elaborate, frugality and thrift were acknowledged as positive norms from Seneca to Kant and Smith to Weber while a sense of improvisation, *Yankee ingenuity*, was among the triggers of the Industrial Revolution (Radjou et al., 2012). Hence, the main task for Europe is one of re-discovering frugal spirits and re-learning frugal approaches. In recent years, there have been indications of a rising number of 'intrapreneurial innovators' in firms as well as a 'maker movement' outside of them which seeks to make this transition – drawing on new information and communication technologies, and promoting co-development between formerly fragmented groups and communities.

What may be even more important is a problem-meets-solution oriented 'frugal mindset' can be brought about by allowing open discussions of current challenges and by giving room to 'entrepreneurial activity within large organisations' as a means to more creatively bundle scarce resources (Halme et al., 2012). Furthermore, society can be considered a laboratory for what is missing in industry: How could Dawanda, the preference for certain food and eating cultures leading to recipe sharing, specialised restaurant recommendations or 'Social Cooking' as well as voluntary support for refugees, to name just a few examples, gain so much momentum in such a short period of time? For large organisations, Jaideep Prabhu thus recommends giving space and room to experiment internally while at the same time seeking to collaborate with actors from society or other national contexts.

Transferring, initiating and learning frugal mindsets

If frugal mindsets can in principle be acquired, yet the current situation is far from satisfactory, new approaches need to be identified to spread and 'teach' them. To do so, it is instructive to build on the **three main preconditions that allow frugal mindsets to thrive: (i) individuals' open attitude and willingness to identify and solve problems, (ii) an appropriate intra-firm environment allowing the spread of unconventional ideas (iii) an external environment or community that provides additional inspiration, visions and ideas.**

Concerning the first aspect, it can be concluded that 'creative minds' may be everywhere, but most often need to be motivated and perhaps incentivised to put forward and pursue their visions and creative ideas. With a view to the second and the third aspect, Cohendet et al. (2010) underline that individual characteristics only partly explain differences in creativity. Contextual factors are of equal importance: "The creative output (products, services, ideas, procedures, and processes) of the entire system stems from the complex mosaic of individual, group, and organizational characteristics and behaviors occurring within the salient situational influences (both creativity constraining and enhancing) at each level of social organization" (Woodman et al. 1993: 298). To promote a frugal culture of innovation and encourage latent or nascent frugal mindsets to thrive, therefore, suitable environments for both learning and practice will have to be nurtured at both an organisational and a local ecosystem level.

In this respect, the following key persons or groups of individuals may play a catalytic role in improving the immediate and larger environment of the frugal solution.

- High-level decision makers who support rather than stifle 'intrapreneurship' and lateral thinking in their organisation and permit contact to external sources of inspiration,
- Early producers who are not necessarily the genuine 'inventors' of the frugal solution but belong to the first ones to diffuse it and demonstrate its commercial viability,
- Early adopters who add momentum to its diffusion by adopting, adapting or transforming its first versions (comparable to beta-users in the field of software development),
- Trend launchers, who as 'spokespeople' or 'promoters' help raise awareness and create relevant user communities for frugal solutions in a certain area.

2.1.2.2. From local ecosystems to larger markets: Issues of scalability

In outlining how frugal thinking can be brought to fruition, the section above describes an initial step in the itinerary of a frugal innovation, from conception to socio-economic impact. To achieve noteworthy socio-economic impact, however, frugal solutions have to be transferred out of their original 'biotope' onto larger markets – actually to reach 'more' people.

Hence, localised ecosystems provide a favourable incubator for frugal innovation but they may eventually become obstacles to scaling situated frugal solutions to a socio-economically and industrially relevant level. If frugal solutions remain overly contingent and their utility proposition dependent on a specific socio-economic context, their impact will remain unduly limited. In the following, therefore, this section will explore some of the characteristics of situated frugal innovation – and the difficulties that these may entail in the process of scaling up their provision beyond their initial context.

Obstacles to scaling up localised frugal solutions to larger markets

In general terms, three main categories of obstacles can be identified that hamper the market enlargement of frugal solutions.

The first category concerns the possible disconnection between producers and users. In the case of local ecosystems one may assume that the community of producers corresponds more or less to the community of users or that at least these two communities are strongly interrelated. In the case of larger markets, this is no longer the case. Producers most often do not constitute a community but rather a sector or industry and if there is any identifiable community of users, this may be rather fragmented. In addition, the perception of frugality may be very different from one socioeconomic context (i.e. market) to another. As a consequence, motivations for 'buying frugal' may be so different that producers are not able to identify the potential broader markets. This may be especially true when it comes to transform a solution developed out of scarcity to 'something hype' because of its simplicity or environment-friendly nature for instance.

The second category relates to the way producers conceive and may develop the production and delivery processes of their frugal solution. For instance, crafts or agricultural products using traditional techniques are often produced in specific regions, using local resources and sold in only a few locations. This may constitute a unique selling proposition, but most often the local producers display neither consciousness nor specific interest to bring these products to larger markets. The same applies to the question of market segments. While local market conditions are usually intuitively well known, aiming for larger markets usually requires further marketing skills, such as a good knowledge of price sensitivity of different market segments. This may be especially true in extreme cases when the initial market corresponds to medium- and low-end market segments in poor or emerging countries and the targets are high-end markets of developed countries. Finally, the case of low-cost air filters³ demonstrates that some propositions may be compelling in some places but not at all relevant elsewhere.

Finally, different implications result from producing and selling at a larger scale for a broadened market. This may concern in particular a minimal level of standardization that must occur at least in the production process if not within the frugal product and/or the service itself. Standardization constitutes in some cases a hampering factor mainly, but not only, because of the initial investments that may be required. In fact the quasi artistic dimension (or at least handicraft character) of small scale (or even unique) frugal products probably gets lost when these frugal products are made available on a larger scale. Customization can be (at least partially) a solution from a marketing point of view, but the initial genuine character may vanish. The same applies to the issue of norms (e.g. safety regulations) when it comes to larger scales of production and/or sale of frugal products and services.

³ smartairfilters.com

In summary, the challenge of spreading innovative frugal solutions to larger markets touches upon the more general challenge of connecting local producers and a broader consumer base. In consequence, a key factor allowing producers to successfully target broader markets is the availability (or development) of appropriate and reliable delivery channels that enable them to bridge geographic distance and market segments with different specificities.

Paths leading from local to larger markets

Depicting the different ways a frugal product or service conceived (and initially produced) within a local ecosystem may be distributed on a larger scale requires consideration of market segmentation. While market segmentation can derive from income segmentation – and in the discussion on frugal innovation is most often referred to in that sense – it may also result from demographic or even lifestyle segmentations, as the case of “Frugal Freiburg”, identified by Leadbeater (2014) vividly illustrates. Furthermore, it results from technological lifecycles that, with the advent of particular enabling technologies, may allow for new and different opportunities for frugal solutions (cf. Gallis and Rall, 2012). Finally, it can result from linguistic, cultural or market characteristics. Arguably, such market segmentation is a much more prominent challenge in the institutionally, culturally, linguistically and economically fragmented European environment than in the much larger markets of e.g. India and China. While these emerging economies are not necessarily less heterogeneous in economic terms, regulatory, cultural and linguistic barriers may be less prevalent in the multicultural nation of India than they are in European Union as, like China, it at least shares a lingua franca.

In that sense, emerging economies may profit from a large market advantage in the field of frugal innovation alike to that commonly attributed to the United States in the high-tech field. Remarkably, most European frugal innovations have so far emerged in those areas that are least affected by a national fragmentation of customer behavior and regulation (Ryanair in air travel; Skype and TransferWise in the virtual domain) while, at the same time, many experts on Eastern Europe suggest that the individual markets of these economies could be too small for large-scale, non-situated business models based on frugal innovation – and structural boundaries too difficult to overcome⁴.

Beyond these macro-level obstacles relating to national boundaries and regulatory barriers, further challenges may result within frugal markets on the side of delivery. Typical retailers, for example, will usually not accept (or legally not be allowed to provide) frugal solutions on their shelves that are not standardised products. Contextually embedded solutions, however, often involve a certain do-it-yourself component which may not meet these criteria⁵.

For its socio-economic impact and commercial relevance, in any case, it is far from enough to demonstrate the viability of a certain frugal innovation in a specific context. Instead, the more relevant question will remain how the interested producer finds ways to adequately connect with and involve an increasingly complex customer base.

In summary, three basic pathways of scaling up frugal solutions can be outlined:

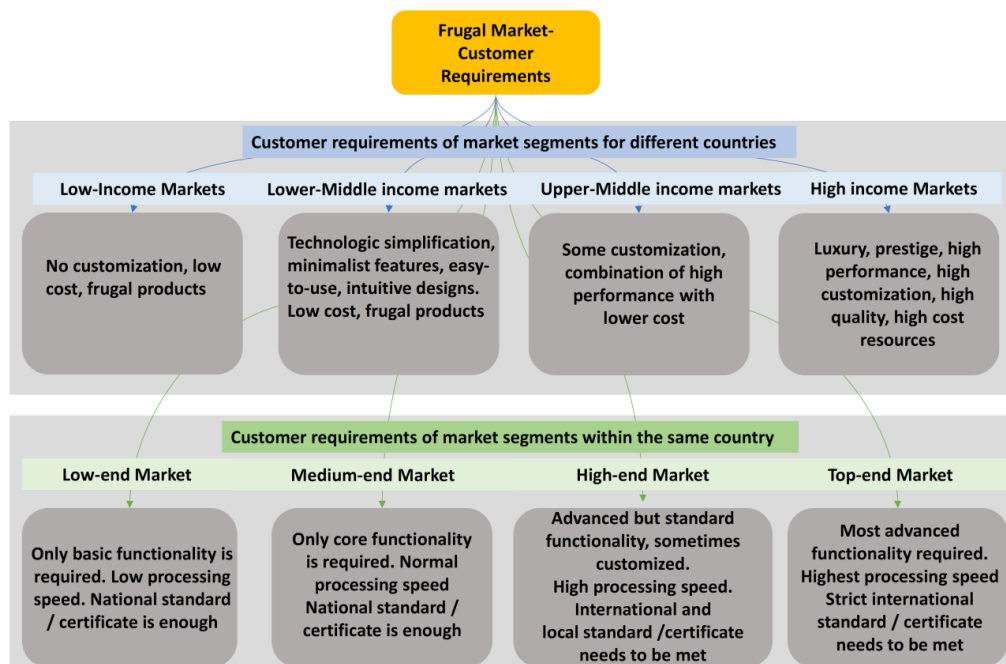
1. The initial frugal inventor or group of inventors develop their own growing business (e.g. as a start-up), expanding its sales from segment to segment.
2. The diffusion of the frugal solution through an expanding phenomenon of adaptation over time without one clearly traceable ‘inventor’ and/or ‘birthplace’. Following global trends, activities may occur simultaneously in different market segments.
3. The solutions found in a local ecosystem serve as a source of inspiration for others – who are not necessarily embedded or linked to this ‘original’ local ecosystem. In this case it is rather an effective translation of the philosophy behind a solution that allows a larger scale of production and/or distribution in totally different market segments.

Against this background, Figure 4 illustrates the implications of market segments in terms of paths leading from local to larger markets.

⁴ Interviews with Prof. Slavo Radosevic, UCL; Mark Boden, IPTS; Yannis Toliás, Innovatiasystems Greece; Prof. Boris Cizelj, Slovenia (former Ambassador to EU)

⁵ cf. example of smartairfilters.com

Figure 4: Background in terms of frugal market-customer requirements



Source: Laboratory for Manufacturing Systems and Automation (LMS) (2015): 27

Mastering complexity

Many of the commonly quoted business cases of and for frugal innovation focus on limiting complexity thus enabling smart, high-utility, but low cost solutions. Unsurprisingly, therefore, many of these business cases have been developed in low-wage countries with comparatively limited educational levels. In and for those, frugal innovation is a natural choice.

From a global perspective, however, most EU Member States are high-wage economies with comparatively high levels of education, for which the more complex parts of the value chain in which substantial value is added are considered more economically relevant. In this context, frugal approaches are often neither required nor the obvious choice.

Once a firm or entrepreneur begins to scale up frugal innovations to high-volume markets, however, additional sets of complex skills are needed that go beyond mere entrepreneurial ingenuity of the grassroots innovation type and depends on the involvement of an educated workforce. Beyond technological qualifications these requirements extend to other parts of value creation, related to contexts of delivery such as general market intelligence, interaction with future customers or co-creation with existing ones.

Relevant areas of such non-technological yet complex knowledge include:

- Collecting, processing and analyzing information on diverse markets,
- Intercultural skills,
- Regulation and standardization management,
- Application related knowledge (e.g. medical applications),
- Technology processing,
- Set up of manufacturing,
- Procurement,
- Distribution in various markets,
- Value chain management.

To draw on such competences successfully, frugal innovators in technologically leading as well as in emerging economies depend on access to qualified personnel with skills beyond the technological realm. In brief, the non-technological challenge to successfully deliver frugal solutions to multiple markets out of growing firms is such that it can only in exceptional cases be addressed through learning-on-the-job alone. In most cases, support staff with formal qualifications in social sciences,

medicine, economics or even humanities will be needed in addition to a core team technological developers with a 'frugal mindset'. Ideally, even the development teams themselves should be interdisciplinary and open.

2.1.2.3. Barriers and enablers: Regulation and institutional frameworks

The question of whether regulation ultimately fosters or hinders innovation has not yet been comprehensively answered. The empirical literature on the impact of regulation on innovation is rather scarce, and often only provides anecdotal evidence, while the few existing quantitative studies show more or less ambiguous results (Pelkmans and Renda, 2014). What most of the scientific literature on the topic has in common is the basic argument that regulation can on the one hand drive innovation by having an "incentive impact", increasing the available resources for innovation, but on the other hand is associated with "compliance costs", having an innovation hindering effect (Carlin and Soskice, 2006; Stewart, 2010). This already implies that the effect of regulation on innovation is dependent on the type of regulation (whether it directly targets innovation or not and whether it is aimed towards short- or long term goals) and also on the context of the targeted firms, e.g. their sector or size (Blind, 2012). The debate on how regulation affects innovation has recently also entered the arena of policy making, since improvements towards making the regulatory framework more innovation friendly can be seen as an instrument to promote countries where an increase in public R&D expenditures is not a viable option, especially after the financial crisis (Blind, 2012).

The question of how regulation particularly affects frugal innovation has not yet been debated in more detail. The mentality of 'frugal thinking' can be seen as a response to constraints in resources – financial, material, temporal or institutional – with the aim of turning them into an advantage for users as well as providers of frugal solutions. Frugal products are characterised as 'good enough' and 'having a better fit' with a view to actual user demand and often are the result of creative and 'out of the box' thinking (Agarwal and Brem, 2012; Bound and Thornton, 2012; Tiwari and Herstatt, 2012; Zeschky et al., 2014). At least at first sight, this stands in conflict with the view of regulation and the need to comply with certain standards (e.g. environmental, safety), laws and intellectual property rights (IPR), which is especially problematic in comparably regulated markets of industrial economies. Consequently, the current opinion of experts⁶ suggests a negative impact of regulation on frugal innovation, as the costs of adapting to a given amount of regulation in a certain market, e.g. bureaucracy, information gathering etc., seem to outweigh the benefits.

Before discussing this in detail, the term regulation has to be defined, to gain a better understanding about where challenges may arise and which policy measures might be adequate to address these challenges. The classic OECD definition states that "regulation refers to the implementation of rules by public authorities and governmental bodies to influence market activity and the behaviour of private actors in the economy" (OECD, 1997). This definition can be further differentiated into economic, social and institutional regulations. Economic regulations cover competition, antitrust, mergers and acquisitions, market entry and price. Social regulations refer to environmental protection, workers health and product and consumer safety, while institutional regulations cover liability law, employment protection, immigration and bankruptcy laws as well as IPR (OECD, 1997).⁷

From these dimensions, it can be derived that there are certain regulation regimes that directly target innovation as an ultimate goal, as in the case of IPR, but the bulk of regulations are geared towards other economic, environmental or social goals. Regulations that do not directly target innovation might nevertheless spur innovation in the sense that firms have to adapt to the regulatory framework by improving their products and processes, but especially here the compliance costs have to be taken into account (Blind, 2012).

A very prominent example of a regulation directly targeting innovation is the patent system, which grants inventors a temporally limited, exclusive right to sell products based on their invention in exchange for full information disclosure. Besides the fact that the patent system is associated with certain costs at the patent process stage (patent application, translation, renewal or lawyer fees) as well as the diffusion stage (opposition, litigation and commercialization), which already might deter firms from filing a patent (Frietsch et al., 2013), the patent system also puts a challenge on frugal innovation from another perspective. Since frugal innovations often are characterised by being "adapted to actual demand" (Bound and Thornton, 2012), they often do not constitute a patentable invention per se, as they may fail to adhere to the novelty criterion within the patent system. This implies that a regulation, in this case IPR, at least to a certain extent excludes frugal

⁶ based on this project's inception workshop held in Brussels, February 17th, 2016.

⁷ Beyond these, tax law, public procurement, labour regulation and standardization and standards have to be mentioned (OECD 1997)

innovators from a system of rules that is supposed to spur innovation. The criteria for patentability, however, at least slightly differ across jurisdictions in terms of what is patentable and how the novelty criterion is interpreted. China, for example, changed its novelty criterion from “new to the market” to “new to the world” to adhere to the TRIPS⁸ agreement in 2009 (Frietsch et al., 2012; Frietsch and Schüller, 2010). Another interesting example is the Indian patent system, which is comparably special in dealing with patents in pharmaceuticals. Although India amended its patent law to adhere to the TRIPS standards and now provides protection for pharmaceutical products, it still limits patents on “incremental” pharmaceutical innovations (Sampat, 2010), which can be seen as a major obstacle for frugal pharmaceutical innovations. These examples show that regulation, i.e. in this case the amendment of the patent system that raised the bar for patentable inventions regarding novelty and inventive step, excludes certain frugal innovations that might not be “new to the world” or “too incremental” from being patented.

However, there are various examples of frugal innovations that have recently emerged in developing economies like India, China, or South Africa. From the regulatory perspective, this might have to do with what has been labeled “institutional voids” in the scientific literature (Khanna and Palepu, 2010), which describe missing institutions and intermediaries within a market economy. Usually, these institutional voids are discussed as driving up transaction costs, as the market lacks access to e.g. information, risk-capital or qualified labor (Soni and Krishnan, 2014). Yet from the perspective of frugal innovations, another way of looking at such deficiencies is that they actually might favor frugal innovations, due to less tight environmental and legal regulations (Bhatti, 2011; Radjou et al., 2012).

A prominent example at this point is the Chinese “Shanzhai” movement. Though Shanzhai used to be seen as a simple culture of product or brand infringement and counterfeiting, it has at least partly moved to become an industry of innovative adaptation of existing goods serving the needs of local markets, e.g. a strong flash-light coupled to an already existing cell-phone for customers in rural areas. This includes rapid production cycles of Shanzhai firms as well as a very high manufacturing flexibility adapted customer needs (Ming and Flowers, 2016; Zhu and Shi, 2010). Another renowned example of a frugal innovation in a less regulated environment is the M-Pesa micro-financing service launched by Vodafone and Safaricom in Kenya and Tanzania in 2007. M-Pesa allows users to easily transfer, deposit and withdraw money with a mobile device, giving the Kenyan people access to the formal financial system (Saylor, 2012). Due to the massive growth of the service, Kenyan banking institutions lobbied for a government audit against the service, which, however, declared that M-Pesa was in line with the country’s objectives for financial inclusion, partly also because M-Pesa engaged Kenyan regulators (Mbiti and Weil, 2011; Ministry of Finance of Kenya, 2009). Thus, the less heavily regulated financial services sector in Kenya allowed Vodafone as a telecommunications provider to enter the financial services market segment. M-Pesa then also expanded to other markets like South Africa or India, but still struggles with the local regulatory requirements.

Similar financial services businesses not only exist in developing countries, but also within the EU. Two examples are TransferWise and TransferGo. TransferWise is a UK-based peer-to-peer money transfer service, developed in Estonia and launched in January 2011, that efficiently routes cross-national payments to avoid costly currency conversion. TransferGo is also a UK-based company, although the idea was developed in Latvia. It follows a similar business model as TransferWise, yet with a different logic. While TransferWise redirects money between senders and recipients to avoid currency conversion, TransferGo sets up digital accounts within the country a person works so money transfers do not have to leave the country. What the two firms have in common is their status as a small payment institution (SPI) within the UK. The SPI status is a license that firms can acquire from the UK’s Financial Conduct Authority (FCA) and the Prudential Regulation Authority (PRA). To become an SPI, firms have to meet certain regulatory conditions within the UK. However, these conditions are less strict compared to becoming an Authorised Payment Institution (API), i.e. the costs related to regulation are lower. This implies that firms in Europe do not face an institutional void in a strict sense. Yet, it is sometimes possible in developed countries to identify ‘institutional niches’ that provide a looser regulatory framework. All of these examples show that domestic and foreign firms are able to use institutionally weaker environments for their innovative advantage with new business- or service delivery models or process innovations, adapted to the local market, while the absence of economic intermediaries might be more problematic for firms from industrialised economies as they are confronted with a less regulated (and unfamiliar) context (Soni and Krishnan, 2014). This might be even more problematic for SMEs as they lack resources to experiment on foreign markets, build up cooperations, labs etc.

⁸ The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) administered by the World Trade Organization (WTO) defines international “minimum rules” for IPR regulation. It was negotiated at the General Agreement on Tariffs and Trade in 1994 and came into force in 1995.

In sum, it can be stated that there is no regulation that is tailor-made to frugal innovation, i.e. there is no direct incentive to innovate frugal and the existing regulations can be assumed to rather scale up costs instead of reducing them. It can thus be hypothesised that regulation is negatively correlated with the emergence of frugal innovations, which might be even more problematic for SMEs than for large firms who are less financially constrained to meet the demands of regulatory compliance.

Yet, from a theoretical point of view, there are at least two angles where policy might come into play. The first is that any regulation regarding frugal innovation should move towards regulating good innovative outcomes rather than the processes of how these outcomes are achieved, i.e. there should be a clear incentive, while compliance costs should be kept at the minimum. Another starting point could be the institutional void that actually seems to favour frugal innovations. Firms from developed economies could be encouraged to generate inventions in less regulated markets by experimenting and/or tapping into local knowledge sources as well as potential customers. In this case, however, it would be extremely important to make sure such processes are ethical and non-exploitative. An option for foreign markets would be to generate a less regulated environment within the home markets where firms are able to test new products and processes without adapting to the full regulatory requirements.

2.2. Frugal innovation as an opportunity for Europe

While the concept and practice of frugal innovation have their roots in emerging and developing economies, this project starts from an assumption that frugal innovation is also relevant to Europe. This section explores why, how and to what extent frugal innovation may be applicable in Europe, considering three main lines of argument:

- Emerging markets offer huge opportunities for European firms. However, to compete effectively in these markets, companies need to embrace frugal innovation, in order to meet demands of highly price-sensitive consumers.
- There is also some demand for frugal innovation within Europe, not only in emerging markets in Eastern Europe but also in developed economies in the west. Further, this demand is likely to increase in future, as a result of socioeconomic and demographic change (e.g. an ageing population) and increasing constraints on resources.
- Frugal innovation could, theoretically, generate additional social and environmental benefits and help to tackle common public policy challenges in Europe, from the challenge of delivering good public services in conditions of austerity and growing demand, to promoting social and economic inclusion and promoting ecological sustainability.

The existing literature on frugal innovation focuses largely (although not exclusively) on issues surrounding the design and manufacturing of frugal products. These themes have relevance in a European context, and are particularly important for this project given its focus on the relationship between advanced technologies and frugal innovation. Nevertheless, this section also notes that other 'lenses' on frugal innovation may also be important for Europe - for example, exploring how digital technologies can make public services more efficient and effective or how frugal business models or business processes can make products and services more affordable. In a similar vein, while demand for frugal innovation in Europe may be driven by many of the same considerations as in emerging economies, there are also some characteristics with a more distinctly European (or at least, Western) flavour, such as a desire among some consumer groups to live more environmentally sustainable lifestyles and move away from excessive consumerism.

In order to take advantage of the opportunities that frugal innovation could offer, European firms need to develop new mindsets or, as this report argues, to rediscover past competences.

2.2.1. (Re)discovering capacities for frugal innovation

As suggested from a conceptual perspective above, many European firms face substantial challenges in embracing or even tolerating frugal mindsets or a culture frugal innovation as they lack frugal thinkers, supportive internal cultures as much as suitable external environments that they could draw on as sources of additional inspiration.

Instead, most technological developers take professional pride in conceiving solutions that are among the most complex and technologically advanced. In the social and professional context of European technology firms or their R&D departments the development of 'good enough' solutions for resource-constrained users, however elegant, (Roland Berger, 2014) is typically not rewarded for three main reasons:

- First, the approach of limiting resources or functionalities conflicts with general premises that engineers (and their managers) have been trained to take for granted,

- Second, most technological development is perceived as a linear process in which considerations on product characteristics are secondary to technology and enter late,
- Third, executives may be cautious of developing entry-level products through fear that they may 'cannibalize' more expensive lines (Winter and Govindarajan, 2015).

From research and development and product design to manufacturing, managing supply chains, distribution, marketing, and providing financing and servicing options for customers, many common assumptions would have to be challenged and processes rethought to establish successful processes of frugal innovation. This, however, can succeed as the example that this of GE's MAC portable ECG diagnosis machine demonstrates, where engineering teams started by setting a price (because affordability was their main criterion), and then worked backwards on product features to ensure its quality (Mukerjee, 2012).

Further, it will be essential to develop closer relationships with potential users to connect to the abovementioned favourable external environments from which inspiration can be drawn. In this respect, Tiwari and Herstatt (2012) highlight the importance of open global innovation networks to frugal innovation and outline several models that firms have developed to create these networks. One such model, polycentric innovation, or decentralised prototyping (Radjou, 2009), emerged from the acknowledgment that most engineers are disconnected from the needs of prospective customers in emerging markets (Fuchs, 2015). European firms have partnered with context and needs-aware local engineers or sent their own engineers to work on specific emerging markets to understand the context and specific needs. Renault-Nissan, for example established a centre for frugal engineering in Chennai, where some of the group's engineers have been working with Indian engineers to develop a new affordable car, answering the actual needs of the Indian middle-class market (Crabtree, 2015).

These new ways of organizing for innovation have been demonstrably important in enabling Western multilaterals to develop frugal innovations for emerging markets. Yet it would be mistaken to give the impression that all capacity for frugal innovation stems from emerging economies. Taking a slightly different perspective, there are fields in which Western firms have led the way in developing frugal solutions. Beyond discount supermarkets, a good example are low-cost airlines, where 'no-frills' operators like Ryanair and Easyjet have developed models that have been adopted across the world, including in emerging markets.

In fact, while recent press articles on frugal innovation tend to imply it is a new phenomenon The Economist (2015), for example, states "after some teething troubles, frugal innovation is on the rise", it can be argued that the conditions that now spur frugal innovation in countries like India previously prevailed in today's industrialised countries. Put differently, Europe has a quite notable frugal past.

For example, many historians argue that it was the not least the scarcity of raw material in e.g. Baden-Württemberg (today one of the wealthiest areas in Europe) that forced people to either emigrate or stay and identify innovative business ideas with limited means. Even now, this mentality of 'productive tinkering' (*tüfteln*) is commonly ascribed to the region and quoted in context of many of its success stories, not least in the field of low-tech innovation (Som and Kirner, 2015). Likewise, a further breed of frugal innovation was prevalent during socialist times in Eastern Europe where economies of shortage (Kornai, 1980) resulted in a scarcity of both goods and inputs to innovation processes. At the same time, therefore, people had to find innovative ways to address everyday problems and to conceive new avenues to develop new goods without inputs taken for granted in other places. Arguably, it was only the economic system itself that prevented further entrepreneurial activities needed for the scaling up of such relevant solutions and, instead, largely relegated them to the informal economy.

On a further note, the demand for raw material and basic goods was especially high during times of war, so that in these (not uncommon) times of shortage frugal solutions were generated and in fact actively encouraged by the government. One such example can be found in Britain during WWII (Bhatti, 2012). At that time, most available resources were dedicated to the war effort. To prevent rising consumer prices as a result of this, the British Board of Trade introduced the Utility Clothing Scheme 1941 (CC41 "controlled commodity"), forbidding the wasteful use of material as well as unnecessary decoration. In order to make fashion still appealing, designers were asked to design new clothes – while meeting the regulations. Eventually, 34 designs for women were created and mass-produced.⁹ In addition, people were asked to "make do and mend" old clothes

⁹ <http://www.vadact.co.uk/fashion/4574375626>. Accessed 22/03/16.

according to a further campaign that was introduced in 1942 and advertised with “Mrs Sew” introducing “resource-efficient” sewing tips.¹⁰

However, frugal innovation was common in now advanced economies not only during times of scarcity and war. Likewise, the rising buying power of an emerging middle class as well as new types of demand spreading across larger parts of the population prompted new types of frugal industrial efforts – as in the case of mass motorisation.

The history of affordable passenger cars can be traced back to the early 20th century. In 1908, the Model T was produced by Henry Ford, often cited with the sentence “I will build a motorcar for the great multitude”,¹¹ at a time when automobiles were regarded as status symbol and only affluent people could afford automobiles. An important step to this end was introducing the integrated moving assembly line in 1913¹² a central process innovation that resulted in cost savings with the effect of lowering consumer prices tremendously. Over time the price could be reduced from about \$850 to \$450 in 1920. Until 1927 when the production of Model T ended, 15 million cars were sold.¹³

In Europe, similar developments are observable, but started later. One example is the French car manufacturer Citroën founded in 1919. In the early 1930s Citroën was the largest car manufacturer in Europe. After the death of André Citroën in 1935, Pierre Boulanger became chairman. He is quoted with the sentence: “we will create a car that can carry four people and 50 kg of potatoes at 60 km/h, while consuming just three litres of fuel per 100 km...” stemming from 1936. Once more, the explicit aim was to build a car affordable for a larger part of the population. The prototype of the 2CV was presented in 1938, but due to WWII, car production ceased. Finally, the 2CV was launched at the automobile exhibition in Paris in 1948. By 1990, five million 2CVs had been sold.¹⁴

During the same period, affordable cars did not only come to the mind of entrepreneurs and managers, but also became a publicly promoted issue of national interest. In the 1920s, Germany saw itself falling behind the United States, France and Great Britain with regard to motorisation – despite the production of passenger cars by Opel and Hanomag. Although several attempts to produce an affordable car for wider consumer groups were undertaken, but the economic crisis hindered their further development. Hence, it was only after the NSDAP takeover in 1933 that the German state announced financial support to promote broader motorisation and the automotive industry. In 1934, Ferdinand Porsche, an engineer based in Stuttgart, submitted an “exposé on the construction of a German *Volkswagen*” (“car for the people”) that described a passenger car for four adults, reaching 100 kph.

At the International Automotive and Motorcycle Exhibition in 1934 in Berlin different car producers and developers presented such solutions for a *Volkswagen*, but Porsche’s original contribution prevailed and was taken up to be further developed. One premise was that the *Volkswagen* should cost no more than 990 Reichsmark. Until January 1937 the Porsche KG developed several prototypes to meet the requirements, but due to foreign currency constraints and a lack of raw materials, their economic viability remained questionable. However, the regime regarded the *Volkswagen* as a national prestige project so that the Deutsche Arbeitsfront stepped in to form what became the Volkswagenwerk BmgH in 1938. In February 1938, construction of dedicated plants began in the specifically formed city of Wolfsburg, taking up Ford’s production facilities as a model. Although people could start buying shares since 1938, WWII intervened and no civilian *Volkswagen* was ever produced under the regime. Quite immediately after the war, in 1946, however, the production of civilian passenger cars was taken up by the Allied Forces, with the plant operating under even more severe constraints than initially conceived of before the war. In 1948/49, about half of the cars produced in Western Germany were produced by Volkswagen, crossing the threshold of the 100,000th car in 1950. For a number of years, production remained focused on evolving versions of the original Volkswagen (to become called ‘the Beetle’) that surpassed Ford’s Model T in terms of number of cars sold by 1972 (Volkswagen AG, 2015) and laid the foundations of a corporate empire that, through its Skoda branch, bears affordability in mind until today. In that sense, the presented cases of endeavours of constructing affordable passenger ‘cars for the masses’ can be regarded as early and very successful examples of frugal innovation in the developed world – as could be argued for Britain’s Mini¹⁵ – which conceptually preceded later

¹⁰ <http://www.iwm.org.uk/history/10-top-tips-for-winning-at-make-do-and-mend>. Accessed 22/03/16.

¹¹ <http://www.modelt.ca/background.html> Accessed 16/03/2016.

¹² <https://corporate.ford.com/company/history.html> Accessed 16/03/2016.

¹³ <http://www.history.com/topics/model-t> Accessed 16/03/2016.

¹⁴ <http://www.citroen.de/unternehmen/historie.html> Accessed 22/03/2016.

¹⁵ <http://added-value.com/mini-the-car-of-the-people/>

relevant efforts by others such as Dacia with the Logan, different Japanese producers with their various 'Kei cars', or, in the extreme case, Tata with its Nano.

As indicated above, this report will therefore maintain that frugal mindsets are neither as such culturally specific to emerging or developing economies, nor in a generic sense new for today's industrialised countries. Historically, these countries faced recurring times of shortages for different reasons as much as ensuing times of dynamism when a broader range of a less than affluent population articulated new, common demands. In principle, it seems that, whenever a framework of shortage was relevant, creative responses to frugality occurred in Europe and other parts of the developed world – just as they do in today's emerging economies.

2.2.2. A market opportunity in emerging and developing economies

"The rise of emerging markets" notes a recent Euromonitor report, "has been perhaps the defining feature of the global economy this century" (Boumphrey and Bevis, 2013). Since the term BRIC was coined in 2001 by a Goldman Sachs executive, the significance of emerging markets in the world economy has increased dramatically. Even while three of the four original BRICs (China, Russia and Brazil, with India the exception) face periods of uncertainty and economic slowdown, they are still huge and growing markets; the four original BRICs are home to nearly half the emerging market population. Meanwhile, smaller emerging markets are gaining in significance, not only elsewhere in Asia but in Africa, Latin America, the Middle East and Eastern Europe. As large markets, experiencing faster rates of growth than industrialised economies, emerging markets represent increasingly important opportunities for European firms. Between 2000 and 2009, the share of euro area exports to Asia grew from 19% to 22%, but exports to the USA declined from 17% to 12% in the same period.¹⁶

Traditionally, Western companies operating in emerging markets have tended to focus on serving 'premium' customers (EY, 2011). Yet in these countries, the fastest growing customer segment is the mid-market (Brandt and Thun, 2010). This segment is already very large. In 2009, 28% of the world's middle class - some 525 million people - lived in Asia, and 10% (181 million people) in Central and South America (Kharas, 2010). It is also rapidly growing: during the next two decades, the middle classes globally could grow from 1.8 billion to 4.8 billion people by 2030, 3 billion of whom will be in Asia. In contrast, the numbers of middle class people in Europe and the USA are projected to remain stable. With many markets for premium goods in emerging economies largely saturated, the key opportunities for Western firms lie in reaching mid-market consumers (Radjou and Prabhu, 2012).

Developing products and services that meet the needs of this customer segment is challenging for Western firms. The emerging middle classes have incomes that outstrip their basic needs (Williamson and Zeng, 2009) and have been described as enthusiastic consumers (Kharas and Gertz, 2010).¹⁷ Yet with small disposable incomes, and a cultural predilection for thriftiness, they tend to be highly price sensitive. Research amongst consumers of soft drinks in Brazil, for example, found that the 'newly-minted middle classes' still tended to prefer low-cost 'generic' brands that compete on price, to heavily marketed, premium brands such as Coca-Cola, preferred by the 'traditional' middle classes (Eizenberg and Salvo, 2014). Products developed for more affluent markets are often seen as over-engineered and too expensive to be within the "window of consideration" in emerging economies (Hesseldahl, 2012). Nevertheless, these very customers are highly conscious of value as well as price. Citing interviews with business leaders working in India, Tiwari and Herstatt (2013) point out that consumers in these markets tend to want to pay "35% of the global price, [for] 90% of the performance".

Western multinationals also face competition from domestic companies to serve the growing mid-level market in emerging economies. Gadiesh et al (2007) and Brandt and Thun (2010) have described how in China, for example, domestic companies that previously served the low end of the market in sectors like automotive and construction machinery have been able to upgrade their capabilities and expand into serving mid-market consumer segments, a process they describe as "the fight for the middle". Increasingly, moreover, multinationals from other emerging economies enter this game as well.

To tap into these consumer segments, several authors argue that European firms need to shift strategies and embrace frugal innovation (e.g. EY, 2011; Roland Berger, 2014). This does not simply mean stripping back products designed for more affluent markets. Instead, firms need to

¹⁶ www.ecb.europa.eu/ecb/tasks/international/emerging/html/index.en.html. Accessed 04/04/16.

¹⁷ For the OECD's analysis, "the middle classes" were defined by their role as consumers, using an absolute definition: the middle classes were defined as those with daily expenditures between \$10 and \$100 in purchasing power parity terms.

gain a deep understanding of users' specific needs and adapt existing products or design new solutions to meet them. Procter and Gamble's launch of a new razor in India is a good example. After observing Indian men shaving with traditional double-edged razors, Gillette's engineers intuited that it might be possible to tempt consumers with a razor that was safer and required less concentration to use - as long as it was also cheap, easy to clean with little water, and delivered a close shave. Since Indian men were willing to spend longer shaving than Western men, however, there was no need for razors to have multiple blades. This enabled Gillette to create the Guard razor using 80% fewer parts than other razors. The Gillette Guard cost only 15 rupees, and has now captured two thirds of the market in India (Winter and Govindarajan, 2015). Developing frugal solutions for consumers in emerging markets tends to involve ruthless prioritisation of features, focusing only on those most important to users (Hesseldahl, 2012, for example, outlines processes used by firms like GE to prioritise features for customers in India) and modularisation - starting from a basic version of a product and giving customers the option to add features as their resources allow (Roland Berger, 2012).

There are already several high-profile examples of European multinationals developing frugal solutions for emerging markets. In healthcare, for example, Siemens Healthcare's low-cost x-ray machine, the Multix Select DR, was developed by a German-Chinese-Spanish team and costs around a third less than the products it replaced (Roland Berger, 2014). In the energy sector, Philips is developing low-cost solar lighting solutions for Africa and is also setting up 'Community Light Centers' powered by solar-powered LED lights to foster community development and entrepreneurship¹⁸. In automotive, China is now the largest sales market for Volkswagen based not least on the local production of market-specific affordable model lines (Roland Berger, 2014) and Renault-Nissan is exploring opportunities in India (Radjou and Prabhu, 2015). In telecommunications, Nokia's 1100 phone is a classic example of frugal innovation, designed to be dust- and waterproof, cheap, robust and with a built-in flashlight (Hesseldahl, 2012); Nokia is now developing information tools and financial services that customers can use via their phones without internet access (Radjou and Prabhu, 2012).

Some evidence suggests that interest in frugal innovation among multinationals is becoming more widespread. A survey of 547 senior managers, board members and executives working in emerging markets¹⁹ found that 36% saw frugal innovation as a major opportunity and claimed already to be taking advantage of it, while a further 40% saw it as a major opportunity that they intended to pursue in future (EY, 2011).

Further, while much of the literature focuses on the experience of multinationals, there may also be opportunities for European SMEs to engage in frugal innovation in emerging markets. Reid et al (2015) document case studies of UK-based SMEs partnering with large firms in China to develop and scale technologies. Moreover, Prabhu (2016) notes that social enterprises and startups also have a role in developing frugal solutions and there is some evidence of such being started by Europeans alongside local entrepreneurs²⁰.

2.2.3. A response to emerging frugal needs and choices in Europe

Much of the literature exploring demand for frugal innovations focuses on large emerging economies in Asia, particularly China and India. Nevertheless, there are also some smaller, but significant, emerging markets within Europe. A report by the World Resources Institute (Hammond et al, 2007) estimated the bottom-of-pyramid market in Eastern Europe to include 254 million people (64 per cent of the region's population), with 36 per cent of the income. Furthermore, these markets are growing faster than Europe's developed markets. The IMF's World Economic Outlook for 2015 projected growth in output of 3.0% in 2015 in 'Emerging and Developing Europe'²¹, compared with 1.5% for the Euro area and 2.5% for the UK (IMF, 2015).

Radjou and Prabhu (2015) document how Renault developed the Logan car for resource-constrained consumers in Eastern European markets. Starting from the challenge of developing a car for €5000 that "married quality and affordability", Renault decided to base R&D for the new model in Romania, where it had recently acquired a new subsidiary, Dacia. Bringing together French designers and Romanian engineers, Renault-Dacia "created a car that used 50% fewer parts than a typical Renault vehicle", yet was spacious and specifically designed to meet the needs of Romanian families. While the Logan was developed for cost-conscious consumers in Eastern

¹⁸ <http://www.communitylightcenters.philips.com>. Accessed 06/04/16.

¹⁹ This survey was carried out by the Economist Intelligence Unit in September 2011.

²⁰ Cf. the example of smartairfilters.com, developed by a U.S. student in Beijing and now scaled all over China and taking root in India

²¹ The IMF refers to CEE as 'Emerging and Developing Europe' including Turkey, Poland, Romania, Hungary, Bulgaria, Serbia, Croatia, Albania, Bosnia and Herzegovina, Kosovo, FYROM and Montenegro.

Europe, Renault soon discovered that there were markets for it in Western Europe as well, and in response, developed a new line of entry-level products using the Dacia brand name. By 2013, the Dacia line was Renault's "cash cow", accounting for more than 40% of the company's global sales (Radjou and Prabhu, 2015). As this example demonstrates, demand for frugal solutions also exists in developed economies, and it seems that multinationals are beginning to recognise this. EY's survey of companies operating in emerging markets (2011) found that 82% of respondents based in developed markets agreed that 'frugal innovation is a concept that has as much relevance in developed economies as it does in rapid-growth [emerging] markets'.

This demand for frugal innovation in developed markets has grown partly because increased poverty, long-term decoupling of economic growth and living standards and the enduring results of recession have led to a reduction in consumer spending. Research on consumer attitudes in the United States found a growing willingness to purchase in-house brands and consider price over brand. As these changes become habits, it is argued that this 'new frugality' is here to stay (Egal et al, 2010). A global study of 15,000 consumers by Boston Consulting Group (2013) uncovered anxiety and pessimism in many Western European countries, with those who believe their economy will improve greatly outnumbered by those who think it will not. While the study found that consumerism was by no means dead - affinity with brands was still strong, particularly among younger people - nevertheless nearly half of respondents in developed economies planned to cut their spending in the next 12 months, and 54% were expecting to 'trade down' (choose cheaper products and services). Those who were planning to 'trade up', meanwhile, revealed a strong focus on value, durability and quality (BCG, 2013). Similar research focused on the UK found that while consumers were becoming more confident, many had recently 'traded down' - and were were "pleasantly surprised" by their experience of lower-cost brands. 59% claimed no longer to prefer higher-priced items (Opinium, 2013). These changing preferences seem to be well illustrated through the example of discount supermarkets. Combined with smart marketing strategies, consumer demand for cheaper products has enabled discounters such as Aldi and Lidl to capture a market share of around 15% in the groceries sector in the European Union, with market share in some countries (like Germany) much higher. Research with consumers suggests a sizeable proportion of those who shop at these stores would continue to do so even if their incomes rose (The Economist, 2014).

Increasing consumer demand for frugal solutions in Europe raises the possibility that some products developed for emerging markets could be adapted for and sold in developed economies, a process known as 'reverse innovation'. Notwithstanding frequently-cited examples like the Renault Logan and GE Healthcare's low cost ECG machine (developed in India, but now being sold in other markets including the USA), there are relatively few examples of where multinationals have developed products for emerging markets and successfully sold them worldwide (Winter and Govindarajan, 2015). Further, it is not only Western firms that can attempt to engage in reverse innovation; some emerging economy firms have also successfully done so (Zeschky et al, 2011). Chinese firm Haier, for example, has the biggest share of the global white goods market of any firm and in 2000 opened a factory in South Carolina (Forbes, 2012), selling low-cost refrigerators to the American market.

Moreover, 'temporarily frugal' situations can occur in any market, including developed ones. In situations of emergency, including accidents, natural disasters but also the recent refugee movement, basic needs have to be met in an effective manner until new provisions are made and infrastructures re-established.²²

Finally, consumer 'frugality' in Europe seems not only to be passively driven by growing resource constraints, but also, amongst some consumer segments at least, by changing values, such as a focus on durability, environmental sustainability, a 'do-it-yourself' ethic and a desire for lower consumption. In early 2016, Ikea's Head of Sustainability claimed that, "in the West we have probably hit peak stuff", and argued that consumers were showing a greater desire for products that could be repaired and recycled (Guardian, 2016). A new website guiding consumers to products that are highly durable, 'Buy Me Once', has received considerable media coverage (The Telegraph, 2016). A new knowledge sharing platform, 'Fixperts'²³ has been launched for people who want to fix everyday problems and share their learning with others. On a similar note, Radjou and Prabhu (2015) argue that Western consumers are becoming not only value-conscious but 'values-conscious', referencing consumer surveys that show widespread willingness, particularly amongst millennials, to switch to socially responsible and environmentally sustainable brands. This sense of idealism underpinning demand for frugal innovation in Europe is also reflected in phenomena such as the maker movement and some initiatives in the so-called sharing economy, as well as in places, such as Freiburg, that have embraced frugal innovation at a community level

²² Interview with Nivedita Agarwal, 29/04/16

²³ <http://fixperts.org/>

(Leadbeater, 2014). These trends add a new dimension of “frugal innovation by choice” which can be very relevant in developed markets.

Having said this, it would be incorrect to assume that these changing values are not relevant in emerging markets, although the Tata Nano does struggle with persistently “traditional” values of customers who see it as a “low reputation” solution. China, for example, has a burgeoning maker movement (Saunders and Kingsley, 2016) and, in light of food and environmental scandals, an increasing awareness of sustainability among the emerging middle classes. Likewise some interviewees suggested that, in Africa, frugal innovation and sustainability are becoming more closely identified.²⁴

2.2.4. European public policy challenges

Individual consumers are not the only potential customers for frugal innovation in Europe. Governments across the EU have implemented austerity measures since the financial crisis of 2008-9 (and some, like Germany and Sweden, began doing so before the crisis). Even though European countries have different economic models, austerity measures have been remarkably similar across the continent, with, for example, a strong focus on reducing the cost of public sector employment through job cuts, wage freezes and other measures (Hermann, 2013). Since it appears that austerity measures in many countries were not only a response to crisis, but also in line with a broader ideological drive towards smaller government (Müller et al, 2014), it is likely that austerity is here for the long term. Meanwhile, an ageing population is increasing social care, health and pension costs, putting additional pressure on public sector budgets. It is not surprising, therefore, that the frugal mantra - ‘doing more for less’ - is commonly heard in the context of public services.

Yet although this would seem to create a strong driver of demand for frugal innovation, it is not clear that there has been significant interest in frugal solutions among public sector organisations in Europe to date - at least in not the more obvious sense of adopting ‘reverse innovations’. As noted elsewhere in this report, regulation can act as a barrier to scaling up of frugal solutions in developed markets. Narayana Health, for example, which has developed a very successful model of low-cost heart surgery in India, believes there is a market for its services in the USA. However, for regulatory reasons it has located its hospital serving this market in the Cayman Islands. There may also be cultural barriers to adoption of frugal innovation from emerging markets. Harris et al. (2016) suggest that the origin of an innovation may make a difference to its likelihood of being adopted in Western healthcare settings, noting that “the adoption of low-income country innovations into high-income country contexts is thwarted in part by perceptions that low-income countries are unlikely to offer innovations of value and that these contexts are “too different” from their own for the innovation to ‘fit.’” Nevertheless, looking through a slightly different lens, it is possible to see frugal innovation principles reflected in some emerging public sector initiatives - for example, a willingness to explore the use of hidden or under-used assets, such as volunteers in public services; challenge-based procurement as a means of sourcing solutions for the public good; and the greater use of big data and smart technologies to gain insights and target services more effectively.

A related area of high current interest among policy makers in Europe, where frugal innovation could be applied, is in services to support and help promote integration of refugees and asylum seekers. A number of innovative housing solutions have reached at least prototype stage, such as IKEA’s refugee housing, tested with the UNHCR in Ethiopia, Jordan and Iraq (Guardian, 2014) and Concrete Canvas shelters, made of concrete-injected cloth (National Geographic, 2014). These solutions are currently operating a small scale and are still relatively high-cost. Beyond manufacturing, digital technologies also offer potential for frugal solutions to support refugees. The Bitnation Refugee Emergency Response project develops solutions to help refugees using blockchain technology, including the Blockchain Emergency ID and Bitnation Visa Debit Cards. The Techfugees initiative, set up in the UK in September 2015 and rapidly spreading to other parts of the world, is engaging the tech community to crowdsource solutions to support refugees.

2.2.5. The potential wider benefits of frugal innovation

Interest in frugal innovation amongst policy makers also stems from the theoretical possibility that it may help to address other public policy challenges, including the ‘Societal Challenges’ highlighted in the context of Horizon 2020. Research and examples to date suggest that frugal innovation can contribute in two main ways.

First, the themes covered by the H2020 Societal Challenges (SCs) are areas in which there is demonstrable potential for successful frugal innovation. For example, many existing examples of

²⁴ Interview with Peter Knorringa, 15/02/16.

frugal innovations fall into the category of “new models and tools for health and care delivery” (SC1: Health, demographic change and wellbeing). Moreover, some of these are also examples of ‘reverse innovations’, having been designed for emerging economies and then successfully introduced in the west. Secure, clean and efficient energy (SC3) has also been a strong focus for frugal innovation in emerging and developing economies, although the context in which these innovations have been designed – lack of access to an electricity grid – means that they may not have so much direct potential for introduction to industrialised economies. Nevertheless, experts interviewed for this study suggested that local, decentralised energy production could provide a ripe opportunity for frugal innovation in Europe.

Second, the characteristics of frugal innovation are complementary to several of the Horizon 2020 Societal Challenges. For example, by increasing access to goods and services, frugal innovation could help to foster socio-economic inclusion (SC6: Inclusive, innovative and reflective societies). There is considerable evidence of this in emerging economies, where well documented examples in sectors like energy (e.g. SELCO’s solar lanterns in India), mobile banking (e.g. M-Pesa in Kenya) and healthcare (e.g. Aravind Eyecare in India) have broadened access to essential services and helped to generate improved social and economic outcomes for customers. There are comparable opportunities in at least some of these sectors within Europe - for example, Mastercard estimates that some 93 million Western Europeans are ‘underbanked’ - but at present few examples of frugal solutions developed for these markets. Similarly, there is considerable potential in how frugal innovation can contribute to achieving the objectives of SC5 (climate action, environment, resource efficiency and raw materials) given the focus of some frugal innovations on a more efficient use of natural resources and the promotion of ‘circular economy’ principles. Nevertheless, as pointed out below, the contribution of frugal innovation to environmental sustainability is not always straightforward and can be in tension with the goal of improving access to goods and services. This can happen if frugal innovation results in the more widespread use of a solution, thus increasing its ecological footprint.

It has also been suggested that frugal innovation can help achieve a range of other socially and economically desirable outcomes for Europe. Consultation in the preparation of this report uncovered aspirations including:

- Preservation of cultural heritage, possibly through combination of traditional manufacturing techniques with frugal distribution methods, to reach wider markets.
- Job creation, as a result of new economic opportunities.
- Promoting global development through research and innovation partnerships, rather than traditional development assistance.

However, while each of these remains a theoretical possibility, none are inevitable outcomes of frugal innovation. For example, Reid et al (2015) found that while collaboration between UK SMEs and large Chinese firms generated new jobs in the UK, the employment gains tended to be much greater in China. The question for policy makers will therefore not simply be whether to promote frugal innovation, but how to promote it in a way that generates the most positive social, economic and environmental outcomes and minimises negative impacts.

2.3. The role of technology for and in frugal innovation

This section argues that technological development is not necessarily integral to innovation. Innovation generally, and frugal innovation specifically, can take place without dedicated technological development. On the one hand, the history of innovation shows that recombination of existing technologies is as at least as important. On the other hand, disruptive innovations – those that transform economic and societal systems – may not always be among the most technologically advanced. Indeed, when first introduced, they may be technologically inferior to alternatives, yet at the same time, a much better fit for users’ needs. Nevertheless, technological development and frugal innovation are not at all incompatible. Even frugal innovations developed from recombinations of basic technologies require a good understanding of available technologies. There are undoubtedly many technologies whose ‘frugal potential’ has so far been under-explored, and many more in development that will offer potential for use in frugal solutions at least in the medium term, such as 3D printing. Meanwhile, ubiquitous technologies, such as smartphones, are already facilitating numerous frugal solutions that would not be possible otherwise. It is also plausible to argue that new technological development may in some cases be needed to advance frugal solutions.

So far, a perceived tension between technological development and frugal innovation arises mostly from the fact that technological development is often still conceived of as a largely linear process in which teams of developers pass through the different stages of technological readiness (TRL 1-9) independent of the outside world – to at the end of the process launch a high-price, highly featured products to obtain return on investment. Frugally inspired reverse engineering processes, in

contrast, puts quite an opposite emphasis. Winter and Govindarajan (2015), for example, succinctly outlined that and how processes of reverse engineering differ from technology-based one in five relevant ways:

- before anything else, they acknowledge the needs of potential users,
- second, they identify the indispensable functions of the solution needed to fix it,
- third, they consider traditional fixes that are already available and the messages they pass on with a view to context specific requirements,
- fourth, they subject all products and solutions to a reality check latest before their first market introduction, ideally already during the development process,
- subsequently, they explore which uses these solutions could have in other contexts.

In detail, they outline “five traps” that must be avoided in designing frugal innovations through reverse engineering by observing “five design principles”.

- matching market segments to existing products,
 - defining problems independent of pre-existing solutions,
- trying to reduce the price by eliminating features,
 - create an optimal solution, not a watered-down one,
- forgetting to think through all technical requirements,
 - analyzing the technical landscape behind the consumer problem,
- neglecting stakeholders,
 - test products with as many stakeholders as possible,
- ignoring that products designed for emerging markets could have global appeal,
 - use emerging market constraints to create global winners.

In new product development processes this implies that some common assumptions will have to be reconsidered and, even more so, for common routines in technological development. In particular, the possible functions of technologies being developed should be considered from various perspectives at early stages (TRL 2-3, “technology concept and/or possible application formulated”) and concrete application contexts beyond the high-price segment should be taken into account when technological validation is transferred from the laboratory to a “relevant environment” (TRL 4-5).

In the following sections, therefore, this report will in more detail explore in which ways and function existing knowledge as well as specifically developed technologies can feed into processes of “frugal new product development”.

2.3.1. Frugal integration: combining available technological knowledge, traditional techniques and new ideas

Innovation without dedicated technological development

As outlined in section 2.1, the key to frugal innovation cannot be identified in one single dimension of the process. Instead, it leads back to the notion of innovation per se. According to Joseph Schumpeter (1911/1934:66), "innovation" refers to "the introduction of a new good ... or a new quality of a good ... a new method of production ... or a new way of handling a commodity commercially" in the process of production and – ultimately – the marketplace; laying the basis for later definitions such as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organisation or external relations" (OECD, 2005).

While, initially, the term 'innovation' was most commonly related to the transfer of inventions and other technological advances into commercial application, the arguably more important point of the definition is the focus of innovation as the successful '**implementation**' of new solutions 'in the process of production' and 'on the market place'. In the course of the further development of innovation theory, this acknowledgement has given rise to a broader understanding than proposed by its founding father(s), one, that beyond technological innovation includes marketing innovations, organisational innovation and service innovations.

More importantly, however, the role of technology in and for innovation has been reconsidered as exemplified in the often quoted yet seldom fully acknowledged work of Kline and Rosenberg (1986). The publication is most often cited with regard to recursive nature of the innovation process. There is, however, a further key feature of their "chain linked innovation model", developed based on practical observations in firms: In innovation processes, firms, in a first step, take recourse to existing knowledge bases – both within and outside the organisation – before they consider the need for dedicated technological development to address a specific problem. In general, the coupling of innovative activities with market demand and users needs has been identified as a constitutive condition for successful innovation since the early 1970s (SPRU, 1972; Rothwell et al., 1974).

In line with this conceptual argument, many firms have in practice developed business model innovations based on 'implementing new solutions' – by considering user needs and market demand yet *without* the dedicated development of technologies (Hirsch-Kreinsen, 2011; Henderson and Clark, 1990), e.g.

- **(Customer) value oriented strategies** focus on new value propositions that leverage a so far latent demand for novel solutions by integrating new channels of delivery, product-oriented services, etc.
- Strategies of **stepwise or gradual innovation** seek to, based on experimentation and trial-and-error, upgrade a standardised product up to the point where it fully meets customer requirements,
- Strategies of **architectural innovation** build on existing technological solutions and components to create new solutions that address specific demands better,
- Strategies of **process specialisation** apply (known) high-tech processes to non-high-tech products, at times to increase quality and robustness and at times to increase efficiency and thus realise lower prices,
- Strategies of **modular innovation** seek to improve the components of an existing product with a view to quality, robustness and, in some cases, price.

Overall, it is thus evident that even outside of the frugal innovation literature the promise of non-technological and low-tech innovation has been broadly recognised (e.g. Som, 2015). Indeed, it seems worth recognising that many of most innovation strategies in large part of the European SME sector, including the famous German *Mittelstand* are predominantly based on what theorists call the doing, using, and interacting (DUI) rather than a classic, more linear science, technology and invention (STI) driven model of innovation.

In practice, many firms take recourse to the business models outlined above, drawing notably on synthetic (technological and technical) and symbolic (design and market trend related) types of knowledge rather than the pure analytical knowledge of science (Asheim and Vang, 2004; Laestadius, 1998). While this crucial difference has for a long time been vividly discussed in the conceptual literature (Arrow, 1962; Sahal, 1981; Rosenberg, 1982; Andersen and Lundvall, 1988)

it has only rather recently been empirically validated (Kamp et al., 2004; Som, 2012; Som, 2015) – and thus politically acknowledged on a broader basis.

In summary, these introductory paragraphs illustrate that, in general, dedicated technological developments are neither a necessary nor a sufficient criterion for successful innovation. Nor can the nature of innovation be sufficiently and comprehensively described as the translation of technological inventions into new products and services.

Recombining available knowledge and traditional techniques

As has been explained in the introductory section, low cost (or longer lifetime) may not be necessarily the only but certainly one defining characteristic of frugal solutions. While some have argued that a key means to that end lies in de-featuring existing products (Hartigan, 2011; Moore, 2011) others have pointed out that to achieve a sufficiently, substantial reduction in inessential cost (Seghal et al., 2011), frugal innovators have to transcend current solutions through the creative leveraging of existing knowledge. While this does not have to imply outright “reverse engineering” (Samuelson and Scotchmer, 2002) it will imply taking recourse to and reactivating existing reservoirs of knowledge (Kline and Rosenberg, 1986), for example in processes of “reverse innovation” (Tiwari and Herstatt, 2012).

Among the various low-tech approaches outlined above, the strategy of recombining existing component technologies to create new or improved solutions while avoiding investments in developing new core technologies thus lends itself naturally to the main business case behind frugal innovation. Different from standard stepwise or gradual innovation strategies they allow for the development of entirely new markets while at the same time keeping down both material and investment cost.

In terms of illustration, the success of China’s Shanzhai firms who successfully and creatively recombined available knowledge accumulated by local producer networks to address unmet demands of the local population with novel products is a prominent case in point (Ming and Flowers, 2016; Design Mind, 2013; Zhu and Shi, 2010; Booz & Company, 2009). This case clearly underlines how going back to technologies already available can suffice to introduce a genuinely new solution to the market and increase the value proposition to the customer while at the same time keeping down costs. Once more, this model does not apply only to the Chinese context but has in a similar sense been characteristic, for example of the conception of the first generation iPhone based on existing technologies (Mazzucato, 2013).

While the outcome and context of the process can be entirely different, the mere notion of “working backwards from a problem” until one arrives at a suitable technological basis to develop appropriate solutions (Gupta, 2011), existing or specifically developed, complex or obvious, is thus not unique to frugal innovation. What is, is the pronounced, conscious emphasis placed on these first stages of the search process to find the simplest, most robust and cost-effective solution (Zeschky et al. 2011; Gupta and Wang, 2009).

As outlined in the conceptual section, frugal innovation is motivated by the aim to address unmet demands of resource-constrained consumers (usually bottom-of-pyramid populations or emerging middle classes (Woodward, 2011; Arnold and Quelsch, 1998) by providing affordable higher value to customers with smaller purses (Zeschky et al., 2011). Against this background, frugal innovators tend to carefully consider available knowledge and go some way to avoid unnecessary R&D investments (Bhattacharyay, 2012). Rather than moving through the first steps of this process swiftly, they will spend more time and energy to find “improvised solution born from ingenuity and cleverness” (Radjou et al., 2012).

To do so systematically, collaborative partnerships with future users are crucial not only to understand which unmet demands exist, but also to which local traditional techniques and social practices providers of frugal solutions can relate to make an improved value proposition (Ray and Ray, 2010). In the past, many Western firms’ and governments’ ambitions to transfer new products without adaptation to substantially different social use environments under frugal conditions have been less than successful. From negative experience in development assistance it has been learned that new product propositions have to relate to and draw on traditional techniques and practices that may in fact already be quite suitable for the local population – if they are to add any utility to their life.

Infusing new ideas and moving beyond the pure architectural stage

A further relevant point of reference to develop an understanding for the relation between technology and frugal innovation can be found in the well-known but sometimes less than fully interpreted differentiation between incremental and radical innovations (OECD, 2005) – as first described by Schumpeter (1911, 1934). Very often, this distinction is considered mostly from a

technological perspective, identifying as radical innovations those that enable a quantum leap in technological terms – as is indeed the case for information technologies, biotechnologies and, more recently, network technologies.

What characterises these technologies more succinctly, however, is their potential to bring about societal and economic transformation by putting incumbent systems of production and service production on an entirely different basis. Notably, many updated illustrations of Kondratieff's (1926) famous cycles mention not the steam engine, but railways; not chemistry per se, but the fertiliser industry; not the Otto engine, but the large-scale production of automobiles, not the Zuse Z3, but IBM's personal computer. Evidently, therefore, the transformative power of innovation does not result from its technological traits per se but from the fact that it is amenable to a large scale application to latent needs (Gallis and Rall, 2012).

Interestingly, therefore, the same authors who point out the key role for architectural innovation as the founding stone of frugal innovations (Ray and Ray, 2010) also liken the process of frugal innovation to Bower and Christensen's (1995) generic model of "disruptive technologies". Essentially, this model draws on existing interpretations of basic Schumpeterian thinking, adding that potentially transformative technologies may initially enter the market not as premium but as simple propositions, technologically still lacking, that eventually improve and replace the incumbent technology at all levels (Christensen, 2009). Common examples are the replacement of large mainframe computers by personal computers, the replacement of landlines by mobile telephony, and, eventually, the replacement of personal computers by smartphones and tablets.

As Ray and Ray (2010) argue, the market entry of novel solutions tends to be dynamic if the technological performance of existing technologies exceeds what relevant customers are able to utilise or pay – so that the technologically simpler solution fits their needs better.

First, it may become evident that the seemingly inferior solution is in fact quite superior or at least displays a better fit with customer demand and, on top of it, comes at a substantially lower price. In this case, the low-level solution will replace the incumbent product as happened prominently with the introduction of the personal computer, or on a somewhat different note, with the partial replacement of chain stores by online traders.

Second, however, architectural innovators may seek to appeal to more discerning customers as their societal and competitive environment develops. By upgrading their solutions from the initial "copies with added features" to more advanced solutions they will seek to access further customer groups. Key to this strategy is modularity in the initial product (Ray and Ray, 2010) which allows the firms to develop some modules further in line with emerging and evolving needs of the local markets and raise the impact of the overall, still frugal, product proposition.

Once more, the example of the Shanzhai community illustrates how – after a first phase of pure architectural innovation (i.e. recombination of whatever technology they got hold of) – many firms have upgraded their business models and products in line with market requirements through gradual infusions of tailor made technological developments (Ming and Flowers, 2016; Booz & Company, 2009). In the meantime, some of them like Xiaomi or BYD have moved even beyond that stage, becoming technological innovators (Paris Tech Review, 2014). At the same time, some have kept their initial business model as it was successful outright (Designmind, 2013).

In any case, such a modular upgrading strategy once more depends on an understanding of traditional techniques and social practices that define a local use context as only this knowledge can bring the frugal innovator in a position to further develop products in a process of co-creation with potential users (Paris Tech Review, 2014; Designmind, 2013). Throughout the years, a plethora of local cooperation models have emerged or been designed to that end of which several have been successful (Zhu and Shi, 2010). Certainly, a regular interaction between developers and customers is crucial and indispensable to fully harness the arguably superior potential of this model of re- rather than de- featuring.

Conclusions

Taking this into account, it is easy to acknowledge that technologies play a natural role as components of frugal innovation. If frugal innovation is understood as a "holistic rethinking of products, services, underlying processes and business models so that companies can squeeze costs and expand the customer base, business and profit" (Jagati, 2011), four main aspects come to play

First, existing technologies are the basis from which all but the most basic frugal solutions are built in a process of recombination. While, importantly, this process does not involve technological development and can in fact be grounded on fairly basic technologies it does involve an

understanding of available technologies and the ability to interpret them in terms of their potential for new product and service propositions.

Second, some fairly recent technologies may be available but less than fully exploited with a view to their potential to support and enable new business models. In this situation, even the targeted use of an existing technology may lead to a product proposition so strong that it can undermine most incumbent solutions without any need for further developments. To achieve this, however, investments have been made into a better understanding of such technologies.

Third, some frugal solutions may only be relevant for a certain market niche or the very bottom of the pyramid. To reach a broader customer base, modules will have to be improved and some additional features will have to be added. In this process, original technological development will have to play a certain role as the problems encountered may not in all cases be fully resolved by a creative reinterpretation of available solutions.

Finally, some frugal solutions may at all stages require infusions of original technological development and even research activities. While this has not always been made explicit in this section, it is evident from the analogy to Kline and Rosenberg's recursive innovation model: Whenever a problem, however basic, cannot be resolved with existing knowledge, recourse will be taken to targeted development to bridge the gap to a relevant product proposition.

2.3.2. Non-frugal means towards frugal ends: developing specific new technologies as components of future solutions

Awareness of value chains and value added

If policy support for frugal innovation aims at increasing the level of growth and creating jobs in Europe, the question of where relevant value added is generated has to be taken into account. Against this background, it will not be enough to simply create new business opportunities for European technology firms, because from a macro-economic perspective, technology development is first of all an investment. Value added (and in that sense 'return on investment'), in contrast, is generated by downstream industry and services. That means, with regard to the economic and social benefit of innovation downstream system integration constitutes the most crucial part of the value chain. Relevant system integrators can be huge OEMs, specialised SMEs as well as mid caps like the so-called hidden champions in Germany. These companies, however, will not be visible as technology firms in the first place, although they are experts with regard to the exploitation of technological potential and market opportunities.

The outcome of technology firms' broadly supported activities, like new materials, new components or new equipment, enables innovative products in the downstream industry. Equally important, however, is the matching between technology firms and downstream sectors which, with a view to the creation of growth and jobs should at least partially be located in Europe. Otherwise the costs for technology development are borne in Europe, but the major part of the revenue is created outside.

Technology-based approaches for frugal innovation

In European contexts, both understanding and practice of technology based innovation procedures often follows the "diffusion of innovations" concept as outlined by Rogers (2003)²⁵. In this theory, "early adopters" play an important role for paving the way for a broad market acceptance of innovations (see above). Characterised by high social status, financial liquidity, and advanced education, these users are expected to generate a first substantive return on investment for research and innovation activities. In a similar manner, demanding high value markets like aerospace can be understood as "early adopters" for technology-based innovation before these are diffused into more commonplace markets like, for example, household appliances. This means that, today, standard technological innovation processes primarily address advanced requirements rather than basic needs and that the first customers that developers envisage as relevant after reaching Technology Readiness Level 9 (TRL9)²⁶ are typically not interested in frugal solutions.

Hence, the question of which innovation procedures could be viable for technology-based frugal innovation has to be explored if standard routines of technology development do not usually support such outcomes. To do so, particular emphasis has to be placed on the issue of return on investment. Technological development, first of all, requires high investments that have to be recovered both on the level of the firm and on that of the economy.

²⁵ Rogers, Everett (2003). Diffusion of Innovations. 5th Edition. Simon and Schuster.

²⁶ TRL9 is the highest level of technology readiness, defined by the European Commission as technologies which have reached full commercial application and are ready for users.

As has been suggested in the literature, frugal solutions will in many cases not justify dedicated technology development as that would make little difference to their utility proposition, and, even if products later are sold at substantial volumes, expenses may be difficult to recover.

Nonetheless, three situations can be envisaged in which such investments might pay off:

- Technologies that have been readily developed to TRL9 and implemented into non-frugal products can be adapted and modified to make them relevant for frugal solutions,
- Specific platform technologies can be developed and later exploited in various areas of application, allowing for a distributed recuperation of development costs,
- Technologies which are developed with the specific purpose of reducing costs can or even have to be first launched in frugal markets to demonstrate their viability.

The three concepts are described in the following.

First, one strategy of technology deployment for frugal applications can be the modification of already introduced technologies. With regard to Rogers' (2003) "diffusion of innovation theory", the target market in this case is "late majority". As, in principle, advanced products are already on the market, the related Technology Readiness Level is TRL9. Also, basic issues of technological scalability have already been solved when "early majority" markets were exploited. Hence, investments can be moderate, and targeted, as most fundamental knowledge is already available. As outlined above, however, the adaptation of technologies to frugal application contexts can make a substantial difference with a view to opportunities for value creation. Undoubtedly, moreover, few high-end products can be de-featured single-handedly. Even technologically, doing so might require specific knowledge and dedicated research.

Another approach to ascertain an adequate return on investment for dedicated research and development aimed at frugal solutions are variable platform-based or modular concepts. These technologies provide the basis for mass customization approaches as constitutive enablers for the launch of frugal solutions in non-homogeneous markets. Undoubtedly, Europe holds quite a competitive position in the production of these technologies while, at the same time, they can be deployed to customise products to the requirements of various target markets in a flexible manner. Barriers to the scalability of technologies from national to international markets may thus be more easily overcome. Examples of relevant adaptable technologies include:

- 3D printing,
- printed electronics,
- microelectronics and embedded systems,
- industrial biotech (feedstock),
- all kind of software enabled approaches,
- material on demand.

Finally, technology development can not only aim at creating new products or de-features them. It can also aim to replace the *function* of existing products by significantly cheaper ones. In this case, a substantive return on investment can be expected from the much increased scale at which such low-cost applications can be distributed and sold. At first, products based on the new technology may not match the performance of existing ones, meaning that conscious efforts have to be taken to minimise this obstacle. Nonetheless, market entry can be hampered, even at much reduced prices, due to a (systemic) lock-in to established technologies. In this case, emerging markets might provide an opportunity to pilot low-cost technologies. After reaching a performance comparable to that of established technologies, the low-cost technologies can be propagated also in European countries.

New technology ecosystems to foster frugal innovation

Today, technology-based innovation is characterised by complex ecosystems characterised by an extreme division of labour and highly specialised actors. Many stakeholders in the research driven domain concentrate on the solution of technology related problems and are not aware of market related problems and potential customer demand, let alone frugal opportunities. This constitutes one of the major reasons for the well-known 'valley of death' between TRL4 and TRL6 in which many technologies end up left behind. In this setting, developers are highly specialised researchers and engineers whose thinking focuses on technological viability and whose conceptual horizon does not extend to target markets. Typically, the first contact between a technology and market intelligence occurs in the sales division of system integrators.

As outlined above, typical frugal innovation processes operate inversely: Real life problems are the starting point while technologies – even dedicated technological development – are in a serving position. That means in order to implement technology-based frugal innovation, it is necessary to crack the typical technology ecosystems and link them together with those who are aware of the real life problems: system integrators and other actors with know-how about technologies' real world potential. If the abovementioned options could be thus activated, this could even become a role model for future technology-based innovation in general helping to finally break the 'European paradox', having a positive impact on the productive deployment of technology in Europe as a whole.

Frugal innovation as testing field

Various aspects that are commonly discussed in technology deployment are specifically relevant in the setting of frugal innovation. Therefore, a successful demonstration of the viability of the abovementioned three avenues towards dedicated technological development for frugal innovation might have spillover effects on Europe's technology based innovation system as a whole. In particular, both the public and the private research and development community can see frugal innovation settings as testing field:

- to implement need-oriented, innovation processes and market driven innovations;
- to raise awareness for market specificity and application requirements;
- to bear in mind and address issues like price/cost and regulation from the beginning;
- to test and pursue innovation processes jointly with stakeholders from ecosystems;
- to avoid a stratification of competences and resulting over-engineering;
- to pilot and consolidate new concepts like mass customization.

The aspects mentioned above are significant in the current technology deployment process in general – and fairly often not sufficiently covered. Putting them to the test and demonstrating their relevance and viability in the 'extreme environment' of frugal applications may help to raise their level of acceptance in other contexts.

Ubiquitous technologies as enablers of frugal solutions

A final, but important, point in relation to technologies as a component of frugal innovations relates to the way in which the spread of technologies opens up opportunities for frugal solutions. Mobile devices are an obvious example. With the number of mobile devices now exceeding the number of people on earth, mobile phones and smartphones are enabling frugal solutions to be developed in a wide range of fields, from mobile banking to health and education (Nordic Innovation, 2016). Peekvision, for example, combines an app and lens adapter to turn an iPhone into a tool that health workers can use to conduct eye examinations in remote areas. High-resolution images can then be shared online with clinicians to diagnose problems and prescribe therapies. Kenya's M-Pesa uses SMS technology to provide mobile money services to 'unbanked' people. The power of these devices to facilitate frugal solutions rests on what one participant at the project's inception workshop described as "ubiquity," and their connectedness. Piggybacking on existing technologies to create frugal solutions is not a new phenomenon – in the 1970s the UK's Open University took advantage of the fact that most people had a television set in their houses to provide 'frugal' higher education services – but the rapid spread of connected devices makes possible a far wider range of solutions than ever before. Meanwhile, the availability of low-cost open hardware such as the Arduino circuit board has enabled, for example, development of a cheap Geiger counter, Safecast, which was given to citizen volunteers in Japan to monitor radiation levels after the accident at the Fukushima Daiichi nuclear power plant in 2011. By 2015, over 15 million data points had been captured, far more than civic authorities were able to measure using traditional methods (Bria et al, 2015). Moving back towards the idea of recombination, components from smart devices can also be used to create new frugal solutions. Nasa's PhoneSat, for example, uses consumer-grade smartphone technology as the control electronics in a very low-cost satellite.²⁷

2.3.3. From 'mass frugal' to 'networked sourcing and delivery'?

As outlined above, industrially manufactured frugal solutions have in the past been associated with standardised mass production. Initially, in fact, the very concept of mass production with its resulting economies of scale enabled the production of "more for less for more people" in the first place. Without the implementation of Fordist and Taylorist principles, frugal solutions would not have become possible in Western industries and mass consumerism would not have emerged in the

²⁷ <http://www.nasa.gov/content/nasas-latest-smartphone-satellite-ready-for-launch>

same manner. During the advent of mass production, frugal solutions represented the previous status quo, bypassed by the industrial revolution and associated with locally contingent, often antiquated, production and delivery systems. In that sense, local diversity and context specificity provided a background from which affordable industrial production was, in a first step, to dynamically depart.

In the overall spirit of the time, therefore, 'mass frugal' solutions became associated with large, centralised corporate empires, strategic market analysis and centralised development, in short with standardisation, homogenisation and a certain disregard for individuality. In consequence, prevailing strategies were characterised by a conceptual dissociation of a few ingenious entrepreneurs on the one hand and a large majority of more or less passive consumers on the other whose needs were conceived of as comparatively similar in central respects. When the overall societal environment changed after WWII, however, the business proposition inherent in individualised – yet still affordable – products became more and more obvious. Still, it was not until many years later that technologies for so-called mass customization would become sufficiently commonplace to perceive situated user and delivery contexts as more than folkloristic relics from the past.

With the advent of additive manufacturing and flexible computer-aided manufacturing systems, however, the rules of the game are beginning to change and, in the view of many, will be changing more dramatically in the coming years (cf. The Economist 2011; Radjou and Prabhu, 2015). For frugal innovation, this is of crucial importance as these technologies will allow manufacturers to combine the low unit costs of mass production with the flexibility of individual customization. Importantly, this will not only become possible through the implementation of new process technologies in the production process but also through new options for co-creation and feedback loops all across the innovation chain.

The following section will therefore provide a brief definition and contextualisation of mass customization per se and, building on that, elaborate in some more detail on processes of co-creation and networked production.

Mass customization

Mass customization refers to efforts aimed at substantial increases in variety without a corresponding increase in costs (Tseng & Jiao, 2001; Pine, 1992). Through company-customer interaction at the conception, fabrication and assembly stages it constitutes a strategy to better meet individual customer's needs at prices close to that of standardised products (Kaplan and Haenlein, 2006). Thus, it by definition creates a substantial opportunity to increase the scope and impact of frugal innovation on developed markets. In the foreseeable future its broad based, technology driven implementation may thus become a technology as equally 'game changing' as the broad availability of steam engines, artificial fertiliser or industrial-scale electricity ('fourth industrial revolution').

In the past, efforts towards mass customization were often mostly conceived of as "effectively postponing the task of differentiating a product for a specific customer until the latest possible point in the supply network" (Feitzinger and Lee, 1997). While this does increase utility – in particular in the area of classic consumer goods – this sort of 'soft' or 'adaptive' customization by the customer will on average have a rather limited transformative effect.

As management research has demonstrated, however, customers perceive substantially increased utility when allowed to adapt their product through "mass customization interfaces" even when the adaptations that they can perform are limited by a number of restricted, or, in fact rather cosmetic changes (Kamis et al., 2008). In that sense, individual customization at the end of the production chain brings solutions somewhat closer to the 'norm' of frugal solutions even if not to the same extent as if the (potential) customer had been genuinely involved.

Nonetheless, "hard" or "collaborative" customization (Chen et al., 2009), i.e. customer-producer interaction at the development stage, is still most likely to provide genuinely transformative potential in the long run. Arguably, such early-stage collaborative efforts are particularly productive as they help to more effectively match the individual specific needs of customers with the growing customization capabilities of manufacturers. This, in turn, resonates with the concept of value co-creation as put forward in the management literature. In the language of economics it suggests that mutual utility will be increased if and when customers can personalise experiences using a firm's product-service proposition to a level best suited to their specific needs and requirements and – at the same time – allow the producer to derive financial or otherwise relevant benefits from that use (Prahalad and Ramaswamy, 2000). To pursue that ambition, firms used to have no choice but to send people to talk to individual customers or conduct telephone surveys – methods by which both bottom of pyramid customers and relevant niche groups with particular preferences were, in the majority of cases, insufficiently covered. At the same time, high entry barriers to participation in product development processes were commonplace with a view to the formal affiliation to relevant firms or universities or at least documented prior qualifications.

These days now appear over, due to technological advances as much as to cultural changes. In the meantime, the culture of many companies has changed from one of in-house development to one of open innovation and (potential) consumers have entered the stage as short-term adapters of by and large predefined products but also as substantial co-developers in FabLabs, makerspaces and Pilot Plants. Importantly, this does not only refer to final, individual customers but also to supplier and customer firms, often SMEs which to an increased extent collaborate up and down the value chain.

So far, mass customization has become prevalent mostly in consumer good oriented industries like textiles, shoes, toys, watches, prefabricated houses, furniture, food and others. By means of software-based product configurators, customers are given the opportunity to add or change functionalities of a core product in a process of 'soft or adaptive customization' – i.e. either shortly before or after purchase. Apart from the configurator itself, this sort of customization does often not even require the implementation of new technologies. Sometimes, variants of one product are simply mass-produced in parallel and sold upon demand. Only where single units require substantial investment and, at the same time, offer a large number of varieties, have genuine processes of mass customization taken hold – as in the car industry. For the time being, there are relatively few genuine 'mass customisers' of material goods to start with and even fewer that involve customers or other external partners at an early stage of the development process. In the coming years, however, this picture may well be changing.

New technological options for co-creation

A few years ago, large scale processes of piloting material goods jointly in groups of individuals were relatively unheard of. At best, some SME who would have otherwise lacked the resources teamed up in collaborative endeavours to put forward new technological propositions that they lacked the resources to explore on their own. In general, the threshold to contribute ideas to technological innovation was high as it required a high level of formal qualification and, as a rule, to be employed in R&D departments of relevant cooperations.

With additive manufacturing and rapid prototyping, however, a game changing technology has been introduced. Since its conception and first demonstration in the 1980s, the technologically viable variants of 3D printing as a prototyping tool have multiplied and become applicable to a much larger range of materials than before, including not only thermoplastics and photopolymers but also metal powders, ceramic powders and metal alloys. Hence, it has become relevant for a large range of industries. Today, 3D printing technologies include fused deposition modeling, fused filament fabrication, robocasting or direct ink writing, stereolithography, powder bed and inkjet head 3D printing, electron-beam melting, selective laser sintering, direct metal laser sintering laminated object manufacturing, electron beam freeform fabrication and others. Also, it has become exponentially cheaper in the past 5 years, years with decent 3D printers now available for less than \$1,000. In consequence, a dynamic culture of joint development emerged in 'makerspaces' that was further enabled by enabling components like credit-card sized frugal computers (Raspberry Pi) and has led to a vivid exchange of findings and ideas on online fora. In such makerspace contexts, formerly passive customers became 'prosumers' engaged in the co-creation and development of products in what some observers see as an emerging "We-Economy" (Hesseldahl, 2015). Increasingly, even larger firms like GE have become interested in sourcing these hubs of creativity and platform providers like Quirky have emerged to cater for that need. Evidently, the threshold to participate in innovation processes has thus been lowered substantially, and the Chinese term 'mass innovation' may in a few years only be slightly overstating.

Furthermore, the plethora of new options arising from the use of cloud computing and big data analysis give firms increased opportunities to scout new markets at early stages and identify precise entry points for the inevitably still needed personal interaction with future customers (Wu et al., 2015). In parallel, cyber-physical systems and an internet of (affordable) things will help to consolidate consumer feedback into the innovation process at various stages and connect products to processes of delivery.

New options for networked production

Even though cooperation in the early stages of the innovation process may provide greater opportunities for mass-customised frugal products than 'mere' adaptive customization, production facilities still have to provide the agility and adaptability to accommodate new designs or even basic characteristics on short notice. Arguably, the requirements that collaborative customization entails in this respect surpass in many cases exceed that of adaptive customization. As mentioned above, processes behind adaptive customization strategies are oftentimes simply resolved through parallel production or, as in the car industry, well proven approaches of modularisation. For the much greater volatility in design that genuine user involvement will bring, in contrast, only smart factories, embedded in real-time cyber-physical systems may provide a sufficient basis.

Arguably, additive manufacturing alone will not deliver on this promise in immediate future, even though some are more optimistic, predicting a potential reduction in prices by nearly 60% in the metal industry (Roland Berger, 2013: 35) or even a general undermining of the once dominant

principle of economies of scale (The Economist, 2011) . To an extent, 3D printing does provide the potential for distributed manufacturing at the household scale of customised, high-value, and complex products (Wittbrodt et al., 2015; Bopp, 2010). It will be some time until a “full scale global additive manufacturing ecosystem” emerges, however, even though its beginnings are on the horizon (Radjou and Prabhu, 2015).

While during the 2000s, additive manufacturing’s applications have typically been on the conception side of the innovation chain, additive methods are moving ever further into the production end of manufacturing in creative and sometimes unexpected ways. In parallel, additive manufacturing joins forces with cloud computing technologies in decentralised and geographically independent networks for distributed rapid manufacturing (Wu et al., 2015, Hopkinson and Dickens, 2006) – either by companies themselves or through matching services like 3D Hubs that put potential customers in contact with nearby owners of 3D printers (3D Hubs, 2015, Horn, 2013). Different from rapid prototyping, however, rapid manufacturing remains far from mature and many of its processes remain technologically unproven. In the short term, selective laser sintering or direct metal laser sintering, some of the better-established rapid prototyping methods, are considered as most promising options. So far, industrial applications have reached some maturity for toys, eyewear, specific components for the aeronautics, car and construction industry, prosthetics, and cases for various electronic products.

‘Industry 4.0’, moreover, will provide increased opportunities. In the nearer future, machines, storage systems and supplies will become embedded in common IT infrastructures and linked up as cyber-physical systems (CPS). Based on more advanced or ‘smart’ robots capable of man-machine interaction as well as new types of cyber-physical production facilities, opportunities to both accommodate greater product variety and to coordinate production with development outcomes and user demand in real time will be much increased. Based on these new options to communicate along the value chain in real time and an increasing abundance of mass data, mass customization in ‘smart factories’ will become much more commonplace than today.

In summary, the impending re-organisation of production processes (‘fourth industrial revolution’) will with some likelihood enable substantially increased efficacy and efficiency in complex production processes which, in consequence, will lead to opportunities for a substantial cost reduction of a much larger range of products than traditional mass production could ever provide (Radjou and Prabhu, 2015). In concert with additive manufacturing, therefore, the trend towards digital factories may indeed harbour a potential to, in the long, run eliminate or at least sideline the former economies of scale as the dominant business model that enables frugal solutions and affordability in industrial production.

2.4. Appraisal and outlook

2.4.1. Weighing tensions between benefits: when is frugal welcome?

To conclude, this report will come back to the question of the normative character of frugal innovation or in short, the issue of what type of frugal innovation is desirable from a societal, ecological and ethical standpoint. While at this stage of the study, no definite answer can be provided, this final section will revisit some central tensions and provide illustrative examples.

Quite evidently, the mere fact that someone, through an ingenious solution provides ‘more with less for more people’ does not per se lead to a more desirable, let alone sustainable outcome until further criteria are fulfilled.

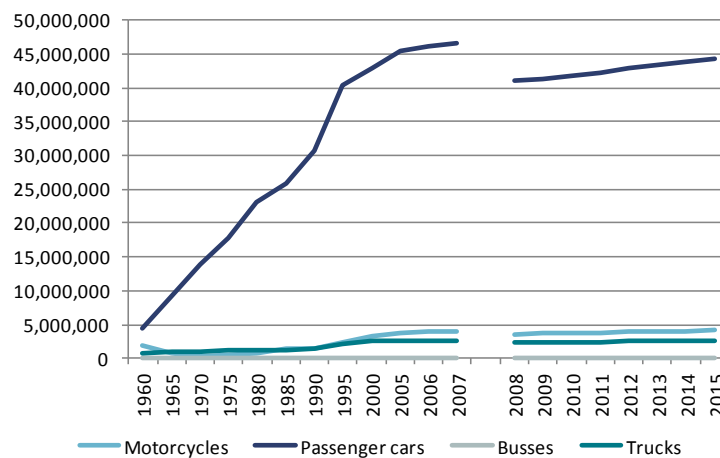
For example, the business model of discounters is clearly frugal with a view to their reduced approach of offering food, beverages and other consumer products at lower prices than in traditional supermarkets. At the same time, many of them are notorious for poor working conditions, low wages, robust negotiation practices and an at best limited regard for ecological sustainability in the production of the goods they offer. Likewise, industrialised food and meat production can with a view to various aspects of the production process easily be considered as frugal. This provision of many formerly inaccessible goods at substantially lower prices, however, leads not only to improved accessibility but also to negative side-effects of mass consumption such as detrimental effects on public health, rising volumes of waste, the unethical treatment of animals and negative environmental impacts due to an overly extensive use of agricultural land.

Similar examples can be found for organisational innovations that allow more people greater comfort and the use of services that were not affordable for them in the past such as package holidays or low-cost airlines. Besides these positive effects, however, both innovations have resulted in undisputable negative environmental consequences and, locally, in at least questionable social outcomes. Likewise, these substantially lower prices for services are in more than isolated cases achieved at the cost of the employees providing them – with a view to wages or working conditions.

Furthermore, the effects of 'more with less for more people' should be assessed from a dynamic perspective. Mass motorisation could be mentioned as one such ambiguous example. When Ford started offering cars 'for the masses' and, at later stages, German and Japanese producers added further affordable automobiles for wider parts of the population, individual transport opened many new economic opportunities and facilitated improvements in wellbeing. At the same time it created many negative effects for the environment and for society in terms of noise, pollution and novel health threats.

Figure 6 shows the development of the stock of motor vehicles in Germany over the last sixty years – triggered by rising incomes and the availability of affordable passenger cars. Additionally, it shows how arguably more sustainable solutions like motorcycles, which in the 1950s and 1960s were used to transport whole families, were gradually replaced by passenger cars. While this development could to an extent be expected from the outset, policy makers not only took a long time to address it but, until today, face grave difficulties in the restructuring of what has become a socio-technological subsystem shaped by easy, and affordable, access for all. At the same time, China and India are moving into a quite similar track development with barely improved strategies for mastering their consequences.

Figure 5: Stock of motor vehicles in Germany, 1960 to 2015



Source: German Federal Motor Transport Authority, illustration Fraunhofer ISI

Until the 1960s, most Western societies held a strong belief in technology and progress. Resources seemed to be inexhaustible, it was assumed that the environment could cope with waste and pollutants and if not, technological solutions would be found for the problems. When this perception started to change, first efforts were initiative to assess technologies, in first reports to the US Senate in 1966 and with the establishment of the US Office of Technology Assessment (OTA) in 1972 (Dusseldorp and Beecroft, 2012). Later on, similar offices were established in European nations to monitor and analyse trends in science and technology and assess their opportunities and risks. Since 2005, the European Technology Assessment Group (ETAG) provides such assessments on social, environmental and economic aspects of new technological and scientific developments to the European Parliament. More recently, the European Commission initiated a debate on 'responsibility' in science, technology and innovation policy to better align its support effort with societal needs. This ambition was reflected in the 2010 framework for Responsible Research and Innovation building on earlier discussions on "Science and Society" as follows:

Responsible Research and Innovation (RRI) refers to the comprehensive approach of proceeding in research and innovation in ways that allow all stakeholders that are involved in the processes of research and innovation at an early stage

- A. *to obtain relevant knowledge on the consequences of the outcomes of their actions and on the range of options open to them and*
- B. *to effectively evaluate outcomes and options in terms of societal needs and moral values*
- C. *to use both of these considerations as functional requirements for design and development of new research, products and services.*

The RRI approach [is key to] the research and innovation process and should be established as a collective, inclusive and system-wide approach." (European Commission, 2013)

Against this background six key dimensions were highlighted (European Commission, 2012):

- Involvement of all societal actors (interest groups representing diverse concerns)
- Gender equality
- Science education to allow broad-based participation in debates
- Open access to the results of publicly funded research
- Ethics – respecting fundamental rights and high ethical standards
- Ensure a conscious governance of responsible research and innovation.

Certainly, frugal innovation must be considered as distinct from the type of science and science-driven innovation that is typically discussed in the RRI discourse. As outlined in this report, many frugal innovations are based on the recombination rather than the scientific generation of existing knowledge and extend broadly into the field of service and organisational innovation. At the same time, they can also be closely related to scientific efforts and display notable overlaps with technology driven innovation.

In any case, the above examples have demonstrated that it will be worthwhile to reflect on their societal and ecological implications of frugal innovations from both a static and a dynamic perspective. For this, existing experiences with technology assessment and responsible research provide suitable templates even if the object of their application may be somewhat different in the context of frugal innovations.

2.4.2. Weighing policy options: how could frugal activities be triggered?

Previous sections have explored the case for frugal innovation as an opportunity for Europe. This report has argued that frugal innovation represents an important avenue for European firms looking to compete in emerging markets, and increasingly, in developed European markets at well. Macro trends, including the long-term pressure on public sector budgets and increased demand on public services arising from an ageing population, as well as the European Commission's aspiration to support 'smart, sustainable and inclusive growth', suggest that frugal innovation has potential as a means of tackling public policy challenges as well. Nevertheless, at present, frugal opportunities both for European businesses and from a public sector perspective remain under-explored. Therefore, while it is not the aim of this interim report (and too early in the lifecycle of this project) to construct a detailed rationale for policy intervention, the evidence discussed so far suggests that there may be a case for policy makers to support frugal innovation – even if, as suggested above, it will be important in doing so to consider, and manage, potential negative impacts of supporting frugal innovations.

Moving on from the question of *whether* policy makers should support frugal innovation, this section briefly considers *how* they could do so. The research carried out as part of this project so far suggests that policy could play a role both in triggering demand and supply of frugal innovation. A first potential role - in fact already being embodied through the funding of this scoping study - involves raising awareness and generating interest in frugal innovation, leveraging the European Commission's role as a convener.

A number of opportunities can also already be identified relating to research and innovation policy. Fraunhofer ISI and Nesta's original proposal to undertake this study outlined a number of potential implications for Horizon 2020 and more specifically, the Leadership in Enabling and Industrial Technologies (LEIT) strategy. A key point made was that the focus of investment in Key Enabling Technologies to date has been on upstream, early stage research, while promoting frugal innovation may require a shift towards investment in later stages of the innovation cycle. This idea has been supported by the research carried out so far, which has re-emphasised, for example, how frugal innovation involves not only (and sometimes not at all) the development of new technologies, but the combination of existing elements to meet user needs in a different way. The possibility of selecting specific technologies that would appear to most readily 'lend themselves' to frugal innovation and focusing on supporting their integration in frugal approaches was also raised in our proposal, and has been further supported by the research to date. Additional potential opportunities include promoting partnerships between firms in Europe and emerging economies, and directing programme funding towards generating frugal solutions for emerging markets in Europe.

Some other existing initiatives of the European Commission seem to have relevance for frugal innovation, without necessarily using this terminology. The European Innovation Partnerships (EIPs) supported under the Innovation Union, for example, are exploring a number of themes in which frugal solutions are likely to emerge, such as the EIP on Smart Cities and Communities, which among other issues looks at integrated energy models, urban mobility, energy efficiency,

low-carbon solutions and, in a broad sense, the circular economy.²⁸ Moreover, the structure and aims of these partnerships - multi-stakeholder groups, intending to speed up the innovation process, and taking problems or challenges as their starting points - lend themselves well to identifying opportunities for frugal innovation. Further exploring the extent to which frugal innovation could become more explicitly embedded in the work of these partnerships may be worthwhile.

Beyond research and innovation policy, the research so far has highlighted the impact of regulation and standards on frugal innovation, both positively - as when new standards, duties and targets push companies to develop more energy-efficient solutions - and negatively, when regulation prevents frugal solutions from being adopted in Europe. Given the importance of these issues, this report has discussed regulation and governance and its implications for frugal innovation in more detail earlier in this report.

The public sector has a huge potential role as a 'customer' for frugal innovation, both from the perspective of procuring frugal solutions from third parties, and of adopting frugal thinking within the design and delivery of services. Exploring ways to stimulate demand from public sector organisations for frugal solutions appears therefore to be a significant opportunity. This could take the form, for example, of funding pilots to explore the potential for adoption of 'reverse innovations' from other contexts, for example in health and education; funding challenge prizes to bring forward frugal solutions to public sector challenges; or supporting learning programmes that aim to develop 'frugal capabilities' amongst public servants in Europe. The broader area of education and skills policy also appears relevant to this agenda, given the need to develop capacities for frugal innovation within European firms, although no specific proposals have emerged from the research to date.

Frugal innovation could also form a focus for European countries' innovation partnerships with emerging and developing economies, in way that both generates benefit for Europe and supports development goals. The UK's Newton Fund²⁹ fund, for example, promotes research and innovation collaborations between UK organisations and counterparts in a number of focus countries, as part of the UK's official development assistance, while the Prosperity Fund³⁰ supports collaborations that simultaneously promote both UK and global growth.

Taking a slightly different track, the research to date highlights that frugal processes are important as well as frugal outcomes - raising the questions of whether frugal innovation principles can be better reflected in policy design itself. This may include, for example, greater use of technology to generate insights that could inform research and innovation priorities, or to source solutions (for example through collective intelligence platforms or challenge prizes).

Finally, this report has also noted that the social, environmental and economic outcomes of frugal innovation will not always be positive and that tensions between these different types of outcomes in some cases. Therefore, the question is not only how policy makers could trigger frugal innovation but how they can do so in a way that maximises positive outcomes and manages tensions.

²⁸ http://ec.europa.eu/eip/smartcities/index_en.htm

²⁹ <http://www.newtonfund.ac.uk/>

³⁰ <https://www.gov.uk/guidance/prosperity-fund-programme>

3. FINAL HYPOTHESES AND PROPOSITIONS

Based on the above sections, the following eight hypotheses have been consolidated.

On mentality

1. A mentality for frugal innovation and technological recombination is not exclusive to emerging economies. It played a central role in Europe's past development and remains prevalent in many market oriented, mid-sized firms. Even in technology-driven contexts, frugal mindsets can be (re)gained through active engagement.

On routines

2. Current routines of technology development will have to be substantially re-thought to enable frugal solutions. Concrete applications of technologies under development will have to be considered at much earlier stages (TRL4-5) and additional actors will have to be involved to integrate a market dimension from the outset.

On openness

3. In Europe, many innovation processes remain contained within firms and fail to relevantly involve potential users - creating a "closed world" with a lack of market awareness and an overt affection to high-tech solutions. Successfully creating frugal solutions will require firms to shift innovation practices towards more open models.

On transformation

4. Key enabling technologies (KETs) will open up new avenues for frugal innovation. In particular, newly available technologies such as various ICT applications, 3D printing and industry 4.0 will not only open up new options for frugal products but, at least equally, for new, frugal processes of innovation and production.

On markets (European)

5. In principle, many trends in European markets spur rising demand for frugal solutions - based on needs and out of choice. While the refugee crisis has added further momentum to the former, aspirations and preferences for the latter remain to be shaped. Finally, the public sector itself can be an important customer for frugal innovation.

On markets (emerging)

6. Frugal innovation is a business opportunity for European firms in emerging markets and many larger corporations have devised strategies on how to leverage it to the best of their ability. Moreover, exposure to emerging market contexts is a suitable tool to engage with differing mentalities, enable learning and improve business models in a holistic sense.

On scale

7. Achieving scale is a key challenge for frugal innovation as solutions will only develop a relevant impact when delivered at large scale. Localised frugal solutions of the grassroots type, however, may in fact not be scalable. In Europe, cultural, linguistic, regulatory and other barriers between nations complicate the challenge.

On tensions

8. Increasing access for more people is not unanimously positive with a view to ethical, ecological and social impact. Detrimental and potentially conflicting outcomes have to be considered. Hence, policy makers should not only promote frugal innovation, but also consider how to do so in a way that addresses and manages potential tensions.

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This literature study explores the quickly expanding body of literature on the subject of frugal innovation with a view to common definitions, central prerequisites and possible avenues of future development. On that basis, it seeks to establish a better and more focused understanding of the manifold opportunities that frugal innovation offers for Europe's firms and citizens. Furthermore, it elaborates on possible ways how existing technological capacities could be leveraged for frugal ends and how new development can further frugal innovation. Despite evident particularities in market conditions, it finds that the process of frugal innovation is by no means unique to developing countries. While, per se, European firms and developers do not face limiting resource constraints, a more conscious acknowledgement of those of others will not only enable them to leverage additional market opportunities elsewhere but also to improve their contribution to societal challenges.

Studies and reports