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Further Developments of the Financially-ESG Sustainable Growth Matrix

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Abstract

Bellandi (2022) has developed a matrix to assess the consistency between sustainable financial growth and sustainable ESG (Environmental, Social, and Governance, hereafter ESG) growth, and how this may impact shareholders versus other stakeholders. This article further builds on that matrix, to link the product life cycle approach and the BCG matrix to the sales growth axis of the matrix and determine both the actual revenue growth and the financially sustainable revenue growth associated to each stage of a product life cycle and each quadrant of the BCG matrix. The article also illustrates how the Life Cycle Assessment methodology can be linked to the product life cycle model, and better quantify the ESG impact of each product life cycle stage on the ESG axis of the financially-ESG sustainable growth matrix. The article shows how the reading of both product life cycle and BCG matrix can be expanded from a proprietory (shareholders) to a societal (other stakeholders) perspective. This opens a new direction of research to evidence alternative ESG improvements in each stage of the life cycle model that may make a product more ESG compliant, therefore suggesting strategies to improve the ESG rating of a business or a company. This article is also a methodological step forward to create an index of ESG sustainable growth, which is currently missing.

Keywords: ESG, sustainable growth, product life cycle, BCG matrix, life cycle assessment

1. Introduction

Bellandi (2022) has developed a matrix to assess the consistency between sustainable financial growth and sustainable ESG growth, and how this may impact shareholders versus other stakeholders. Finding an equilibrium between ESG-sustainable growth and financially sustainable growth is important because it has serious implications for the consistency of the overall growth of a company, and the relationship between its shareholders and other stakeholders. Under that approach, the matrix horizontal axis shows whether a company revenue grows faster or slower than financially sustainable, and the vertical axis shows whether a company is growing faster or slower than ESG sustainable. If revenue growth exceeds financially sustainable growth, financial growth is at the expenses of shareholders. In the reverse case there is unfulfilled financial potential for shareholders. If ESG factors are less than sustainable, financial growth is at the expense of stakeholders other than shareholders. If ESG factors are more than sustainable, additional financially sustainable growth that is not pursued is an unfulfilled potential for other stakeholders. The matrix identifies four quadrants, to which different strategies are applicable. Quadrant 1 indicates situations where a company grows more than financially sustainable but ESG is lower than average as compared to the industry peers. Here, growth is unsustainable: both shareholders and stakeholders lose. Companies in Quadrant 2 are ESG laggard that grow slower than financially sustainable. Here, ESG growth constrains financial growth: if company grows more, other stakeholders subsidize shareholders. Quadrant 3 identifies ESG leaders that grow slower than financially sustainable, a situation which identifies unfulfilled financial and ESG potential, or a potential for restructuring. Finally, Quadrant 4 identifies ESG leaders that grow more than financially allowed. Financial growth constrains ESG growth: shareholders subsidize other stakeholders, or there is a potential for financial re-engineering.

This article further builds on that matrix in Bellandi (2022) to find connections with other important management models. This is important, because it permits to investigate what these approaches may have in common that could leverage their integrated use as inputs to the financially-ESG sustainable growth matrix. In fact, revenue growth is a feature of certain established management studies that have become famous in the past years, namely the

product life cycle approach and the BCG matrix. This article tries to reconcile those approaches with this new tool and see what this may reveal not only from a financial perspective but also about the ESG implications. Given that the product life cycle approach and the BCG matrix are well established concepts in management studies, such an integration may be beneficial in extending the reach of their theoretical formulations and re-using the principles underpinned in those models to amplify their potential use to comprise the ESG dimension in corporate growth strategy. Furthermore, the article researches the points of tangency between the recent methodology of life-cycle assessment (hereafter, LCA) and the product life cycle approach, to find how it can further leverage the said matrix.

The first section of this article draws a picture of the key literature related to the life cycle approach, BCG matrix, and LCA. After describing the research questions and hypotheses, the discussion section builds the link between these models and the financially-ESG sustainable growth matrix. The last section summarizes the conclusions. First, this integrative perspective identifies the circumstances that present sustainable growth gaps in the product life cycle and BCG matrix. Second, it amplifies the embedded dimension of ESG that was not present when the product life cycle and the BCG matrix were created, and it shows that product life cycle and BCG matrix can be expanded from a proprietory (shareholders) to a societal (other stakeholders) perspective. Third, from a dynamic analysis standpoint, this study highlights that the soundness of the big "societal portfolio" depends on how many industries and sectors are in the life cycle stages, a new approach of industrial policy. Finally, this article illustrates how the LCA methodology may represent an input to convey a more precise and punctual assessment of actual versus sustainable ESG growth in the vertical axis of the financially-ESG sustainable growth matrix. This is an important point, given that no ESG metrics that can represent an ESG growth indicator exists so far.

2. Literature Review

This paragraph reports relevant literature related to product life cycle, BCG matrix, and LCA, but it does include an exhaustive historical account. The focus of this article is not to draw a critical review of those tools. Their pros and cons have been considerably studied and are not further investigated here. This article acknowledges their vast use. Findings of these methods are explained in the discussion section of the article to the extent they are pertinent to the specific issues treated in this study and demonstrate the logical continuity between those approaches and the present work.

Product life cycle is a traditional corporate strategy concept. In the past, several management studies have theorized the corporate implications of each phase (among others, Forrester, 1959; Patton, 1959; Clifford, 1965; Levitt, 1965; Buzzel, 1966; Catry et al., 1974; Staudt et al., 1976). Vernon (1966) expanded the concept to the international product life cycle, to consider how the development patterns interact among initiator and foreign countries. Rink et al. (1979) reported the different shapes of the curve that have been suggested in literature, the application to different sectors, the level of product concept to which the model is applied, and research made on its stages. Porter (1980) expanded the model from the initial field of marketing to the implications in terms of competitive strategy for each of its stages. There has also been intense criticism of this model, in relation to theoretical aspects, practical issues of applicability, levels of aggregation, and empirical issues of validation (Tellis et al., 1981). To overcome these weaknesses, they proposed an evolutionary approach to product growth. Prasad et al., 2019 expanded the product life cycle model to emerging markets.

As known, the BCG matrix is another iconic strategy tool, developed by the consulting company Boston Consulting Group in the 70s (Henderson, 1970; Henderson, 1973; Henderson, 1979). The relationship between the BCG matrix and profitability, investment, and cash flows has been studied in literature (for example, Hax et al., 1984). Hambrick et al. (1982) reviewed literature for BCG into four sets of normative, empirical, and situational propositions. Morrison et al. (1991) walked through the journey that gave birth to the matrix, its implementation and variations, including the views of supporters and detractors. The BCG matrix has been criticized in many respects, including oversimplification for the use of only two dimensions, ambiguity in the definition of relevant markets and axes of the matrix, and inappropriate application of the instrument (Pidun et al., 2011). Reeves et al. (2014) revamped the matrix to include new hints for modern accelerated competition. Hensmans (2019) moved from the BCG matrix to develop a new matrix that could be applied to platform companies.

The life-cycle assessment is a widely used methodology based on ISO 14040:2006 (2020) and ISO 14044:2006 (2020) for evaluating the environmental burden of products and processes along their life cycle. Among seminal works on LCA, Consoli et al. (1993) set the technical framework and the different stages of LCA, while Fava et al. (1993) expanded its reach to several applications. The LCA model has been studied by different authors, and sometimes identified as an engineering product life cycle (E-PLC) (Cao et al., 2012). Alting (1993) divided the assessment at product design level into the six stages of needs recognition, design/development, production, distribution, usage, and disposal/recycling. Asiedu at al. (1998) distinguished four phases of design development,

production, use, and disposal. Westkaemper et al. (2001) used five phases: concept, design, manufacturing, assembly, use and support, reuse and/or recycling. Khasreen et al. (2009) reviewed the application of LCA to a specific sector, namely building construction. The European Commission (2003) published the Integrated Production Policy (IPP), with the goal of increasing the life of products. That project has classified products into three buckets: environmental impact (EIPRO), environmental improvement (IMPRO), and Policy Implications. The goal was to identify and assign them to environmental impact categories, then devise ways of reducing environmental impact, and finally implement the policy.

The financially-ESG sustainable growth matrix had been created by Bellandi (2022). While academic literature has extensively studied the relationship between ESG and corporate financial performance, there are virtually no academic contributions on the topic of the consistency between financial and ESG sustainable growth. That matrix reports the difference between actual revenue growth rate and financially sustainable growth rate in the horizontal axis, and a proxy for the difference between actual ESG growth and ESG sustainable growth in the vertical axis. It identifies four quadrants to detect four different unbalanced situations of financial versus ESG growths, based on which shareholders versus other stakeholders may gain or lose. This new matrix represents a tool to guide management in setting both financial and ESG sustainable growth rates and the consistency between the two, understanding the strengths and weaknesses of a company's positioning on the map against its sector and its competitors, studying its multi-year trend in terms of virtuous versus vicious paths, drilling down to the root causes at the level of ESG and financial policies, and eventually re-positioning strategies for future comprehensive sustainable growth.

3. Research Method and Hypothesis Development

The research questions of this article originate from the observation of two phenomena. On one hand, as explained in the introduction, sales growth is a common feature of both the product life cycle approach and the BCG matrix, although applied at different levels (product or their aggregations versus market levels). On the other hand, the concept of life cycle is a common feature of the product life cycle and LCA. While the former model is more marketing and management oriented, the latter has a direct connection with the environmental dimension. These two phenomena may have a direct connection with the financially-ESG sustainable growth matrix, which makes of sales growth and ESG growth two explicit variables. Therefore, the intuition is that the sales growth axis of the financially-ESG sustainable growth matrix might be linked to former management studies on product life cycle and BCG matrix. At the same time, the ESG growth axis of the matrix might be linked to the LCA methodology. Another consideration is that the financially-ESG sustainable growth matrix adds the dimension of comparison between actual growth rates and financial and ESG sustainable growth rates. As financial sustainable growth depends on profitability, investments, and net cash flows (see Bellandi, 2022 for details), and management studies have discussed these features in relation to the product life cycle and the BCG matrix, a linkage may also be established between these two models and financial sustainable growth, which is an inherent feature of the financially-ESG sustainable growth matrix.

Therefore, the first research question is to understand the relationship between, on the one hand, the product life cycle and BCG matrix and, on the other hand, the financial growth axis of the financially-ESG sustainable growth matrix. As that axis is the result of actual sales growth minus financially sustainable growth, the article first studies the implications of positioning the actual growth in the matrix for each phase of the product life cycle and for each quadrant of the BCG matrix. Then, it filters the impact of each of those phases and quadrants on the attributes that determine the financial sustainable growth. The effect on the actual and sustainable growth will predict or explain the positioning of each of these stages and quadrants on the horizontal axis of the financially-ESG sustainable growth matrix. A hypothesis that this article intends to test is that there must be link between the implications of the sales growth dimension in the product life cycle approach and the BCG matrix and the financially-ESG sustainable growth matrix.

The second research question is whether the LCA methodology can help better quantify the ESG impact of each product life cycle stage in the ESG axis of the matrix. Bellandi (2022) uses MSCI ESG rating as a proxy of a company's proximity to its ESG sustainable growth, as an ESG index of sustainable growth does not exist yet. This link with LCA may be a way to create a more precise and punctual quantification of current ESG loads versus ideal or theoretical ESG loads, as better explained in the discussion section of this article. Another hypothesis that this article intends to test is that there must be a link between the product life cycle model and LCA, which may permit to draw ESG implications on the ESG axis of the financially-ESG sustainable growth matrix. If this proves to be correct, there is a potential for further research on how to reuse lessons learnt from management studies on these models in terms of consistency between financial policies and ESG policies.

4. Discussion

4.1 The Link between Product Life Cycle and the Financially-ESG Sustainable Growth Matrix

The basic tenet of the product life cycle model is that a product is naturally deemed to follow a certain pattern from cradle to grave, i.e., the life cycle model, which approximates a bell-shaped curve, commonly divided in four (sometimes five) steps: infancy (also called introduction), growth (herewith development, to avoid confusion with terms used in the sustainable growth matrix), maturity, and decline.

The actual growth rate is an input to the product life cycle approach: high and increasing in the infancy stage, very high in the development phase, low and decreasing in maturity, negative in decline. As each stage has a level or range of growth rates, this may be used as an input to actual growth rate of revenue in the financially-ESG sustainable growth matrix.

As a new ramification, this article enquires which of the features derived from the product life cycle may be relevant to financially sustainable growth, and the answer is investment, profitability, and net cash flows. The past theory cited in the literature review section has established that, in general terms, a product in infancy stage requires high investment in product design and development, advertising and marketing, including setting up specialized distribution channels. Mass production investment characterizes the growth stage, and so advertising and distribution although with a lower weight of respective expenditures on sales. The last two stages mark a decrease in investment, but maturity may increase distribution costs.

In terms of profitability, infancy is associated with negative or low profits, the development phase with high profits, maturity with very low margins and a search for efficiency, while the decline phase decreases margins and triggers a cost saving exercise.

Finally, net cash flows are highly negative in infancy, still negative during development, high in maturity, and positive but decreasing during the decline period.

Therefore, a financially sustainable growth typical of each stage can be derived by looking at investment, profitability, and net cash flows. Infancy would be expected to have a very low financially sustainable growth, because of the high level of investment and low profitability (both decreasing actual ROI), and negative cash flows (increasing external financing needs, possibly debt-to-equity ratio and cost of debt). On the contrary, the development stage would be expected to produce a mid-low sustainable growth, given its high profitability. Of course, its level depends on the amount of investment, which is however lower than in the previous phase although still high, and net cash flows which are turning to positive or even highly positive. In the last two phases it would be reasonable to assume moderate-low sustainable growth: while profits are low because of still high distribution costs albeit low investment, net cash flows are highly positive. Therefore, in terms of positioning on the horizontal axis of the matrix, infancy has an actual growth higher than financially sustainable, development growth has no significant gaps, maturity has an actual growth slower than sustainable, and decline is in a similar situation but with a smaller gap.

Although the product life cycle, which was developed in the 60s-80s, does not tell much on the ESG side, some key points may be inferred. The above-mentioned literature has established that quality of products is generally low in the infancy stage, while it increases as a product improves during the development phase. Product features are stable for mass production in the last two steps, with superior quality in the maturity stage. In maturity the product probably becomes outdated, its features are no longer up with the recent technological innovations, unless product features are rejuvenated in late decline should the product be revamped for a new life. By assuming a direct relationship between quality and ESG compatibility, or by considering design for ESG as a feature of quality, the above findings may give some clue about the potential direction affecting EGS as a function of life cycle. The ESG implications of life cycle will be deepened later in this article through the new theories of LCA. Consequently, in terms of positioning on the vertical axis of the matrix, infancy is assumed to have an actual ESG growth rate faster than ESG compliancy would call for. Development stage is quite balanced on the medium actual growth and sustainable ESG compliancy. In maturity, ESG features would permit a higher growth than actual. In decline, both actual growth and ESG sustainable growth are low.

We can now draw some observations about the implications on the newly developed financially-ESG sustainable growth matrix of the product life cycle model. As Table 1 and Figure 1 show in terms of the financially-ESG sustainable growth matrix, an infancy stage is likely to have an actual growth that is faster than financially sustainable growth. If a low product quality level slows ESG compatible growth, the natural placement of this stage in the matrix would be quadrant 1, which means a non-sustainable growth, both financially and ESG-wide, where both shareholders and stakeholders lose. However, this gap should be read as a current gap: if the product

proves to be successful, ESG compatible and profitable, it will generate higher sustainable growth in the future. The development stage is instead expected to be better balanced: actual financially sustainable growth and ESG sustainable growth are all good or acceptable, placing the segment at the cross of the axes or slightly on Quadrant 4. Maturity means Quadrant 3, that is, unfulfilled financial and ESG potential, or potential for restructuring. Here, the actual sales growth is lower than both financially and ESG sustainable. The decline phase, by decreasing the ESG potential, moves into Quadrant 2, with both ESG and financial growth playing as constraints, unless product improvements are devised. In fact, it is not uncommon that in the decline phase innovation plays a vital role in re-defining products and services for life cycle extension. However, a sales increase would require and ESG improvement for that growth to be societally beneficial.

Table 1. Implications of the Life Cycle Model on the Financially-ESG Sustainable Growth Matrix

Product Life Cycle Stage	Actual Revenue Growth	Financially Sustainable Growth	ESG Sustainable Growth	Financially-ESG sustainable growth Matrix Quadrant	Draft Conclusions
Infancy	High and increasing	Very low	Low	Quadrant 1	Unsustainable growth now: a bet for society and company
Development	Very high	Mid-low	Mid	Cross of the axes or slightly on Quadrant 4	Balanced and fully sustainable growth
Maturity	Low and decreasing	High	Very high	Quadrant 3: financial restructuring needed	Unfulfilled financial and ESG potential, or potential for restructuring. Attention points for society and company to push more
Decline	Negative/ Decreasing	Low	Low	Quadrant 2: stuck, unless innovated	Additional growth requires ESG improvement to be societally beneficial. Attention points for innovation

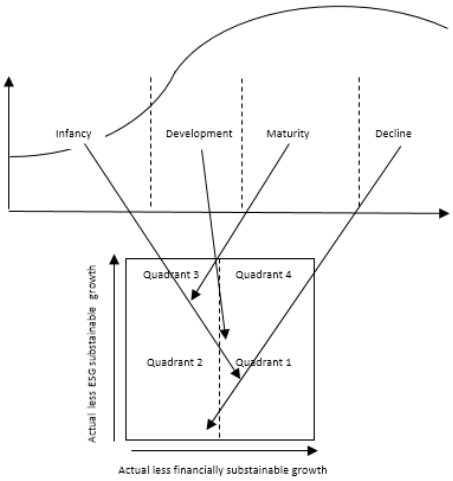

Figure 1. Implications of the life cycle model on the financially-ESG sustainable growth matrix

4.2 The Link between the BCG Matrix and Product Life Cycle

Another intermediate step of the analysis consists in exploring the connections between the BCG matrix and the product life cycle model. The BCG matrix reports a company's relative market share in the horizontal axis and growth rate in the vertical axis. Here, growth rate is for the market, not for a specific company or a product, as an indicator of the attractiveness of that specific market. Conversely, the product life cycle model is at product level (or also applicable at business or company levels). Although this aspect would require a more sophisticated level

of detail, it does not undermine the fundamental logics of analysis that is conducted here. Unlike the BCG matrix, the product life cycle does not consider market share as an explicit variable. Therefore, to overlap the two approaches we need to make some simplifying assumptions. We assume a "natural" patter, where a company's relative market share follows the physiological dynamics in the BCG matrix. We assume that a product/business in infancy is consistent with a 'question mark' quadrant in the BCG matrix. It is too early to decide whether that product/business will develop or will be abandoned. If it does move to the development stage in the product life cycle model and the company does acquire a strong relative market share, it would naturally position itself in the "stars" quadrant. As a company is highly pushing a "star" segment, that product would likely be in the development phase. The logical placement of a mature business in the life cycle model is the "cash cows" quadrant in the BCG matrix. In fact, that product is well established, and the company can cash in the position it has already reached. Finally, a product/business in decline would overlap with the "dogs" quadrant, and the company must decide whether to prune that declining product or invest the cash it generates to maintain it. Of course, all this is directional, as real situations may to a certain extent be at variance.

4.3 The Link between Product Life Cycle and BCG Matrix and the Financially-ESG Sustainable Growth Matrix

The analysis above has shown the link between product life cycle and the newly developed financially-ESG sustainable growth matrix. Now the issue is what the implications of the BCG matrix are in terms of parameters that may affect sustainable growth in the financially-ESG sustainable growth matrix. Again, the key variables to look at are profitability, investment, and net cash flows. The BCG matrix assumes that market share brings cost reduction through the effect of experience curves. In terms of profitability, this means that "stars" and "cash cows" quadrants would have high profits, although "stars" would somewhat require high costs too. In addition, "question marks" require greater costs if the company wants to develop them. Consequently, profitability would be expected to be negative or low. "Question marks" and "dogs" do not have, or do not fully have, those benefits.

In terms of cash flows, the effect of high sales in conjunction with the experience curve also brings a positive relationship between market share and cash flows generation. On the other hand, the faster the growth rate, the more the need for investment, i.e., use of cash flows. "Question marks" and "stars" require very high and high investment, respectively. "Cash cows" necessitate moderate or low investment, while a company would likely disinvest a "dog" or otherwise keep on investing the cash generated to maintain it.

Therefore, a "question marks" quadrant would normally have negative net cash flows (low generation, high use) and therefore likely require external financing, a "stars" quadrant is expected to have limited positive or negative net cash flows (high generation and high use). "Cash cows" would have positive net cash flows (high generation, low utilization), and "dogs" would show limited positive or negative net cash flows (low generation, low utilization). Net cash flows are here intended as the difference between cash generation and cash utilization, like free cash flow.

Therefore, financing needs at this level would likely require external financing, therefore increasing the debt-to-equity ratio and the cost of debt or otherwise increase equity capital issued. In both cases, this would decrease the financially sustainable growth (unless, in the latter case, the expected return of additional investment is more than proportionate to the additional capital raised).

All in all, the financially sustainable growth of a "question mark" is expected to be very low if not null. A "star" would show a mid-low level, a "cash cow" a very high sustainable growth rate, and a "dog" a mid-high level.

The discussion so far answers the first research question, i.e., the relationship between the product life cycle and BCG matrix and, on the other hand, the financial growth axis of the financially-ESG sustainable growth matrix.

For what concern the ESG dimension, this is drafted here based on considerations on quality and product design in the different stages of the product life cycle that have been identified in traditional literature. The ESG variable will be better investigated below to address the second research question. Like the infancy stage in the life cycle model, "question marks" present an actual growth that is faster than financially sustainable growth. If a low-quality product slows EGS compatible growth, the natural placement of this stage in the matrix would be Quadrant 1, which means a non-sustainable growth where both shareholders and stakeholders lose. Again, this gap should be read as a current gap: if the product proves to be successful, ESG compatible and profitable, it will generate higher sustainable growth in the future. For "stars", actual financially sustainable growth and ESG sustainable growth are all good or acceptable, placing the segment at the cross of the axes or slightly on Quadrant 4. "Cash cows" means Quadrant 3, that is, unfulfilled financial and ESG potential, or potential for restructuring. Here, financially sustainable growth is probably rated very high, versus high in mature products. Finally, "dogs" would be expected in Quadrant 2, similarly to products in decline in the life cycle model.

Figure 2 illustrates how all these factors tend to determine a natural correspondence between the BCG matrix and the financially-ESG sustainable growth matrix. A final warning: the BCG matrix follows a portfolio concept. Although it may be applied to a company overall, it is thought at business unit level to analyze the consistency of a portfolio of business. This again is not an issue, as the same level of analysis can be applied to the financially-ESG sustainable growth matrix.

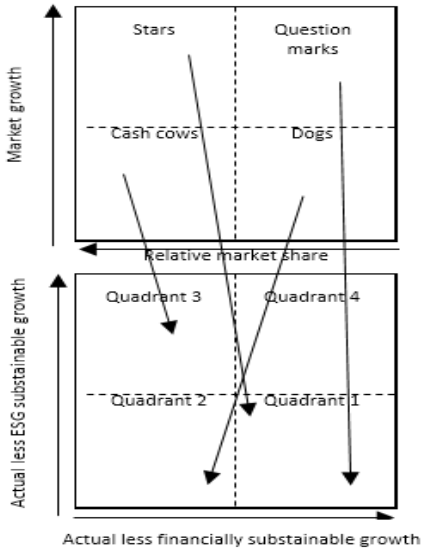

Figure 2. Implications of the BCG matrix on the financially-ESG sustainable growth matrix

Now, Table 2 illustrates the conclusions on the links between these two traditional corporate strategy models (the product life cycle and the BCG matrix) and the sustainable financially-ESG sustainable growth matrix. The impact of the BCG matrix tends to overlap to that drawn in Table 1 for the life cycle model.

Table 2. Implications of the BCG matrix on the financially-ESG sustainable growth matrix

BCG Matrix	Actual Revenue Growth	"Natural" Placement in the Life Cycle Model	Financially Sustainable Growth	ESG Sustainable Growth	Financially-ESG sustainable growth Matrix Quadrant
Question marks	High	Infancy	Very low	Low	Quadrant 1
Stars	Very high	Development	Mid-low	Mid	Cross of the axes or slightly on Quadrant 4
Cash cows	Low/Decreasing	Maturity	High or very high	Very high	Quadrant 3: financial restructuring needed
Dogs	Negative/Decreasing	Decline	Low	Low	Quadrant 2: stuck, unless innovated

4.4 The Link between Product Life Cycle and Life-Cycle Assessment

The LCA methodology consists of certain steps: defining the goal and scope, creating the life-cycle inventory analysis (LCI) of inputs and outputs, assessing the potential environmental impacts (life cycle impact assessment – LCIA), interpreting the results, reporting and critical review, considering limitations of the LCA, drawing relationships between the LCA phases, and understanding the conditions for use of value choices and optional elements.

To answer the second research question, i.e., whether the LCA methodology can help better quantify the ESG

impact of each product life cycle stage in the ESG axis of the matrix, key is whether the LCA concept can be escalated up to be integrated into an ESG growth strategy formulation, i.e., used as one of the inputs to the financially-ESG sustainable growth matrix.

In terms of unit of account, it may be argued that the LCA methodology is more evident when applied to long-lived products, such as buildings, as it can analyze the environmental impact in each of the construction phase. However, the LCA might be reasonably applied to any product. Second, it may be reasonably held that such a methodology could be extended to a "business" concept of life cycle that is typically used in management and business studies (e.g., from product introduction to marketing launch to face-lifting, life extension or rejuvenation of a product in the maturity stage) and not only taken from an engineering perspective. The following discussion intends to show how this can be done.

It is reasonable to expect that a "micro" LCA might be apply to each stage of the life cycle model of a product. To illustrate, assume that a product has a typical LCA cycle from raw materials to storage in, manufacturing, assembly, packaging, storage out, transportation, wholesale, retail, installation, use, maintenance, reuse, scrapping or disposal, and recycle. To the extent that product is produced and sold in all of the life cycle stages, all or part of the steps in that LCA cycle will be performed in each of the four phases of the life cycle model. The key point is that the selection of which of these processes will be done, the way they will be done, their lengths, methods used, and their ESG loads will vary depending on the phase of the life cycle model, because each of them will strategically focus on different activities and steps depending on the configuration and features of product and the business model employed in that phase of the life cycle. This is because in the infancy stage the knowledge of that product is still initial, the methods are introductory and customers reaction is largely unknown. Conversely, in the maturity phase, for example, the company may induce customers to use the product more, in different occasions, differently, or even modifying it for a different application. This may mean changing customer targets and therefore distribution channels, moving to different production processes or technologies. Also, technology is better known later in the product life cycle, and new techniques may have been developed. For example, Cao et al. (2012) note that a product in infancy stage would ordinarily have a shorter lifespan for its first customers and probably a good end-of-life recovery value. A product in growth phase may have flaws in design and a lower quality to require more service and remanufacturing in the end-of-life stage. Servicing second-hand products that are in the phase of decline may be problematic due to lack of spare parts.

All in all, LCA blueprints and the consequent ESG loads would be expected to change for the same product in each of the four phases of the life cycle model. Another scenario may also exist. A product may be developed for a limited, partial application in the infancy stage, therefore involving less steps of the LCA cycle. Then, as time passes by, the industry may develop new applications, uses, product features, etc., changing radically the production process, its steps and lengths, hence impacting the LCA results.

This exercise of linking the LCA methodology to the product life cycle approach may have dramatic consequences. In fact, because of the logics explained above, it may permit to associate specific LCA cycles to the business life cycle of a product and to attribute ESG weights, which would allow to assess the ESG rating of each of the life cycle phases for the same product. In the logics of the financially-ESG sustainable growth matrix, this means being able to better quantify the ESG growth dimension and conclude whether the actual ESG positioning of a product in a stage is superior or inferior to its benchmark. A benchmark may be defined both on an internal-relative basis (each stage to the others, where the best ESG performant one is considered the benchmark), or on an external basis (the company versus its industry or peers, considered as a benchmark), or on a normative basis (the actual LCA against what the LCA would look like for an ESG optimized process for that product). As it becomes clear now, ESG sustainable growth rate for that company might be assumed at the ESG benchmark level associated to that ideal LCA optimized product cycle, or to the industry leaders, or the best internal relative ESG outcome. This is an important point, given that Bellandi (2022) has caveated that an ESG growth indicator does not exist yet, and therefore has used a proxy in the financially-ESG sustainable growth matrix. This association may solve this issue by creating an ESG growth indicator. Figure 3 illustrates.

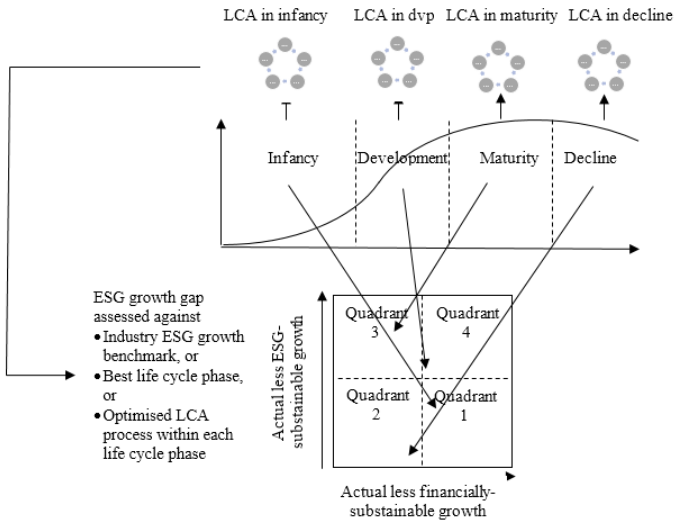

Figure 3. LCA integrated in the financially-ESG sustainable growth matrix

Finally, this new direction of study would permit to evidence alternative ESG improvements in each stage of the life cycle model that may make a product more ESG compliant, therefore suggesting strategies to improve the ESG rating of a business or a company.

In summary, in terms of the financially-ESG sustainable growth matrix, an ESG-sustainable growth rate might be better quantified and attached to the different features, processes, systems, and inputs that can make the same product ESG compliant. Of course, the use of LCA in this perspective would require a clear specification of this in the goal definition and scoping. Also, a clear definition of the functional unit of analysis is necessary. As the financially-ESG sustainable growth matrix may be applied at product, business, or company level, any misunderstanding of what is going to be assessed should be avoided.

This perspective is functional to business strategy and planning, not necessarily intended to go down to a level of detail from an engineering perspective. This is a new direction of research, to which a more specific study may follow.

5. Conclusions

This article shows how both the product life cycle approach and the BCG matrix can be linked as inputs to the sales growth axis of the financially-ESG sustainable growth matrix created by Bellandi (2022) to determine both the actual revenue growth and the financially sustainable revenue growth associated to each stage of a product life cycle and each quadrant of the BCG matrix. The article also illustrates how the LCA methodology can be linked to the product life cycle model, and better quantify the ESG impact of each product life cycle stage on the ESG axis of the financially-ESG sustainable growth matrix. Finally, it builds a full picture of integration of the product life cycle approach, BCG matrix, and LCA methodology into the financially-ESG sustainable growth matrix.

Some additional conclusions may be drawn from both a static and a dynamic analysis. As to the former, this article shows that the reading of both product life cycle and BCG matrix can be expanded from a proprietory (shareholders) to a societal (other stakeholders) perspective.

In an infancy stage or for a “question mark” product, both investors and society at large invest in a product that at that moment appears not to be sustainable. The issue is whether it will become an ESG threat, and whether it will turn to be profitable. If their bet proves to be successful, a development-stage product, even more if qualifying as a “star”, will become balanced from both angles. The real question is whether that product can be developed without representing an ESG burden to the society. If all cumulated effects to shareholders and other stakeholders are a net positive, it is generally held to be desirable. As the product matures and/or becomes a “cash cow”, some face lifting may be necessary, both to accommodate new ESG requirements and its actual financial growth. Finally, a declining product, likely a “dog”, may represent a hazard, i.e., societally undesirable, as outdated as to ESG compatibility, unless innovation extends its life and improves its ESG characteristics. Although this is a known concept from an economic perspective, the new dimension is the attention to ESG breakthroughs that may strike the societal balance positive again.

From a dynamic analysis standpoint, the traditional success and disaster sequences of the BCG matrix may be tested from the perspective of the financially-ESG sustainable growth matrix. The ideal sequence identified along the BCG matrix is a product moving from being a "question mark" to a "star", to a "cash cow", to finally a "dog". From the perspective of the financially-ESG sustainable growth matrix, this means that such a product moves from a situation where both shareholders and stakeholders lose (Quadrant 1 of that matrix) to Quadrant 4 where shareholders subsidize the other stakeholders, to a need to restructuring (unfulfilled financial and ESG potential in Quadrant 3), to Quadrant 2 where other stakeholders subsidize shareholders. There are two serious ESG gaps: in Quadrant 1 (applicable to infancy or "question mark" products) and Quadrant 2 (decline or "dogs" products) where ESG efforts would need a rebalancing. The disaster sequence in the BCG matrix (a "star" product becoming a "question mark" and then a "dog") clearly shows the worst of ESG gaps. Although the product life cycle and the BCG matrix may be functional to a portfolio strategy from an economic perspective, the soundness of the big "societal portfolio" depends on how many industries and sectors are in those stages, a new approach to industrial policy.

Finally, this article shows how the LCA methodology may represent an input to convey a more precise assessment of ESG growth versus ESG sustainable growth in the vertical axis of the financially-ESG sustainable growth matrix. This is an important point, given that an ESG growth indicator does not exist yet. This exercise of linking the LCA methodology to the product life cycle approach may permit to associate specific LCA cycles to the business life cycle of a product and to attribute ESG weights, which would allow to assess the ESG rating of each of the life cycle phases. It would also permit to evidence alternative ESG improvements in each stage of the life cycle model that may make a product more ESG compliant, therefore suggesting strategies to improve the ESG rating of a business or a company.

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