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ABSTRACT: "Corporate Environmental Sustainability" has become a widely used term. It implies that an individual firm has the capacity to effectively manage and control the harm inflicted upon the natural environment by its processes, products and business models – a notion we refer to as an organization's "manageability of environmental impact". This paper argues that the organization-level concept of corporate sustainability cannot be meaningfully discussed unless it is understood in light of three conditions: market growth dynamics, ecosystems complexity, and supply chain structure. These economic, ecological and industry-organizational conditions outside the organization's boundaries severely limit an organization's manageability of its environmental impact, suggesting that the cheerfully optimistic connotations of the concept "corporate sustainability" must be tempered accordingly. Using market growth rates and environmental impact manageability, we develop four scenarios to further illustrate the dynamics and challenges to sustainability in each setting, and derive implications for management research and practice.

KEYWORDS
Corporate Environmental Sustainability, Market Growth, Environmental Impact, Ecosystems, Eco-Efficiency

I. INTRODUCTION

Much has been written in the management literature over the last 20 years on the principles of corporate environmental sustainability and how to achieve it (Etzion; Marcus and Fremeth; Schaltegger et al.; Schmidheiny; Shrivastava; Starik and Rands). At the same time, the growing attention to and pressure for environmental protection has pushed industries and firms to adopt a wide range of new organizational approaches, measures and technologies aimed at reducing and controlling pollution levels and improving their ecological efficiency (Haanaes et al.; Lacy et al.). Yet in spite of growing efforts and commitments by corporations to reduce their

ecological footprint, environmental degradation not only continues, but is accelerating (IPCC; Hassan et al., WRI).

Examining some global trends provides further context. The world economy has expanded, with global consumption expenditures growing at an average of 3% per year since 1970. Fueled by increases in energy demand of 2.2% annually from 1990 to 2005 (EIA, 2010a; EIA 2010b) and accompanied by unsustainable resource depletion and emissions trends, this growth requires an overall biological capacity (the world's ability to absorb environmental impacts) estimated at about 18 billion global hectares – the equivalent of 1.5 Earths (GFN). Carbon dioxide emissions have risen by 48% in the last two decades and are expected to increase by an additional 29% in the next 20 years. Thirty-six million hectares of forests have disappeared between 2000 and 2005, 15 million of these in Brazil alone (WRI). The portion of irrigated land used for agriculture reached 287 million hectares in 2007, or 18.5% of total cultivated land (FAO), which has significant consequences for the availability of water globally. According to WWF, populations of vertebrate species have declined by nearly 30% during the period 1970-2007 (WWF, 2010).

And yet, in spite of the undeniable relevance and growing urgency of these alarming trends, it remains unclear how companies can contribute to environmental sustainability (Kallio and Nordberg; Marshall and Toffel) and to date, efforts of associating environmental sustainability with improvements in competitiveness and better financial performances have proven elusive. This paper examines barriers to implementing corporate environmental sustainability outside the corporation, and in doing so, it broadens the investigation of conditions under which firms can realistically aim for environmental sustainability. We argue that any efforts to effectively, i.e., "sustainably", align the firm's environmental impacts with the cycles and dynamics of the natural environment must account for a number of factors that have been largely ignored in the literature on corporate environmental sustainability.

We propose that a number of economic, ecological and industry-organizational factors act as critical constraints on a firm's ability to sustainably align its impacts with nature, yet have received virtually no attention by environmental management scholars: (1) the evolution and dynamics of the markets in which the firm competes, specifically market growth and market size, and (2) the ability of a firm to manage its environmental impact as a function of the complexity of ecological systems and the position of a firm in the supply chain. Coupling the constraints from these partially exogenous factors with a firm's limited capacity to control environmental impacts along its supply chain helps to explain how the effectiveness of corporate environmental strategies can be undermined to the point of eliminating any net-beneficial effect.

Mapping high and low market growth rates against hypothetical high and low levels of an organization's ability to manage its environmental impacts further illustrates the importance of each variable for sustainability. A closer examination of the four resulting scenarios highlights the importance of developing more systemic as well as effective green governance approaches that support greater alignment between organizational strategies, market evolution and ecosystems dynamics, and thus make "corporate environmental sustainability" a more achievable goal.

The paper proceeds as follows. First, we briefly review the literature on corporate environmental sustainability in management theory, then critically examine two of the leading environmental sustainability frameworks: eco-efficiency and the triple bottom line (De Simone and Popoff; Elkington). Second, we discuss several factors

that act as major constraints on an organization's ability to reduce or eliminate its environmental footprint and, more generally, achieve corporate sustainability: growth dynamics and size associated with the evolution of markets, the complexities of ecosystems and associated challenges of assessing a firm's impact, and finally a firm's location and role in its supply chain. Third, drawing on these considerations, we generate four scenarios to probe more deeply into whether corporate (environmental) sustainability is a legitimate and credible concept at the firm level, and what is needed to make it a more meaningful concept. We conclude with implications for management and policymakers, and explore further directions for research.

II. CORPORATE ENVIRONMENTAL SUSTAINABILITY IN THE MANAGEMENT LITERATURE

Corporate environmental sustainability has gained increasing momentum within the business world since the term sustainable development was first popularized in the late 1980s (WCED). In the field of management and organization science, a growing stream of research has originated from this concept, addressing specific features of the relationship between companies and the natural environment (Etzion). The early 1990s were marked by the formation of international networks of scholars, such as The Greening of Industry Network (GIN) and the Organizations and Natural Environment (ONE) Interest Group in the Academy of Management, followed by the progressive diffusion of terms like greening and natural environment in the management literature.

The pioneering research of that time raised attention to short-comings in earlier organization studies literature, which had 'de-naturalized' the environment (Shrivastava) and developed knowledge and theorizing "… as if organizations lack biophysical foundations" (Gladwin et al.). In the path-breaking and foundational Academy of Management Review Special Issue on "ecologically sustainable organizations" in 1995, a group of scholars aimed to re-conceptualize organizational theories, stressing the centrality of the natural environment in management (Gladwin et al.; Hart; King; Jennings and Zandbergen; Purser et al.; Shrivastava; Starik and Rands). This ambitious effort marked a significant progress in the literature, planting the theoretical roots for the field and providing legitimacy for a number of scholars interested in investigating the relation between organizations and the natural environment.

Over the years, researchers from various managerial disciplines such as strategy, organization theory, marketing, operations, finance, and accounting, have addressed the natural environment in management, drawing on different theories and paradigms from their respective domains. Despite a huge diversity in terms of contributions, research has consolidated around few dominant themes.

At the firm level, studies have mainly focused on the organizational attributes that allow companies to attain improvements in their environmental and financial performances. Some scholars have investigated the role of resources and capabilities in the greening of companies (Aragon-Correa and Sharma; Russo and Fouts; Sharma and Vredenburg). Another broad stream of literature has focused on the "business case," investigating the impact of environmental management on firm competitiveness (Ambec and Lanoie; Christmann; Orsato; Porter and Van der Linde), and on the relation between environmental and financial performance (King and Lenox; Klassen and McLaughlin). By acknowledging the existence of win-win solutions, these scholars have contributed to further legitimate environmental management practices in organizational decision-making

processes (Berchicci and King). The role of market growth garnered little scholarly attention, with one notable exception: Russo and Fouts found that the positive relationship between environmental and economic performance became stronger in higher-growth industries.

Another stream of research on corporate sustainability has explored the relationship between the firm and the many actors of the organizational environment. Institutional and stakeholder theories have dominated this stream of contributions that look in depth at the types of environmental responses to exogenous stimuli or pressures (Bansal and Roth; Delmas and Toffel; Hoffman; Kassinis and Vafeas; Sharma and Henriques; Winn; Winn and Keller).

Recent review articles on the state of the art of corporate greening in the management literature analyzed the main contributions published in leading management and organizational journals (Bansal and Gao; Berchicci and King; Etzion; Kallio and Nordberg), finding a theoretically rich and methodologically rigorous body of research. However, the review articles also highlight that most of this research is incremental with regard to management science, in that it draws on dominant organization theories to build knowledge in this new field. With this research providing only limited input for the discussion of the critical aspects of the environmental sustainability challenge, such as the economic-growth paradigm (Gladwin et al.; Banerjee; Kallio and Nordberg; Purser; Hahn, Kolk and Winn) or the complexity of ecological systems (Shrivastava, Pogutz and Winn), the opportunity for more disruptive contributions has been missed. Similar criticisms can be made of the most popular frameworks widely associated with corporate sustainability in practice. We now discuss two of them in more detail.

III. ECO-EFFICIENCY AND THE TRIPLE-BOTTOM LINE: A CRITICAL REVIEW

In recent years researchers and practitioners have developed a number of approaches toward corporate environmental sustainability, including eco-efficiency (WBCSD), triple bottom line (Elkington), natural step (The Natural Step), ecological footprint and carbon footprint (Wackernagel and Rees), eco-effectiveness, and cradle-to-cradle design (Braungart et al.). These frameworks provide principles, methodologies and guidelines, suggesting options to reduce the ecological damage from business organizations and offering measurement tools in support of managers' decision making. To illustrate how corporate sustainability in practice suffers from similar shortcomings as scholarly work, we take a closer look at two of the better known and widely used corporate sustainability frameworks guiding companies' actions with regard to the protection of nature: eco-efficiency and the triple bottom line.

Eco-efficiency was first introduced by Schaltegger and Sturm in 1990 as a promising business link to sustainable development (Schaltegger and Sturm) and was promoted by the World Business Council for Sustainable Development in the early 1990s. It has been defined as "… the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle to a level at least in line with the earth's carrying capacity" (DeSimone and Popoff: 47). Eco-efficiency aims to combine notions of ecological with economic efficiency such that firms are able to save money in the production and delivery of goods and services, while simultaneously reducing environmental impacts and resource intensity throughout the life cycle of a product.

Over the years, the concept of eco-efficiency has become widely accepted, with a proliferation

of different definitions in business and political communities (Braungart et al.). Scholarly research shows evidence that eco-efficiency can produce win-win solutions, improve firm competitiveness and reduce costs (WBCSD; Sinkin et al.). Initiatives toward eco-efficiency imply innovation in both technologies and practices at process, product, and system levels, allowing companies to integrate environmental concerns into their conventional business model. The idea of eco-efficiency has become popular both as a firm strategy and an indicator of the value generated per unit of environmental impact (Huppes and Ishikawa), as well as for its capacity to increase productive output per unit of resources used (Schmidheiny; Welford).

On the other hand, eco-efficiency as a sole driver for corporate sustainability is insufficient (Dyllick and Hockerts). It has been criticized as a framework that legitimates conventional business models, favoring the search for incremental and efficiency-based innovations and the preservation of dominant business practices (Michaelis). Braungart, McDonough and Bollinger, for example, maintain that in the short-term eco-efficiency strategies offer opportunities to reduce costs and environmental impacts, but that in the long-term they are insufficient to achieve ecological sustainability since they:

- do not address the necessity for a fundamental redesign of industrial material flows,
- do not address the question of toxicity of materials,
- promote only incremental reductions of environmental impact per unit of production, without regard to absolute measures of impact, such as multiplier effects from production growth.

These scholars further observe that eco-efficiency is based on the assumption of a one-way, linear and cradle-to-grave flow of materials. They argue that alternative principles like eco-effectiveness and cradle-to-cradle strategies must be pursued when designing products, organizations and industries, if they are to exhibit a positive relationship with ecosystems and provide environmental, social and economic benefits.

In this paper, we introduce and discuss yet another important aspect of sustainability not addressed by eco-efficiency. In fact, we argue that – even when improvements in environmental performance correlate positively with the associated value-creating process – the overall environmental performance of a firm can still decline. In other words, from an ecological perspective, doing less bad is not necessarily positive – and can be far from enough. Schaltegger captures this dynamic in the broader principle of ecological effectiveness, which measures the absolute environmental performance of the firm (e.g. the tonnes of CO2 emissions generated or reduced by the company during a certain timeframe). In a situation where only "relative," as opposed to "absolute" decoupling occurs, resource depletion increases, and ecosystem damage continues, as is true, for example, for carbon emissions (Holm and Englund).

A second well-known approach to sustainability is the so-called "triple bottom line". The concept—first theorized by Elkington in 1994 (Elkington)—requires organizations to consider the societal impacts of their actions and strategies, emphasizing the need to balance economic goals with social and ecological goals (Hacking and Guthrie). In order to do this, companies should not only focus on the economic value that they add – and on the legal responsibilities they have – but also on the environmental and social value that they add or destroy. This approach has been promoted effectively by worldwide organizations such as the Global Reporting Initiative (Foran et al.). A growing number of multinational companies have adopted the approach, acknowledging the increasing attention of different stakeholders toward

the environmental and social impacts of their daily decisions, and recognizing the importance of conforming to changing social norms and of voluntarily contributing to the community in which they operate in a transparent manner.

Nevertheless, the triple bottom line has been criticized for the absence of a clear methodology, and the fact that in some cases it was no more than a vague commitment to social and environmental concerns, a 'catchphrase,' that does not ultimately lead to sustainability (Marshall and Toffel; Schaltegger and Burritt). In addition, triple bottom line strategies are often unable to effectively balance and harmonize the three realms, leading to conflicts between them that complicate the measuring and achievement of the three goals, and can require difficult trade-offs between them. Furthermore, economic objectives remain paramount (Marcus and Fremeth; Hahn, Figge, Pinkse and Preuss), with environmental targets often marginal and with no comprehensive assessment of the absolute ecological impact of a firm's activities.

The two approaches, eco-efficiency and triple bottom line strategies, thus share the same, fundamental shortcomings: the weak correlation between the performances they measure, and the actual capacity of ecosystems to adequately respond to environmental pressures. Environmental sustainability is not concerned with relative improvements, but depends on absolute thresholds and on the capacity of ecosystems to absorb emission releases and rebound from external shocks (Arrow et al.). At the firm level, an effective or true incorporation of environmental sustainability into 'corporate sustainability" should guide firm behavior to operate within the following parameters (Dyllick and Hockerts; The Natural Step):

- the rate at which a firm uses resources cannot exceed the rate at which these resources are replaced, replenished, or substituted by alternative resources;
- the rate at which a firm generates emissions through transformation processes and products cannot exceed the rate at which these emissions can be assimilated by the natural environment.

Corporate environmental sustainability thus depends on the effectiveness of the firm's actions to comply with external targets such as the assimilative and regenerative capacity of specific ecosystems where the firm operates (Marshall and Toffel). Yet the ability to pursue this goal is challenged by many factors and dynamics – endogenous and exogenous with respect to the individual firm's boundaries – and which reside at organizational, industry-organizational and ecosystem levels.

IV. CONDITIONS OF IMBALANCE BETWEEN THE FIRM AND THE NATURAL ENVIRONMENT

Since the Rio de Janeiro Earth Summit in 1992, the business community has progressively acknowledged its responsibility for promoting the path toward a more sustainable society (Schmidheiny). Despite efforts to frame the concept of corporate environmental sustainability, managerial practices have ultimately proven to be only partially effective, with sustainability-driven strategies only marginally mitigating a firm's negative impact on nature. The oil and gas industry serves as an example: despite the introductions of sustainability measures and technologies over the years, major accidents – such as BP's oil spill in the Gulf of Mexico in 2010 – continue to occur and absolute carbon emissions getting bigger, rather than smaller. Similarly, several leading multinational companies in the personal care and energy sectors have been accused of contributing to the rapid deforestation of large areas of Indonesian and Malaysian rainforest because of their activities

related to palm oil production (Nellemann et al.).

At the same time, multi-national corporations have, over recent decades, become extremely powerful organizations, rivaling countries in terms of productivity, employing millions of people, generating well-being, influencing political elections, and generally participating in shaping societal cultures and individual values (Suddaby et al.).

In light of these developments, several questions arise: To what extent can companies individually contribute to turning this trend of natural deterioration around by contributing to environmental sustainability? To what degree are companies prisoners of larger economic and social systems and find themselves dominated by exogenous forces that limit any real possibility to pursue sustainable business models (Michaelis)?

In response to these questions, we identify a number of conditions that are only partially controllable by the single firm, and which significantly limit the firm's ability to align its impacts with natural environment dynamics: market growth and size, ecosystems complexity, and location and power within its supply chain. We examine the impact of each on a firm's ability to manage its footprint and, more broadly, to broaden our understanding of the sustainability challenge.

V. MARKET CHARACTERISTICS AS A CONSTRAINT ON CORPORATE SUSTAINABILITY

Market characteristics. The discourse of growth is paramount in our capitalistic society, even more so in the current economic crisis, and involves multiple dimensions, including economical, political, cultural, psychological (Spangenberg).

From an environmental viewpoint, and since Malthus's population growth theory, many scholars from different scientific fields have investigated the relationship between population dynamics, increase in the economy's size and shortage of natural resources (Boulding; Daly and Cobb; Ehrlich; Georgescu-Roegen; Rockström). In the early 1970s, Meadows et al. raised the question of the (ecological) limits to growth, challenging the idol of modern capitalism and pointing out the risks of a societal model that is based on an intensive exploitation of natural resources. Their watershed study prompted much research and many publications, fuelling a huge debate that has engaged prominent scientists for four decades (Ayres; Kerschner), and leading to the development of alternative approaches such as Herman Daly's "steady-state economy", Serge Latouche's "de-growth" paradigm, and the WWF's "One Planet Living."

Market growth rate.

The concept of growth has been broadly discussed in the strategic management, business policy, and marketing literatures. The rate of development of a specific product market in which the company competes depends on the stage in the industry/product life cycle (PLC). Determining whether an industry is in the introduction, growth, maturity or decline stage helps gauge underlying market changes, assess different *growth rates* and trajectories associated with each stage and understand stage-specific competitive dynamics. Furthermore, market growth can be used as a predictor for the diffusion curve of a specific product or technology. New and developing markets are characterized by growing consumption patterns and primary demand, while mature markets are usually characterized by steady or declining consumption trends and replacement demand (Kotler and Armstrong). New markets develop during the geographical extension of markets (e.g. emerging markets in countries such as China, India, or Brazil) or as a result of new opportunities arising in response to unsatisfied needs involving sociological, psychological, technological, but

also environmental issues (Sanne; Buenstorf and Cordes). Managerial interest in market growth varies with the attractiveness of a business, where fast-growing markets are considered more attractive than mature or declining markets. The life cycle stage of an industry also affects the intensity of rivalry and profitability (Porter). Companies that do business in expanding markets need to capture the growth and increase sales as a key strategic option to maintain or gain competitiveness, thus taking advantage of market leadership positions and experience curves (Cho and Pucik; Wheelen and Hunger).

The growth of markets is a condition that influences corporate environmental sustainability through different pathways. Recent studies (Jorgenson and Clark) have shown that market evolution, growing consumption, and economic development more generally, affect a firm's ability to decrease its impact on nature and can easily offset any improvements achieved through eco-efficiency, cleaner production designs or green products (Clark; Mont and Plepys).

Many markets in developing countries such as China, India, Brazil, Indonesia, and Russia are in the early stages, as new industries rapidly take shape. This is fostered by a rapidly growing *primary demand* for a wide range of products and services, such as energy. In China and India, energy consumption rose by 14.5% between 2005 and 2007, increasing these countries' share from 10% in 1990 to 20% of the world's total energy markets. Companies that are targeting these markets have to handle complex trade-offs between economic, environmental and social goals. Such high market growth rates can easily eclipse any gains in environmental efficiency obtained through innovations at process and product level.

Mature markets, on the other hand, because of their slow growth rates and prevailing *replacement demand*, can benefit from technologies that capture environmental efficiency gains through the substitution of old products. We can expect that companies operating in these markets can align more easily with the ecosystems' absorptive and regenerative capacity as green technologies and clean products are developed.

Market size.

A second aspect related to market growth is overall *market size*. Some categories of products target mass markets at worldwide level, while others focus on niche markets or small segments of consumers. Small market size can affect environmental sustainability positively, since ecosystems are exposed to lower levels of stress as a result of fewer total pollutants released and fewer total resources utilized. As long as ecosystems function within their assimilative and regenerative capacity, they can continue to provide crucial services.

On the other hand, when perturbations to ecosystems exceed their carrying capacity, ecosystems are damaged and the supply of ecosystem services sharply decreases (Costanza). Familiar examples of large market size and associated overexploitation of natural resources are cod and tuna fisheries; influenced by globalization trends, changes in consumer demand have exhausted these ecosystems' capacity to regenerate and maintain their vitality and productivity. Cars provide another example: driven by the economic growth of China and non-OECD countries, the market size for passenger vehicles is expected to double over the next two decades, with the associated increase in energy consumption and greenhouse gases emissions generating massively increased pressure on climate change (IEA).

In summary, we argue that corporate environmental sustainability cannot be meaningfully discussed without considering the dynamics associated with a *market's growth rate*, as well as (relative and absolute) *market size*.

Market conditions are often exogenous to the single

firm, which operates with limited power to challenge taken-for-granted imperatives of increasing material production and consumption associated with certain industry cycles. Nonetheless, major companies can lead market evolution and technological transformation, drive consumption patterns and affect demand, or further amplify market changes as a result of their choices for competitive strategies. In either case, decisions in terms of product portfolio, segment targeting and internationalization strategies have major impacts on the effectiveness of the firm's environmental strategy, and can increase or reduce the single firm's alignment with the assimilative and regenerative capacity of natural ecosystems.

VI. MANAGEABILITY OF ENVIRONMENTAL IMPACT AS A CONSTRAINT ON CORPORATE SUSTAINABILITY

The second broad variable we introduce to the debate on corporate environmental sustainability refers to the firm's capacity to effectively manage and control the harm done to the natural environment by its processes, products and business activities in general. What does it mean for a firm to manage its environmental impact? How much can a single firm contribute to its environmental sustainability through pollution prevention techniques, cleaner production, managerial systems, green design, and innovation?

Below we describe another major condition affecting the ability of the single firm to effectively manage its environmental impact, the ecosystem complexity which stems from characteristics of those ecosystems that provide the services the firm depends on. We also briefly touch on how the firm's supply chain structure influences this variable.

Ecosystem complexity.

The complex nature of ecosystems is a major topic in the ecology literature (Levin; Holling; Folke et al.). Ecosystems emerge from the dynamics of the relationships between biological beings, organizations and the environment (Espinosa et al.). They consist of large numbers of heterogeneous components that interact in parallel and have a number of basic properties associated with any complex adaptive system (Levin). First, ecosystems are *non-linear systems*; transformations occur through complex paths primarily governed by reinforcing stochastic events, non-linear causation, and path dependency. Second, they are composed of a *variety of species*, and the generation and maintenance of this diversity is a fundamental condition for their functioning. Third, ecosystems are based on a range of different *flows* including nutrient, energy, material, and information flows that interconnect the single parts in a web of relations. Systems of nature (for example, forests, lakes, and rivers), systems of organizations (for example companies, agencies, governments, NGOs), systems of humans (for example, culture, settlements, cities and organizations) are interlinked in never-ending adaptive cycles of growth, accumulation, restructuring, and renewal (Holling).

As a result of this complexity, ecosystems generate services that are not homogeneous across landscapes or seascapes, nor are they static phenomena in terms of temporal scales (Fisher et al.). This is the case for a forest that provides a water regulation service downstream and over time, or a forest that provides a carbon sequestration service. In either case, temporal scales and spatial scales referring to ecological dynamics and organizational timeframes might differ (Kok and Veldkamp). Ecosystems, for example, could suddenly collapse as a result of many years of perturbations, with consequences for the firms and individuals that

depend on their services (MEA). Moreover, ecosystems jointly provide multiple services that can be beneficial to different organizations, as in the case of regulated stream flows, generating benefits for recreation opportunities and providing water for agricultural irrigation and industrial purposes.

Organizations may compete for the use of the same ecosystem service, such as forests that act as sinks for climate regulation for some, and as sources of wood and energy for other organizations (Fisher et al.). Based on these considerations, we argue that the level of an ecosystem's complexity influences the likelihood for a single firm to effectively manage its environmental impact. Spatial and temporal trade-offs or joint benefits may occur, limiting the possibility for a company to clearly measure and monitor ecosystem responses to specific perturbations or environmental strategies (Cumming et al.).

We have mentioned that firms generate impacts on the natural environment through the use of resources as inputs (services provided by ecosystems and non-renewable resources) and through the release of outputs (such as emissions, waste, toxins, and products) into different environmental media (air, water, soil) or ecosystems. Firms produce impacts from transformation processes that are part of their own business, be they extraction, production, or distribution, and via value-adding processes provided by other members of the supply chain along the entire life cycle of a product or service – from raw material extractions to its final disposal ("cradle to grave") or through re-introduction in closed loop systems ("cradle to cradle") (Braungart et al.). Many of these types of impacts are now monitored and tracked by medium and large companies as a result of policies and regulatory requirements. Physical accounting and material flows diagrams are examples of how companies can monitor their mass balance.

The question is how much this information actually contributes to understanding the harm generated by the single firm to the ecosystems. To what extent do the perturbations generated by the activities of the single firm harm the ecosystems? Given the characteristics of complex adaptive systems, could meaningful metrics even be found? What is the resilience capacity of the ecosystem where the firm is releasing pollutants? How long does it take for a damaged ecosystem to recover?

When we investigate the manageability of the single firm's environmental impact, we should extend our approach from the firm's mass balance (inputs utilized and outputs produced) , which is a function of the product/process ecological efficiency and of the firm's environmental capabilities (cleaner production, pollution prevention, green design, etc.), to the actual effects on the natural environment which depend on the ecosystems' capacity to respond to the firm's perturbations. The relationship between the ecosystems' resilience and perturbations is uncertain and non linear, and is determined by the characteristics of complex adaptive systems. Clearly, the management of such complexity requires a holistic and systemic approach, which is largely incompatible with the way in which single business organizations operate. What is needed then is new types of governance and decision making processes that more effectively respond to the challenges of the complex system and which involve policy makers,

1 Several companies have developed ecological accounting systems to measure their environmental impact by tracking material flows. The mass balance (or material balance) provides a representation of this impact in physical units, measuring the total inputs transformed (materials, components, energy, water, other resources) and the total outputs generated (final products, air pollutants, waste, etc.) at the plant or company levels. These measures do not, however, capture the effects on the effects on ecosystems dynamic.

local agencies and other participants beyond the individual firm (Costanza et al.).

Supply chain structure.

Today, large firms with well-known and highly visible brands are expected to operate sustainably, protect the natural environment and respect social standards (Marcus and Fremeth). Consumers and nongovernmental organizations in particular hold firms responsible for their direct and indirect environmental impacts, and they include their upstream suppliers and downstream operations for product dismantling and disposal (Sarkis, Shrivastava). Such pressures on firms to accept extended product responsibility mean that organizational boundaries of the firm (Santos and Eisenhardt) are becoming less clearly defined, and that the firm's supply chain, its structure, and the firm's position within the supply chain need to be considered when investigating the concept of corporate environmental sustainability.

The structure of the supply chain affects the ability of the firm to assess, manage and control its environmental impact, since different manufacturing operations – or different supply chain phases – are responsible for diverse impacts on ecosystems. Consider, for example, the different types of environmental impacts associated with the cultivation of cotton versus its manufacturing in the textile industry, or environmental risks associated with oil extraction versus those in its final distribution for oil and gas companies. Similarly, firms operating in the same industry, but offering products or services at different locations in the supply chain might generate different environmental impacts. This heterogeneity in terms of environmental impacts is often the consequence of corporate strategies, but may also be due to specific environmental strategies. For example, a company may decide to reduce its direct ecological impacts by outsourcing some phases of the production process, such as the ones directly involved with natural resources extraction, or the disposal of the final product, or those that generate a high degree of environmental damage. As a result, environmental manageability also depends on the degree of environmental commitment and responsibility assumed by the company with regards to its environmental performance. To date, companies have mainly addressed their direct environmental impacts, focusing primarily on those environmental issues which directly involve the company (Malovics et al.).

Nevertheless, there has been much discussion about how companies should extend their responsibilities to include indirect environmental impacts and implement approaches based on full life cycle management. Firms are, in fact, held increasingly accountable from "cradle to cradle", that is, for operations taking place along the entire supply chain (Sarkis) and they are asked to adopt strategies and policies that facilitate their suppliers' and their customers' protection of ecosystems (Darnall et al.).

Unfortunately, managing and controlling the various environmental impacts generated along the supply chain is not an easy task. First, there are structural features such as the length of the supply chain and the geographical and organizational distance to suppliers. With increasing numbers of tiers between the company and its partners, and increasing geographical dispersion of supply chains, the level of organizational complexity grows and lessens the ability of a single company to manage the environmental impact generated outside of its boundaries and to enforce its environmental policies.

There are also internal organizational characteristics affecting the firm's capacity to exercise control over other supply chain members and its portfolio of suppliers. Firms that are vertically integrated may be able to exert more pressure on their partners than companies with low

level of integration. The ability of a single firm to manage and control its environmental impact along the entire value chain also depends on the power the company has to enforce environmental policies and induce its subcontractors to reduce their own environmental impact.

To conclude, two major conditions affect corporate environmental sustainability: *market characteristics*, which can offset the effectiveness of the firm's environmental strategy; and the *manageability of the environmental impact*, which is a function of the complexity of the ecosystems with which the company interacts, of structural characteristics of the supply chain, and of firm characteristics affecting its position and power within its supply chain. From the perspective of the single firm, market characteristics, ecosystem characteristics and supply chain characteristics are largely exogenous and beyond the control of managers of an individual company. Even key market players and big brand names find it difficult to challenge the imperative of market growth and limit the exploitation of ecosystem services. And while intra-organizational features may appear to be more manageable and controllable, we know from organization studies just how difficult it is to orchestrate deliberate organizational change within an organization. It is also worth noting that, to date, we have no examples of firms that have demonstrated the ability to effectively neutralize their environmental impact in terms of ecological sustainability.

VII. FOUR SCENARIOS FOR ENVIRONMENTAL SUSTAINABILITY

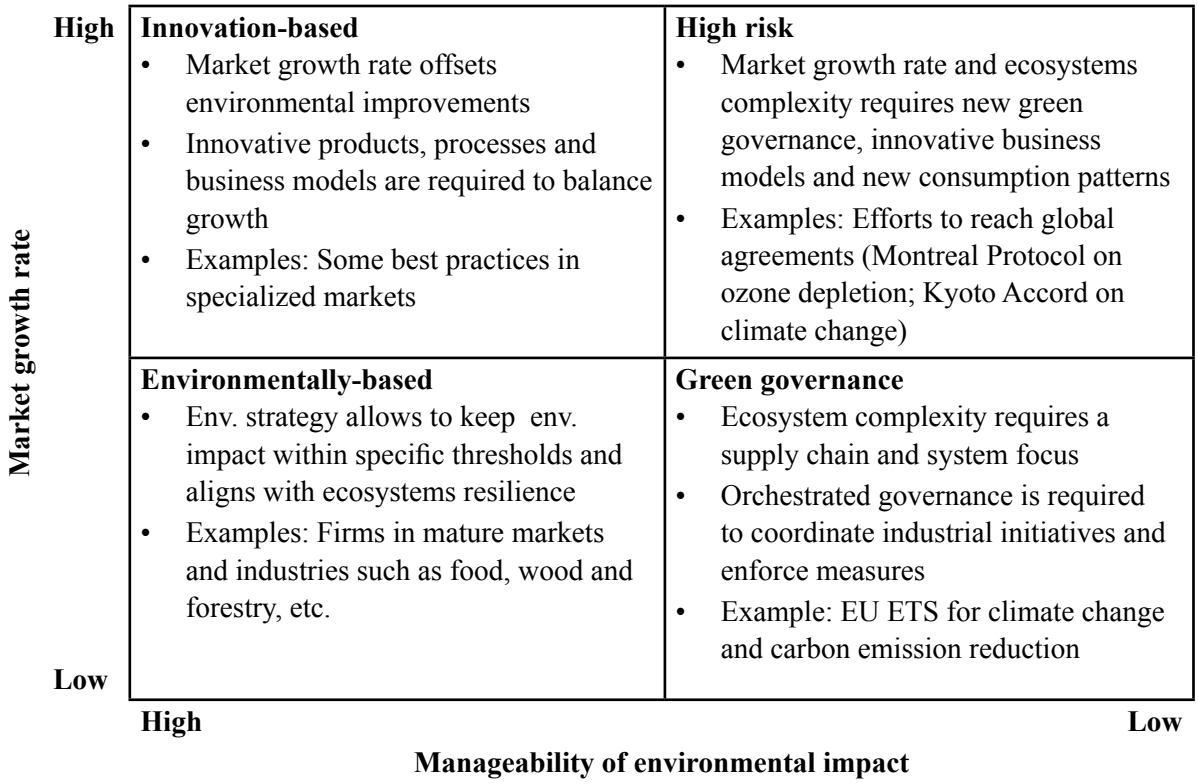

Figure 1 - Four scenarios for environmental sustainability

The broader debate about organizations and the natural environment has guided scholars and practitioners in the attempt to define an environmentally sustainable corporation (Hart; Jennings and Zandbergen; Marshall and Toffel; Starik and Rands). Drawing further on two of the variables described, market growth and manageability of environmental impact, we construct a two-by-two matrix to generate four different scenarios (see Figure 1).

For the purpose of developing scenarios, we focus on market growth rate only, and distinguish between high and low growth rates. While we realize that the capacity of ecosystems to assimilate external perturbations depends on the absolute amount of resources utilized (which correlates with the overall size of markets), our intention here is to focus on market growth more narrowly, in part to highlight its critical importance in the corporate sustainability literature. With regard to the second dimension, we distinguish between high and low manageability. High manageability represents the case where an individual firm has the capacity to implement effective environmental strategies, has some control over ecosystems dynamics and the effects of its own environmental impacts on the ecosystems' perturbations. Low manageability suggests that the complexity of the ecosystem combined with the supply chain structure inhibit the possibility for the single firm to implement effective environmental actions. Below, we elaborate further on each of the four scenarios.

Environmentally-balanced scenario.

The first scenario, which we name "environmentally-balanced," is characterized by low market growth rates combined with the possibility to directly manage environmental impact. Firms that compete in mature markets dominated by a replacement demand are more likely able to both control their environmental impact and align their operations with ecosystem functioníng and absorptive capacity. In this scenario, the implementation of a green strategy, the introduction of environmental innovations and clean technologies, and the adoption of environmental management systems allow the firm to improve its overall environmental performance. Improvements can be both relative (eco-efficiency) and absolute (eco-effectiveness).

At the same time, the firm's environmental impact affects mainly local ecosystems (e.g. a forest, a river, a lake, a pond) with spatial scales and time scales compatible with the firm's operational cycles. Competition over the utilization of ecosystem services is limited, for example because the services or benefits that the ecosystem provides are excludible from access or use to others. In sum, they are manageable by the single organization (Fisher et al.). Examples for this case come from firms operating at a local level, in sectors such as the food industry (e.g., organic foods) or forestry. These companies directly manage the ecosystems they rely on for the provision of natural resources, and directly pay for the mismanagement of resources.

Green governance scenario.

Many industrial activities in the industrialized world fit with a scenario where conditions of low market growth are combined with low environmental manageability. The complexity of the ecosystems affected by the firms' activities or products requires coordinated and extensive action and commitment, and the focus shifts from the individual company to the entire supply chain or economic system. We are again in a situation of mature markets with reduced growth, pointing to the possibility to reach a condition of balance with the assimilative capacity of ecosystems through the development of green governance mechanisms (e.g. policies, self-regulations, etc.).

An example of this case is the European

Union Emission Trading Scheme (EU-ETS), launched in January 2005 with the goal of reducing greenhouse gas emissions (GHG) by 8% from 1990 levels by 2012. Here the complexity of the climate change challenge, both in terms of ecosystems and organizational manageability, has imposed an orchestrated model of governance, involving heterogeneous stakeholders (Crona and Hubacek; Veldkamp et al.). The system covers 12,000 installations representing approximately 50% of total EU GHG emissions. Emission caps are defined based on the final environmental target (temperature as a function of GHG concentrations) and emissions permits are distributed according to the defined emission cap, with the possibility to trade them in a market. In a generally mature market such as Europe, which is characterized by low growth rates, the definition of a reduction target and adoption of a cap and trade system does not meet as much resistance from the industry as might happen in high-growth markets, and this measure can be seen as a credible and effective option for internalizing the external cost of carbon emissions and drive low-carbon innovations.

Innovation-based scenario.

Many markets in emerging counties or in innovative industries are characterized by high dynamism and sharp growth rates. Companies operating in these industries can manage their environmental impact by developing efficient environmental strategies, or by adopting clean technologies and environmental management systems. Nevertheless, market growth rates may offset the environmental efficiency gains the firm is obtaining: when sales grow rapidly, improvements in environmental efficiency need to occur at a rate faster than market growth in order to obtain absolute environmental benefits. This is a critical challenge that many companies have to face when they move from local to global markets, or from niche to mass markets. In this scenario, product, process and business model innovation plays a key role in balancing growth. Lovins, Lovins and Hawken, in their work on natural capitalism, have suggested strategies for major shifts in business practice that can solve many environmental problems under profitable conditions.

Well-known companies such as Patagonia (Fowler and Hope), the Body Shop, Interface (Stubbs and Coklin) or the Brazilian beauty-products provider Natura (Bonifacio), have introduced closed-loop factories, re-designed products, adopted innovative eco-friendly materials, and radically changed their business model in order to protect ecosystems and biodiversity. These companies provide examples of sustainable growth, acquiring market leadership in their segments, and becoming 'best practice' examples. Cases like these relate to specialized market segments. We argue that problems shall still arise when such firms decide to move into global mass markets, globalize their supply chains, or are acquired by other multinational brands such as l'Oreal with the Body Shop.

We conclude that even in these successful and celebrated cases, the myth of growth has never been contested, even as sustainability thinking has prioritized technology and business innovation as the ingredients to square the circle.

High risk scenario.

Lastly, the conditions of low manageability and low market growth rates suggest a situation where environmental sustainability is an extremely difficult challenge. Many ecosystem services we all depend on are already seriously compromised. This is the case for climate regulation services, air quality regulation, erosion regulation and for provision services such as fisheries, to name a few (MEA; Rockström et al.). Complexity derives in part from the fact that these benefits are jointly produced

(many ecosystems contribute to the generation of the same service), and from the fact that they are both spatially and temporally unrelated to industrial and organizational life-cycles. As a result, new green global governance is required to approach this complexity, involving multiple organizations from diverse institutional spheres, including politics, the economy, science, etc.

We use an example typically considered to be a successful response: the reaction to the ozone depletion. Here, the release of anthropogenic ozone-depleting substances (chlorofluorocarbons or CFCs and halons) lead to the appearance of the Antarctic ozone hole, with serious risks for humans and ecosystems (the ozone layer protects from dangerous UV radiations). The enforcement of the Montreal Protocol (signed in 1987 by 25 nations) and subsequent amendments (today, the accord involves some 167 counties) have resulted in phasing out these substances, leading to a reduction of the concentration in the atmosphere of ozone-depleting gases and to some signs of ozone-stratospheric recovery. In this example, major conditions of market growth for CFCs, including rapid development of this industry in emerging economies, and ecosystems' complexity prompted the international community to join in a concerted effort to ban these dangerous substances and protect the natural environment. Single firms had to manage within this new regulatory setting and search for innovative solutions to substitute these chemicals while shutting down entire production plants.

Other examples such as climate change or overexploitation and losses of the oceans' and fisheries' stocks, on the other hand, are evidence of failures of international green governance. Until now, for instance, the search for global green agreements for a post-Kyoto treaty has been crushed both by developing economies determined to undertake their own path of industrialization and development, and by industrial lobby opposition. Some individual companies competing in these markets, despite their efforts to protect the natural environment and improve eco-efficiency, are probably contributing to increasing the exploitation of natural resources in absolute terms, pushing them beyond their resilience capacity. Forms of compensations, such as carbon emission offsets, appear insufficient in the face of these markets' pace of growth. We argue that this is the scenario in which coordinated initiatives, new forms of super-national and local governance (Veldkamp ey al.), new business models and the search of innovative patterns of consumption are most urgently required. At the same time, we need to improve our knowledge of environmental conditions and dynamics, and of the effects on humankind (Folke and Gunderson).

To sum up, corporate environmental sustainability entails different challenges under the different conditions discussed in this paper. Corporate environmental sustainability, in light of our exploration of constraining factors, appears to be a far less convincing or realistic concept. Exogenous and endogenous forces severely limit the ability of the individual firm to develop an effective environmental strategy, making this concept flawed and ambiguous. The environmental challenges before us require holistic approaches to monitor global and local ecosystems' dynamics, call for new forms of green governance that can orient the behavior of firms and foster cleaner innovations, and necessitate far more radical reflections on the imperative of production and consumption growth and the relation with nature's boundaries.

VIII. IMPLICATIONS AND CONCLUSIONS

Our paper offers a number of contributions to the fields of management, policy and research. First, we have stressed the relevance of ecological effectiveness, and we have pointed out that firms have

to abandon the safe waters of eco-efficiency (Dyllick and Hockerts). The focus on efficiency responds to the logic of productivity, and therefore easily fits with managerial routines that legitimize environmental investments, but nature does not respond to this logic. Environmental sustainability depends on the interaction between organizations, products, ecosystems and their characteristics (e.g. resilience). We argue that corporate environmental sustainability cannot start until firms acknowledge the complexity of the natural environment and try to incorporate nature's boundaries into their strategy. We think that this topic deserves extensive additional research. Management studies and environmental science need to bridge the disciplinary distance that until now has characterized the two fields. There is a great need and urgency for further progress, and management theory must investigate the complexity of the relationship between organizations and nature in order to support firms in the development of effective environmental strategies (Pogutz and Winn).

On a practical level, the availability of useful and useable data on the state of the natural environment will be critical in the next decade. The creation of accessible database and information systems that favor the integration of the firm's environmental accounting with information on ecosystems dynamics will greatly improve the effectiveness of firm-level environmental strategy, not to mention increase stakeholder pressures for firms to act. In the domain of natural science, improvements are required both in the capacity of observing ecosystems and in forecasting their future conditions (Folke and Gunderson); in the field of management, new competencies and commitments will be required to usefully manage such information by, for example, supporting green innovation processes and the formulation of environmental strategies.

Some scholars have pointed out that management practice until now has favored the massive amplification of the imperative of increasing production and consumption (Banerjee, Shrivastava, Purser).

Another contribution regards the relationship between industrial cycles, market growth and corporate environmental sustainability. We believe our analysis helps recognize the importance of these forces in shaping firm environmental impact, despite the scarce attention in the management literature to date (with the exception of very few contributions). We have been surprised by this lack of attention, both by scholars in the field of management, and in the subfield of organizations and the natural environment, as if the topic of growth was not part of the organization science domain. We think that management scholars have both a responsibility to start addressing these issues (as scholars from other disciplinary fields are doing) and are bound to find fertile ground for scholarly inquiry.

However, we have noted that the rate of growth of markets affects the possibility for the firm to develop an effective environmental strategy, offsetting the benefits obtained with green innovation or environmental management systems. The question remains: Can a firm be called environmentally sustainable when its absolute environmental impact increases over time? In the current situation, when many ecosystems are already seriously damaged and their resilience is compromised both locally and globally, we suggest that the answer is "probably not." Moreover, we have highlighted that market size matters as well. In absolute terms, firms competing in specialized markets have less impact than companies targeting mass markets serving millions of consumers. For these firms it is probably easier to implement a green strategy that fits with nature's boundaries. Should we consider these firms more environmentally sustainable than companies that are focusing on large segment of consumers?

Even in this case, more investigation is needed to better understand the linkages between growth, competitiveness and environmental

sustainability. We think that an important avenue of research relates to the quest for innovative business models capable to create value and to challenge the dominant production and consumption patterns.

Another critical area relates to growth in emerging economies and firms environmental strategies. In synthesis, these countries are facing two alternatives with different impacts on the global environmental challenge: to leapfrog to a postindustrial society or to transform through a more environmentally-intense (i.e., harmful) industrialization phase. Several questions arise: How are large multinational companies approaching these markets from the environmental perspective? How are these companies managing tradeoffs between local and global environmental aspects and between environmental and social issues? Can we find innovative business models in these countries that are based on local capabilities that reconcile market growth with environmental sustainability?

In this paper, we hoped to draw attention to exogenous forces not previously studied, that limit the ability of the single firm to realistically target environmental sustainability. Indeed, we question not only the factual accuracy of the term corporate environmental sustainability, but suspect that its usefulness must be considered within very narrowly defined goals of prompting incremental improvements. We have also stressed the importance of a holistic perspective, deliberate and orchestrated green governance, and broader system innovations in the service of sustainability. We argue that in many situations, the individual firm is not the right unit of analysis for assessing environmental progress. Companies have many options to reduce their impact at the single organizational level (from clean technologies, to ecosystem restoration), but global ecological problems are not the result of a single firm's action, despite its power or size. Ecosystem complexity over spatial and temporal scales requires close involvement and coordination across supply chains and industries as the appropriate unit of analysis for facing environmental problems. We think that both management scholars and practitioners should pay more critical attention to the widespread use and faulty meaning of the term corporate environmental sustainability.

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