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Understanding the Growth by KILT Model and TYPUS Metrics

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Abstract: The goal of the study is investigating the odd claim of the human civilisation, which modifies the wild *natural* surrounds by *synthetic* alterations, defined improvements, bestowing ‹value added›. Indeed, the history seems sanctioning that the ‹life-quality› on the earth has been expanding, with enhanced chances and increased resources, compared to the native prospects of the wilderness. Only at the millennium turnover, the ecology globalisation shows the impeding threats of over-depletion/pollution, exceeding the extant recovery and reclamation capabilities of the environment. The new imperative turns to be the ‹sustainable growth›, with caginess in defining if the trends can be positive, being conditioned by the empowered recycling, retrieval and renovation measures. In fact, *sustainability* requires *lifecycle* supply-chain visibility, resource bookkeeping and revamp planning. The lifecycle starts when the idea of a product is born and lasts until complete disposal after realisation and operation. In the musts' specification/analysis, the crucial policy (global plans, detailed design, assembly plots, etc.) are followed by manufacturing, testing, delivery, diagnostics and operation, advertising, service, maintenance, etc.; then, disassembly and firing are scheduled, requiring reclamation and recovery, via re-cycling (material reprocessing) or re-using (part refurbishing). The present study summarises pilot cues for understanding the product-process agendas, using the **TYPUS** metrics and the ***KILT*** model, prospected by the authors, in previous works.

Keywords: Lifecycle Management, Economy Globalisation, Ecology Globalisation, Sustainable Growth, Eco-Project
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1 Introduction

The civilisation is founded on the intentional alteration of the earth surroundings, due to come-up singularities: the *life*, by the ‹agentive› wherewithal, promoting self-proliferation; and the *intelligence*, by the ‹rationality› empowerment, granting decisional skill. The *active* self-propagation allows organising the ambience, trailing the ‹fitness rule›, namely, adapting the current life-forms to the extant driving conditions. The *cogent* decision-making lets choosing pace-wise improvements, and rejecting damages, on condition of conscious understanding of observers/actors, gifted of free will. The discussion on the *life*/*intelligence* singularities is omitted, still, we can tell that the humans are peculiar observers/actors: the civilisation requires the

pre-existence of rather weird requisites and the pre-setting of quite specific moves, to enable suited positive fallouts.

The *agentive*/*rational* alteration of the *natural* sceneries is oriented towards creating political and economic oddities, i.e., the assembly of clans, companies and countries and the setting of barters, trades and chattels. The lists include, at first, ‹collective order› examples, and, subsequently, ‹business tidiness› options. The itemised *inventions* connect to the *mind* worlds. They are intangible construal: the ‹collective order› permits generating political value added; the ‹business tidiness› consents arranging vocations and backing transactions. Nothing similar exists in the *natural* spheres, not even, in the animal realms out of the mankind idiosyncrasy. The civilisation, on these grounds, builds on mind inventions, i.e., on the culture and ethics artefacts, passing knowledge pieces and principled behaviours of individuals and communities. The intangible hue of the changes is *intelligence* driven, sanctioning mankind survival and growth deployment by series of methods, typically summarised as [Huemer 2013], [Palombella 2013], [Schmidt 2013], [Thompson 2013], [Walter 2013]:

- the *opportunistic* economy of pickers/hunters attaining sustenance from current wild sources;
- the *transformation* economy of actors using planned produce and manufacturing alternatives;
- the *chomp* economy of players drawing over-depletion/pollution, in regard to native recovery.

The initial way is just agentive driven, in common with animals; it will be fateful, if similar to locust behaviour. The next mode is *rational* chance, chiefly, supported by technical know-how; the *agricultural* and the *industrial* revolutions are the noteworthy innovations, timely, pioneered by mankind. The last practice is impending threat of ecology shifts; it is manifest that the *rationality* requires revising the *transformation* plans. However, the shortly recalled cues tell that the growth is complex outcome: the ‹value added› develops on culture and ethics artefacts, making tough extricating which input or role has critical fallouts. The analyses of this study provide exploratory hints, to decrease the involvedness of the new millennium challenge, using the ‹sustainable growth› concepts related to the distinct ‹value added› sources that are actually involved. The dealing is limited to the technical aspects; an extended list of reference books is provided, to suggest a further reading and to reach a better understanding of the outlined frames.

2 The References and Goals

The men, looking at their surrounds, are aware of the ‹becoming›. To deal with it, the accounts look at *mechanistic* or *organismal* readings. The former attains coherence by the ‹natural laws›; the latter, by the ‹life› singularity. However, this requires metabolism processes, with suited foodstuffs and continuous chains; i.e., it stops without apt sources. From the very set off, the men recognise that their survival (and growth) depends on the ‹natural capital› availability. Later, it turns out that the *opportunistic* way is only solution for the life-forms, but the ‹intelligence› singularity permits choices. The alternatives are ‹human capital› construal. The issues could stay

unspoken, bringing about the ‹collective order› and ‹business tidiness› inventions. They might be formalised into lumped specification, in view of assessing the value added trends by, maybe, the ‹financial capital›, or, also, aiming at the transformation know-how by the ‹technical capital›.

The ‹human capital› is recalled to complement ‹ethics› and ‹culture› assets. It is permanent motor of the civilisation, involving intended goals. The ‹technical capital› contribution appears, since the beginning, crucial support, because the processes with high value-added require expertise and professionalism. The two are often left hidden elements, as, in an entrepreneurial project, the explicit lumped specification is, just, done by the ‹financial capital›, singling out the *money*, as trade support. With the ecology globalisation, the relevance of the raw materials turns critical: it is no more allowed to neglect earth stocks as if they are inexhaustible and as if their use does not contaminate the biosphere when the end-of-life parts are dropped. The explicit balance of the ‹natural capital›, then, is imperative, because a different course is dishonest: it steals benefits to individuals and companies, presently enjoying the grabbed ‹natural capital›, and it leaves waste and pollution to third people and to future generations, [Petersen 2013], [Sainsbury 2013], [Schwager 2013], [Temin 2013], [Torvinen 2013].

From now on, ecology requires the whole rethinking of trade and business implements. The return on investment is considerably dependent on the scale dealings of the *native* provisions. The enterprise's profitability is forced to look at ingenious resort to the *artificial* stocks, raising value-added from intangibles. The focus on ‹technical capital›, aims at invention-and-inventor centred innovations, fostering the intellectual activity rewarding. The community *vs*. enterprise partition shows that the latter characterises, from the onset, by the *knowledge* processing, which qualifies a structured body, aimed at business goals. The singling out of layered collective orders at *public* interests, within governmental ranges is feature, enhancing the efficiency of the western style industrialism, particularly evident along with the three last centuries. The future will require revising most of ‹collective order› and ‹business tidiness› concepts, because such synthetic habits do not anymore provide the past helpfulness. In the following, factual details are summarised, to better analyse the ‹added› trends, rooted in the (above mentioned) four capital assets.

2.1 The Standard References

The separation of four capital assets does not mix-up their actual roles. Only the ‹human› and ‹natural› items belong to intangibles; the ‹technical› and ‹financial› pieces are mind constructions. At first, the ‹technical› contribution did not appear explicitly, maybe, ascribed as God's award, not requiring separate inventory. Later, the division from the ‹human capital› distinguishes sets of opportunities, namely:

- the intrinsic benefits, bestowed by the ‹cohesion bonds› of groups/nations;
- the definite value-added, developed by ‹workforce›, along manufacturing;
- the in-built improvements, supplied by entrusting fit ‹mind by-products›;
- the explicit advantages, obtained after applying purposeful ‹know-how›;
- the implicit metrics, giving ‹legal assessment and replacement› choices;
- the fit money, ‹jack-of-all-trades›, quickly converted in different items.

The list exemplifies the *constituent* either *instrument* functions of the assets,

selecting the ‹human›, ‹technical› and ‹financial› roles. Each time, we discriminate two supplementary tracks: the first most likely implied. At the end, we can establish the following definitions, [Caldararo 2013], [Raynor 2013], [Stockman 2013], [Thompson and Gutmann 2013], [Versiero 2013]:

- the *human capital* is the stock of latent wealth, present in the interacting organised society, the engaged labour forces and the related citizens' relational capabilities and wherewithal;
- the *technical capital* is the stock of the cumulated assets in useful know-how and other technological tools, with the inclusion of robot life-and-intelligence processes, among the routine transformations;
- the *financial capital* is the stock of the cumulated wealth in money and any other official or *de facto* payment means, with management of structured products and asset-based enhancers.

The division of the *instrument* function has a long history with ‹money›; it is already evident with ‹workforce› in the industrialism; it is expected playing essential duties with the ‹cognitive revolution› by the robot age advances. In actual facts, the explicit lumping of the ‹technical› and ‹financial› assets simplifies the analyses on the ‹value added› building. The ‹natural capital› remains central concern of the ecology globalisation, [Gorbis 2013], [Mourlon-Druol 2013], [Polak 2013], [Rogers 2013], [Vargas 2013]. It defines:

- the *natural capital* is the stock of potential wealth present in tangible resources, piled up as earth resources, and/or obtained by the processing/reprocessing of the extant material provisioning.

For sure, the four capitals are appraised only once the ‹money› is defined. Only the men have to deal with assets and chattels, and are involved with ‹cohesion bond› worth or ‹knowledge› expediency. By the *transformation* economy, the ‹natural capital› value-added is confined into mere handlings and basic treatments: during the agriculture age, limited to renewable stuffs; during the industry one, entailing non-renewable extents. The ‹technical capital› is *necessary* but not *sufficient* guide for fit value-added transformations. With the *cognitive* revolution, it will play relevant *constituent* roles, further to *instrument* ones, developing and making use of ‹embedded laws› of *agentive*/*rational* processes. In like time, this coded know-how evolves together with the general organisation ‹laws› of man's collective society, preserving the critical leadership to the ‹human capital›. The *constituent* functions are robot age privilege, exploring direct resort to joint *artificial* life/intelligence operations. The *cognitive* revolution is required avoiding the *chomp* economy pitfalls.

2.2 The Goal Organisation

The goal of the study addresses the sketched frameworks, dealing with *lifecycle conformance certification*, LCC, by *product lifecycle manager*, PLM, for inclusive product-service specification, adding *service engineerin*g, SE, and *reverse logistics*, RL, for oriented requirements. The lifecycle starts when the idea of a product (service, etc.) sprouts, and lasts until the disposal (or reuse, recycling) of the given delivery. In the first phase, the requirements gather analyses and planning (global/detailed/assembly plots, etc.); then, we deal with part manufacturing, testing, delivery, diagnostics and servicing. Control, advertising, sales and service (maintenance and repair, etc.) are parts of the LCC. Finally, when the product is worn

out or becomes useless, there is destruction (disposal) or recovery (e.g. disassembly of used, but useful parts) or recycling (e.g. melting again). These processes need to be modelled at the design stage, with enterprise's commitments depending on the complexity of the supply chain, [Goti 2010], [Moffat 2011], [Popov 1997], [Teuteberg 2010], [Viana 2010].

The lifecycle conformance certification shall appraise the ecology footprint (environmental effects, energy/material-consumption, CO_2 emission, etc.) of manufacturing and operation of different products and services. A known balance states: *a cup of coffee needs the consumption of 600 litres of water, if everything is taken into account* (all included, from watering plants, to dish washing). The goal is clearly defined; nonetheless, the solving proposals are quite poor. The ***KILT*** model and **TYPUS** metrics are purposely specified, to make the analyses consistent [Cascini 2008], [Michelini 2000], [Michelini 2002], [Putnik 2005], [Putnik 2007]. The main goal needs to model and quantify the complete supply (products, by-products, trash and their effects) of the firm, and to enumerate all the relevant steps of the whole LCC course, with related overall figures.

The renovation of the world socio-economic layouts requires unique changes, aiming at sustainable development by the establishment of fit ‹sustainable corporations›, having the lifecycle responsibility of the supply chain, under suitable accreditation and certification schemes. In connection, some notions and linked relationships are worthy compulsions, rooted in the suited LCC points of view, [Abele 2005], [Cruz Cunha 2013], [Kahraman 2009], [Odum 1971], [Wills 2009]:

- to use products-services, specified on the extended enterprise's operation spheres;
- to discern between the abilities provided by a facility and the tangible supply chains;
- to distinguish amongst the tangible and intangible value-added provided by a delivery.

The future results will help examining the on-duty corporation eco-consistency. Moreover, the enterprise policy (as singled out fallout) can be evaluated, taking into account several environmental, ecological, human and other issues of the sustainable development and, notably, their eco-consistency.

3 The Renewable and Non-renewable Stocks

The *ecology* warning, with the tied restriction on *spontaneous* changes, which further totally do not alter the existing equilibriums, is quite recent entry in the society scientific background, based on the otherwise impending threats of the over-pollution and over-consumption. The uncontaminated nature, as perfect model of virtue is recurrent image, rich of charm. The concept is, unhappily, rather entangled, having links with extraordinary numbers of facts affecting the humanity history. The intricacy of those notions depends on the *nature-culture* opposition, assuming that wilderness is primary state, and civilization is artificial modification. Such *nurture* conflict assumes that the bringing up (or fostering care from the nursery) modifies the inborn idyllic attributes. Quite the opposite, men have the civilisation mission, if we trust the anthropic principles, in strong or weak form, [Barrow 1991], [Campbell

2001], [Close 2012], [Strawson 2006], [Zobaa 2011], believing in the ‹nature› matching utility.

The ecologic fundamentalism clashes against the anthropic principle. In point of fact, the man aspires to transcend the current nature, in view to justify the intrusion, through explicit acts and instances and to improve his surroundings. The hope might apply to the transcendent God; otherwise the dream relates to the evolution, and the struggle for life is expected leading to the best-fit winners. These pictures are recurrent vision, instituting the *progress* is fundamentalism of the human capital champions. It is, however, factual acknowledgement that the life quality is wholly *artificial* option. Even without naive hopes, the civilisation can enjoy *a posteriori* entrustments.

Today, the *ecologism* encounters the damages of the industrial activity, founded on the manufacture transformation efficiency, making withdrawals from finite earth stocks, and piling up garbage and pollutant amounts, exceeding the natural recovery potentials. Hence, *natural* opposes to *artificial*, in view to limit dumping and contamination, moving back the growth rate at pre-industry figures. In the anthropic vision, the *nature* never opposes to the *man*, being, in the reality, only helpful complement of the progress. Besides, the term ‹natural capital› is a recent designation, proposed by the ecology movements, but it matches quite obvious issues, as above outlined.

The designation is, moreover, notably effective, when right bookkeeping schemes are requested. The production of everything necessitates material, which, unavoidably, ought to be taken from somewhere. The balances split up the renewable and the non-renewable resources. The latter shall classify in terms of (upfront, instrument, etc.) usefulness, (express, ensuing, etc.) toxicity, (local, global, etc.) rarity, and so on, assuming the unidirectional flow from the provisioning, to useful ends. The *point-of-sale* denotes the manufacturer's interest, leaving the entire responsibility of the use, misuse and disposal to the purchasers. These irresponsible supply chains are made legal by the current bylaws, to be, in reality, better classified as superficiality or swindle. The description relies on an *economic* productivity, defined on manufacture, while exploiting the instant supply/demand balance in the material's provision, with no worry for the surround. The tax system follows similar logics: e.g., the VAT moves along the supply chain, charging the increments, utterly neglecting the correlated spoil amounts and effluence levels. As said, the method is faulty: the earth stocks will run out; the environment will turn lethal; only the today consumers (producers and buyers) profit.

The outlined remarks require revising the existing attitude about the supply chains. The distinction between the tangible and intangible aspects of a delivery requires aiming at transformations, which maximise the value-added conferred by the latter one, [Ashegiran 2001], [Freedman 2006], [Muñoz 2009], [Sroufe 2007], [Tischner 2001]; the following points deserve notice:

- the intangibles, chiefly, relate to wily treatments, rooted in financial and technical capitals;
- the tangibles engage the natural capital by instrument/constituent setups of the human one;
- the business stability needs a model for the explicit evaluation of all the (four) capital assets;

- the lawfulness requires an (example) metrics for the tangibles' appraisal, by legal metrology.

The above four points stress again concepts widely examined: the need to give autonomy to the natural capital, in view that the visibility might motivate enhanced eco-consciousness; the manufacturers' responsibility on the product lifecycle, leaving aside the misleading restriction on the consumers. Both concepts are, perhaps, obvious, but are late in the awareness of many current operators, which prefer naive (actually, *egoistic*) simplifying assumptions, not to give visibility to the ecology cycle. On these points, more virtuous supply chains are deemed to establish, aiming at better balancing the available resources, not to permit the hoardings and lootings of confident profiteers.

3.1 Financial Capital Prospects

The money is ancient invention, providing the market efficiency, and replacing the barter. The earliest settings addressed an impractical unit, a pecus say a *goat* (from which *pecuniary* means), suitably replaced by metal coins. The money is the substitute of goods, having *worth* standardised according to covenants and sanctioned by the ruling authority. It is not, by itself, *wealth*, but instance of *wealth*, readily becoming currency, for trade setups. The instrument role of the financial flows is identified by bank and banking transactions, with twin executions, [Sudoh 2005], [Tepper 2009], [Wiggin 2009], [Wolf 2008], [Zweig 2007]:

- credit management, creating venture companies, looking at profit through risk investments;
- debt management, offering loans at interest, originating asset-backed security engagements.

The current economic globalisation sees the finance market encumbered by offers of *sovereign* debt, for amounts exceeding the GDP, as governments need bigger loans for the current expenditures. The situation tempts speculative bubbles, in which the *structured* finance exploits creating *virtual* wealth, making profit from the indebtedness of the weaker countries. The *virtual* wealth manoeuvres deserve due deepening, but are out of the present interests.

3.2 Technical Capital Prospects

The man controlled industrial cycles are recent conquest. The *industrial* revolution is considered to be typical outcome of the *capitalism*, especially promoted by venture companies, which are entitled to pursue public and private profits, backed by nation-state. Widespread exploitation of *artificial energy* is primary technological innovation; the steam power is original enabler. The subsequent trend, being recent achievement, has throughout descriptions. The industry, fundamentally, defines as the business establishment, which nicely exploits structured work-organisation and the facility-integration: this brings to the workforce worth, readily included, as the human capital.

The ‹industry› concept entails more details. Its meaning is: branch of trade or manufacturing, assuring productive efficiency; or diligence and habitual employment in useful activities (*industrious* is equal to *diligent*). The industrial *revolution* has turned the old (third) meaning, in the other two. The process is somehow mirror of the

one pursued by the word culture, from the land cultivation, to the people instruction. All rounds, the technical capital is, until today, the prime instrument driving the progress, enhancing the planning of the transformation economy.

As said, in its original form, the industry was based on the *scientific* work-organisation and the *economy of scale* through the mass-production. The robot technologies have brought out the *intelligent* work-organisation and the *economy-of-scope*, by the one-of-a-kind manufacture. The *industry* patterns undergo changes; the variations amplify the opportunities, which add to the ones offered by the *agricultural* revolution, compelled to move at the *natural* life pace.

The industrialism has promoted the affluent society and consumerism. The drawbacks are well assessed; they open impending threats to the earth progress. The manufacture process concerns *non-renewable* resources. The irreversible transformations deteriorate the surroundings, with damages to the bio-sphere. The changes towards the *intelligent* work-organisation depend on integrating computer engineering tools. These are recognised as key help to dematerialise, and relevant support for the natural capital bookkeeping.

Once made clear the negative aspects of the industrialism, the search for remedies shall start. The total suppression of the material goods is just non-sense. The burning up of inanimate stuffs is standard process to carry on the vital cycles. The resort to *artificial* energy highly (and selectively) speeds up the consumption rates, but again, the simple suppression of the option is gibberish, not to wipe out the current quality of life. The doable remedies are, quite sadly, only partial and temporary, [Chen 2009], [Helm 2012], [Pastorok 2001], [Steher 2009], [Walker 2008]:

- to augment the tangibles' productivity, obtaining larger output, while lowering the native exploited input (by process effectiveness and recovery/reclamation closure);
- to discover suited to re-materialise cycles, renewing the amount of useful earth stocks, at artificial rates (robot age technology transformations).

The success of remedies will not aim at the unlimited progress, rather at *bounded-growth*, linked to *weak* anthropic bio-sphere's duration forecasts. The current engineering concerns aim at how to improve the resource effectiveness. They include a mix of opportunities, such as the following:

- to reinvent the manufacture cycles, under resource-manager liability;
- to avoid waste, planning closed-flows, chaining outputs into inputs;
- to deliver functions, replacing goods, under unified overseeing;
- to invent domotics, optimising the energy controlled delivery;
- to supply lifecycle-service, doing maintenance and refurbishing;
- to perform reverse-logistics, up to mandatory recovery targets.

The example list shows already well understood businesses, which are deemed to expand in the near future. The to re-materialise remedy is longer term issue, involving, most likely, the agricultural ideas, to deal with animated resources, and to exploit suitable bio-mimicry transformations, which enable the related self-reproduction capacities. It is now not possible to abolish the industrial products; the remedies aim at finding out conservative tracks and replacement means, according to suitably planned restoring/remediation criteria.

The doable remedies have the extra imperative trait of urgency. The climate changes hurry up the need of lowering the contamination, starting by the CO_2

emission. This comes from the oxidization processes, including the ones of animal life. The earth atmosphere is highly oxidising, having the 21% of oxygen. Some 4.5 billion years ago, the atmosphere was reducing. The actions of photo-synthesis moved to today's balance; without it, the CO_2 would become dominant. The current composition is only marginally stable: at higher O_2 concentration, self-combustion establishes (24% of O_2). Besides, the living beings need energy, and mainly exploit the $2H_2 + O_2 \Rightarrow 2H_2O$, fairly exothermic reaction, which allows keeping life-suited temperature.

The today atmosphere has the 0.05% CO_2 (78% nitrogen, 1% argon). Bigger CO_2 emissions will rise side fallouts (greenhouse effect, etc.), altering the biosphere equilibrium. The real dynamics depends on multiple factors. Several models are in use, to simulate potential scenarios. The control of the CO_2 emission is critical request, to preserve the rather peculiar earth habitat, having negligible CO_2, in spite of a too oxidizing atmosphere. The environment-industry will become tomorrow's key business, which adds to the entrepreneurial developments. The innovation is a technical capital challenge.

4 The Shop-floor Modelling: Industrial Approach

The manufacture activity cannot be suppressed, even while the transformation of raw materials, based on *artificial* energy, is paradigmatic example of consumerism and natural capital decay. When planning for remedies, we need to look at apt models, in keeping two fundamental demands, [Cruz Cunha 2009], [Michelini 2010], [Michelini 2012], [Pardue 2009], [Quintela Varajao 2009]:

- to recognise that the natural capital use requests refunding of all the withdrawals;
- to assess and to bill the materials costs, with resort to fair legal metrology schemes.

The former is shortly outlined in the following point; the latter is considered in the fifth paragraph.

4.1 The KILT Model

The refunding needs synthetic models, defining the manufacture process. The portray links the delivered quantities, $\boldsymbol{Q}$, to the four capital assets: technical $\boldsymbol{K}$, financial $\boldsymbol{I}$, human $\boldsymbol{L}$ and natural $\boldsymbol{T}$; earlier models limit to financial $\boldsymbol{I}$ and human $\boldsymbol{L}$ capitals. Simple relations are in use to specify the instant $\boldsymbol{Q}$ or the incremental $\Delta\boldsymbol{Q}$ quantities:

- $\boldsymbol{Q}^{\circ} = \alpha_o\, \boldsymbol{IL}$; $\boldsymbol{Q}^{*} = \gamma_o\, \boldsymbol{KILT}$
- $\Delta\boldsymbol{Q}^{\circ} = \beta_o\, \boldsymbol{IL} - \beta_I \boldsymbol{I} - \beta_L \boldsymbol{L}$; $\Delta\boldsymbol{Q}^{*} = \delta_o\, \boldsymbol{KILT} - \delta_K \boldsymbol{K} - \delta_I \boldsymbol{I} - \delta_L \boldsymbol{L} - \delta_T \boldsymbol{T}$

The know-how $\boldsymbol{K}$ innovation has non negligible effects on the tangibles' $\boldsymbol{T}$ bookkeeping. In the scheme, all the contributed technical $\boldsymbol{K}$, financial $\boldsymbol{I}$, human $\boldsymbol{L}$ and natural $\boldsymbol{T}$ capitals are included, to supply evident account of tangibles and intangible effects. The tetra-linear dependence presumes to operate nearby equilibrated assets. With optimised choices, the negative extras of the incremental balances accomplish the sensitivity analyses, separately giving the individual asset contributions. The balance requires transforming all the assets in *money*.

In the $\boldsymbol{KILT}$ model, lacking one contribution, the balance is lame: the found

productivity figures become untruthful or meaningless. The analyses investigate the piling up invariance against the resort to non-proprietary technologies, or to off-the-market loans, or to work out-sourcing or productive break-up. The *money* transformation requires cautions.

In fact, the tetra-linear dependence means the equivalence of assets alone, and their synergic cumulated action. The company return is optimal, if the (scaled) factors are balanced; the current scaling shall express in a *single* money the four capitals (the output ***Q*** has proper value, with the four inputs homogeneity). The return vanishes or becomes loss, if one contribution disappears. The loss represents the imbalance between the constituent flows: know-how, money, work out-sourcing, bought semi-finished parts, or the likes, as if one asset could become useless.

In the bi-linear model, the tangibles ***T*** (utilities or commodities) are attainable without limits. They do not affect the manufacture business; the affordable growth trend is undefined. The changes in technology, knowledge or know-how simply rescale the productivity of tangibles, processed along the material flow. The *new* model presumes the direct concern of the sustainability bounds for energy saving, pollution avoidance, natural goods preservation, and the like. These bounds require introducing the figure of the resource *efficiency*. The replacement of material goods is a cost for the society, with non-negligible environmental impacts, which shall be paid by the holders of benefits (and not poured out on third people and future community).

The earlier dependence on the financial ***I*** and human ***L*** capitals is perhaps the result of the dialectic opposition between plant owners and labour. Yet, the neglect of the tangibles ***T*** factor is surprising, as the manufacture duty has no output, without materials and energy. The addition of the intangibles ***K*** is characteristics of the knowledge paradigms, and an earlier entry could have been devised from the new economy. With the manufacturer's lifecycle responsibility, the explicit role of ***K*** and ***T*** needs to emerge, since the companies' profitability will become critically dependent on how these factors are balanced; the ***T*** *vs*. ***K*** dialectic opposition is tomorrow's challenge.

The scaled ***T*** factor measures the natural capital use/misuse, with annexed allegations. The technology ***K*** concern has fallouts at the design, production and sale phases, and in the manufacture business, is dealt with, for *trade fairness*, by the quality engineering guidelines. The conformance-to-requirement of the *quality* standards binds design (technical specification files), to delivery approval testing. Anyway, the technology ***K*** comes as primary transformation factor, affecting the manufacture process throughput.

The productivity bookkeeping is merged into global ***Q*** assessments, to provide synthetic pictures, with visibility of all the four capital assets, as the enterprise's function/facility guardians. The manufacture shop-floors generate value chains, providing ***Q*** guesses based on the market requests, including the welfarism charges (***L*** factor), according to the enacted rules, and, from now on, the ecologic fees (***T*** factor), following, e.g., the in-progress EU directives. With the ***KILT*** model, the four manufacture assets easily apply, without modifying many assessed traditional habits.

4.2 The Tangibles Productivity

The environment protection is man's right at universal range, with the aim to safeguard the future generations, today not at all represented by efficient political

parties or governmental agencies. The democratic consensus or international agreements are deprived of justifications, whether limited to care the interests of the today's citizens. The *fair* socio-political approach, put forward by the knowledge paradigms, compels protecting the (without voice) generations to come, by compensation ways, such as [Glazer 2009], [Morino 2011], [O'Neill 2001], [Troccoli 2009], [Tzafestas 1997]:

- to create a tax system, which consolidates the wealth corresponding to the accomplished withdrawal from the natural capital, following deposit/refund-like arrangements;
- to forbid natural capital withdrawals that exceed quotas, roughly equal to the reverse logistics recovery, or (hopefully) to the bio-mimicry stimulated generation, in view to keep the original natural capital level, by neutral yield.

The first way is formal, since, transforming different capitals, the equivalence criteria are, at least, ambiguous. The second, if coherently applied, faces decay limitations, and today runs into the life quality decrease, towards the thrifty society. It is, moreover, possible to merge the two ways, using the *deposit-refund* choice as first instance, thereafter keenly researching innovative technologies, out of reverse logistics, which perform active *replacing* resources and full eco-remediation, to achieve neutral yield of the *inherited* natural capital.

Many unanswered questions exist (e.g., in terms of comprehensiveness). The EU environmental policy looks aiming at united way. The bookkeeping of the tangibles' decrease and pollutants' increase becomes primary demand, with, as side request, the assessment of the restoring onerousness. So, closed-cycle economic/ecologic processes are prerequisite of the manufacture markets to come. The analyses need to be quantitative, to make meaningful comparisons, fulfilling the assessments by recognized standards. The consistent closed-cycle appraisal brings to concepts such as the below new metrics (or similar equivalent standards).

5 Eco-watching/Appraisal by TYPUS Metrics

The use of clever to de-materialise schemes is relevant opportunity, allowing the creation of riches, little entailing the entropy decay, going together with all the material manipulations. More at the point, in the ***KILT*** model, this means addressing the ***K*** and ***I*** factors, while minimising the ***T*** involvement. The ***L*** factor has a more tangled role: it belongs to the tangible inputs and, as such, it contributes to the entropy decay, along with the related metabolic processes and, to a particular extent, with the intentional manipulation of the surroundings, notably, entailing *artificial* energy and *synthetic* transformations. In truth, the analyses built taking into account the anthropic values imagine that the civilisation occurs, because the cosmos' inner order foretells such an outcome, so that the life and intelligence singularities are the mark of the human progress *stability*, at least, within given allocated spans.

If this reading is defendable, the human capital role has entangled aftermaths, being the essential inventor and driver of the civilisation, with constituent functions. In the present paper, the focus is limited on the modelling of productive activity, for assessing its eco-sustainability. Thus, these more general justifying projections are omitted. Limited clues are hereafter outlined, with topics more closely related to the ***KILT*** model.

5.1 Human Capital Prospects

The ***L*** factor of the ***KILT*** model relegates to workforce domains: the ***I*** and ***L*** dialectic is known fact of the industrial ages. In the value-added creation, nonetheless, the human capital plays much more relevant roles. The man centred anthropic construal is rooted in analysing the life and intelligence singularities: the former supplies *agentive* talent, directly engaged in the workforce rating; the latter brings in *rational* aptitude, allowing decision-keeping for selecting assessed utility goals. Many rationality achievements remain at implied range, when prised through market-poised ways; this is the case of most socio-political arrangements, notably, leading to the extant collective orders that give effectiveness to the countries and related governments.

The ecology globalisation, today, says that the over-depletion/contamination of the industry paradigms requires a new revolution, in which the life and intelligence singularities will be directly involved, through robot age implements, in view of the cognitive revolution, [Johnson 2013], [Michelini 2008], [Michelini 2009], [Rosner 2004], [Wallace 2010]. The human and technical capitals prospects will combine together in cognizance-like processes, having to de-materialise and to re-materialise ends, making it feasible to reach the necessary reclamation and restoring targets of the eco-sustainability.

5.2 Natural Capital Prospects

The ***T*** factor, in any case, is essential figure to be monitored, using appropriate standards: the **TYPUS**, *tangibles yield per unit service* is example metrics. The measurement plot covers the whole materials supply chain, from procurement to recovery, so that every enjoyed *product-service* has associated eco-figures, assembling the resources consumption and the induced fallouts, requiring remediation. The results are expressed in money, resorting to arbitrariness in establishing stock-replacing prospects. The point is left open, but, it needs to be detailed, to provide quantitative (legal metrology driven) assessment of the "*deposit-refund*" balance.

The metrics is self-sufficient standard, aiming at the natural capital intensive exploitation. The supply chain lifecycle visibility needs monitoring and recording the joint economic/ecologic issues, giving quantitative assessment of all the input/output materials and energy flows. The new tax system has to operate on these data, establishing consumption rates at the input, and pollution rates at the output, to obtain the "wealth equivalent" of the overall impact (as for the first mentioned way), [Michelini 2002], [Michelini 2008], [Michelini 2010], [Michelini 2012], [Putnik 2005].

When suited metrics, such as **TYPUS**, is adopted, conservative behaviours are soon fostered. The ecologic bent of the taxing systems becomes enabling spur, to turn the knowledge paradigms towards environmental friendly goals. The objective is to look after capital conservative arrangements, notably, as for the *natural* assets. In different words, the objective is to save the wealth (the *capital*), and to tax the consumption (the *imbalance* of the natural resources).

Today, the eco-fee evaluation is quite obscure, due to political biases. It leads to taxing schemas, which are drawn from the costumers' interests, more than in proportion to the *actual impact* (net depletion combined to pollution). The eco-

protection, switched into consumers (producers and buyers) business, is starting point, to look for higher efficiency, over the whole supply chain, from provisioning to recovery, using clear *all-comprehensive* effectiveness criteria, thus, singly dealing with each capital asset (starting from the tangibles' productivity).

Tomorrow, the natural capital bookkeeping will be standard routine of the knowledge society. Today, the *economic* accounting to detect unlawful habits (crime, repression, etc.) is obvious practice, affecting personal liability. Similarly, the thought-out *ecological* accounting needs to develop into steady rehearsal, in view of charging the actual consumers (to the safeguard of third people, future generations included). Resorting to knowledge paradigms, the tax regulation restructuring is compulsory, because the socio-political standpoint management becomes fundamental contribution to effectiveness. The bigger question is how to distinguish the community's from the individual's duties.

The solution offered by the (western world style) capitalism is noteworthy issue, resorting to fit ‹business tidiness› options, empowered by the ‹sustainable corporation› responsibility. A personal liability is consequence of the freedom independence, in organising exclusive fortunes. In place of shared figures, the individual accountability offers rewards through competition. The averaged taxation of input/output materials and energy flows is simple, being linked to nominal parameters, limiting the control to out-of-all quantities (provisioning and land-filling). The issue is local communities business, with visible fees refund, depending on the efficiency of the average balances. The *ecological* accounting through the **TYPUS** metrics is straightforward affair, needing to address the single supply chain, by pace wise checks, necessarily done by the product-service dealers. The competition shifts at the ‹big society› level; the lifecycle manufacturers' responsibility is viable bookkeeping charge, under the registered overseeing of ‹certifying bodies›, ruled by ‹settlement councils›. At least, this is fair practice, deserving attention.

6 Conclusions

The study's goal is the technical, ecological, environmental and social examination of the lifecycle conformance certification, LCC, of any delivery (provision, consumable, service) using the **TYPUS** metrics and the ***KILT*** model. The lifecycle starts when the idea of a product is born and lasts until complete disposal, through realisation and operation. Our real goal is to give some means and tools to calculate specific values, which correspond to different phases of the product lifecycle. We specially emphasise re-use and re-cycling as important LCC topics, due to approaching water, energy and raw material shortages. As for *supply*, we mean anything which is used by end buyers (a car, a cup, a bike, or part of them, etc.), or which is used by dedicated clients to produce or to run other products (a machine tool, a robot, a house, a test environment, etc.), or which is used to manage everything else (a firm, a factory, a ministry, etc.). We differentiate between simple products and extended products and between tangible and intangible parts (aspects) and take into account service as it was a product, too.

The **TYPUS** metrics and the ***KILT*** model tell that the delivery of a firm can be computed through a seemingly simple joint modulation of four main factors, i.e.: Knowledge (innovation), Investment, Labour (human capital) and Tangibles

(materials), scaled by appropriate coefficients and additional adjustments. Delivery includes goal-products, side effects (water consumption, CO_2 disclosure, etc.). Based on these relationships, actual data can be given on effects, side effects and the further tunings of products and productions, whether the **TYPUS** metrics is taken into account. The ***KILT*** model allows appraising the future cognitive revolution deployments, when the human and technical capitals will modify, to include their explicit *constituent* contributions, in addition to the *instrument* ones. We are not allowed to omit ***T***; the ***K*** and ***L*** factors are ostensibly added chances; the ***I*** help requires suited warnings.

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