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# A Comparison of German and Indian Innovation Pathways in the Auto Component Industry

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## Abstract

This paper is a part of a series of analyses conducted within a BMBF-funded research project to investigate potentials of frugal innovations for Germany. One of the objectives of this project has been to identify innovation pathways that foster frugal innovations. Since auto component suppliers based in India are known to contribute significantly to the development of “affordable and good quality” vehicles, it was considered useful to conduct comparative studies of the prevalent innovation pathways in Germany with those in India. This paper is based on our investigations of innovation pathways in Indian and German auto component industries and aims to provide a coherent comparative analysis.

After discussing similarities and differences in Indian and German innovation pathways, a reference model for frugal innovation pathways is outlined. The results provide insights on how certain elements of frugal innovation pathways could be implemented in Germany in order to create solutions that are affordable, fulfil the requisite quality standards and avoid unnecessary usage (wastage) of resources. Altogether, exploratory connections are identified which provide impetus for further research and can be thought-provoking for relevant business, social and political stakeholders.

## Keywords

Frugal Innovation; Innovation Pathways; Path Dependency; Automotive; Auto-Component Industry

## Acknowledgements

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## 1. Introduction

The topic of frugal innovation is receiving increasing attention in scholarly discourse, especially in the context of emerging economies such as China and India. Rapid economic growth in these countries has created conditions favourable for the emergence of a new middle class interested in affordable and relatively simple (technological) solutions meeting their specific needs. Recently, however, the question has been raised, how relevant frugal innovations for the German market and other industrialized economies are. Examples, such as beating heart surgeries and low cost electrocardiograms show how frugal solutions originally innovated for emerging economies also find their way into niche markets of the Western world and can challenge traditional players as disruptive innovations (Christensen, 1997, Kroll et al., 2016, Prahalad, 2012, Radjou and Prabhu, 2015). In addition, societal trends seem to foster the acceptance of frugal innovations in Germany (Tiwari et al., 2017).

This study is part of a joint project between the Fraunhofer Center for International Management and Knowledge Economy (IMW) in Leipzig and the Institute for Technology and Innovation Management at the Hamburg University of Technology (TIM-TUHH) investigating the relevance of frugal innovation for Germany. A core question of this research project is how frugal innovations, which primarily originate in emerging economies, may differ from traditional innovations in the Western world in respect to their innovation processes. Insights about the underlying innovations pathways can provide better understanding of frugal innovations and help firms in developing frugal solutions to the benefit of the society at large.

This paper builds upon two preceding analyses conducted within the research project: (1) An analysis of innovation pathways in the Indian auto-component industry (Tiwari and Kalogerakis, 2017a, b); and (2) an analysis of innovation pathways in the German auto-component industry.<sup>1</sup> The current paper aims to provide a coherent comparison of German and Indian innovation pathways in the auto component industry and to establish understanding on how innovation pathways foster the emergence of this kind of innovation. Innovation pathways are described by a set of factors that determine the outcome of innovation processes within an organisation or a whole industry (Dosi, 1982, Mitra et al., 2015). They are influenced by path dependency which is an organizational process explaining organizational persistence. Based on Thrane et al. (2010) and Mitra et al. (2015) we have identified a set of internal and external factors that in combination can be used to analyse innovation pathways (see Table 1).

The auto-component industry is chosen as an example to compare German and Indian innovation pathways, because several cars developed by Indian and global vehicle manufacturers have already been discussed as examples of frugal innovation, such as Maruti A Star (Kulkarni, 2009), Tata Nano (Chacko et al., 2010) or Renault Kwid (Midler et al., 2017). Although it is known that component suppliers have strongly contributed to these frugal innovations, it is still unclear which factors fostered their success. Furthermore, the automotive sector is rated as one of the most important branches of German industry currently facing great challenges due to increasing globalisation and the emergence of new disruptive trends (Diez, 2012). Hence, the auto-component industry was chosen to compare German and Indian innovation pathways and to analyse factors contributing to frugal innovations.

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<sup>1</sup> The investigation of innovation pathways in Germany's auto components sector was conducted by Fraunhofer IMW, while TIM-TUHH studied them in the Indian context. The corresponding sections in this paper (section 2.2 by Fraunhofer IMW and section 2.3 by TIM-TUHH) are based on these two coordinated studies.

Development of Innovation Pathways	
Internal Factors	External Factors
Business model and strategies	Established standards and conventions
Organizational structure	Cultural concepts and norms
Corporate culture	Economic developments
Established innovation processes	Regulatory requirements
Prior knowledge and competencies	Political context
Applied technologies	General technology development

**Table 1: Influencing factors of innovation pathways<sup>2</sup>**

Our results provide insights concerning differences and similarities of innovation pathways in the German and Indian auto-component industry. The points discussed in detail here encompass the specification of development goals, cost pressure, use of external knowledge, aiming for highest quality vs. reduced time-to-market as well as regulatory and sociocultural influences on innovation pathways. Furthermore, a reference model for frugal innovation could be developed providing specific information about frugal innovation processes for interested companies and insights concerning future research needs.

The paper is structured in four main sections. In section two characteristics of the auto-component industry are explained to provide a background for further analyses. In the third central section German and Indian innovation pathways in the auto-component industry are compared. Afterwards, in section four, a reference model for frugal innovation pathways is outlined. The paper ends with a concluding discussion in section five.

## 2. Characteristics of the auto-component industry

### 2.1. The global auto-component industry

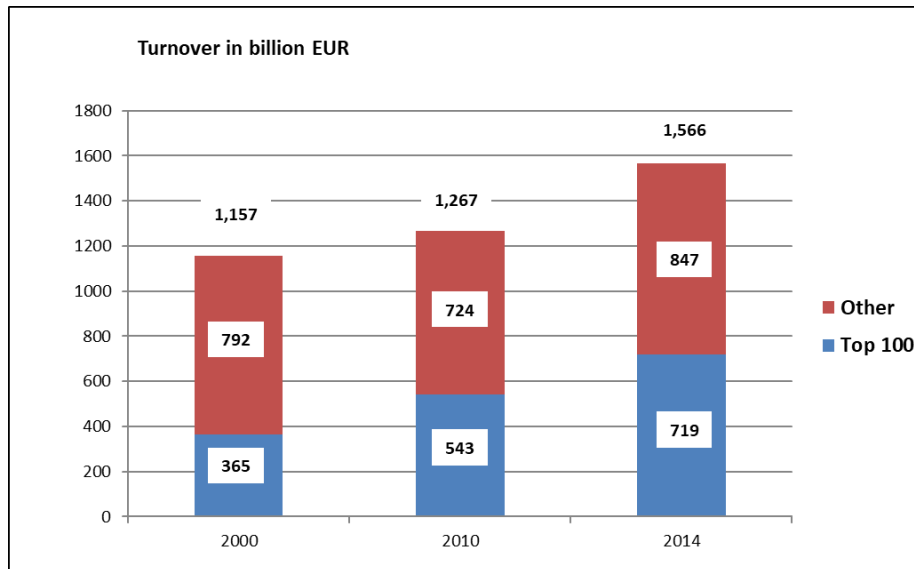
The global auto-component industry constitutes an important part of the global automotive industry with a constantly rising revenue development. From 2000 to 2014, the turnover increased by 35% (see Figure 1). At the same time, the cumulative revenue share of the top 100 component suppliers grew from 32% to 46%, indicating a continuing consolidation in the industry.

There is a special power distribution within the automotive industry. A small number of giant OEMs (Original Equipment Manufacturers) “carry out most aspects of product design, the production of most engines and transmissions and nearly all vehicle assembly within their own facilities. They are large employers, traders and innovators. They have substantial coordination and buying power in the chain. ... But, since the early 1990s, outsourcing has led to the creation of large global suppliers, which have taken on a more extensive role in the areas of design, production and foreign investment. The largest

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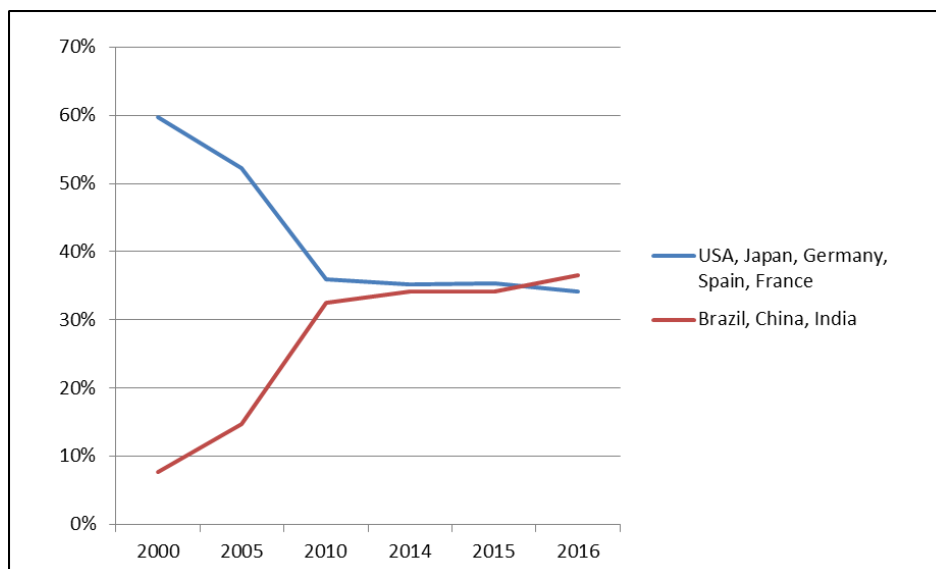
<sup>2</sup> Source: Tiwari and Kalogerakis (2017b)

20-30 suppliers have shifted the balance of power away from leading automakers, although in a very partial and incomplete way.” (Sturgeon et al., 2009, p.17)



**Figure 1: Turnover development of auto-component suppliers worldwide<sup>3</sup>**

Automotive OEMs have been increasing their global activities due to large demand in emerging economies “in Asia (mainly China, the Republic of Korea and India), Latin America (mainly Mexico and Brazil) and Eastern Europe (mainly the Russian Federation)” (Sturgeon et al., 2009, p.12). Stagnation in traditional markets has also contributed to this trend. For illustration of the changing geographical competitive landscape, see Figure 2.



**Figure 2: Share of selected country groups in global automotive production<sup>4</sup>**

By their rising global activities, OEMs have forced their suppliers to produce in a more globally

<sup>3</sup> Source: Adapted from Berylls Strategy Advisors (2015b)

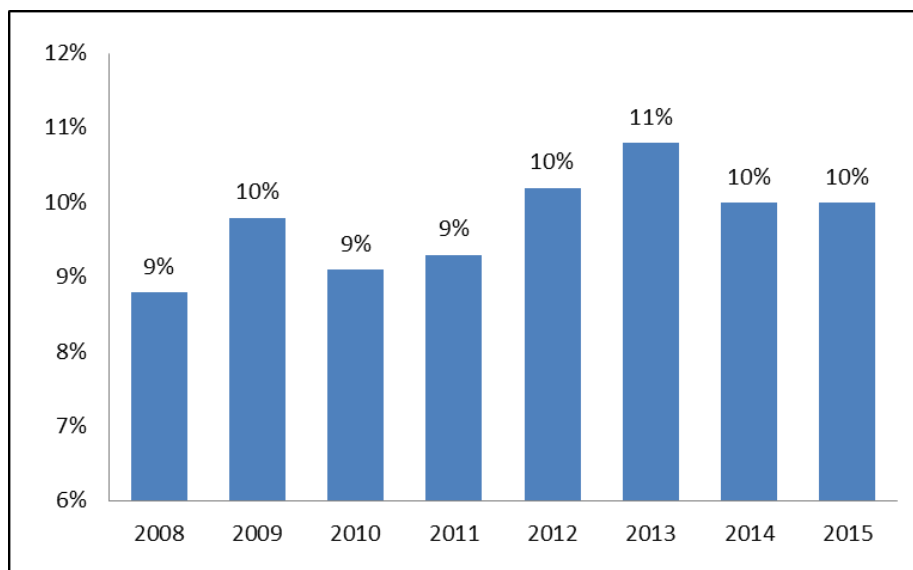
<sup>4</sup> Source: OICA as published by Statista 2017

dispersed fashion, too. Today, there exist both global as well as local suppliers in the automotive industry. Final assembly of automotive vehicles often takes place close to the end-markets and suppliers seek geographical proximity to OEMs to ensure Just-in-Time delivery and to reduce transportation and warehousing costs, wherever feasible. All this “has resulted in local, national and regional value chains in the automotive industry being ‘nested’ within the global organisational structures and business relationships of the largest firms” (Sturgeon et al., 2009, p.10).

Following this short background information about the global auto-component industry, the German and the Indian auto-component industry shall be described in more detail in the next two sub-sections.

## 2.2. The German auto-component industry

The automotive industry is one of the most important sectors in the German economy ensuring both innovative growth and employment (e.g., Barthel et al., 2015). Based on facts and figures from the year 2015, the Centre for European Economic Research (ZEW) describes the German automotive industry as very innovative: “Vehicle construction remains the most innovative sector in the German economy. No other industry spends more on innovation and generates higher revenues with new products.”<sup>5</sup> (ZEW, 2017, p.1). With expenditures on R&D to the tune of 19.6 billion EUR in 2014, the automotive industry accounts for one third of Germany’s total R&D activities (Germany Trade and Invest, 2016). This is also reflected in the high innovation intensity of the industry as depicted in Figure 3.



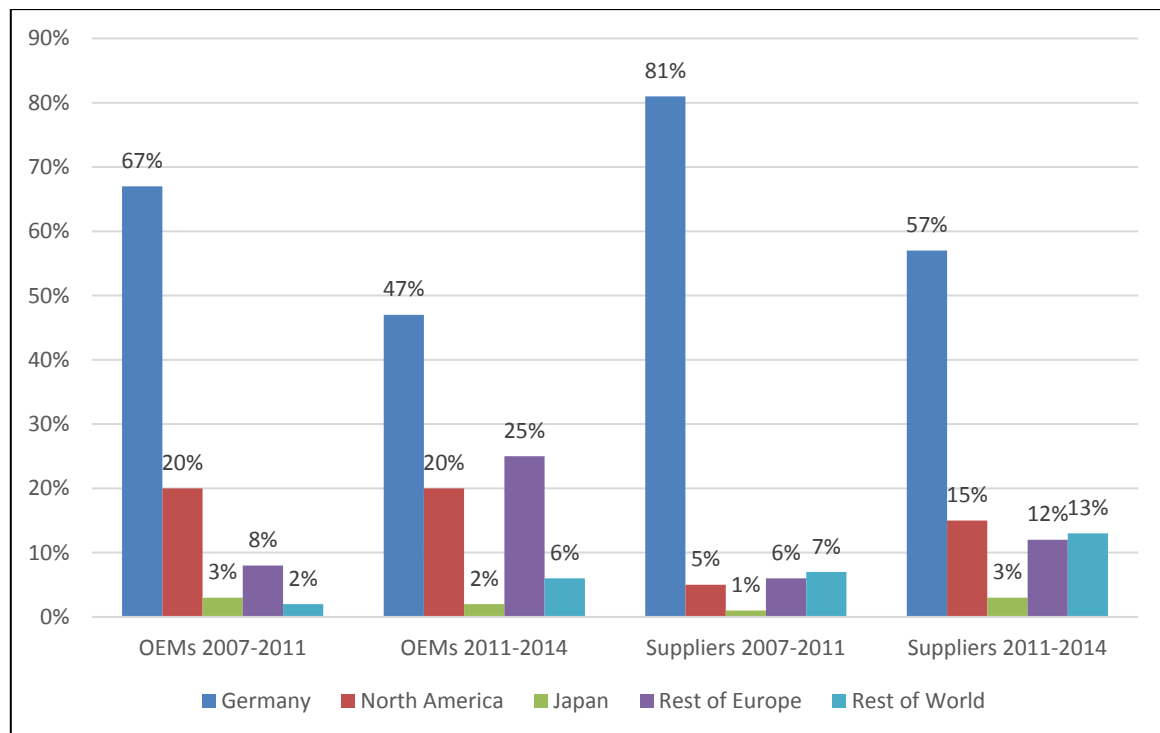
**Figure 3: Innovation intensity of the automotive industry in Germany<sup>6</sup>**

Such innovation efforts happen to a large extent in the auto-component industry. A study by Oliver Wyman (2015) reveals that 61% of all research and development (R&D) activities in the German automotive sector are carried out by the suppliers and only 31% belong to OEMs. In addition, 8% of R&D activities are provided by third parties, such as consulting & engineering firms. Due to increasing international competition in the automotive sector, the German Association of the Automotive Industry (VDA) states that innovation is key to international competitiveness (Bratzel et al., 2016).

<sup>5</sup> Authors’ own bridged translation from original German

<sup>6</sup> Source: ZEW as published by Statista 2017; Companies with at least five employees. Innovation intensity is the share of turnover spent on innovation projects.

German auto-component suppliers are further characterised by increased internationalisation strategies. It has been argued that intra-industry relationships between auto-component suppliers and OEMs have entered a new era of international linkages after a long phase of prevailing “patriotism” (Bratzel et al., 2016). Up to 2010, a pre-dominant focus by the component suppliers on the domestic market and domestic German OEMs can be observed; whereas from 2011 onwards auto-component suppliers have been increasingly likely to cooperate internationally in their innovation activities. The same holds true for German OEMs which were primarily focused on national suppliers in the past but in recent years have begun to seek international cooperation as well. Yet, despite the occurring internationalization of R&D in the industry, the majority of innovation activities still predominantly occurs in the home country with national suppliers as the preferred partners, which is depicted in Figure 4.



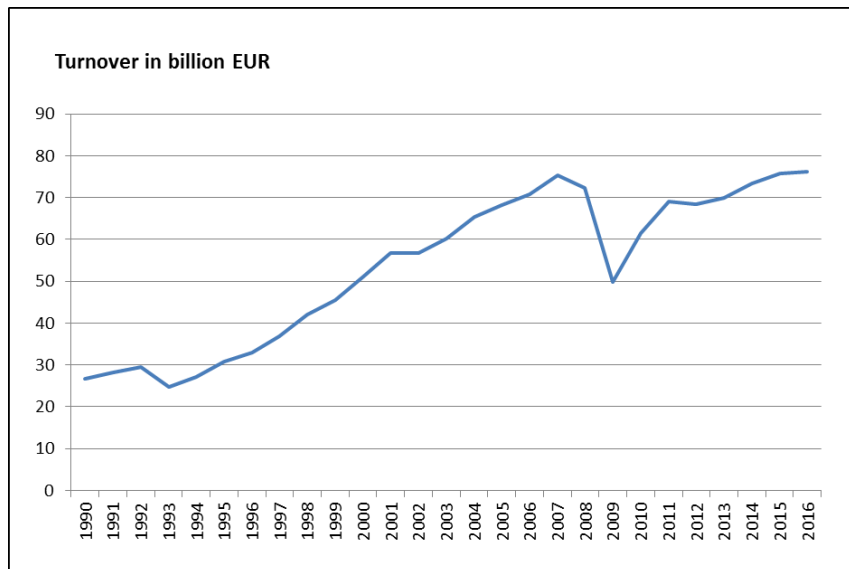
**Figure 4: International cooperation of German OEMs and suppliers<sup>7</sup>**

In 1980, the vertical range of manufacture of automotive OEMs was about 50% and today reaches only about 25% (Diez, 2012, p.85, Wissmann, 2016). Turnover in the German auto-component industry (see Figure 5) has been constantly increasing from 1990 (26.8 billion EUR) until 2007 (75.4 billion EUR), which represents an annual growth-rate of 16% for this time period. Due to the financial crisis, however, turnover fell to 49.9 billion EUR in 2009, but has recovered to 76.3 billion EUR in 2016 – similar to the turnover from 2007 (see Figure 5).

German auto-component suppliers have a leading position worldwide in diverse technology sectors such as vehicle electronics and drive engineering (Barthel et al., 2015). A further characteristic of the German auto-component industry is the high proportion of medium-size companies, many of which are still family-owned. Finally, German companies also have a very strong position concerning the area of development service providers. In 2010, 21 of the 25 worldwide largest development service providers based on their automotive turnover had their origin in Germany (Diez, 2012, p.85-88). And in 2013, still

<sup>7</sup> Source: Bratzel et al. (2016, p.51)

14 out of the 25 worldwide largest development service providers based on their turnover in automotive engineering had their headquarters in Germany including the first two positions (Berylls Strategy Advisors, 2015a, p.16). This, however, also shows that competition is emerging and the competitive position of firms is no more as secure. This development makes it an imperative to look for alternative innovation pathways being successfully used by firms elsewhere.



**Figure 5: Turnover in the German auto-component industry<sup>8</sup>**

“The automotive industry finds itself in the midst of a global structural change – economically, politically as well as ecologically. It does not seem exaggerated to speak of a ‘turning point’ requiring a review and reorientation of entrepreneurial strategies. In the past, the German automotive industry has successfully adapted to changed framework and market conditions, as key economic indicators suggest. The question arises as to whether, and above all, how this will continue in the future” (Diez, 2012, p.151).<sup>9</sup> In order to remain highly competitive with respect to globalisation and new emerging forms of mobility several structural changes have been implemented, including process innovations and worldwide relocations of manufacturing sights. The ongoing structural and societal changes in the mobility sector, however, will pose challenges to the German automotive industry – including the component suppliers (see e.g., Barthel et al., 2015).

### **2.3. The Indian auto-component industry<sup>10</sup>**

In the period from Independence (1947) until the early 1980s the automotive industry in India was strongly regulated. Companies had to act within a complex system of industrial licences and permits which the Indian government introduced to protect the domestic industry leading, however, to relatively high prices and low-quality of products. In the 1980s, a modernization program for the industry was initiated bringing new foreign competences to the country. But it was only after a severe economic crisis hit India in 1990/91 that a major economic liberalization programme started resulting in a dynamic development of the industry (Diebolt et al., 2016, Kumaraswamy et al., 2012, Tiwari and Herstatt, 2014).

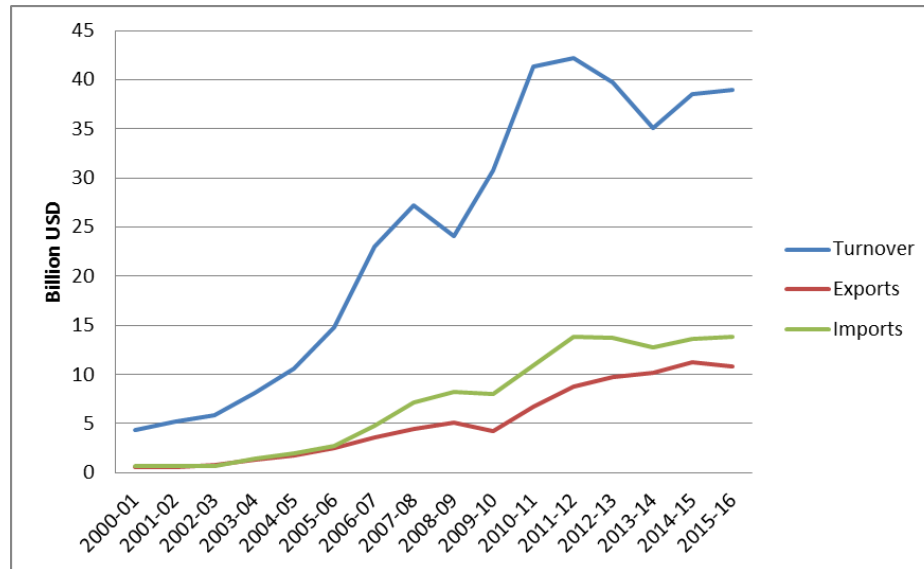
<sup>8</sup> Source: VDA as published by Statista 2017

<sup>9</sup> Authors’ own abridged translation from original German

<sup>10</sup> This section draws on Tiwari and Kalogerakis (2017a, b) which can be consulted for a more detailed overview.



Since the turn of the millennium, the industry has registered an enormous growth. The overall industry turnover has increased by a compounded annual average growth rate (CAGR) of 15.6%, exports by 21.4% and imports by 22.4% between FY 2000-01 and FY 2015-16, which has far outperformed the Indian economy as a whole that has grown by ~7% in this period (IMF, 2016). The growth trend in absolute numbers can be seen in Figure 6.

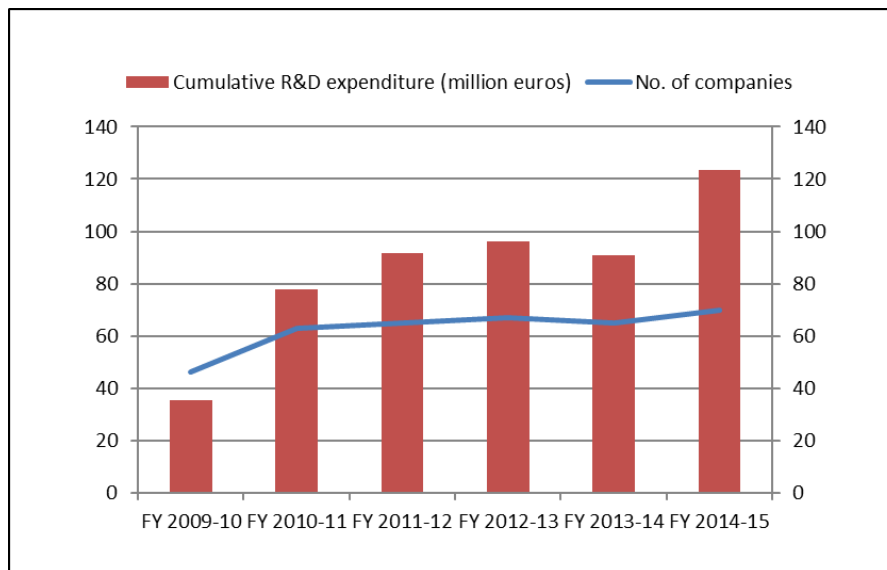


**Figure 6: Development of India's auto-component industry<sup>11</sup>**

Before liberalisation of the industry, innovation activities in India's auto-component industry were rather limited. Instead of investing in new technological processes, suppliers tried to benefit from cheap manual labour (Kumar and Puranam, 2012). After liberalisation of the industry, large global OEMs and component suppliers entered the market resulting in new standards concerning quality and flexibility as well as new technologies being introduced to the country (Diebolt et al., 2016). Although R&D expenditures in India's auto-component industry are still low compared to industrialised countries, they are on a rising path, as the analysis of the annual reports of 123 publically-listed firms from this sector revealed (see Figure 7).

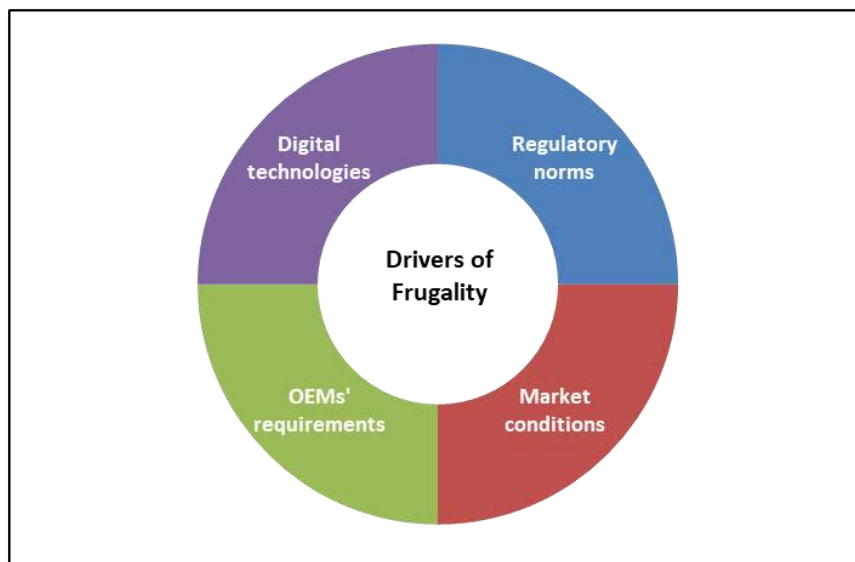
The average R&D intensity of Indian auto component suppliers in the formal sector, for whom the data were publically available, is only 0.52%, but there exist exceptions. Several companies seem to have realised the importance of innovation activities and show above average R&D efforts, for example *Kinetic Engineering* (4.4%), *ANG Industries* (3.9%), *Rane (Madras) Limited* (3.0%), and *Sundaram Brake Linings Ltd* (2.7%) (Tiwari and Kalogerakis, 2017b).

<sup>11</sup> Source: based on ACMA/SIAM data, see also Tiwari and Kalogerakis (2017a)



**Figure 7: Cumulative R&D expenditure by publically-listed component suppliers<sup>12</sup>**

Tiwari and Kalogerakis (2017b) have identified innovation patterns in the Indian automotive industry fostering frugal innovations. While extreme price-sensitivity of the Indian automobile market forces firms to develop very cost-effective solutions, increasing global competition and new national regulations concerning safety and emissions demand higher quality levels from the component suppliers. Hence, requirements of OEM's, new regulatory norms as well as specific Indian market conditions set the stage for frugal innovations in the auto-component sector. Furthermore, digital technologies act as a key enabler of frugal innovations in this industry by reducing the need for material components and by enabling better test/simulations to fit specific requirements (see Figure 8).



**Figure 8: Drivers of frugality in the Indian auto-component industry<sup>13</sup>**

Process innovations are found to constitute a crucial part of the prevalent innovation strategy in the Indian auto-component industry and these innovations are often based on an extensive use of digital

<sup>12</sup> Source: Tiwari and Kalogerakis (2017b)

<sup>13</sup> Source: Tiwari and Kalogerakis (2017b)

technologies. Implemented new processes based on digital technologies also form the basis for very competitive time-to-market strategies followed by some Indian auto-component suppliers. Leapfrogging certain stages of technological development is made possible for Indian auto-component suppliers due to cooperation between Indian and global companies as well as due to acquisitions of companies overseas. But also “engineering research and development (ER&D) service providers have emerged as disruptive innovators in the traditional automotive value chain” (Tiwari and Kalogerakis, 2017b, p.17).

### **3. Comparison of innovation pathways**

This comparison builds upon the two preceding research studies concerning innovation pathways in the German and Indian auto-component industries.<sup>14</sup> This section discusses these coordinated but separately generated results to gain further insights about common features and to identify differences concerning innovation pathways in Germany and India.

#### **3.1. Specification of development goals**

The auto-component industry, as an ancillary industry in the business-to-business (B2B) segment, is largely dependent upon the specifications set by automotive OEMs. This situation seems to influence innovation processes in the auto-component industry in a certain way irrespective of the geography. This relation of dependence is further complicated by the complex and systemic nature of automotive development projects. Hence, our results in Germany as well as in India indicate that OEMs (and even Tier-1 suppliers) usually give rather strict development goals to their suppliers. Innovations in the auto-component industry are, thus, often incremental in nature and dominated by ideas and projects of the OEMs providing little freedom for proactive or radically new innovations from the suppliers.

In Germany, however, experts from the auto-component industry evaluate the specification of development goals given from OEMs to suppliers as “110%”, which is rather over-specified. An automotive expert at a German industrial association suggested, “We can see that the OEMs determine very concrete specifications about how a new model or a new development of a model ought to look like.” Regarding this point, slight differences seem to exist in India.

Indian OEMs sometimes, especially when working on frugal projects, encourage suppliers to work together and develop the requisite specifications in a collaborative effort, as has been reported in the literature (Chacko et al., 2010, Wielgat, 2002). Apart from the desire to reduce coordination effort and increase effectiveness by directly integrating the suppliers in the development project, our interviews suggested that sometimes the Indian OEMs also desire to learn from the suppliers, because for most of them their own experience with technological innovations is still limited. An expert working for a German supplier with business interests in India said, “And then, of course, there are customers who are not so experienced, for example in Asia. As one can see, they still really need help from us. You sometimes have to talk to them and say, ‘Attention, what you're imagining does not make much sense’. But they also expect that. ... We nominated you, because you have the know-how and the expertise and, of course, we want to be supported in some topics.”

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<sup>14</sup> The individual publication based on the study of innovation pathways in Germany’s auto-component industry is under preparation and shall be published by Fraunhofer IMW in due course. The study of innovation pathways in India’s auto-component industry which was conducted by TIM-TUHH has been published as Tiwari and Kalogerakis (2017a, b).

Altogether, we observed many similarities in the way development goals are set in the industry, even if there are some differences in the level of specifications and the freedom given to the suppliers to bring in own ideas. It must be kept in mind though that the freedom given to a supplier is in some way also related to his prior experience and role in the project.

### 3.2. Cost pressure

OEMs generally use their position of power in the global auto-component industry to enforce low prices for the parts they order. Hence, cost-pressure in the auto-component industry is a common challenge and auto-component suppliers need to manage their business resources cost-efficiently to succeed globally. This situation explains why, besides product innovations, process innovations are strongly pursued within this industry. Digitalisation of processes seems to be a relevant topic in Germany as well as in India which is expected to generate process simplifications. In both countries digitalisation and process innovations are evaluated as key competitive factors.<sup>15</sup>

Although a general cost-pressure is characteristic for this industry, we could observe the very different levels of cost-pressure in the two countries. As the average consumer in India has a much smaller budget available than the average German consumer (NUMBEO, 2017) and the middle-class in India is rising, there exists a high demand for small affordable cars in India. For example, in 2016, the bestselling car in India with 245,094 units was the Maruti Alto 800 (Kennedy, 2017). This car is offered within a price range of EUR 3,523 (INR 246,752) for the cheapest version, and EUR 5,390 (INR 377,513) for the most advanced version.<sup>16</sup> In Germany, in contrast, the bestselling car in 2016 was the VW Golf with 235,935 units.<sup>17</sup> Here, the cheapest version is offered for EUR 17,850 and the most advanced version for EUR 44,800 (Volkswagen, 2017).

Based on these price differences, German OEMs and their suppliers are able to operate on a quite different cost level than their Indian counterparts. However, as described in section 2, internationalization of the German auto-component industry has been progressing recently. The former “community of destiny” (German: *Schicksalsgemeinschaft*) between German OEMs and German suppliers has become decoupled to a large extent. A rising cost-pressure is reported by German auto-component suppliers, especially SMEs often experience the rising cost-pressure as threatening (Pankow, 2016). Yet, according to investigations by Fraunhofer IMW as a part of this project, German automotive suppliers do not feel a strong enough financial need or pressure to develop non-high-end products for emerging markets; “we have full order books,” is a typical statement from an employee responsible for innovation in a German auto-component supplier (SME).

### 3.3. Use of external knowledge

Overall, German auto-component suppliers are reported to rather seldom seek external technological

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<sup>15</sup> A recent, separate study by Bergmann and Tiwari (2017), which was not conducted as a part of the presented BMBF-project, made a different observation in this regard. Their (non-representative) case studies of 6 leading German auto-component suppliers indicated much greater emphasis on product innovation by firms in comparison to process innovations.

<sup>16</sup> Price is ex show room Delhi; 1 Euro = 70,0449554 INR; Maruti Suzuki (2017)

<sup>17</sup> Sales figures: New registrations according to “Kraftfahrt-Bundesamt” (German Federal Motor Vehicle Office), [www.kba.de](http://www.kba.de)

knowledge for their innovation processes. They generally assume this to be one of their core-competences needing protection. Yet, especially large German suppliers observe innovation processes in their own and in related industries – to get inspirations and information on market and customer development. One interviewee, an Innovation Process Manager working for an SME said that they consider the „benchmark of different markets where interesting innovations have been brought forward, even in different industries, and we check to what degree these innovations can be transferred to our industry”.

Therefore, German suppliers often look for new knowledge in customer and market surveys. Knowledge about the local and regional market is especially sought by experts and regional innovation-networks. We furthermore found that German component suppliers seek geographical proximity to OEMs in order to profit from knowledge spill-overs and sub-industry associations, such as forging associations. Large German suppliers furthermore frequently aim to anticipate or foresee innovations that OEMs will demand in the future. Amongst these suppliers, it is common practice to pursue trend research and to organise workshops and pitches with customers, foresight and innovation experts.

Indian auto-component suppliers, in contrast, often absorb external technological know-how using open global innovation networks (OGINs) both within and outside their firm and national boundaries. Due to their historically lower level of technological know-how compared to German suppliers, they are aware of the need to, and very much open to, use external know-how and technologies in order to compete successfully. For this matter, they use licenses, technological collaborations with other companies or universities as well as foreign direct investments in technologically more-advanced countries. Furthermore, they profit from the presence of the global IT-industry in India to get access to newest technologies and outsourced expertise and thereby generate leapfrogging effects.

### **3.4. Core competences: Highest quality vs. time-to-market**

Innovating auto-component suppliers in Germany consciously place their main focus on delivering their technological performance guarantees – most importantly the promised technical quality and customization of their products. There is a strong tradition in the German automotive industry to strive for technological excellence (Diez, 2012, p.79f.). Advanced technological performance adhering to high quality standards can be seen as core-competence of German auto-component suppliers. Hence, German suppliers often engage in developing innovations that can be regarded as new-to-market or even new-to-world.

Indian auto-component suppliers, on the other hand, less often seek to develop new-to-world or even new-to-market innovations. They rather aim to catch up with technological best practices. As argued above, they do not hesitate to seek technological know-how externally and frequently establish collaborations with large globally acting companies. Apart from their low costs, Indian auto-component suppliers often seem to compete based on short “time-to-market” offers for OEMs looking for new parts to integrate into their cars. Flexibility of processes as well as availability of a high number of skilled workers that can be rented on demand provides competitive advantage. In sum, Indian auto-component suppliers, especially the large ones, try to compete on the global automotive market by offering state-of-the-art technological practices and fast as well as flexible processes with rather low costs. Hence, so far, most of their innovations are incremental and only few players aspire to develop new-to-market innovations.

### 3.5. Regulatory and sociocultural influences

In Germany, adherence to strict regulatory technological and environmental standards, or at least a carefully constructed perception thereof as the recent “Diesel-gate” scandal has shown, has been a widespread practice for a long time. New standards can trigger innovations, but only seldom provide radically new challenges for German innovation teams. In India, in contrast, regulatory standards on technologies and environmental protection, and especially their implementation, have been rather lax and it is only now that they are being strengthened significantly. As a result, we found evidence that regulatory advances, for example stricter emission norms, have strongly increased innovation pressure in the Indian auto-component industry. In conjunction with the high price sensibility of the market they provide key impetus for achieving “affordable excellence”.

Looking at societal influences, strong cultural differences exist between Germany and India. These differences also affect expectations in the respective automotive markets of these countries. In Germany, high-tech quality products are strongly appreciated in large groups of the society and premium cars are often used as status symbols. Hence, an altogether strong purchasing power combined with high-tech fascination still provides a large market for premium cars. In India, on the other hand, there exists a much greater acceptance for affordable products, technologies and services in the society.<sup>18</sup> At the same time, in India some auto-components are needed in a more robust version due to given factors (e.g. extensive use of horns) or different climatic conditions.

Concerning the overall mind-set and technologic expectations of society, we found that there is (still) a historically grown German appreciation of complex and technologically advanced solutions. There is a lower acceptance of technologically simpler solutions. We therefore suggest that Germany is characterised by a strong “technology push”. In India, on the other hand, we see a comparatively stronger “market pull”. There is a stronger readiness and motivation to implement challenging practical and ad-hoc applications. One Indian interviewee representing an Indian supplier with subsidiaries in Germany opined, “We are more cost-minded than our German colleagues. And this is by no means a criticism of my German colleagues. But here we tend to be a little more practical in terms of how one would go about doing things. In Germany, you know, they expect that you have to have the best of the best available at your fingertips before you start doing it. Then it obviously becomes more expensive as a process.”

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<sup>18</sup> See, for example, a study on acceptance of frugal cars reported in Tiwari (2017).

## 4. A reference model for frugal innovation pathways

Based on the insights that we have generated by the means of literature review (Tiwari et al., 2016), a German trend analysis concerning frugal innovation (Tiwari et al., 2017) as well as the identification of innovation pathways in India (Tiwari and Kalogerakis, 2017b), we have developed a reference model for frugal innovation pathways (see Figure 9).

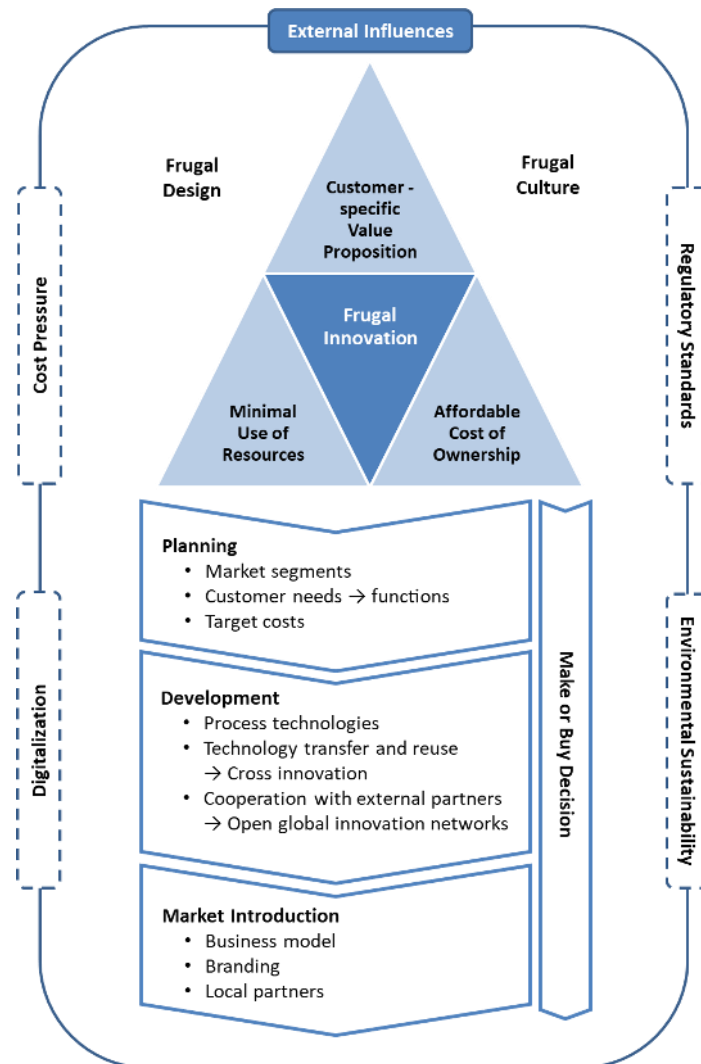


Figure 9: A reference model of frugal innovation pathways

### 4.1. Elements of frugal solutions

Frugal innovation is primarily constituted by three main characteristics: (1) A customer-specific value proposition, (2) minimal use of resources, and (3) affordable cost of ownership. In our research, we could identify several innovations from Indian auto-component suppliers aiming in this direction. Especially, when analysing annual reports of select companies, key words such as “low cost solution”, “resource efficiency” and “value engineering” could be identified in sections describing innovation efforts of the respective companies (Tiwari and Kalogerakis, 2017b).

Frugal innovation is framed by frugal design and frugal culture. Mind-set differences could be identified between engineers working in India and those working in Germany concerning our empirical sample. Indian engineers seem to be more open to quick and practical solutions, whereas in Germany, engineers

are rather groomed to strive for technological excellence, that sometimes turns into an “objective unto itself” relegating actual user needs into the background.

Differences in mind-set also encompass the willingness to seek and accept technological solutions stemming from outside the own company. The Not-Invented-Here syndrome seems to influence Indian engineers and managers in the auto-component industry at a much lesser level. In our study they were, on average, assessed to be more open concerning the adaptation of external knowledge than their counterparts working for German companies. Based on insights generated in this project, it can be proposed that mind-sets can foster or hinder frugal innovations and should be considered as a key factor in frugal innovation pathways.

## 4.2. The frugal innovation process

Looking at innovation processes leading to frugal innovations we differentiate between three phases: planning, development and market introduction. In order to generate customer-specific value propositions with a target of low costs and minimal use of resources, the planning phase seems to be crucial to direct a project towards frugal solutions. Especially understanding end-customer’s or end-user’s needs and demands, and identifying core-functionalities that should be incorporated into the product are key requirements in this phase.

In the development phase, process innovations seem to play a significant role to manufacture frugal products. High importance of process innovations to reduce costs as well as to ensure quality standards could be observed in India. In addition, Indian auto-component suppliers seem to be very open to adopt technologies developed elsewhere and to collaborate with external partners. Thereby, they are able to reach technological leaps fast and with limited in-house R&D resources.

Research on frugal innovation suggests that the choice of business models, branding strategies and support of local partners are decisive factors in frugal innovation processes (Bhargava and Seetha, 2010, Maira, 2015, Rosca et al., 2016). Our insights from the auto-component industry, however, are limited in this regard. Nevertheless, local presence was considered relevant from German as well as from Indian perspective. Both German and Indian suppliers stressed the importance of localization – the ability to innovate and produce locally in order to match customers’ needs and production. Besides, branding strategies seem to play an increasing role in the Indian automotive market. The *Tata Nano* which was communicated to be the cheapest car in the world was not as successful in the market as expected, despite several technological innovations. In contrast, frugal cars that also stress specific quality aspects or features highly appreciated by the target customers were much more successful, as for example Maruti Suzuki’s *A-star* which includes a modern appearance as well as a set of innovative technologies to provide increased engine performance and acceleration. Addressing customer aspirations therefore remains a necessary condition for the success of frugal innovations.

Looking at the whole process, a constant evaluation of make or buy decisions seems to be characteristic for frugal innovation processes. Our research indicates that Indian auto-component suppliers, on average, show greater flexibility than the investigated German companies in this regard. Thereby, they seem to be able to realize higher costs savings without neglecting basic quality issues.



### 4.3. External influences

So far, we have discussed frugal innovation pathways from a company perspective. Innovation pathways are, however, also complemented by external factors. Especially our trend analysis (Tiwari et al., 2017) provided valuable insights into this matter. Altogether, we identified four critical external factors positively influencing frugal innovation pathways: Cost pressure, digitalization, regulatory standards and environmental sustainability.

First, cost pressure provides a strong incentive to innovate frugally. Although a general cost pressure was noticed in the global auto-component industry, India is, as an emerging economy, acting on a quite different cost level than Germany. Hence, Indian auto-component suppliers are quasi required to deliver extremely cost-effective solutions in order to succeed.

Second, digitalization has already been identified in our trend analysis as an enabler of frugal innovation (Tiwari et al., 2017). This coherence could also be observed in the auto component industry. Especially large component suppliers in India (e.g., Bharat Forge), in company publications highlight their efforts to advance digitalization or Industry 4.0. The role of digitalization as an enabler of frugal solutions in the auto-component industry in India has also been discussed in section 2.3.

Third, regulatory standards can provide incentives for frugal innovation. Regulations set by the Indian government concerning safety and emission standards foster frugal solutions, as frugal solutions typically take place when appropriate quality standards need to be reached within a very strict and demanding cost frame. The Indian government explicitly supports frugal innovations in the form of affordable excellence and encourages companies to follow frugal innovation pathways.

Fourth, a strong connection between frugal innovation and environmental sustainability was expected based on our literature review and trend analysis. Although frugal innovation is discussed controversially with respect to environmental gains, we see the potential to establish a strong positive connection between these topics. A reduction to core functions of a product with the aim to minimize use of resources along the whole value chain provides a valuable ground for environmental sustainability. Especially, if affordable costs of ownership lead to a longer use period of the product and costs of waste disposal and recycling are also considered, frugal solutions will increase environmental sustainability. In India, for example, small component suppliers reported of process innovations leading to increased resource efficiency that at the same time also helped to reduce their costs (Tiwari and Kalogerakis, 2017b). Less environmental impact is also one of the core drivers for the increasing acceptance of frugal products and services in the developed world (Tiwari, 2017).

## 5. Conclusion

Based on identification and a subsequent comparison of innovation pathways in the German and Indian auto-component industry we have identified certain characteristics in innovation pathways that might be particularly useful in creating frugal solutions. These could possibly also provide German auto-component suppliers some insights about developing and implementing a strategy for frugal innovations in the future. According to Diez (2012), the German automotive and auto-component industry has despite its traditional strength a number of weaknesses, such as high personnel and energy costs, risk of over-engineering, demanding high price positioning, a poor product portfolio for enabling affordable small cars and generally a low market presence in Asia. These factors are supported by our research to

a considerable extent, even if several firms have taken measures to correct this anomaly and a few of them have come up with frugal solutions of their own for the emerging markets.

Due to changing global market conditions and the great future potential of the emerging economies these weaknesses constitute threats to the competitiveness of German companies. Asked about their assessment of the relevance of frugal innovation for the German auto-component industry, experts mostly agreed that German companies need to engage more in frugal innovation since this approach will provide many advantages, such as access to global markets.

For Indian companies, too, the innovation pathways of their German counterparts may contain some useful insights. For example, Indian companies can also try to engage in anticipating innovation trends and thus to co-shape the emerging future trends in technological domains of their expertise. Many Indian companies from the auto-component sector have invested abroad, especially in Germany, and are integrating open innovation across national and firm boundaries. German companies should also show greater openness for externally-generated knowledge and seek complementary synergies in the emerging lead markets of frugal innovation. While many German firms have invested in the emerging economies, they often restrict their activities to marketing/distribution, to some extent production and to a lesser extent product adaptation. Very few firms actually attempt to integrate these locations in their innovation value chains, which, as our study shows, would be an advisable step. They could potentially reap rich benefits from the socio-cultural diversity, first-hand knowledge of the market-specific demand patterns and the technological expertise of a vast pool of skilled professionals. The resulting innovations would also create positive external effects for the innovation system of the host nations (e.g., India), leading to a win-win situation, since innovations are not merely a “zero-sum game”.

Summarizing, in this paper we have analysed how an alternative frugal approach to innovation may look like. Our results indicate that successful companies will probably pursue a hybrid strategy, a combination of both approaches – “pursuing technological advancement, while ensuring frugality”. Frugal innovation pathways provide a number of potential advantages for companies:

- Development of new sources of revenues in growing global markets as well as in the home market
- Customer-oriented quality and functionality
- Reduced “time-to-market” as well as increased flexibility of business processes
- Increased resource efficiency

Furthermore, new breakthrough research can also be triggered by frugal innovation demands. For example, in the automotive industry new lightweight materials are developed in order to reduce overall costs. Especially the combination of high-tech with frugal design, can lead to interesting solutions with great potential. In order to use the advantages of frugal innovation pathways, overall a paradigm shift seems to be needed in German innovation culture in order to guarantee future access to global markets – especially in emerging countries.

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