The Ecological Allowance of Enterprise: An Absolute Measure of Corporate Environmental Performance, its Implications for Strategy, and a Small Case

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ABSTRACT: In order to determine the sustainable ecological scale of business activities, the measure ecological allowance is introduced in this contribution. Its main idea is that every enterprise "owns" a certain allowable ecological impact that can be calculated through relating impact and economic performance. This measure then enables the evaluation of absolute environmental performance of a business enterprise, compared to only relative measures as in most other approaches. The measure is explained and detailed with a case from the German automotive industry and complimented by a scenario analysis of different configurations of self-owned and carsharing cars, including technological and economic parameters.

KEYWORDS
Ecological Allowance, Degrowth, Sustainable Development, Business Strategy

I. INTRODUCTION

The revival of economic growth skepticism in recent years in policy research on sustainable development (Stiglitz, Sen, and Fitoussi) as well as the rise of the degrowth movement in Europe and beyond (Latouche) questions the central paradigm of today's economy. The debate however focuses almost exclusively on the macroeconomic level, with little regard for the business enterprise. Only scant research has been carried out here, and mostly on a rather conceptual level (Reichel, O'Neill, and Bastin). What can be derived from that is a reminder of the importance of size or "scale" (Daly), not only on the global level but also on the firm level. In order to determine the sustainable ecological scale of business activities, the notion *ecological allowance* (Reichel and Seeberg) is introduced, the idea that every enterprise "owns" a certain allowable ecological impact. To some extent this is a top-down procedure, moving from globally sustainable ecological impact to the industry and firm level, thus complementing ecological footprint approaches and measures from lifecycle assessment (Huijbregts, Hellweg, Frischknecht, Hungerbühler, and Hendriks). With ecological allowance a measure and a method is developed, that enables the evaluation of absolute environmental performance of a business enterprise, compared to only relative measures as in most approaches, via the means of relating allowable ecological impact and economic performance, that is acting as an "allocator variable."

In the first part of this contribution, the measure is explained and detailed with a case from the German automotive industry. The second part derives a strategic framework from the reasoning behind the measure of ecological allowance. Whereas in the third part, some insights from an empirical study on an alternative strategy for car manufacturers, the car2go concept, are used for a prospective case on how a change in the strategic position of an enterprise can change its ecological and economic impact. The result is a small scenario analysis of different configurations of self-owned and carsharing cars, including technological and economic parameters. The findings of the paper regarding measure, strategy, and scenarios will be discussed and in the end, some conclusions are drawn for a future research agenda on absolute corporate environmental performance indicators and their connection to business strategy in an economy "beyond growth" (Daly).

II. DEVELOPING "ECOLOGICAL ALLOWANCE"

In order to develop the measure of *ecological allowance* (EA), the nature of the impact has to be defined and here it appears to be most feasible to start with carbon dioxide (CO_2). Not only is CO_2 very easily measurable, it is also the most discussed emission in the current climate debate and firms turn towards it in matters of e.g., their carbon footprint. Additionally, CO_2 is closely connected to all production and use activities of a firm's products and thus provides a reasonably well working proxy for its overall ecological impact. Secondly, the chosen proxy for ecological impact needs to be transformed into a cap for an individual firm and this requires several calculation steps.

II.I. DEFINE A GLOBAL ALLOWANCE OF THE PROXY

In order to limit global temperature rise to the 2 °C-guardrail, the maximum sustainable yield for CO_2 in the Earth's atmosphere is at around 750 billion metrical tons (Gt) from 2010 until 2050 (Messner, Schellnhuber, Rahmstorf, and Klingenfeld). This would give us a 67%-probability to stay below the limits that have never been breached since the dawn of modern humankind around 150,000 years ago (cf. Nordhaus). After 2050, emissions would need to stay at an extremely low rate and the later reduction occurs, the lower the after 2050 rates need to be. For ease of use the 750 Gt are evenly distributed until 2050, thus resulting in 18.75 Gt per year.

II.II. APPLY ALLOWANCE TO INDUSTRY SECTOR

At least two options appear to be feasible. Either the allowance is calculated with reference to the global scale of the industry in focus or it is broken down to the national industry level. In both cases *gross value added* (GVA) coming from standard GDP calculation can provide guidance for allocating ecological allowance to the industry of the firm in focus. Also, we apply the proxy completely to industry, i.e., consumers are out of the equation. The reason behind this is both simple and complex. The output approach to calculating GDP, as one of the three approaches in GDP calculation, does not involve consumption. At the same time, it is difficult to make consumers responsible for their ecological impact. Not only do they hardly change their behavior patterns, despite all the information given by eco-labeling and CSR communication, but to place the burden on them implies lifting it from the producers (Carrington and Neville). Producer responsibility, however, cannot end at the factory gate. This is our normative assumption, and it is also very practical for it alleviates the calculus to become overly complex when incorporating consumption behavior as well.

II.II.I. ALLOWANCE AT GLOBAL INDUSTRY LEVEL

Using Worldbank data for 2007, and focusing on gross value added, world total has been at 50 trillion USD in current prices. The manufacturing sector accounted for roughly 18 percent of that. The yearly ecological allowance of carbon dioxide emissions for all manufacturing firms would then be around 3,375 million tons. To break this number down further to different industries, data becomes a scarce resource. For the global automotive industry, no gross value added is available. However, as an end-consumer industry, we can take sales to be the best proxy for it and use data from the Fortune Global 500. Here, the 2008 figures of "motor vehicles and parts" amount to 2,075,407 million USD. Given the general lack of data we use it as a first rough estimate, which gives us a gross value added contribution of 4.15 percent and a yearly allowance for the global automotive industry of around 778 million tons of CO_2 per year. Given some 873 million private cars worldwide in 2007 this would then set the global industry allowance per vehicle at 891 kg CO_2 per year, including production, use and end of life.

II.II.II. ALLOWANCE AT NATIONAL INDUSTRY LEVEL

Turning to the national level and staying with the automotive industry, the gross value added in 2006 was at 110 billion EUR, combining the statistical items C34 (Motor vehicles. trailers and semi-trailers) as well as C50 (Sale, maintenance and repair of motor vehicles and motorcycles – retail sale of automotive fuel), which are roughly 137.5 billion USD at average 2006 exchange rates (Statistisches Bundesamt). Following the same reasoning as on the global level, German automotive industry then has about 0.275 percent of global gross value added and is thus allocated with 51.56 million tons of CO_2 per year. According to the German *Kraftfahrtbundesamt* there are about 50 million passenger cars in Germany, thus setting the allowance per vehicle at 1,031 kg per year (KBA). Both global as well as national figures are within a margin of error of around fifteen percent and, as a first rough estimate, appear to be valid for further use.

II.III. COMPARING TO ACTUAL ECOLOGICAL IMPACT

As a special case, we take the German car manufacturer Daimler AG and use their available data on environmental performance, especially from sustainability and environmental reporting (Daimler AG). Following the data, the carbon intensity per vehicle is 1,833 kg on average (Mercedes-Benz-Cars). The average kilometers travelled per year in Germany remain stable at around 12,000, whereas average car use is twelve years, amounting to 144,000 km over a car's lifecycle (KBA). Fuel consumption of Mercedes-Benz cars from Daimler is 7.35 liters per 100 km, which can be calculated into roughly 170 g CO_2 per km. That equals 2,040 kg per year and almost 24.5 tons of carbon dioxide emissions during the lifetime of the vehicle. Average end-of-life CO_2 emissions for an automobile are approximately 0.43 tons. Note that some of the figures can be taken more or less directly from the manufacturer while others are more general and thus should be considered with care in the calculation of ecological impact. Adding up the numbers, the lifecycle CO_2 emissions are 26.7 tons or 2,228 kg per year. By comparing actual impact and ecological allowance it is clear that in the case of Daimler, an overshooting of its allowance by 53 to 60 percent occurs. That means that Daimler is overusing ecological space with its products compared to the gross value added its industry is providing for society.

III. STRATEGIC FRAMEWORK FOR ECOLOGICAL ALLOWANCE

Taking a strategic perspective on EA, several implications follow. First, in combining EA reasoning with more traditional views on the economic conditions of business success, such a framework spans along two dimensions, the economic dimension relating revenue and costs, and the ecological dimension relating allowance and impact. In other words: economic as well as ecological bottom line make up the strategic space for evaluating the environmental performance of enterprise. Table 1 shows this framework (cf. Reichel and Seeberg):

Ecological Bottom Line Economic	Impact ≤ Allowance	Impact > Allowance
Revenue ≥ Costs	1.Rightsize Business	2.Ecological Excess
Revenue < Costs	3.Economic Loss	4.Eco-Eco Disaster

Table 1: Strategic Framework for Ecological Allowance

In the example of building EA as detailed in this contribution, Daimler would most certainly find itself in the second quadrant of "Ecological Excess," meaning that although the economic bottom line is met, it is missing the ecological bottom line, thus being an environmental "underperformer."

Turning the attention to EA itself, two strategic levers can be identified. To tackle the problem of impact as one elemental part of the equation, reduction strategies come into focus. Although most apparent, the other side of the coin should not be missed: increasing allowance.

III.I. REDUCING ECOLOGICAL IMPACT

At least three strategic options can be found in order to reduce impact. Probably the most preferred option is *technology* i.e., reducing impact by means of eco-efficiency (OECD; Alkemade, and Hekkert) and eco-effectiveness (Dyllick and Hockerts; Young and Tilley; Braungart, McDonough, and Bollinger). However valid the technological path to reducing impact is and will remain (Reichel) the shortcomings and limitations are not to be underestimated, especially when single-handedly focusing on efficiency increases (Polimeni, Mayumi, Giampietro, and Alcott; Russo). The far easier way in terms of reducing impact with no further investment is *reduction of sales and production capacity*. It is clear that such a strategy can only be communicated to stakeholders, and more crucially to shareholders, if accompanied by an *increase in profit margins* e.g., by focusing on high end markets and extended revenue creation through product use over a longer product lifecycle (Reichel, Goll, and Scheiber).

III.II. INCREASING ECOLOGICAL ALLOWANCE

At first, an increase in EA appears to be odd. However, when closely examining the way it is calculated, several options arise for business strategy. As EA is determined by gross value added as "allocator," one strategic move is to increase the company's GVA share compared to its industry. Another option, requiring some form of collusion or joint operation either economically or by means of political lobbying, is to increase one's industry GVA share compared to other industries and economic sectors. Although this contribution started with reference to growth skepticism, the line of argument as developed here clearly points into the direction of selective growth of certain business and industries at the expense of others. We thus conclude that if taking environmental performance and EA as its measure serious, the result will be an increased competition for "ecological space." Of course, another strategy for increasing allowance is also the reduction of sales and capacity, which might be a dominant strategy with significant leverage effects on the ecological position of a company. However, as has already been noted this requires some economic compensation and in the next section, a prospective case for this option will be developed.

IV. THE PROSPECTIVE CASE OF CAR2GO

Staying with Daimler and turning towards its recent move into the market for carsharing, this business model innovation (Johnson 55-57) can act on both strategic levers of reducing impact and increasing allowance. Car2go is a limited liability company owned by Daimler, operating an open-ended, one-way carsharing system in Germany (Ulm and Hamburg), Canada (Vancouver, BC) and the United States (Austin, TX) with Daimler's Smart vehicles (Reichel et al.). The revenue model behind car2go does not require any sort of membership, just a one-time registration fee and an electronic chip attached to the driver's license. After that, users can select any Smart vehicle in the system, pick one up, drop it off anywhere within the geographical limits (normally within the municipality) and pay on a per-minute basis. Access is given either via phone, the internet or so-called smartphone apps. The importance of this new business model in the automotive market is echoed by the move of carsharing into the commercial mainstream, with significant and growing financial returns in the future (Shaheen, Cohen, and Chung). Firnkorn and Müller conducted the first empirical survey on how the introduction of a system like car2go would change behavior patterns of consumers. They also modeled different CO_2 reduction scenarios based on the empirical findings.[1] The willingness not to replace their own car by a new one within the next five years and instead use car2go is "very high" with 14 percent and "high" (five-point Likert scale) with another 14 percent of the sample, consisting of citizens in the city of Ulm (including both car2go users and non-users). What is even more compelling is the finding that 20 percent of the sample (nine percent "very high" and eleven percent "high") are willing to dispose a car they are currently using by car2go. The authors conclude the empirical survey that the introduction of car2go will in fact not increase CO_2 emissions through some kind of rebound effect (Binswanger) but contribute to a significant CO_2 reduction.

IV.I. ECOLOGICAL IMPACT OF CAR2GO

In order to evaluate the ecological impact of the car2go business model, we abstract from figures concentrating on the user of car2go, but focus on the physical product itself, the Smart vehicles in use per year. The car2go fleet in Ulm has about 200 cars in operation. Given the 120g CO_2 per km of a Smart, and otherwise sticking to the figures above, the product impact per year amounts to 1,628 kg CO_2. There is some uncertainty in those numbers as there is no data available on the lifecycle of a car2go Smart, so we decided to go with the numbers for a standard Mercedes-Benz. For ease of use and a first approximation of impact, this can been seen as sufficient for further inquiry. One carsharing vehicle, as other empirical research shows, can

1 Credit has to be given to Prof. Martin Müller from Ulm University for sharing his insights on the car2go project.

remove between 4.6 to 20 cars from the roads, and consistent with the car2go study, up to 32 percent of carsharing users gave up their own car through carsharing, with more than 25 percent of users avoiding the purchase of a new car (Shaheen et al.). For Germany, it can be shown that between four and eight privately owned cars are replaced by carsharing (BCS). Out of cautiousness and not to exaggerate the implications of this business model for the automotive industry, we chose to stay at the lower band and calculate with a removal rate of 1:4. That would imply a net change in the amount of vehicles on the road through car2go of about 600 cars taken off the roads in Ulm. Assuming that all 800 cars substituted by the 200 Smarts had the same ecological impact as a standard Mercedes-Benz of 2,228 kg CO_2 per year, this would then amount to a reduction from 1,782,400 kg per year to 325,600 kg of the car2go fleet i.e., a reduction of more than 80 percent. It is important to note that this reduction is achieved not from the point of view of the consumer i.e., that it is a reduction in the personal CO_2 account, but from the point of view of the producer. To calculate the new impact in comparison to EA, we just need to multiply the initial product impact with the removal rate, thus resulting in a new "virtual" impact of 407 kg CO_2 per year, assuming that one car is owned and used by only one person. The higher we estimate the removal rate of car2go, the greater the impact reduction. However, even with the most conservative estimate of 1:4 the impact reduction brings Daimler well below its EA – if its business model would solely rest on the car2go concept and *ceteris paribus*.

Of course, *ceteris* is never *paribus*, especially when demanding a complete change in the business model of a company. The transition towards the car2go concept would mean an abandonment of most of Daimler's production capacity and product lines, which in turn would result in a reduction of GVA from car sales, thus lowering its EA. As shown above, there is some ecological space for lowering EA through GVA reduction – up to 60 percent –, however in order to manage such a transition, GVA needs to be retained from the car2go market segment. Also, as there is indeed ecological space, a complete transition appears to be unnecessary. The "gap" between the 407 kg coming from car2go and the 891 or 1,031 kg from the classical model of doing automotive business, can be filled by maintaining to be a car manufacturer and seller, while at the same time moving into more service-oriented business models. Actually, this would be the move towards product-service-systems yielding large potentials for improving environmental performance (Mont).

IV.II. MODELING FOR ECOLOGICAL ALLOWANCE

We will conduct a scenario analysis by using a simple spreadsheet model in order to better understand the implications of EA and its connection to corporate degrowth and sustainable business strategies.

Our model is a static model i.e., there are no dynamical aspects taken into account. It cannot be used for any kind of transition scenarios from an actual state towards an ecological more feasible state. The main model assumptions are the same as in the car2go example above:

- Removal rate is 1:4 i.e., one carsharing car substitutes for four self-owned cars.
- CO_2 emissions of carsharing car are 120 g/km, self-owned car 170 g/km.
- Emissions from production (1,833 kg) and recycling (430 kg) are identical between carsharing and self-owned cars.
- Annual mileage of a self-owned car is 12,000 km.
- Average lifecycle of a self-owned car is twelve years.

In addition to these assumptions, the mileage of a carsharing car is set at roughly 34,000 km per annum (Sperling and Shaheen), i.e., switching towards carsharing does not only reduce the number of cars on the road, but also the average mileage per car. Also, the lifecycle of a carsharing car is roughly one fourth of a self-owned car due to its increased use i.e., four years on average. This is calculated within the model by comparing the 144,000 km lifecycle mileage of a self-owned car with the 34,000 km per year of a carsharing car. What is also newly introduced in the model in order to calculate gross value added, are some economic assumptions:

- Price of a Smart car is roughly around 12,000 EUR (Smart).
- Price of a self-owned car is estimated to be three times as much i.e., 36,000 EUR (which seems feasible for a Mercedes-Benz C-type according to Daimler's own price listings).
- Per-minute rate of car2go is at 0.24 EUR (car2go).
- Automotive industry's share from global gross value added remains fixed at 0.275 percent, thus resulting in a fixed per year allowance of the industry of about 51.54 Mt CO_2.
- Initial self-owned car inventory is 50 million (figure for Germany, KBA).

We will research five scenarios: the business as usual case with about 5,000 carsharing cars (figure for Germany, cf. Loose); the same case but with an efficiency increase in CO_2 emissions of fifty percent; a case with only carsharing cars substituting the entire German car fleet; a mix-scenario of carsharing and self-owned cars with an efficiency increase of fifty percent; another mix-scenario with increased efficiency and increased prices for both carsharing and self-owned cars that turns out to be the rightsize business scenario. The results are summarized in table 2.

IV.II.I. SCENARIO 1: BUSINESS AS USUAL

Scenario 1 displays the current situation in Germany, where carsharing amounts to only 0.04 percent of the entire car fleet. With the given average CO_2 emissions, the total allowable emissions of the automotive industry are overshooting the global cap more than twice as much, roughly about 2.16 times, with a total annual impact of 111.4 million tons. The economic output of the German automotive industry is taken as a base line for comparison with all the other scenarios.

IV.II.II. SCENARIO 2: BUSINESS AS USUAL WITH EFFICIENCY INCREASE

Scenario 2 shows a possible trajectory for industry evolution that is in line with the dominant paradigm of efficiency increase. This is the most likely path the automotive industry will take, as e.g., the first tentative step toward more efficient vehicles was achieved with regulation regarding the emission limit of cars in the European Union with 120 g/km (European Commission). In our model we take this one step further and reduce the emissions of self-owned and carsharing cars by fifty percent i.e., a reduction to 85 g/km and 60 g/km. This drastic reduction brings down product impact, averaged across both self-owned and carsharing cars, to 1,209 kg CO_2 per annum. However, this is still exceeding the product allowance of 1,031 kg by factor 1.17.

IV.II.III. SCENARIO 3: 100 PERCENT CARSHARING

This is the most radical scenario, with a complete substitution of 50 million self-owned cars with 12.5 million carsharing cars. Three out of four cars would be taken off the road, a dramatic change in everyday life, especially in urban areas. But even such a scenario would not bring economic activities of the automotive industry in line with its ecological allowance. Product allowance per car increases due to the lower fleet numbers – less vehicles, described as a reduction strategy in chapter 3.2 – but impact is still higher by thirteen percent. There are fewer cars in use, but use intensity of carsharing cars is three times higher than that of a private car (12,000 km/year vs. 34,000 km/year), notwithstanding the fleet effect of actually removing cars. Regarding the total emissions, a decrease of 47.9 percent could be realized, however at a high economic price: an industry degrowth of almost 90 percent. The political and social disruptions caused by such a scenario cannot be estimated.

VI.II.IV. SCENARIO 4: MIX-SCENARIO WITH EFFICIENCY INCREASE

Scenario 4 takes a step back and looks at a situation where there are 5 million carsharing cars and 30 million self-owned cars, both with an efficiency increase as in scenario 2. Product impact is within allowance, it undershoots by roughly four percent, with an overall reduction of CO_2 emissions of about 55.8 percent. The degrowth of the automotive industry would be much less severe than in scenario 3, as it retains about two thirds of its original size, thus degrowing in accordance with the reduction in fleet size.

IV.II.V. SCENARIO 5: RIGHTSIZE BUSINESS

The final scenario aims to combine both ecological as well as economic bottom-line. In going beyond scenario 4, we increase prices of car sales by one third and thus doubling the per-minute rate of carsharing. For a situation with 4 million carsharing

Scenario	1	2	3	4	5
Name	Business as usual	Business as usual, 50 % more efficient	100 % Carsharing	Mix, 50 % more efficient	Mix, 50 % more efficient, increased gross value added
Change in fleet size in percent	-	-	-74.99	-29.98	-23.98
Self-owned cars	49,980,000	49,980,000	-	30,000,000	34,000,000
Carsharing cars	5,000	5,000	12,500,000	5,000,000	4,000,000
Industry gross value added level in percent	100	100	11.3	64.6	98
CO2 emissions in t	111,407,824	60,418,023	58,071,875	49,286,250	51,514,833
Reduction compared to Scenario 1 in percent	-	-45.8	-47.9	-55.8	-53.8
Product impact in kg CO2	2,229	1,209	4,646	1,408	1,356
Product allowance in kg CO2	1,031	1,031	4,124	1,473	1,356
Overshoot	2.16	1.17	1.13	0.96	1

Table 2: Modeling scenarios

cars and 34 million self-owned cars, this scenario produces an exact matching of product allowance and impact. What is even more interesting is the industry level. There is almost no degrowth as regards gross value added involved, the automotive industry applying such a rightsize business strategy would stay at around 98 percent of its initial size.

V. DISCUSSION

Three lines of thought developed in this paper will be discussed: the measure of ecological allowance, the strategic framework arising from it, and the prospects described in the modeling scenario.

In calculating ecological allowance, the even distribution of CO_2 over the forty-year time period is questionable. There are at least two other distributions feasible: a linear decrease and an s-shaped decrease. The s-shaped decrease might be the most realistic case, turning the global allowable cap into a dynamically changing variable, starting at a high level and decreasing over time towards some value shortly above zero. However, the calculation of a company's strategic position in the framework in table 1 would then require a constant updating of the value of EA. Also, the product impact could not be calculated on actual, yearly data as this would be outdated with next year's EA calculation. It would probably be more accurate to calculate for an average EA spanning the product's lifecycle. If the increased realism of other distribution paths for CO_2 benefits the overall reasoning behind the measure of ecological allowance it needs to be examined in further studies.

What is also arguable is the exclusive focus on producers by using gross value added and thus neglecting consumers. An inclusion of consumers would add to the measures realism; however it would also add complexity. The benefits on the other hand are very uncertain. Despite the rhetoric consumers too often do not "walk their talk" (Carrington) and abstain from sufficiency-oriented behavior patterns. Therefore a key indicator on a company's absolute environmental performance can be seen as a valuable instrument to bring the "natural case for sustainability" back into business (Dyllick).

What surely is a severe critique in calculating EA and the position of company's within the strategy framework is the calculation of an industry's GVA. On different aggregate levels (industry, national, global), different statistics apply, often with huge time lags in presenting "actual" data. The real difficulties however arise from the need to draw a boundary and the decision where exactly the boundary should be drawn. We have included, in chapter 2.2.1, sales figures from the Fortune Global 500 in the industry section "motor vehicles and parts" whereas, in chapter 2.2.2, we have chosen not only product-based figures but also data from vehicle maintenance and fuel sales. In a certain way this mirrors the problems lifecycle assessment faces when calculating product impact. The boundary question will be a key research area for measuring EA and an absolute necessity to strengthen it methodologically.

The strategic framework suggests two clear "generic" strategies. The first strategy is the increase of ecological allowance through a zero-sum competition i.e., at the expense of others in the industry or as a combined effort of one industry against another. On the microlevel this strategy leads to a certain concentration of economic power, while on the macrolevel there is structural change within the economy. The second strategy, the decrease of ecological impact, cannot be exclusively followed by adhering to efficiency means but requires a negative-sum competition based on the contraction of product base. We have called both strategies "generic" as this reasoning appears to match very closely the industrial economic approach of Michael E. Porter and his market-based view of the firm. The two strategies could be seen as the result of what happens if the natural environment is introduced as a sixth force of competition. The focus on position, however, is not sufficient for the demand for business model transformation. In order to clarify the theoretic connection of EA reasoning and its results to management thought, more elaboration of its possible theoretical contributions are needed. Especially the resource-based view, that has been formulated in taking the natural environment into account (Hart), could be of use here if the focus of attention is on organizational change and learning.

Turning towards the model, several assumptions have to be criticized. First of all, the fixed share of the automotive industry of global gross value added. If this number increases, the allowance of the automotive industry, and each individual automotive company, increases and thus other rightsize business positions can emerge. However, given the overall development of the automotive industry, this number is just as likely to decrease significantly over the next decades (Roland Berger). For Germany e.g., Roland Berger projects that the automotive industry will give way to the environmental industry as the new leading industry regarding both employment and gross value added within the next decade (BMU).

Scenarios 2, 4 and 5 are assuming a fifty percent efficiency increase in CO_2 emissions. Given that the average rate of efficiency increase as regards CO_2 in the automotive sector is roughly 1.6 percent per annum i.e., it would take almost 44 years to arrive at such low emission rates (Meyer and Wessely). Even if technological breakthroughs are taken into account as for e.g., Daimler is doing in their technology outlook, there is only a slight possibility to see widespread decrease in emissions to such low rates within the next decade (Daimler AG). But ten years from now, the climate neutral amount of CO_2 left will then demand much lower emissions than "just" fifty percent. So the most favorable scenario 5 needs to be carefully reconsidered with much lower efficiency increases. This would most likely make some form of more severe degrowth necessary. The overall surprising results of scenario 3, the total substitution of self-owned cars with carsharing cars, namely that it cannot deliver enough ecological benefits, have to be viewed in the light of two critical assumptions: the lifecycle of a carsharing car is severely shorter than that of a self-owned car and its annual mileage remains fixed. A change in both assumptions e.g., lifecycle extension to that of a self-owned car and a reduction in annual mileage of about ten percent brings this scenario within the limits set by ecological allowance. Similar reductions in scenarios 2, business as usual with efficiency increase, would also produce an ecological beneficial result, but only if we assume a 20-year lifecycle of a self-owned car. However, longer lifecycle tend to slow down diffusion of technological progress unless accompanied by some form of ongoing remanufacturing and renovation of the product.

In general, all of the scenarios except the business as usual case would require time to become reality. Not only does any technological advance in engine technology need time, the transition towards an individual mobility provider, instead of just producing cars, also needs time. This means that the actual achievement of CO_2 reductions would be stretched across some transition period. However, as has been briefly sketched in the previous paragraph, this would then demand an even lower ecological impact in order to stay in line with the absolute cap on CO_2 formulated in chapter 2.1. For a better understanding of the transition towards a rightsize business along the lines sketched in this contribution a more dynamic model needs to be built that not only explicitly takes strategic decisions and investment choices, but also employment strategies into account.

What can be derived from the model and the scenarios, as limited as they are, is that no business as usual approach following the established trajectory of efficiency increase can really bring corporate environmental performance in line with the limits of a finite planet. For the automotive industry the results are overwhelming, and maybe overwhelmingly dramatic. The transition towards mobility provision and services is not a fashion fad; it is a necessary requirement for any sustainability strategy that deserves to be named as one.

VI. CONCLUSIONS

The need for adequate indicators in order to determine the "right size" of business can be met by the calculus for ecological allowance. It provides an absolute yardstick for measuring environmental performance and provokes strategic discussion in directions not encountered. For the first time, the notion of beyond growth or even degrowth can be captured for the business enterprise in a single indicator. The implications stemming from EA are multifold. On the side of the ecological bottom line, research needs to connect the top-down reasoning of EA with the more bottom-up reasoning of the many footprinting methods (e.g., carbon footprinting) and lifecycle assessment. The "allocation" of absolute caps on emissions remains difficult, as GVA might not be available for all industries on all levels. Also, the concentration on CO_2 is debatable; especially as the entire resource debate from industrial ecology is excluded, or at best, approximated. However, EA connects to existing methods of lifecycle assessment and refocuses attention towards producer responsibility beyond the point of sale. On the side of the economic bottom line and strategy, the reciprocal dependencies of EA and GVA (and thus impact) require clarification. The sketched strategies of reducing impact and increasing allowance have to be further elaborated and substantiated by case studies. For the small case of carsharing in the automotive industry and the findings of the model scenarios, it has been shown that some form of both physical as well as economic degrowth is inevitable under absolute ecological limits. One possible future lies in a combination of efficiency strategies and a dramatic change to a sharing-economy business model. This will not mean the end of economic reasoning or earning decent profits as the scenario analysis has shown. What it does mean is a great transition in the way we do and evaluate business in front of the reality of a finite Planet.

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